R&S®RTO
Digital Oscilloscope
User Manual

1332.9725.02 — 09

User Manual

ROHDE&SCHWARZ

This manual describes the following R&S®RTO models with firmware version 3.60:

- R&S®RTO2002 (1329.7002K02)
- R&S®RTO2004 (1329.7002K04)
- R&S®RTO2012 (1329.7002K12)
- R&S®RTO2014 (1329.7002K14)
- R&S®RTO2022 (1329.7002K22)
- R&S®RTO2024 (1329.7002K24)
- R&S®RTO2032 (1329.7002K32)
- R&S®RTO2034 (1329.7002K34)
- R&S®RTO2044 (1329.7002K44)
- R&S®RTO2064 (1329.7002K64)

- R&S®RTO1002 (1316.1000K02)
- R&S®RTO1004 (1316.1000K04)
- R&S®RTO1012 (1316.1000K12)
- R&S®RTO1014 (1316.1000K14)
- R&S®RTO1022 (1316.1000K22)
- R&S®RTO1024 (1316.1000K24)
- R&S®RTO1044 (1316.1000K44)

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Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol , e.g. R&S®RTO is indicated as R&S RTO.

Basic Safety Instructions

Always read through and comply with the following safety instructions!

All plants and locations of the Rohde & Schwarz group of companies make every effort to keep the safety standards of our products up to date and to offer our customers the highest possible degree of safety. Our products and the auxiliary equipment they require are designed, built and tested in accordance with the safety standards that apply in each case. Compliance with these standards is continuously monitored by our quality assurance system. The product described here has been designed, built and tested in accordance with the EC Certificate of Conformity and has left the manufacturer’s plant in a condition fully complying with safety standards. To maintain this condition and to ensure safe operation, you must observe all instructions and warnings provided in this manual. If you have any questions regarding these safety instructions, the Rohde & Schwarz group of companies will be happy to answer them.

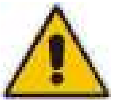
Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for any purpose other than its designated purpose or in disregard of the manufacturer's instructions. The manufacturer shall assume no responsibility for such use of the product.

The product is used for its designated purpose if it is used in accordance with its product documentation and within its performance limits (see data sheet, documentation, the following safety instructions). Using the product requires technical skills and, in some cases, a basic knowledge of English. It is therefore essential that only skilled and specialized staff or thoroughly trained personnel with the required skills be allowed to use the product. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation. Keep the basic safety instructions and the product documentation in a safe place and pass them on to the subsequent users.

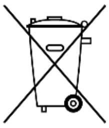
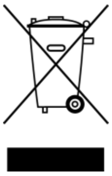
Observing the safety instructions will help prevent personal injury or damage of any kind caused by dangerous situations. Therefore, carefully read through and adhere to the following safety instructions before and when using the product. It is also absolutely essential to observe the additional safety instructions on personal safety, for example, that appear in relevant parts of the product documentation. In these safety instructions, the word "product" refers to all merchandise sold and distributed by the Rohde & Schwarz group of companies, including instruments, systems and all accessories. For product-specific information, see the data sheet and the product documentation.

Safety labels on products

The following safety labels are used on products to warn against risks and dangers.

Symbol	Meaning	Symbol	Meaning
	Notice, general danger location Observe product documentation	| ○	ON/OFF Power
	Caution when handling heavy equipment 	⏻	Standby indication
	Danger of electric shock	⎓	Direct current (DC)

Basic Safety Instructions

Symbol	Meaning	Symbol	Meaning
	Caution ! Hot surface	∿	Alternating current (AC)
	Protective conductor terminal To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth	≂	Direct/alternating current (DC/AC)
	Earth (Ground)	⧈	Class II Equipment to identify equipment meeting the safety requirements specified for Class II equipment (device protected by double or reinforced insulation)
	Frame or chassis Ground terminal		EU labeling for batteries and accumulators For additional information, see section "Waste disposal/Environmental protection", item 1.
	Be careful when handling electrostatic sensitive devices		EU labeling for separate collection of electrical and electronic devices For additional information, see section "Waste disposal/Environmental protection", item 2.
	Warning! Laser radiation For additional information, see section "Operation", item 7.		

Signal words and their meaning

The following signal words are used in the product documentation in order to warn the reader about risks and dangers.

⚠ DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates information considered important, but not hazard-related, e.g. messages relating to property damage. In the product documentation, the word ATTENTION is used synonymously.

These signal words are in accordance with the standard definition for civil applications in the European Economic Area. Definitions that deviate from the standard definition may also exist in other economic areas or military applications. It is therefore essential to make sure that the signal words described here are always used only in connection with the related product documentation and the related product. The use of signal words in connection with unrelated products or documentation can result in misinterpretation and in personal injury or material damage.

Operating states and operating positions

The product may be operated only under the operating conditions and in the positions specified by the manufacturer, without the product's ventilation being obstructed. If the manufacturer's specifications are not observed, this can result in electric shock, fire and/or serious personal injury or death. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

1. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products: predefined operating position is always with the housing floor facing down, IP protection 2X, use only indoors, max. operating altitude 2000 m above sea level, max. transport altitude 4500 m above sea level. A tolerance of ±10 % shall apply to the nominal voltage and ±5 % to the nominal frequency, overvoltage category 2, pollution degree 2.
2. Do not place the product on surfaces, vehicles, cabinets or tables that for reasons of weight or stability are unsuitable for this purpose. Always follow the manufacturer's installation instructions when installing the product and fastening it to objects or structures (e.g. walls and shelves). An installation that is not carried out as described in the product documentation could result in personal injury or even death.
3. Do not place the product on heat-generating devices such as radiators or fan heaters. The ambient temperature must not exceed the maximum temperature specified in the product documentation or in the data sheet. Product overheating can cause electric shock, fire and/or serious personal injury or even death.

Electrical safety

If the information on electrical safety is not observed either at all or to the extent necessary, electric shock, fire and/or serious personal injury or death may occur.

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the mains-supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with a protective conductor contact and protective conductor.
3. Intentionally breaking the protective conductor either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
4. If there is no power switch for disconnecting the product from the mains, or if the power switch is not suitable for this purpose, use the plug of the connecting cable to disconnect the product from the mains. In such cases, always ensure that the power plug is easily reachable and accessible at all times. For example, if the power plug is the disconnecting device, the length of the connecting cable must not exceed 3 m. Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, the disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cables on a regular basis to ensure that they are in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, ensure that the cable cannot be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.

6. The product may be operated only from TN/TT supply networks fuse-protected with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket provided for this purpose. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages $V_{rms} > 30$ V, suitable measures (e.g. appropriate measuring equipment, fuse protection, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC 60950-1 / EN 60950-1 or IEC 61010-1 / EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the protective conductor terminal on site and the product's protective conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fuse-protected in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.
14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1). Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.

2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal/Environmental protection", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. Laser products are given warning labels that are standardized according to their laser class. Lasers can cause biological harm due to the properties of their radiation and due to their extremely concentrated electromagnetic power. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).
8. EMC classes (in line with EN 55011/CISPR 11, and analogously with EN 55022/CISPR 22, EN 55032/CISPR 32)
   - Class A equipment:
     Equipment suitable for use in all environments except residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings
     Note: Class A equipment is intended for use in an industrial environment. This equipment may cause radio disturbances in residential environments, due to possible conducted as well as radiated disturbances. In this case, the operator may be required to take appropriate measures to eliminate these disturbances.
   - Class B equipment:
     Equipment suitable for use in residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings

Repair and service

1. The product may be opened only by authorized, specially trained personnel. Before any work is performed on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.

2. Adjustments, replacement of parts, maintenance and repair may be performed only by electrical experts authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, protective conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

Batteries and rechargeable batteries/cells

If the information regarding batteries and rechargeable batteries/cells is not observed either at all or to the extent necessary, product users may be exposed to the risk of explosions, fire and/or serious personal injury, and, in some cases, death. Batteries and rechargeable batteries with alkaline electrolytes (e.g. lithium cells) must be handled in accordance with the EN 62133 standard.

1. Cells must not be taken apart or crushed.
2. Cells or batteries must not be exposed to heat or fire. Storage in direct sunlight must be avoided. Keep cells and batteries clean and dry. Clean soiled connectors using a dry, clean cloth.
3. Cells or batteries must not be short-circuited. Cells or batteries must not be stored in a box or in a drawer where they can short-circuit each other, or where they can be short-circuited by other conductive materials. Cells and batteries must not be removed from their original packaging until they are ready to be used.
4. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
5. If a cell develops a leak, the fluid must not be allowed to come into contact with the skin or eyes. If contact occurs, wash the affected area with plenty of water and seek medical aid.
6. Improperly replacing or charging cells or batteries that contain alkaline electrolytes (e.g. lithium cells) can cause explosions. Replace cells or batteries only with the matching Rohde & Schwarz type (see parts list) in order to ensure the safety of the product.
7. Cells and batteries must be recycled and kept separate from residual waste. Rechargeable batteries and normal batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.
8. Follow the transport stipulations of the carrier (IATA-DGR, IMDG-Code, ADR, RID) when returning lithium batteries to Rohde & Schwarz subsidiaries.

Transport

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.
2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.

3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

Waste disposal/Environmental protection

1. Specially marked equipment has a battery or accumulator that must not be disposed of with unsorted municipal waste, but must be collected separately. It may only be disposed of at a suitable collection point or via a Rohde & Schwarz customer service center.
2. Waste electrical and electronic equipment must not be disposed of with unsorted municipal waste, but must be collected separately.
   Rohde & Schwarz GmbH & Co. KG has developed a disposal concept and takes full responsibility for take-back obligations and disposal obligations for manufacturers within the EU. Contact your Rohde & Schwarz customer service center for environmentally responsible disposal of the product.
3. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
4. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

For additional information about environmental protection, visit the Rohde & Schwarz website.

Customer Support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and will work with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz equipment.

Up-to-date information and upgrades

To keep your instrument up-to-date and to be informed about new application notes related to your instrument, please send an e-mail to the Customer Support Center stating your instrument and your wish. We will take care that you will get the right information.

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ROHDE&SCHWARZ

Contents

1 Preface

1.1 Key Features

The R&S RTO Digital Oscilloscope provides fast signal acquisition and analysis. Outstanding key features are:

- 1 million waveforms per second waveform acquisition rate
- Highly accurate digital trigger system
- Very low noise floor
- Precise measurements due to single-core A/D converter
- High measurement speed, even for complex analysis functions
- Easy and intuitive to operate
- High-quality line of probes

For a detailed specification refer to the data sheet.

The R&S RTO Digital Oscilloscope brings various benefits in your daily work:

- Find rare signal faults quickly with no trade-offs for measurement and analysis due to highest acquisition rate and shortest blind time.
- Access and analyze prior waveforms in the memory using the history function
- Get fastest results even with maximum data with hardware-accelerated processing: mathematical operations, mask tests, histograms, automatic and cursor measurements, and spectrum display.
- Capture closest successive events with the real-time digital trigger system. It works with high trigger sensitivity at full bandwidth and very low trigger jitter.
- Get key measurement results at the push of a button with Quick Measurement
- Easy to use:
  - Smart and straightforward user guidance
  - Color-coded control elements for clear identification
  - Signal icons with drag & drop functionality
  - Toolbar with frequently used functionality
- Verify and debug embedded systems using the options for triggering and decoding of serial protocols such as I²C, SPI, UART, CAN, LIN and FlexRay
- Turn the R&S RTO into a mixed signal oscilloscope using the MSO option and analyze up to 16 additional digital channels

1.2 Documentation Overview

This section provides an overview of the R&S RTO user documentation. You find the documentation on the product website at:

www.rohde-schwarz.com/manual/rto

Getting started manual

Introduces the R&S RTO and describes how to set up and start working with the instrument, and describes basic operations. A printed English version is included in the delivery. Editions in other languages are available on the product website.

Instrument help

The help offers quick, context-sensitive access to the functional description directly on the instrument.

User manual (Instrument)

Describes all instrument functions in detail. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance and instrument interfaces. Includes the contents of the getting started manual.

The *online version* of the user manual provides the complete contents for immediate display on the internet.

Manuals for compliance test options

For compliance test options, test procedure manual are available. Test fixtures are described in separate manuals, which are delivered with the fixture in printed form.

- Test procedure manuals are available for:
  - R&S RTO-K21 USB 2.0 Compliance Tests
  - R&S RTO-K22/K23/K24/K25/K86 Ethernet Compliance Tests
  - R&S RTO-K26 MIPI D-PHY Compliance Tests
  - R&S RTO-K92 eMMC Compliance Tests
- Test fixture manuals are available for:
  - RT-ZF1 USB 2.0 Compliance Test Fixture Set
  - R&S RT-ZF2 Ethernet Compliance Test Fixture Set
  - R&S RT-ZF3 Frequency Converter
  - R&S RT-ZF4 10BASE-Te Fixture
  - R&S RT-ZF5 Ethernet Probing Fixture

Service Manual

Describes the performance test for checking the rated specifications, module replacement, firmware update, troubleshooting and fault elimination, and contains mechanical drawings and spare part lists. The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

Instrument security procedures manual

Deals with security issues when working with the R&S RTO in secure areas.

Basic safety instructions

Contains safety instructions, operating conditions and further important information. The printed document is delivered with the instrument.

Data sheet and brochure

The data sheet contains the technical specifications of the R&S RTO. It also lists the options with their order numbers and optional accessories. The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/rto

Release notes and open source acknowledgment

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation. The open source acknowledgment document provides verbatim license texts of the used open source software.

See www.rohde-schwarz.com/firmware/rto. The open source acknowledgment can also be read directly on the instrument.

Application notes, application cards, videos

These documents deal with special applications or background information on particular topics.

See www.rohde-schwarz.com/application/rto

1.3 Options Described in this Document

In addition to the base unit, the following options are described in this documentation:

Type	Designation	Order No. for RTO2000	Order No. for RTO1000
R&S®RTO-B1	MSO	1304.9901.03	1304.9901.03
R&S®RTO-B6	Waveform and pattern generator	1329.7054.02	n.a.
R&S®RTO-K1	I²C and SPI serial decoding	1329.7260.02	1304.8511.02
R&S®RTO-K2	UART/RS-232/RS-422/RS-485 serial decoding	1329.7277.02	1304.8528.02
R&S®RTO-K3	CAN and LIN serial triggering and decoding	1329.7283.02	1304.8534.02
R&S®RTO-K4	FlexRay™ serial triggering and decoding	1329.7290.02	1304.8540.02
R&S®RTO-K5	I²S (audio) serial triggering and decoding	1329.7302.02	1317.3620.02
R&S®RTO-K6	MIL-STD-1553 serial triggering and decoding	1329.7319.02	1317.7419.02
R&S®RTO-K7	ARINC 429 serial triggering and decoding	1329.7325.02	1317.7425.02
R&S®RTO-K8	Ethernet serial triggering and decoding	1329.7331.02	1326.0220.02

Type	Designation	Order No. for RTO2000	Order No. for RTO1000
R&S®RTO-K9	CAN-FD serial triggering and decoding	1329.7348.02	1325.9881.02
R&S®RTO-K10	SENT serial triggering and decoding	1329.7354.02	1326.1549.02
R&S®RTO-K11	I/Q software interface	1329.7360.02	1317.2975.02
R&S®RTO-K12	Jitter analysis	1329.7377.02	1317.4690.02
R&S®RTO-K13	Clock data recovery	1329.7383.02	1317.4703.02
R&S®RTO-K17	High definition mode	1329.7419.02	1326.0536.02
R&S®RTO-K18	Spectrum analysis	1329.7425.02	1326.3029.02
R&S®RTO-K19	ZoneTrigger	1329.7431.02	n.a.
R&S®RTO-K31	Power analysis	1329.7502.02	1317.5739.02
R&S®RTO-K40	MIPI RFFE serial triggering and decoding	1329.7519.02	1325.9900.02
R&S®RTO-K42	MIPI D-PHY serial triggering and decoding	1329.7525.02	1326.2668.02
R&S®RTO-K44	MIPI M-PHY serial triggering and decoding	1333.0267.02	1333.0250.02
R&S®RTO-K50	Custom Manchester and NRZ serial triggering and decoding	1329.7531.02	1326.0236.02
R&S®RTO-K52	8b10b serial triggering and decoding	1329.7548.02	1326.0894.02
R&S®RTO-K55	MDIO serial triggering and decoding	1329.7554.02	1326.0713.02
R&S®RTO-K60	USB 1.0/1.1/2.0/HSIC serial triggering and decoding	1329.7560.02	1320.6690.02
R&S®RTO-K61	USB 3.1 Gen 1 serial triggering and decoding	1326.3112.02	
R&S®RTO-K63	USB-PD serial triggering and decoding	1326.3135.02	1316.3129.02
R&S®RTO-K65	SpaceWire serial triggering and decoding	1326.2868.02	1326.2851.02
R&S®RTO-K72	PCI Express 1.x/2.x serial triggering and decoding	1326.3741.02	
R&S®RTO-K76	CXPI serial triggering and decoding	1326.3170.02	1326.3164.02

1.4 Conventions Used in the Documentation

1.4.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.4.2 Conventions for Procedure Descriptions

When operating the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

2 Getting Started

Note: the following chapters are identical to those in the R&S RTO Getting Started manual for R&S RTO2000 instruments.

2.1 Preparing for Use

This section describes the basic steps to be taken when setting up the R&S RTO for the first time.

NOTICE

Risk of instrument damage due to inappropriate operating conditions

Specific operating conditions are required to ensure accurate measurements and to avoid damage to the instrument. Observe the information on appropriate operating conditions provided in the basic safety instructions and the instrument's data sheet.

2.1.1 Unpacking and Checking the Instrument

To remove the instrument from its packaging and check the equipment for completeness, proceed as follows:

1. Pull off the polyethylene protection pads from the instrument's rear feet.
2. Carefully remove the pads from the instrument handles at the front.
3. Pull off the corrugated cardboard cover that protects the rear of the instrument.
4. Carefully unthread the corrugated cardboard cover at the front that protects the instrument handles and remove it.
5. Check the equipment for completeness using the delivery note and the accessory lists for the various items.
6. Check the instrument for any damage. If there is damage, immediately contact the carrier who delivered the instrument. Make sure not to discard the box and packing material.

Packing material

Retain the original packing material. If the instrument needs to be transported or shipped later, you can use the material to protect the control elements and connectors.

2.1.2 Positioning the Instrument

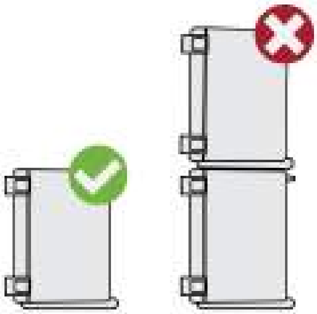
The instrument is designed for use under laboratory conditions. It can be used in standalone operation on a bench top or can be installed in a rack.

⚠ CAUTION

Risk of injury when stacking instruments insecurely

Never stack instruments on top of each other. The instrument's top surface area is too small to stack multiple instruments. Stacked instruments can tilt over and cause injury or damage the instrument.

If you need to stack instruments, install them in a rack.



2.1.2.1 Standalone Operation

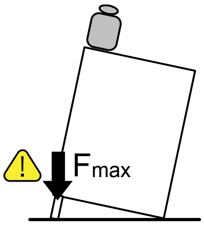
For standalone operation, place the instrument on a horizontal bench with even, flat surface. The instrument can be used in horizontal position, standing on its feet, or with the support feet on the bottom extended.

CAUTION

Risk of injury if feet are folded out

The feet can fold in if they are not folded out completely or if the instrument is shifted. This can cause damage or injury.

- Fold the feet completely in or out to ensure stability of the instrument. Never shift the instrument when the feet are folded out.
- When the feet are folded out, do not work under the instrument or place anything underneath.
- The feet can break if they are overloaded. The overall load on the folded-out feet must not exceed 200 N.



2.1.2.2 Rackmounting

The instrument can be installed in a 19" rackmount using a rack adapter kit. The order number is given in the data sheet. The installation instructions are part of the adapter kit.

NOTICE

Risk of instrument damage due to insufficient airflow in a rack

If the instrument is run with insufficient airflow for a longer period, the instrument overheats, which can disturb the operation and even cause damage.

Make sure that all fan openings are unobstructed, that the airflow perforations are unimpeded, and that the minimum distance from the wall is 10 cm.

2.1.3 Starting the Instrument

⚠ WARNING

Risk of injury and instrument damage

The instrument must be used in an appropriate manner to prevent electric shock, fire, personal injury, or damage.

- Do not open the instrument casing.
- Read and observe the "Basic Safety Instructions" delivered as a printed brochure with the instrument.
  In addition, read and observe the safety instructions in the following sections. Notice that the data sheet may specify additional operating conditions.

NOTICE

Risk of instrument damage due to inappropriate operating conditions

An unsuitable operating site or test setup can damage the instrument and connected devices. Before switching on the instrument, observe the information on appropriate operating conditions provided in the data sheet. In particular, ensure the following:

- All fan openings are unobstructed and the airflow perforations are unimpeded. The minimum distance from the wall is 10 cm.
- The instrument is dry and shows no sign of condensation.
- The instrument is positioned as described in the following sections.
- The ambient temperature does not exceed the range specified in the data sheet.
- Signal levels at the input connectors are all within the specified ranges.
- Signal outputs are connected correctly and are not overloaded.

2.1.3.1 Powering On

The R&S RTO can be used with different AC power voltages and adapts itself automatically to it.

⚠ CAUTION

Risk of injury

Connect the instrument to an outlet that has a ground contact.

If grounding is *not* ensured by the mains system, ground the instrument using the protective earth conductor on the front panel and an appropriate cable.

Do not use an isolating transformer to connect the instrument to the AC power supply.

1. Connect the power cable to the AC power connector on the rear panel of the R&S RTO.

2. Connect the power cable to the socket outlet.
3. Switch the main power switch at the rear of the instrument to position **I**.

   The power key on the front panel lights up.

When you power up the instrument, be sure to comply with the warm-up phase specified in the data sheet before you start measurements.

You can leave the main power switch on to preserve your last instrument settings. To disconnect from power supply, power off the instrument.

2.1.3.2 Starting Up and Shutting Down

The POWER key is located in the bottom left corner of the front panel.

To start up the instrument

1. Make sure that the R&S RTO is connected to the AC power supply and the main power switch on the rear panel is in position **I**.
2. Press the POWER key on the front panel.

   The instrument performs a system check, boots the Windows operating system, and then starts the R&S RTO firmware.
   The POWER key turns green and the illuminated keys on the front panel light up. If the previous session was terminated regularly, the oscilloscope uses the last settings.

To shut down the instrument

► Press the POWER key on the front panel.

   All current settings are saved, and the software shuts down. The standby power only supplies the power switch circuits and the optional oven quartz (OCXO, option R&S RTO-B4).
   Now it is safe to power off the instrument.

The "Exit" function in the "File" menu shuts down only the firmware application. To shut down the instrument completely, also shut down the operating system in the "Start" menu.

2.1.3.3 Powering Off

Powering off is required only if the instrument must be disconnected from all power supplies.

It also interrupts the power supply of the OCXO (option OCXO Reference Frequency, R&S RTO-B4).

1. If the instrument is running and the POWER key is green, press the POWER key on the front panel to shut down the instrument.

2. Switch the main power switch at the rear of the instrument to position 0.
3. Disconnect the AC power cable from the AC power supply.

NOTICE

Risk of losing data

If you switch off the running instrument using the rear panel switch or by disconnecting the power cord, the instrument loses its current settings. Furthermore, program data can be lost.

Press the POWER key first to shut down the application properly.

2.1.3.4 EMI Suppression

Electromagnetic Interference (EMI) may affect the measurement results.

To suppress generated Electromagnetic Interference:

- Use suitable shielded cables of high quality. For example use double-shielded RF and LAN cables.
- Always terminate open cable ends.
- Note the EMC classification in the data sheet.

2.1.4 Connecting External Devices

The following interfaces for external devices are provided:

- USB connectors, see also "USB" on page 35
- Monitor connectors, see also "DVI-D" on page 37 and "DISPLAYPORT" on page 37

2.1.4.1 Connecting USB Devices

The USB interfaces on the front and rear panels of the R&S RTO allow you to connect USB devices directly to the instrument. The number of USB connectors can be increased by using USB hubs. Due to the large number of available USB devices, there is almost no limit to the expansions that are possible with the R&S RTO.

The following list shows various USB devices that can be useful:

- CD-ROM drives for easy installation of firmware applications
- Keyboard and/or mouse to simplify the operation and the entry of data, comments, filenames, etc.
- Printer for printing measurement results

All USB devices can be connected to or disconnected from the instrument during operation.

Installing USB devices on R&S RTO is easy under the Windows operating system, because all USB devices are plug&play. After a device is connected to the USB interface, Windows automatically searches for a suitable device driver.

If the operating system does not find a suitable driver, it prompts you to specify a directory that contains the driver software. If the driver software is on a CD, connect a USB CD-ROM drive to the instrument before proceeding.

When a USB device is disconnected from the R&S RTO, Windows immediately detects the change in hardware configuration and deactivates the corresponding driver.

The properties of external USB devices are configured in the operating system, not in the R&S RTO software. It is recommended that you use mouse and keyboard to access and modify the settings of the Windows operating system. To access Windows, press the Windows key on the external keyboard, or select "File" > "Minimize" on the R&S RTO menu.

Connecting a USB flash drive or CD-ROM drive

If installation of a USB flash driver or CD-ROM drive is successful, Windows informs you that the device is ready to use. The device is made available as a new drive ("D:") and is displayed under Windows Explorer. The name of the drive depends on the manufacturer.

Connecting a keyboard

The keyboard is detected automatically when it is connected. The default input language is English – US.

Use the Windows "Start" menu > "Control Panel" > "Change keyboards or other input methods" to configure the keyboard properties.

Connecting a mouse

The mouse is detected automatically when it is connected.

Use the Windows "Start" menu > "Devices and Printers" > "Mouse" to configure the mouse properties.

Connecting a printer

When printing a file, the instrument checks whether a printer is connected and turned on and whether the appropriate printer driver is installed. If necessary, printer driver installation is initiated using the Windows' "Add a Printer" wizard. A printer driver needs to be installed only once.

You can load updated and improved driver versions or new drivers from a USB flash drive, or another external storage medium. If the instrument is integrated in a network, you can also install driver data stored in a network directory.

Use the Windows "Start" menu > "Devices and Printers" > "Add a printer" to install the driver.

2.1.4.2 Connecting an External Monitor

You can connect an external monitor or projector to the DVI-D connector on the instrument's rear panel. See also: "DVI-D" on page 37.

You can also use the DisplayPort connector, see "DISPLAYPORT" on page 37.

Before connecting an external monitor, ensure that the monitor and the R&S RTO are connected to a ground contact. Otherwise the instrument may be damaged.

After connecting an additional monitor or projector to the instrument, configure it for usage. The relevant settings are Windows settings but you can configure the displays directly in the instrument setup.

1. Check the input type of the monitor or projector. Make sure to select the correct cable. To use a VGA monitor, an active DVI-D to VGA adapter is required.
2. Press the SETUP key.
3. Select the "System" tab.
4. Tap "Display / Monitors".
5. To show the instrument's display content only on the external monitor, select "Projector only".
   To show the instrument's display content on both the oscilloscope and the external monitor, select "Duplicate".

The touchscreen of the R&S RTO has a screen resolution of 1280 x 800 pixel. Most external monitors have a higher screen resolution. If the screen resolution of the monitor is set higher than the instrument's resolution, the application window uses a 1280 x 800 area of the monitor display. For full screen display, adjust the monitor's screen resolution using "Additional display settings".

2.2 Instrument Tour

This chapter describes the front and rear panels of the instrument including all function keys and connectors, and also the touchscreen with its control elements.

2.2.1 Front Panel

The front panel of the R&S RTO is shown in Figure 2-1. The function keys are grouped in functional blocks to the left and the right of the touchscreen. Below the screen, various connectors are located.

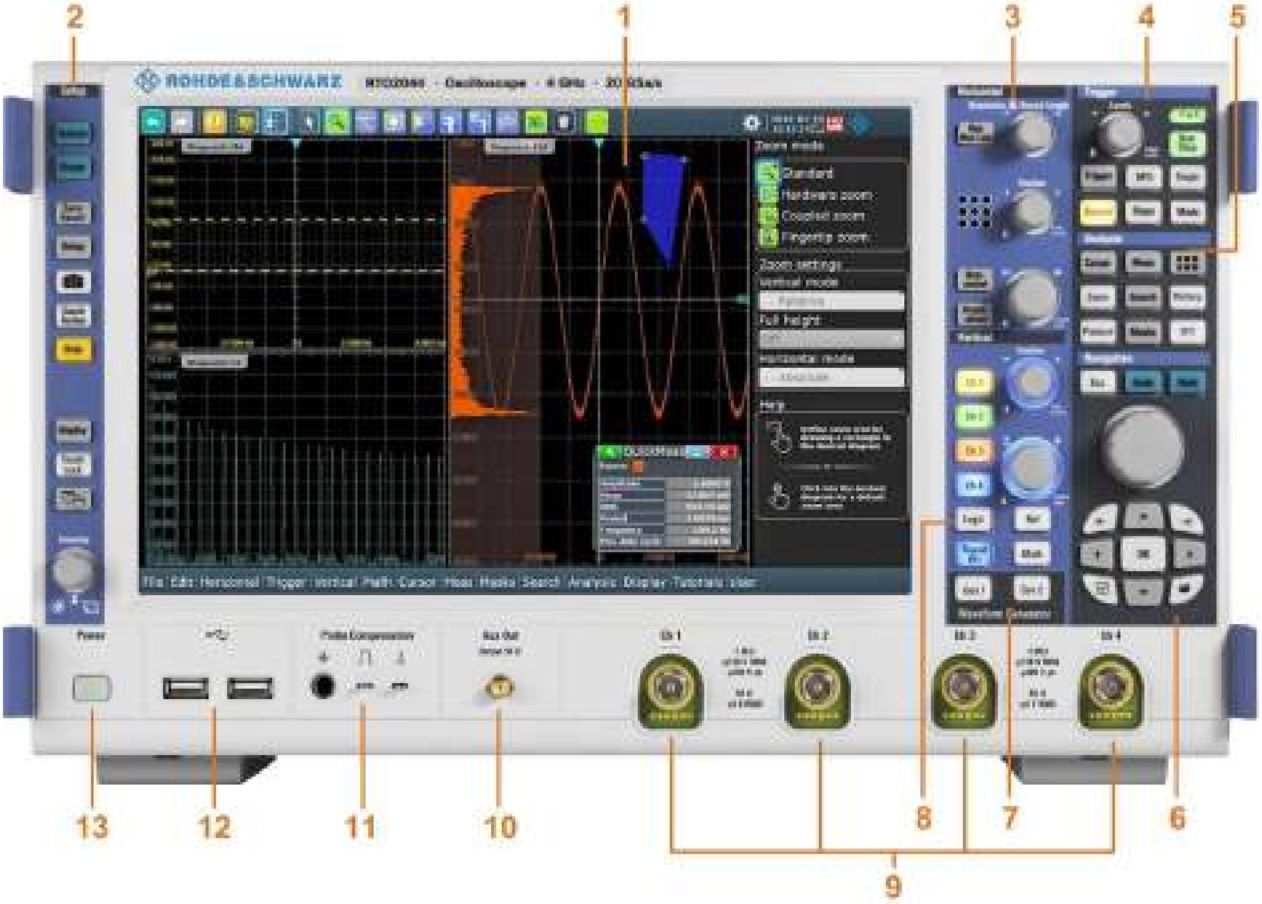


Figure 2-1: Front panel of R&S RTO2044 with 4 input channels

1 = Touchscreen
2 = SETUP controls
3 = HORIZONTAL controls
4 = TRIGGER controls
5 = ANALYSIS keys
6 = NAVIGATION controls
7 = WAVEFORM GENERATOR keys
8 = VERTICAL controls
9 = Input channels
10 = AUX OUT connector
11 = Connectors for probe compensation and grounding
12 = USB connectors
13 = POWER key

NOTICE

Instrument damage caused by cleaning agents

Cleaning agents contain substances such as solvents (thinners, acetone, etc.), acids, bases, or other substances. Solvents can damage the front panel labeling, plastic parts, or screens, for example.

Never use cleaning agents to clean the outside of the instrument. Use a soft, dry, lint-free dust cloth instead.

2.2.1.1 Setup Controls

SETUP keys set the instrument to a defined state, change basic settings, and provide print and help functions. The intensity rotary knob adjusts the display contrast for several display elements.

AUTOSET
The instrument analyzes the enabled channel signals, and adjusts appropriate horizontal, vertical, and trigger settings to display stable waveforms.

PRESET
Resets the instrument to a default state. All measurements, mask tests, zoom, and most individual settings are deleted, and all channels except for channel 1 are disabled. You can define preset configurations and save them to a file. The PRESET key can be configured to set either factory defaults or a user-defined preset configuration.

SAVE RECALL
Opens and closes the "File" dialog box, where you can:

- Save instrument settings
- Load instrument settings which were saved before
- Save waveform data and measurement results
- Define a naming pattern for autonaming of files

SETUP
Opens and closes the "Setup" dialog box, where you can:

- Access Windows configuration and install firmware updates
- Configure the touchscreen
- Check and install option keys for software options
- Check availability of hardware options
- Configure LXI and GPIB (if installed)

Camera 📷
Performs the action that is assigned to the key in "File" menu > "Frontpanel Setup" > "Hardkeys". By default, the key saves a screenshot of the waveform display.

See also: Chapter 3.3.2, "Hardkeys: Function Assignment", on page 106

HELP
Opens the appropriate help topic for the active tab. If no dialog box is open, the contents page of the help appears.

TOUCH LOCK
Locks the touchscreen to prevent unintended use. When the touchscreen is off, the key is illuminated. Press again to unlock the touchscreen.

DISPLAY
Opens and closes the "Display" dialog box to configure the appearance of the waveforms, the diagram layout, color tables, and also the XY-diagram.

INTENSITY
Adjusts the intensity of the waveforms on the screen, or the background transparency of dialog boxes, or the transparency of result boxes. If a dialog box is open, turning the knob changes the transparency of dialog boxes. If a result box is open, the transparency of result boxes is changed. Otherwise the waveform intensity is adjusted. Press the knob to toggle between the three settings. The controlled parameter and its value are shown in the input box in the lower right corner of the screen.

2.2.1.2 Horizontal Controls

The keys and rotary knobs in theHORIZONTAL functional block adjust the acquisition basic settings and the horizontal parameters. These settings are effective for all channel waveforms.

RES REC LEN
Opens and closes the "Setup" tab in the "Horizontal" dialog box, where you can set the resolution and the record length.

HORIZONTAL
Opens and closes the "Setup" tab in the "Horizontal" dialog box, where you can:
- Adjust the time scale, and acquisition time
- Adjust the horizontal position, and reference point
- Enable the roll mode

ACQUISITION
Opens and closes the "Acquisition" tab in the "Horizontal" dialog box, where you can define the acquisition processing (decimation and arithmetic).

RESOLUTION / RECORD LENGTH
The rotary knob changes the resolution or the record length. Press the knob to toggle the setting. The controlled parameter and its value are shown in the input box in the lower right corner of the screen.

For resolution, turn clockwise to increase the resolution: the time between two acquisition points gets shorter. Record length and sample rate increase while the acquisition time remains constant.

For record length, turn clockwise to increase the record length, and the resolution increases too - the time between to acquisition points gets shorter.

POSITION
The rotary knob changes the horizontal position of the waveform or the position of the reference point on the screen.

You can select if the knob changes the position or the reference point in "File" menu > "Frontpanel Setup" > "Knobs". To set the value to zero, press the knob. The current value is shown in the input box in the lower right corner of the screen.

"Horizontal position" defines the time distance of the reference point from the zero point of the diagram. Turn clockwise to move the waveform to the right.

"Reference point" defines the position of the reference point on the screen. Turn clockwise to move it to the right. The reference point marks the rescaling center of the time scale. It is indicated by a gray triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

SCALE
The rotary knob adjusts the time scale for all signals. The time scale is also known as timebase.

Turn clockwise to stretch the waveforms. Doing so, the scale value *time/div* decreases.

Press the knob to toggle between coarse and fine scale adjustment.

2.2.1.3 Vertical Controls

The keys and knobs in the VERTICAL functional block select a signal and adjust the vertical scale and position of the selected signal.

CH <N>
Turns on, selects, and configures a channel. If the channel is selected, the key lights up in the corresponding channel color .

The effect of the keypress depends on state of the channel:
- If channel is off: Pressing the key turns on the channel and selects it.
- If the channel is on, but not selected: Pressing the key selects the channel waveform.
- If the waveform is selected: Pressing the key opens the "Vertical" dialog box for the appropriate channel.

The vertical rotary knobs are focused on the selected waveform and they are illuminated in the color of the selected waveform.

LOGIC
Opens the dialog box for configuration of parallel buses and digital channels. The key lights up if you enable at least one parallel bus. You can switch off the selected bus using the SIGNAL OFF key.

REF
Opens the "Reference" dialog box, where you can configure and display reference waveforms. Press the key repeatedly to switch to the reference waveform to be configured.

The vertical rotary knobs are focused on the selected reference waveform, and they are illuminated in the color of the selected waveform.

MATH
Opens the "Math" dialog box, where you can configure the calculation of new waveforms using various mathematic operations on other waveforms. Press the key repeatedly to switch to the math waveform to be configured.

The vertical rotary knobs are focused on the selected math waveform, and they are illuminated in the color of the selected waveform.

POSITION (upper knob)
The upper rotary knob changes the vertical position or the offset of the selected waveform. The horizontal axis and the selected waveform are moved vertically. Turn clockwise to move up the waveform.

You can select if the knob changes the position or the offset in "File" menu > "Frontpanel Setup" > "Knobs". To set the value to zero, press the knob. The current value is shown in the input box in the lower right corner of the screen.

- Position indicates the vertical location in divisions.
- Offset moves the vertical center of the selected channel to the offset value.

The knob lights up in the color of the selected waveform.

SCALE
This rotary knob adjusts the vertical scale for the selected waveform. The knob lights up in the color of the selected waveform.

Turn clockwise to stretch the waveform. Doing so, the scale value V/div decreases.

Press the knob to toggle between coarse and fine scale adjustment.

SIGNAL OFF
Turns off the selected signal and selects the next channel, math, or reference waveform.

The key is illuminated in the color of the selected signal and changes the color according to the new selection.

2.2.1.4 Trigger Controls

The keys and knob in the TRIGGER functional block adjust the trigger and start or stop acquisition.

TRIGGER
Opens and closes the "Trigger" dialog box, where you can:
- Select a trigger type and configure it.
- Set general trigger parameters and control the acquisition run.
- Qualify the trigger event with logic patterns.
- Configure a sequence of subsequent trigger events.

LEVELS
The rotary knob sets the trigger level for all trigger types. Turn clockwise to move up the trigger level. If the selected trigger type requires two trigger levels - upper and lower level - press the knob to toggle between the two levels.

SOURCE
Opens a dialog box where you can select the trigger source. Press the key again to switch the source. The key lights up in the color of the selected trigger source.

SLOPE
Toggles the trigger slope or trigger polarity, dependent on the trigger type. The current setting is shown on the trigger label, which is in the upper part of the signal bar on the touchscreen.

MODE
Toggles the trigger mode between Auto and Normal. The current setting is shown on the trigger label.

RUN STOP
Starts and stops the continuous acquisition. A green light indicates a running acquisition. A red light shows that acquisition is stopped.

SINGLE
Starts a defined number of acquisition cycles. A green light indicates running acquisition. A red light shows that acquisition is stopped. To set the number of acquisitions, press the TRIGGER key, select the "Ctrl/Action" tab, and set "Average count (N-single count)". Press the key again to stop running acquisitions.

2.2.1.5 Analysis Keys

The keys in the ANALYSIS functional block provide direct access to measurement and analyzing functions. If you press CURSOR, ZOOM or MEAS, the operation starts on first keypress, and a second keypress opens the corresponding dialog box. If you press another function key, the dialog box opens.

CURSOR
Displays vertical and horizontal cursors in the active diagram and displays the "Cursor Results" box.

Cursors are markers which are placed at points of interest on a waveform. The instrument measures the cursor positions and delta values between parallel cursors.

If you press the key while a cursor measurement is enabled, the "Cursors" dialog box opens.

In "Cursors" dialog box, you can:
- Configure up to 4 cursor sets
- Define style and labels of the cursors
- Connect the cursor to the waveform and couple the cursors

MEAS
Starts the default automatic measurement for the active waveform and displays the "Measurement" result box.

If you press the MEAS key while a measurement is enabled, the "Measurements" dialog box is displayed, where you can:
- Configure amplitude and time measurements, eye, spectrum, and histogram measurements
- Configure gated measurement
- Configure long term and statistic measurements
- Configure actions to be executed if specified limits are exceeded

App Cockpit ▦
Opens the "App Cockpit" dialog box, where you can select and configure a measurement or analysis function directly, without knowing its position in the menu or toolbar.

The "App Cockpit" button on left edge of the menu has the same effect.

ZOOM
Displays a zoom diagram for the active diagram. The key is illuminated if at least one zoom is active. If you press the key while the zoom function is on, the "Zoom" dialog box opens, where you can configure several zoom areas for detailed signal observation.

PROTOCOL
Opens the "Protocol" dialog box which contains the configuration of serial buses and the settings for decoding the signals.

The key lights up if the decoding of a serial bus is active. You can switch off the decoded bus using the SIGNAL OFF key.

MASKS
Opens and closes the "Masks" dialog box. Masks are used for error detection and compliance tests of digital signals.

You can:
- Configure masks and masks segments
- Define mask test parameters
- Configure actions triggered by mask violation
- Configure the mask display

SEARCH
Opens and closes the "Search" dialog box, where you can:
- Configure trigger or measurement events to be searched for
- Limit the search by gating

- Configure the presentation of search results

HISTORY
The sample memory contains a number of stored acquisitions before the current one which is shown in the display. Press the key to open the quick access "History" dialog box, where you can view the stored acquisitions and use them for further analysis. Press the key again to open the main "History" dialog box with more settings and information.

The key is illuminated as long as a history acquisition or replay is displayed.

FFT
Opens and closes the FFT setup.

The key lights up if an FFT is active. You can switch off the FFT math waveform using the SIGNAL OFF key.

2.2.1.6 Navigation Controls

The rotary knob and the navigation keys provide an alternative way to navigate in dialog boxes and to enter numeric data.

See also: Chapter 2.4.7, "Using Dialog Boxes", on page 92

Navigation rotary knob
The navigation knob has various functions:
- In numeric entry fields: turn to increase or decrease the value.
- In tables: press to activate the edit mode, turn clockwise to increase the value or turn counterclockwise to decrease it, and press to enter the value and move to the next cell.
- To set cursor positions, histogram areas, and mask points in input boxes: press to toggle the parameter, turn clockwise to increase the value or turn counterclockwise to decrease it.

- To move zoom area, cursor line, or gate in diagrams: Turn to move the element that has the focus, and press to toggle the focus.

UNDO
Reverses the last setting actions step by step. Undo is not possible after load and recall actions, and after creating a reference waveform.

REDO
Recovers the undo steps in reverse order.

ESC
Closes a dialog box or input box.

OK
The OK key has various functions:
- In usual dialog box, in an opened selection list: the key applies the selected value.
- In tables: the key activates the edit mode. If the table cell is in edit mode, the key confirms the value, quits the edit mode and moves to the next cell.

Field left, Field right
In dialog boxes and tables, the keys move the focus.

In diagrams, the keys switch the focus between zoom areas, cursor lines, and gates.

Checkmark ☑
The checkmark key ☑ has different functions depending on the focus:
- In usual dialog box: if the focus is on a selection list, the key opens the list and applies the selected value.
- In tables: activates the edit mode.

Tab
The tab key has various functions:

- In a dialog box that has only horizontal tabs, the key switches the horizontal tabs.
- In a dialog box that has horizontal and vertical tabs, the key switches the vertical tabs preferably. If the focus is on a horizontal tab, it switches the horizontal tabs.
- In a table or diagram, the key moves the focus in the same way as the ▸ key.

Up arrow ▲, Down arrow ▼
The up and down arrow keys have the following effects:
- In numeric edit fields: increase or decrease the parameter value.
- In tables: scroll vertically through the rows.
- In dialog boxes, for option buttons in a column: select an option. In an open selection list, the keys scroll the list.

Left arrow ◄, Right arrow ►
The left and right arrow keys have the following effects:
- In edit fields: move the cursor.
- In tables: scroll horizontally through the columns.
- In dialog boxes, for option buttons in a row: select an option.

2.2.1.7 Power Key

The POWER key is located on the lower left corner of the front panel. It starts up and shuts down the instrument's software.

The light of the key shows the instrument state:

- Orange: Standby, the main power switch is on, the software is shut down.
- Green: The instrument is ready for operation.

See also: Chapter 2.1.3, "Starting the Instrument", on page 19.

2.2.1.8 Input Connectors

The R&S RTO has two or four channel inputs to connect the input signals using active and passive probes.

The input connectors are provided with a special Rohde & Schwarz active probe interface, and they are BNC compatible. Thus, the instrument can automatically detect passive probes with standard BNC connector and active Rohde & Schwarz probes having the Rohde & Schwarz probe interface.

The input impedance is selectable, the values are 50 Ω and 1 MΩ.

⚠ WARNING

Risk of electrical shock or fire

Voltages higher than 30 V RMS or 42 V peak or 60 V DC are regarded as hazardous contact voltages. When working with hazardous contact voltages, use appropriate protective measures to preclude direct contact with the measurement setup:

- Use only insulated voltage probes, test leads and adapters.
- Do not touch voltages higher than 30 V RMS or 42 V peak or 60 V DC.

⚠ CAUTION

Risk of injury and instrument damage

The instrument is not rated for any measurement category.

Make sure that the input voltage on *channel inputs* does not exceed 200 V peak, 150 V RMS at 1 MΩ input impedance and 5 V RMS at 50 Ω input impedance.

Transient overvoltages must not exceed 200 V peak.

When performing measurements in circuits with transient overvoltages of category II, III or IV circuits, make sure that no such overvoltages reach the R&S RTO input. Therefore, use only probes that comply with DIN EN 61010-031. When performing measurements in category II, III or IV circuits, it is mandatory to insert a probe that appropriately reduces the voltage so that no transient overvoltages higher than 200 V peak are applied to the instrument. For detailed information, refer to the documentation and safety information of the probe manufacturer.

Explanation: According to section AA.2.4 of EN 61010-2-030, measuring circuits without any measurement category are intended for measurements on circuits which are not connected to the mains system.

2.2.1.9 Other Front Panel Connectors

Besides the input connectors, the instrument has USB connectors and probe compensation connectors at the front panel.

USB
Two USB type A connectors that comply with standard USB 2.0. They are used to connect devices like keyboard, mouse, printer and USB flash drive.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m.

PROBE COMPENSATION
Probe compensation terminal to support adjustment of passive probes to the oscilloscope channel.

⏚	Protective earth conductor for grounding the instrument.
⎍	Square wave signal for probe compensation with 1 kHz and 1 V_{pp}.
⊥	Ground connector for probes.

AUX OUT
Output of the internal calibration signal, if the signal is configured to external destination.

2.2.2 Rear Panel

Figure 2-2 shows the rear panel of the R&S RTO.

Figure 2-2: Rear panel of R&S RTO

1 = AC power supply connector and main power switch
2 = LAN connector
3 = USB connectors, type A
4 = DisplayPort connector
5 = USB Device connector, type B
6 = DVI-D connector for external monitor
7 = Optional connectors for waveform and pattern generator (option R&S RTO-B6)
8 = External trigger output
9a = Optional connectors for digital probe (Mixed Signal Option R&S RTO-B1, shown in figure)
9b = Optional GPIB connector (option R&S RTO-B10, not shown in figure)
10 = External trigger input
11 = Optional OCXO with input and output of the reference signal (option R&S RTO-B4)
12 = Kensington lock slot to secure the instrument against theft
13 = Optional exchangeable hard disk: solid state disk (option R&S RTO-B18) or standard hard disk drive (option R&S RTO-B19)
14 = Lugs to attach the accessory bag

AC power supply connector and main power switch

Connection to the AC power line. The R&S RTO can be used with different AC power voltages and adapts itself automatically to it. The nominal voltage and frequency ranges are displayed on the rear panel and quoted in the data sheet.

If grounding is *not* ensured by the mains system, ground the instrument using the protective earth conductor on the front panel and an appropriate cable.

The AC main power switch also interrupts the power supply of the OCXO (option OCXO Reference Frequency, R&S RTO-B4).

When you power up the instrument, be sure to comply with the warm-up phase specified in the data sheet before you start measurements.

See also: Chapter 2.1.3, "Starting the Instrument", on page 19

USB
Two USB type A connectors that comply with standard USB 3.0. They are used to connect devices like keyboard, mouse, printer, and flash drive to store and reload instrument settings and measurement data.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m..

LAN
8-pin RJ-45 connector used to connect the instrument to a Local Area Network (LAN). It supports up to 1000 Mbit/s (10/100/1000BASE-T Ethernet).

USB DEVICE
USB 3.0 interface of type B (device USB) to be used for remote control of the instrument.

DISPLAYPORT
DisplayPort connector for an external monitor or projector. It supports DisplayPort version 1.1a.

DVI-D
Digital connector for an external monitor or projector. The monitor shows the complete content of the instrument's screen.

See also: Chapter 2.1.4.2, "Connecting an External Monitor", on page 23.

EXT TRIGGER IN
The BNC connector for external trigger input is used to control the measurement by an external signal. The input impedance can be selected in the trigger configuration, the values are 50 Ω and 1 MΩ. The trigger level can be set from -5 V to 5 V. The maximum input voltage is 30 V RMS at 1 MΩ input impedance and 7 V RMS at 50 Ω input impedance.

TRIGGER OUT
The BNC connector for external trigger output is used to provide the internal trigger signal of the oscilloscope to trigger other instruments for synchronized measurements.

When a trigger occurs, the R&S RTO creates a pulse of 5 V with a source impedance of 50 Ω and delivers it to the external trigger output. The instrument can also send the pulse on mask test violation or violation of measurement limits and margins.

If the connector is terminated with 50 Ω, the signal level is 2.5 V (50 mA). With 1 MΩ termination, the level is 5 V. A short-circuit of the connector to ground creates current of 100 mA.

To enable the trigger out signal, select "Trigger" menu > "Ctrl/Action". Here you also adjust polarity, delay, and length of the pulse. The default is a positive pulse of 100 ns. The minimum delay is 800 ns.

RTO MSO
Mixed Signal Option, input for digital signals (parallel buses). The hardware module and logic probe come with option R&S RTO-B1. The module provides connectors for two logical probes with 8 digital channels each (D0 to D7 and D8 to D15).

The maximum input voltage is 40 V peak at 100 kΩ input impedance. The maximum input frequency for a signal with the minimum input voltage swing of 500 mV (V_{pp}) is 400 MHz. For detailed specifications, refer to the data sheet.

RTO-B4
Optional REF IN (left) and REF OUT (right) connectors coming with option R&S RTO-B4 OCXO 10 MHz.

The input frequency ranges from 1 MHz to 20 MHz in 1 MHz steps. The input impedance is 50 Ω.

The output frequency of the OCXO is 10 MHz, the impedance is 50 Ω. For detailed specifications, refer to the data sheet.

RTO-B6
Optional connectors for the waveform generator (option R&S RTO-B6). For detailed specifications, refer to the data sheet.

GEN1, GEN2	BNC connectors
PATTGEN	Connector for the pattern generator

RTO-B10
Optional GBIP connector coming with option R&S RTO-B10 GBIP interface. For detailed specifications, refer to the data sheet.

2.3 Trying Out the Instrument

This chapter introduces the most important functions and settings of the R&S RTO step by step. The complete description of the functionality and its usage is given in the "User Manual". Basic instrument operation is described in Chapter 2.4, "Operating the Instrument", on page 74.

Prerequisites

- The instrument is set up, connected to the mains system, and started up as described in Chapter 2.1, "Preparing for Use", on page 16.
- A probe is available.

For these first measurements, you use the internal calibration signal, so you do not need any additional signal source or instruments. Try out the following:

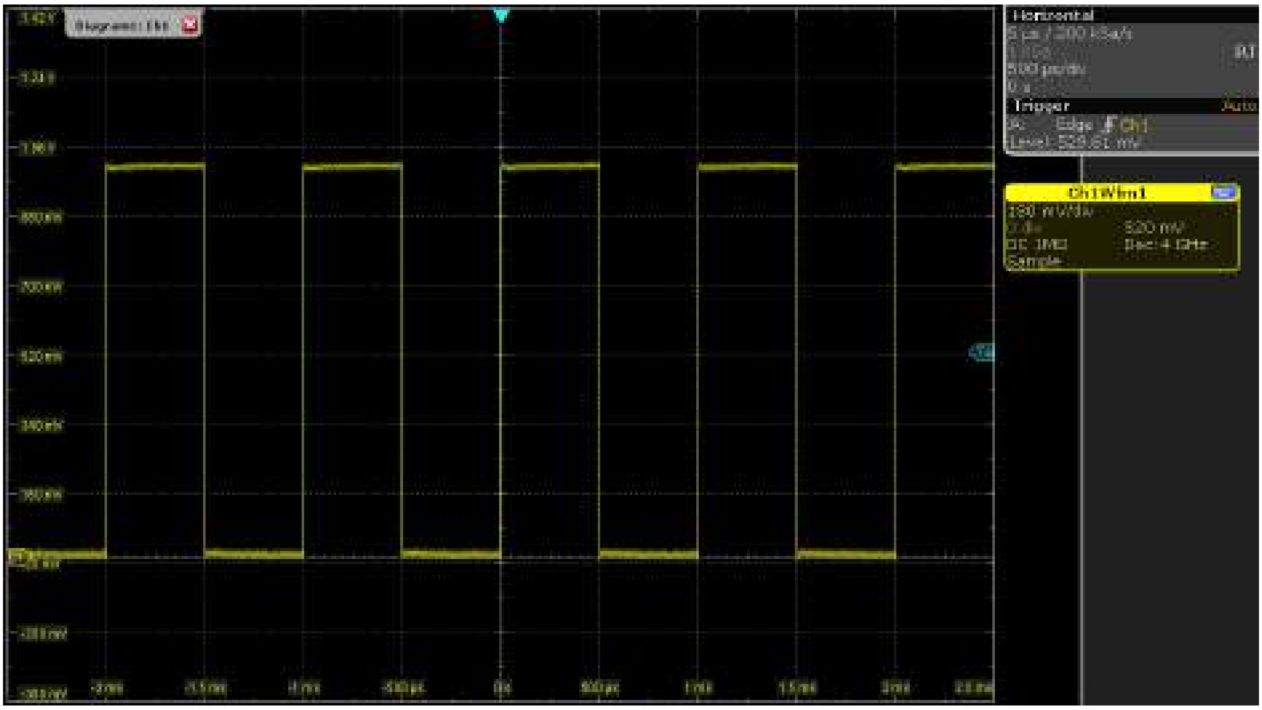
2.3.1 Displaying a Basic Signal

Displaying the input from a signal channel is simple and straightforward. Furthermore, you get to know some basic trigger functions. The R&S RTO provides wide-ranging trigger functions to find various signal anomalies, which are described in the instrument help and in the "User Manual".

1. Press the PRESET key on the front panel (in the SETUP area on the left).
2. Connect the probe to the input connector CH 1.
   Connect the probe's ground connector to the right compensation pin ⊥, and the tip to the left pin ⎍.

   The instrument recognizes the probe, and a signal is displayed in the diagram.
3. Press the AUTOSET key on the front panel (in the SETUP area on the left).

   Autoset finds appropriate horizontal and vertical scales and trigger conditions to present a stable square waveform. The trigger is set to edge trigger on rising edge with auto trigger mode.

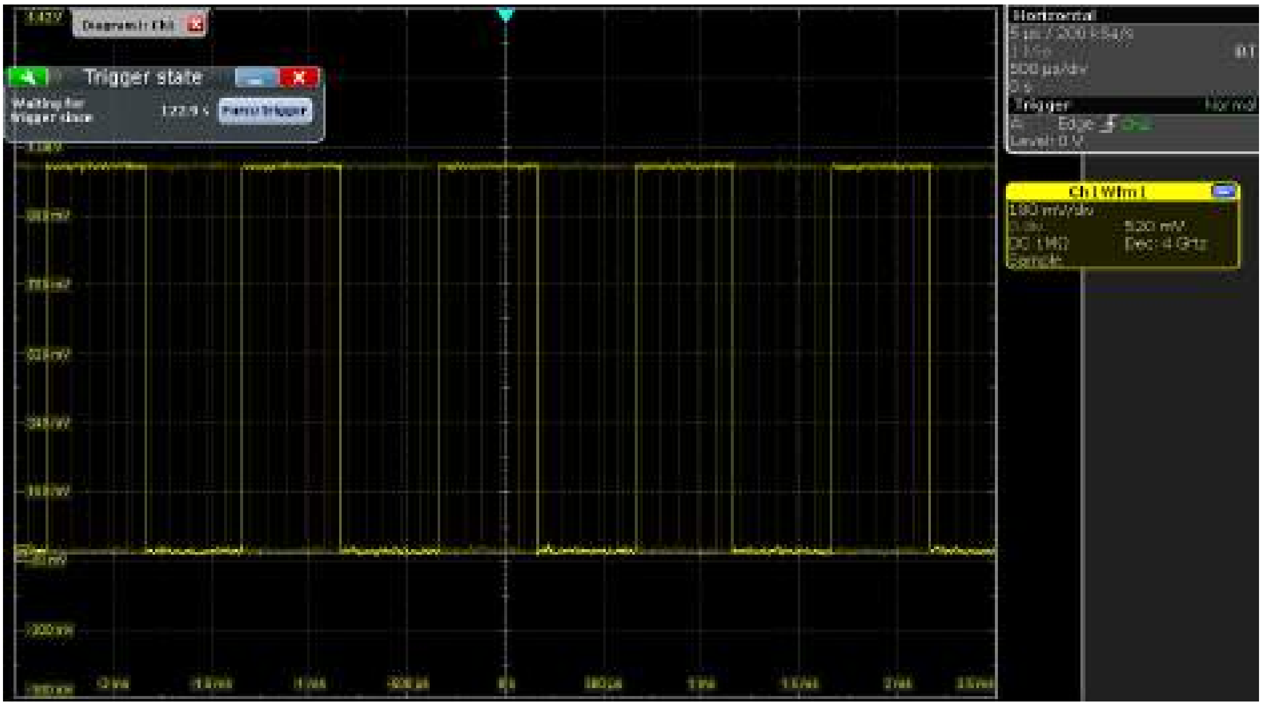


4. If necessary, compensate the passive probe as described in Chapter 4.9.1, "Adjusting Passive Probes", on page 197.
5. In the TRIGGER area of the front panel, press the SOURCE key. Press the key again to switch the trigger source to "C2".

An unstable waveform is displayed. In auto mode, the instrument triggers repeatedly after a time interval if no real trigger occurs.

6. In the TRIGGER area, press the MODE key.
7. Check the "Trigger" settings in the upper right corner of the screen.

   The trigger mode has changed to "Normal". The waveform is no longer refreshed, and the "Trigger state" message box appears. The instrument cannot find a real trigger event because there is no signal on channel 2.



8. Tap the "Undo" icon on the toolbar repeatedly until the trigger mode is "Auto" and the trigger source is "CH1".

9. Press the SLOPE key to toggle the trigger slope.
   Watch the waveform and the "Trigger" settings.

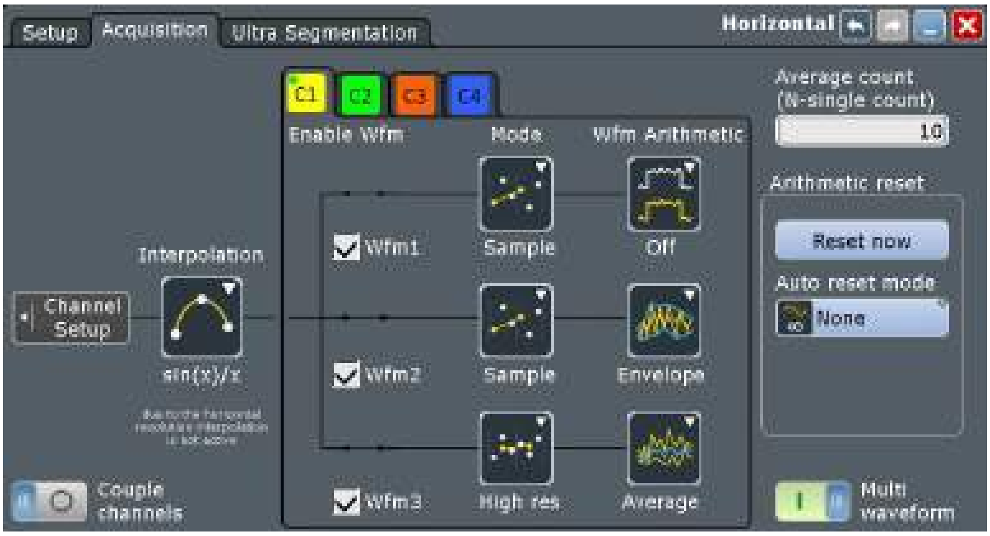
2.3.2 Acquiring Data

Although you are using only one input channel, you can acquire the calibration data using three different arithmetic methods and display the results in separate waveforms.

1. In the HORIZONTAL area, press the ACQUISITION key.
2. In the "Acquisition" tab of the "Horizontal" dialog box, enable all three waveforms ("Wfm1", "Wfm2", "Wfm3").

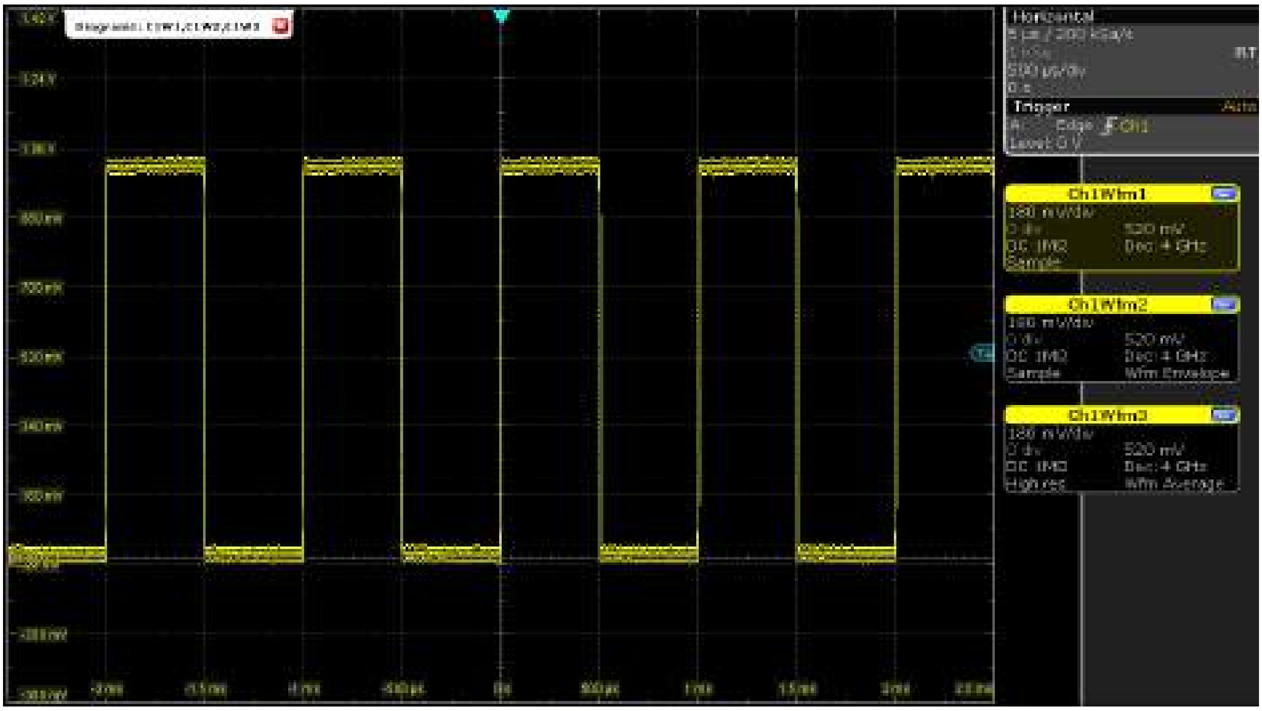
If you cannot see these settings, enable "Multi waveform" in the lower right corner of the dialog box.

3. For Wfm1, select the "Mode" = *Sample* and "Wfm Arithmetic" = "Off".
4. For Wfm2, select the "Wfm Arithmetic" *Envelope*. The "Decimation" type is automatically set to *Peak detect* to display the correct envelope waveform.
5. For Wfm3, select the "Decimation" type *High Res* and the "Wfm Arithmetic" *Average*.



6. To close the "Horizontal" dialog box, tap ☒.

   The three waveforms are displayed in one diagram. The corresponding signal icons are displayed in the signal bar.



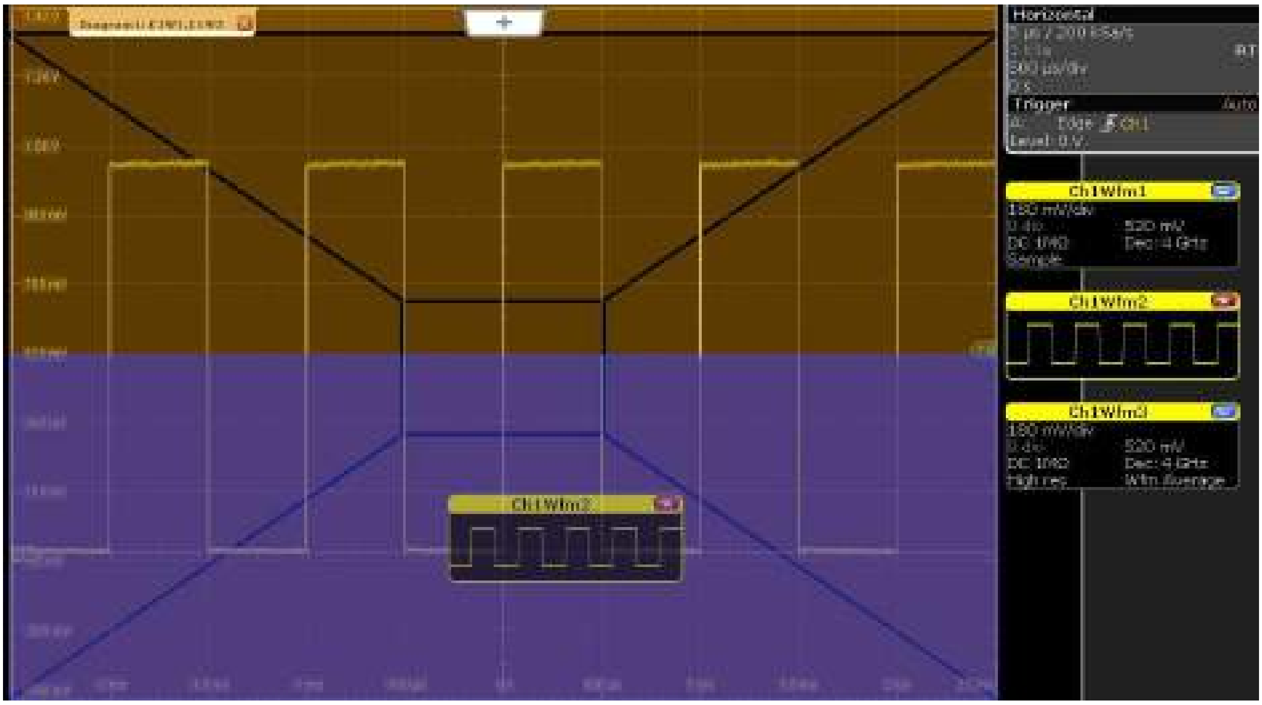
2.3.3 Organizing the Display

Now, the display has become confusing with so many waveforms in one diagram. You can display each waveform in a separate diagram and then define a useful label for each diagram. You can also hide diagrams you do not currently need, and display them later again.

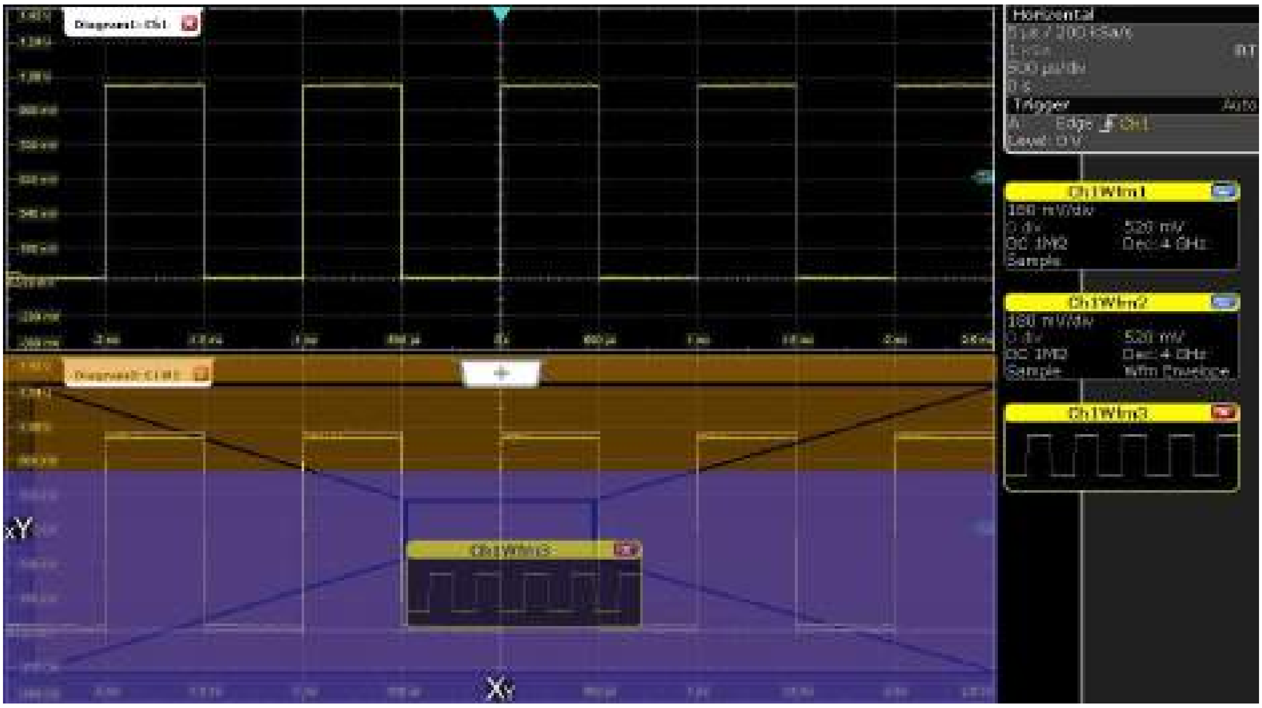
To manage several diagrams

1. Drag the signal icon for "Ch1Wfm2" from the signal bar to the bottom half of the diagram area.

   The SmartGrid appears and a blue area shows where the waveform will be placed.



2. Drag the signal icon for "Ch1Wfm3" to the bottom half of the diagram so that it covers an area beneath "Ch1Wfm2" and drop it there.



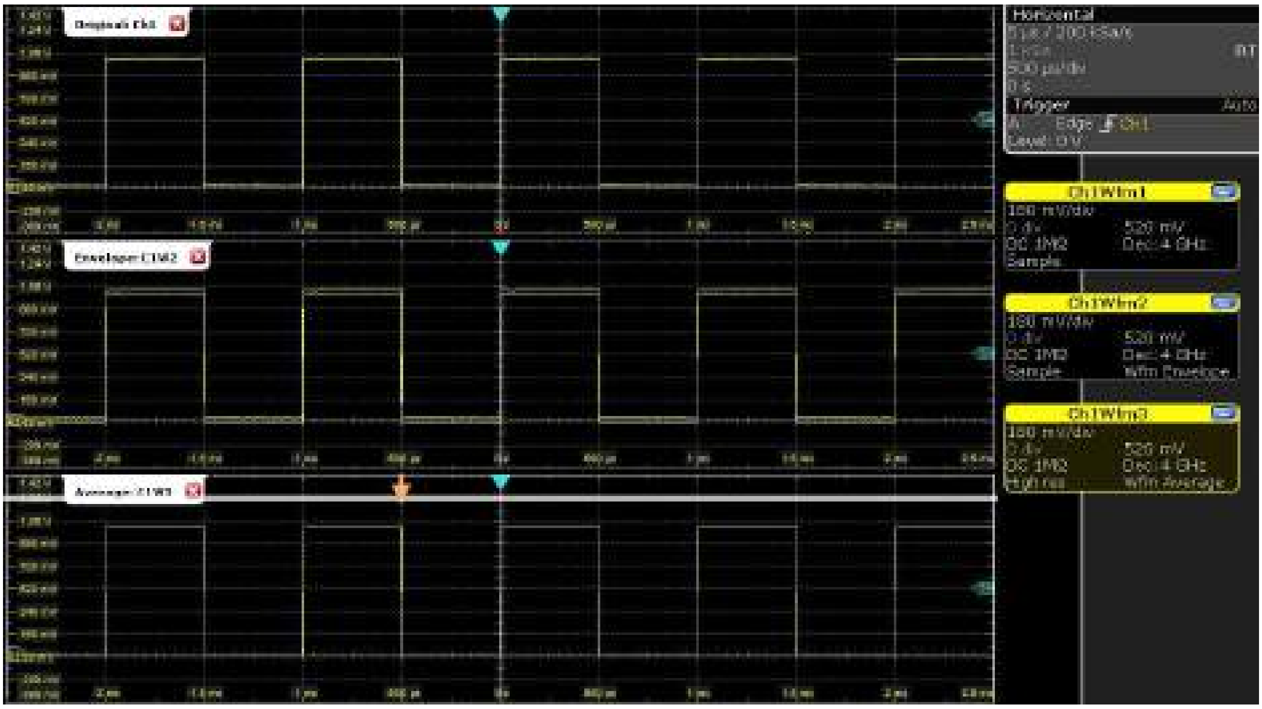
The three waveforms are now displayed in separate diagrams.

3. Rename the diagrams so that the label indicates the diagram content:
   a) Double-tap the label for "Diagram 1: Ch1".
   b) On the on-screen keyboard, enter *Original*.

   c) Tap OK.
   d) Repeat these steps to rename "Diagram 2: Ch1Wfm2" to *Envelope*.
   e) Rename "Diagram 3: Ch1Wfm3" to *Average*.

   The diagram titles are shown together with the waveform number that is displayed in the diagram.

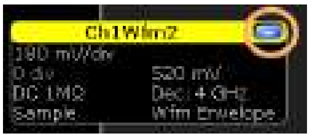
4. To change the size of a diagram, drag its horizontal edge to the required position.



To delete waveform diagrams

For the procedures in the following sections, we need only the original waveform diagram. So we close the other two diagrams.

1. To minimize the waveform in diagram "Envelope: Ch1Wfm2", tap ▬ "Minimize" in the "Ch1Wfm2" signal icon.

   The diagram is removed and the signal icon in the signal bar displays a live view of the signal.

2. Tap ☒ "Close" in the signal icon for "Ch1Wfm2".

   The signal icon is removed from the signal bar, the waveform is switched off.

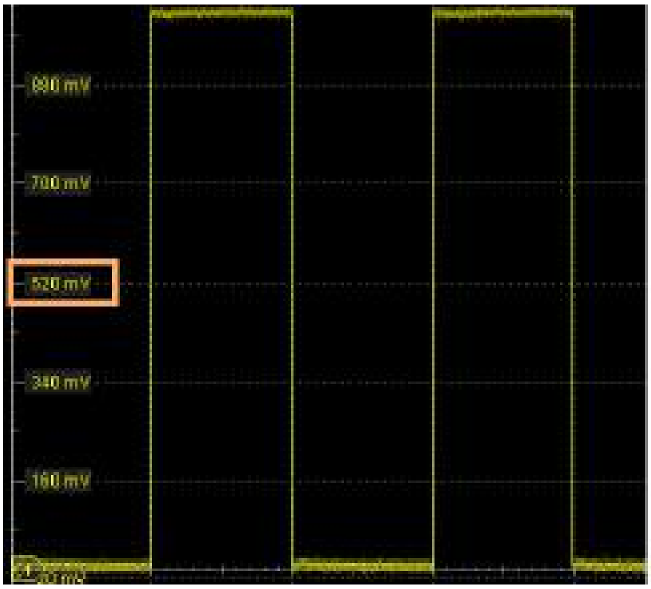
3. Switch off the "Average:Ch1Wfm3" waveform using the toolbar function:

a) Tap the "Delete" icon on the toolbar.

b) Tap the waveform in the "Average: Ch1Wfm3" diagram.
The waveform is switched off, its signal icon and the empty diagram are removed.

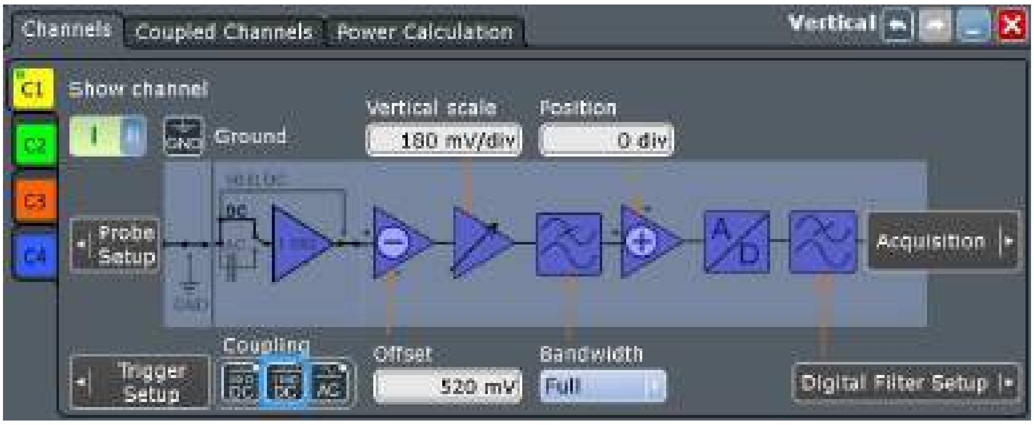
2.3.4 Changing the Waveform Scaling and Position

As you can see on the y-axis of the display, the calibration signal has a vertical offset of about 520 mV. The value can differ. This value is also indicated in the signal icon for channel1 (2nd row).




Ch1Wfm1
180 mV/div
0 div
520 mV
DC 1MΩ
Dec: 4 GHz
Sample

If you press the CH1 key, the "Vertical" settings dialog box also displays the "Offset" value. The offset is the DC component of the signal.



Vertical scale: 180 mV/div
Position: 0 div
Offset: 520 mV
Bandwidth: Full

If you use a passive probe, you can filter the DC component by using the AC coupling function. Then you quickly the new trigger level, and try out the scaling functions.

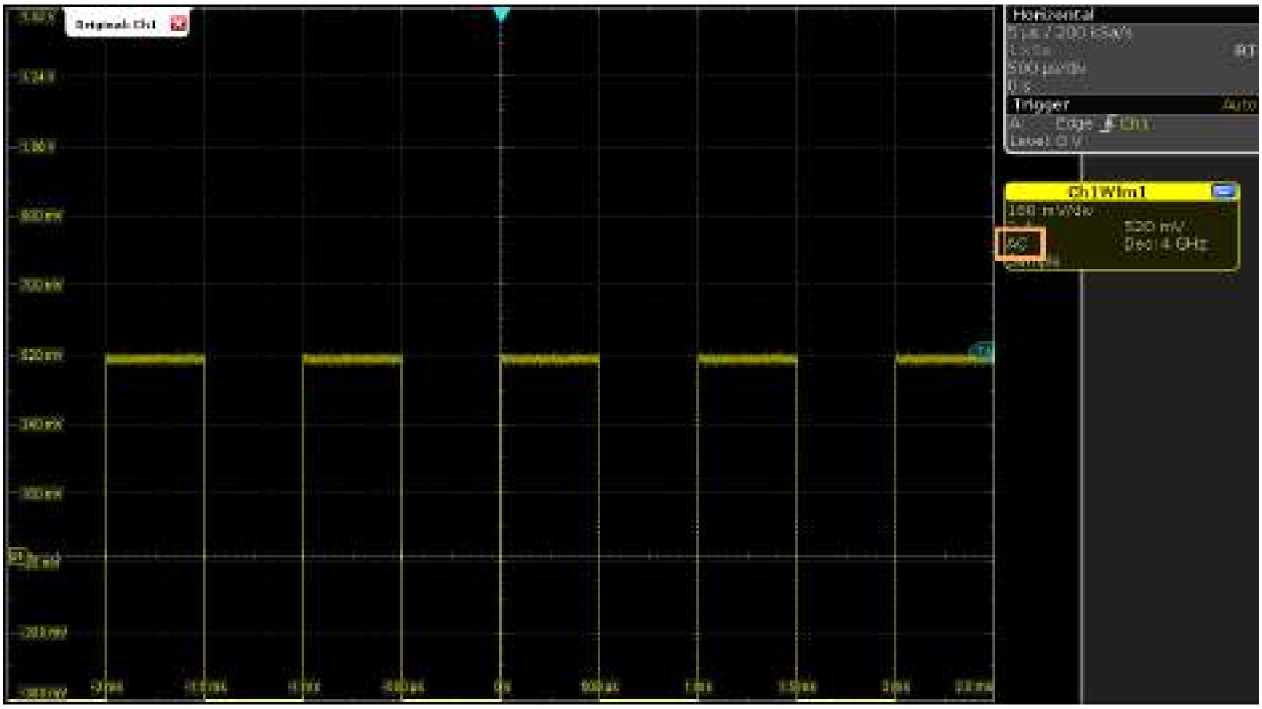
1. In the VERTICAL area, press the CH1 key.

   The "Vertical" dialog box is shown.

2. Change the "Coupling" to "AC".

3. To close the dialog box, tap ☒.

   The DC component of the signal is eliminated; the waveform position moves down vertically and is now centered around 0 V.



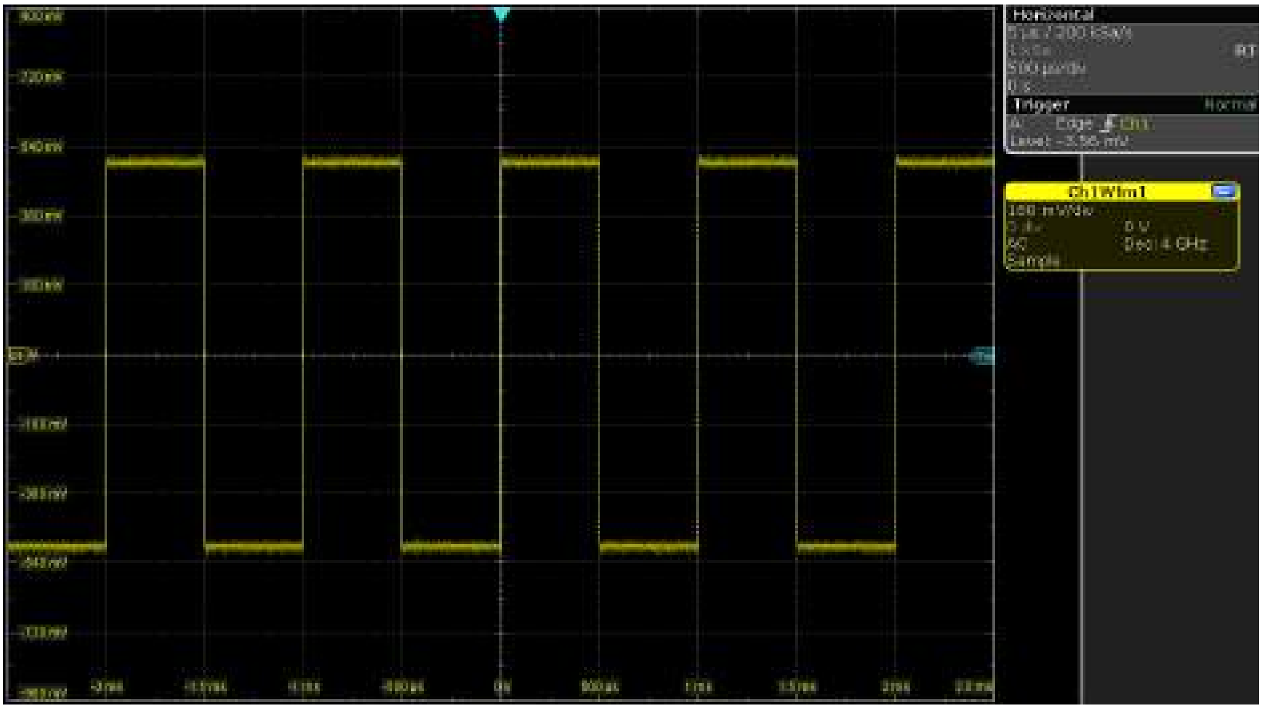
4. To move the waveform back to the center of the screen, eliminate the offset in the vertical settings: Press the upper rotary knob in the VERTICAL area (Offset/Position knob).

   The waveform is now displayed in the center of the display, with the x-axis crossing at 0 V. The waveform might be unstable if the trigger level is above the waveform.

   Note: If this step does not work as described, check the function assignment of the rotary knob. The second row of the signal label shows the vertical position on the left and the offset on the right. The white value is assigned to the rotary knob, while the grey value is not. To change the assignment, use "File" menu > "Hardkey Setup".

5. Tap the "Find level" icon on the toolbar.

   The instrument adjusts the trigger level, and a stable waveform is displayed.



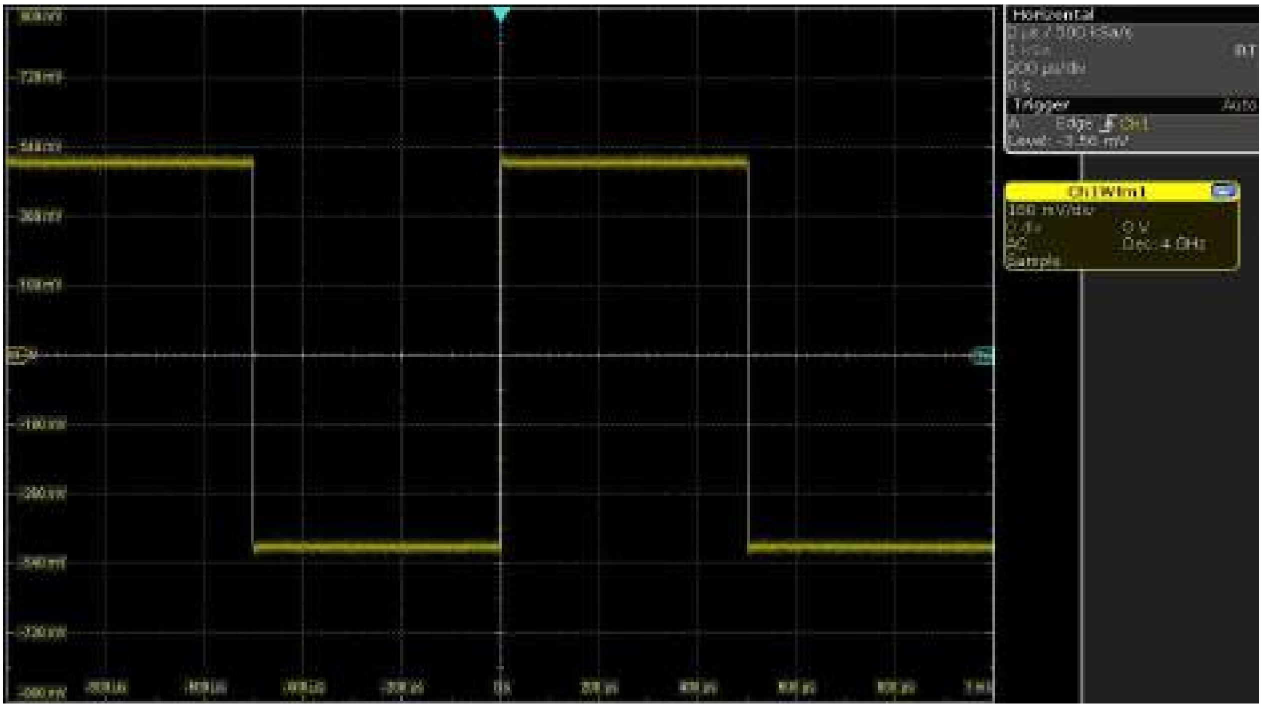
6. To examine one pulse in more detail, change the horizontal scale. Try these methods:
   - Touch the screen with two fingers and spread the fingers horizontally.
   - Turn the horizontal Scale.

   When you turn the knob, the current scale factor per division is displayed in the lower right corner of the display. You can switch between a small and large step size of the scaling factor by tapping the step icon, or by pressing the horizontal Scale.

   Time scale

   200 ns/div



7. To return to the original scaling, try the UNDO key in the NAVIGATION area. Press the UNDO key repeatedly until the original scaling is displayed. Press the REDO key to retrace the undone steps. Thus, you can toggle between the two displays using the undo and redo keys until you perform a different action.

   Alternatively, you can:
   - Touch the screen with two spread fingers and pinch them together in horizontal direction.
   - Tap the "Undo" icon on the toolbar.

If you use an active single-ended probe, you can measure the DC component of the signal directly at the probe tip by means of the integrated R&S ProbeMeter:

1. On the "Vertical" menu, tap "Probe Setup".
2. Make sure that the correct channel is selected on the left tab.
3. In the "Additional" section, tap "ProbeMeter".

   A result box shows the DC voltage measured by the R&S ProbeMeter.

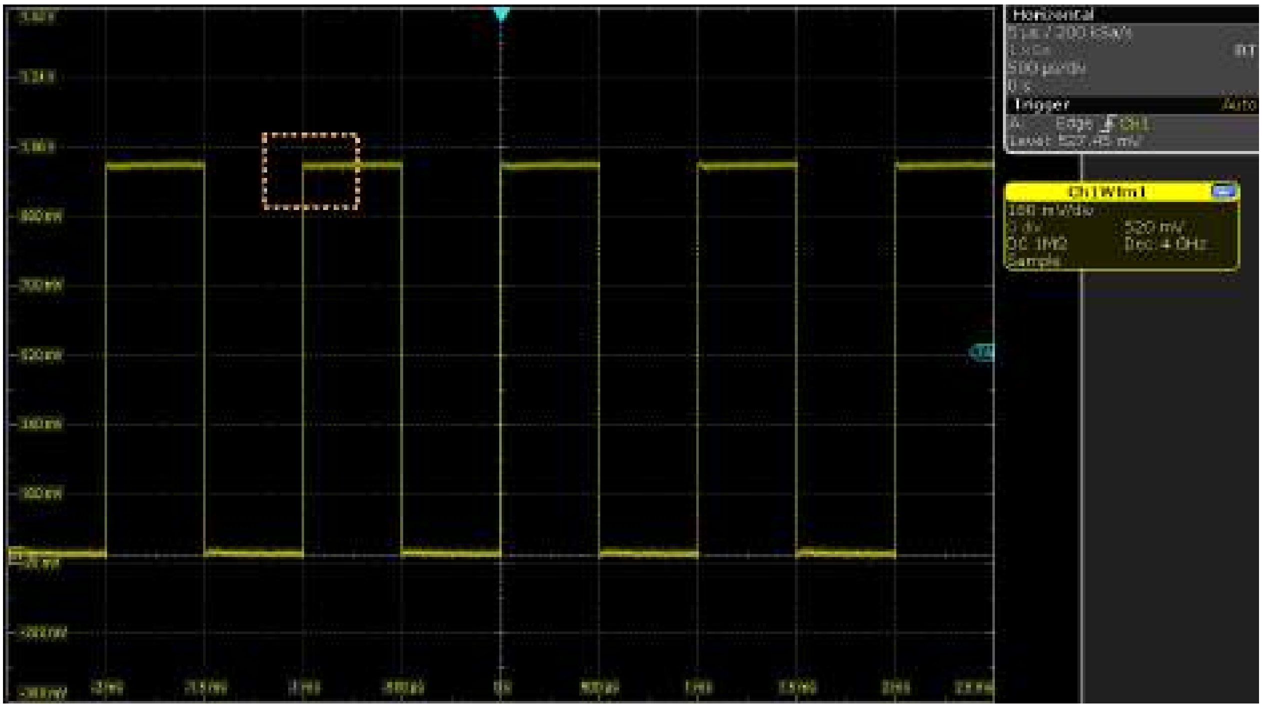
2.3.5 Zooming into the Display

Using the SCALE rotary knobs, you can change the scaling of the time base and signal amplitudes in order to enlarge the waveform. To see more details, use one of the zoom functions. The instrument has 4 zoom types, 2 of them you try out in this section.

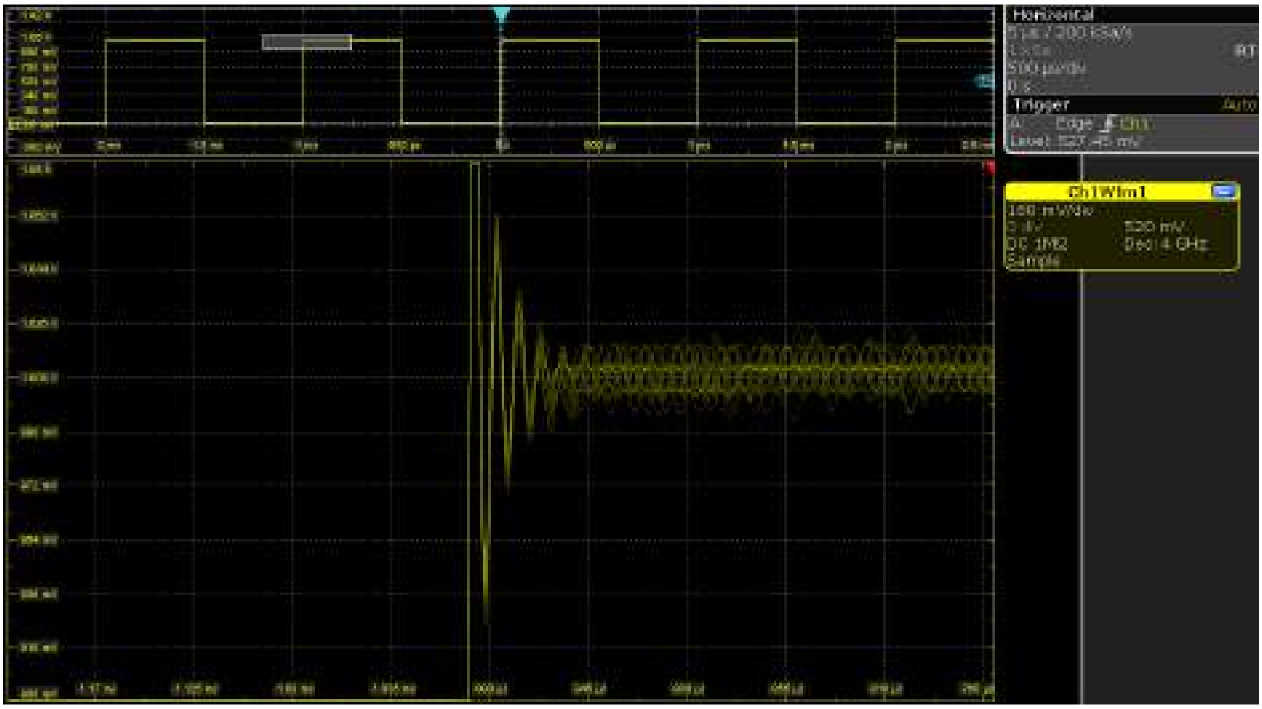
The usage of zooms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Zoom".

2.3.5.1 Using the Standard Zoom

1. Restore the default signal channel settings by pressing the PRESET and AUTOSET keys.
2. On the toolbar, tap the "Zoom" icon.
3. Tap the position in the diagram that you want to define as one corner of the zoom area. Then drag your finger to the opposite corner of the zoom area.
   While you drag your finger on the touchscreen, a dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger.



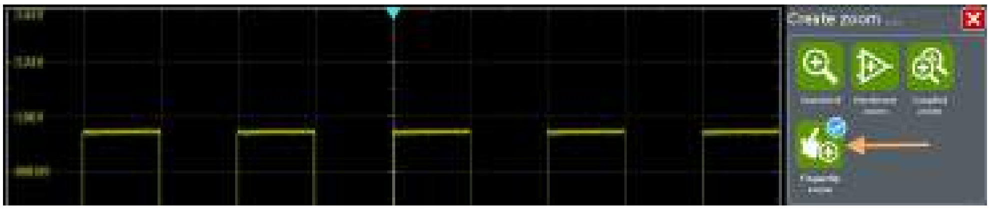
The indicated area is magnified in a new zoom diagram. The original diagram indicates the zoom area as a rectangle.



4. To remove the zoom window and make room on the display for other results, tap "Delete" on the toolbar and then the zoom window.

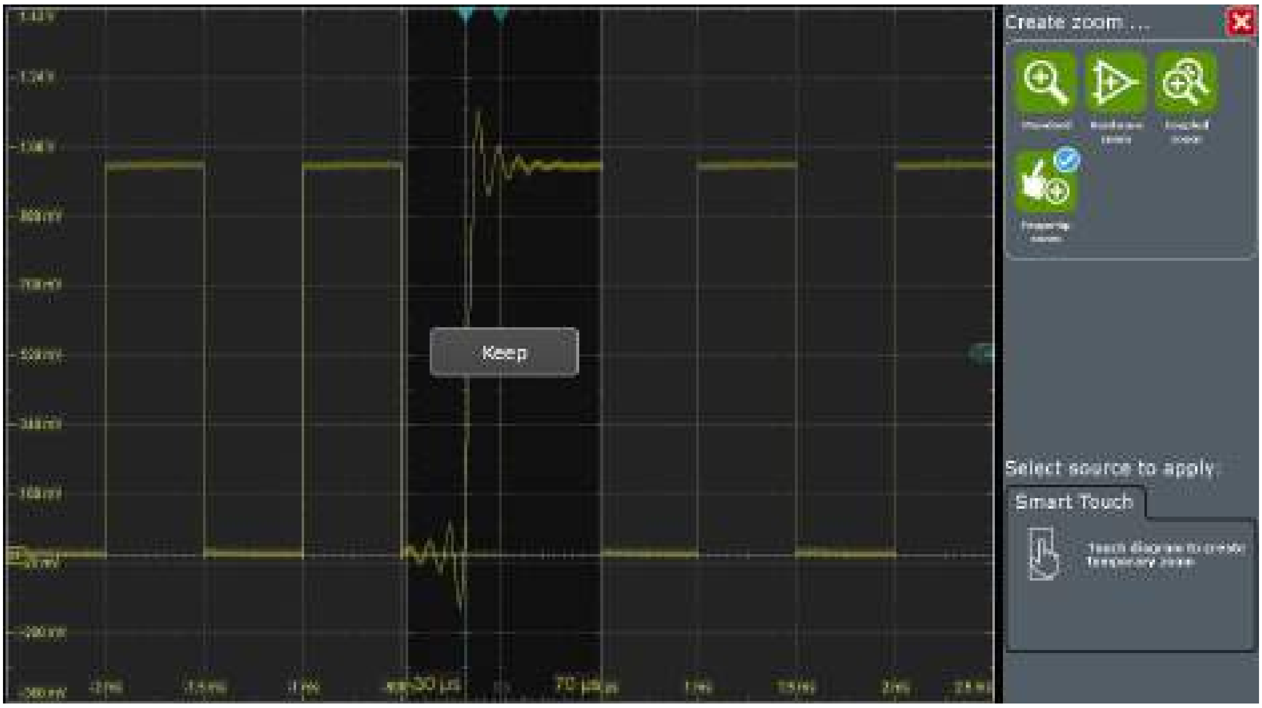
2.3.5.2 Using the Fingertip Zoom

1. Tap the "Zoom" icon on the toolbar.
2. In the sidebar, tap "Fingertip zoom".



3. Touch the waveform and move your finger very slowly in horizontal direction.

   Tip: You can turn the NAVIGATION knob to change the zoom factor while holding the waveform.
4. Release the finger when the waveform segment of interest is visible in the zoom.
5. Tap "Keep" to convert the fingertip zoom into a standard zoom diagram.



2.3.6 Displaying the Waveform History

During a continuous acquisition, the instrument stores the acquired data in the memory and shows the current acquisition on the display. When the acquisition was stopped and a new acquisition is started with RUN STOP or SINGLE, the memory is cleared and written anew. The history accesses and displays the samples that were saved before the current acquisition.

In the following example, you acquire 10 waveforms, and display the 3 most recent waveforms.

1. In the HORIZONTAL area, press the ACQUISITION key.

   The "Horizontal" settings dialog box opens.
2. Set the "Average count" to *10* to perform 10 waveform acquisitions.
3. Close the "Horizontal" dialog box.
4. In the TRIGGER area, press the SINGLE key.

   Ten waveform acquisitions are performed. The most recent acquisition is displayed in the diagram.
5. In the ANALYSIS area, press the HISTORY key.

   The quick access "History" dialog box appears, and the history mode is enabled.
6. Tap "Play".

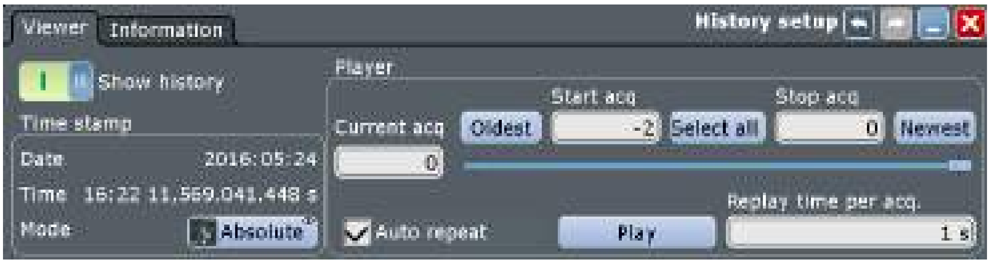
   The ten stored waveforms are displayed one after the other, but very fast.

7. In the "Current acq." field, enter *-4* to display the sixth waveform, counted from acquisition start. The latest acquisition has the number 0, the oldest has -9.

Available acqs: 10
Current acq: -4
Time: -23.99999991 ms

8. Tap 🔧 to open the "History" setup dialog box.
9. Enter *-2* in the "Start acq" field. Tap "Newest" to enter *0* in the "Stop acq" field.

   Thus the three latest acquisitions are displayed.
10. In the "Replay time per acq." field, enter *1 s* to display each waveform for one second.
11. Enable the "Auto repeat" option to see the three waveforms repeatedly.



Show history: I
Time stamp
Date: 2016:05:24
Time: 16:22 11.569.041.448 s
Mode: Absolute
Current acq: 0
Start acq: -2
Stop acq: 0
☑ Auto repeat
Replay time per acq.: 1 s

12. Tap "Play".
    The currently displayed waveform is indicated in the "Current acq." field.
13. Close the "History" dialog box so you can see the waveform better.
14. Tap "Running" to stop the display.
    During running display, the "Play" is labeled "Running".
15. Close the quick access "History" dialog box.

    The history mode is disabled. The HISTORY key is no longer illuminated.

2.3.7 Performing Basic Measurements

Using the R&S RTO, you can perform and display different measurements simultaneously. The color of the results in the result table corresponds with the source waveform color.

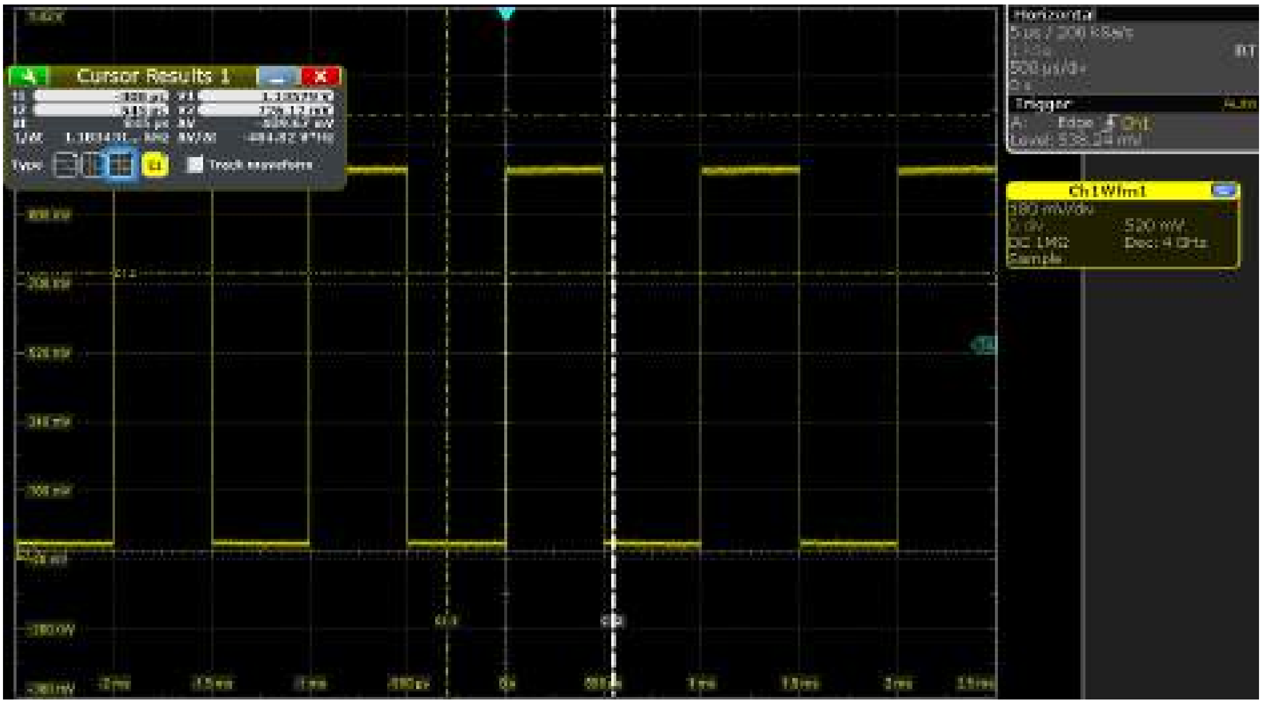
2.3.7.1 Performing a Cursor Measurement

1. Restore the default signal channel settings: Press the PRESET and AUTOSET keys.
2. Tap the "Cursor" icon on the toolbar.

3. Draw a rectangle on the screen where you want to place the cursor lines.

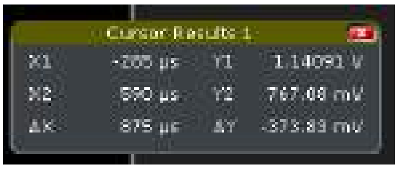
   The cursor lines appear in the diagram and the "Cursor Results" box opens. The measured waveform values at the cursor positions are displayed.

4. You can move the cursor lines in different ways:
   - Touch a cursor line and drag it on the screen.
   - Tap a cursor line to activate it. Then turn the NAVIGATION knob to adjust the position.
   - Enter the position values in the result box.



5. To save space in the display, tap "Minimize" in the result box.

   The most important results are shown in the result icon.



Cursor Results 1

X1	-285 µs	Y1	1.14091 V
X2	590 µs	Y2	767.08 mV
ΔX	875 µs	ΔY	-373.83 mV

6. To remove the result icon and make room on the display for other results, tap the red cross on the icon label.

2.3.7.2 Performing an Amplitude Measurement

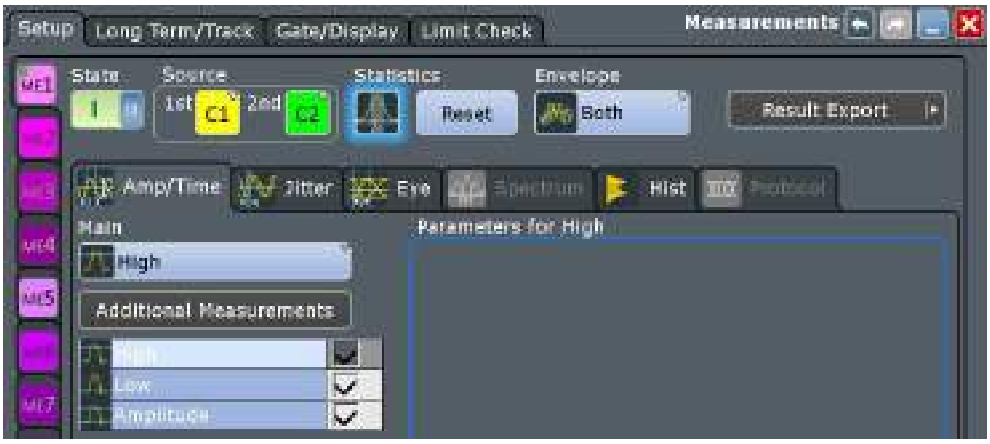
To measure the voltages of a pulse quickly, measure the amplitude in the time domain.

1. To restore the default signal channel settings, press the PRESET and AUTOSET keys.
2. Tap the "Measurement" icon on the toolbar.
3. In the sidebar, select the measurement types, for example, "High", "Low", and "Amplitude".

4. Tap the diagram in which you want to measure.

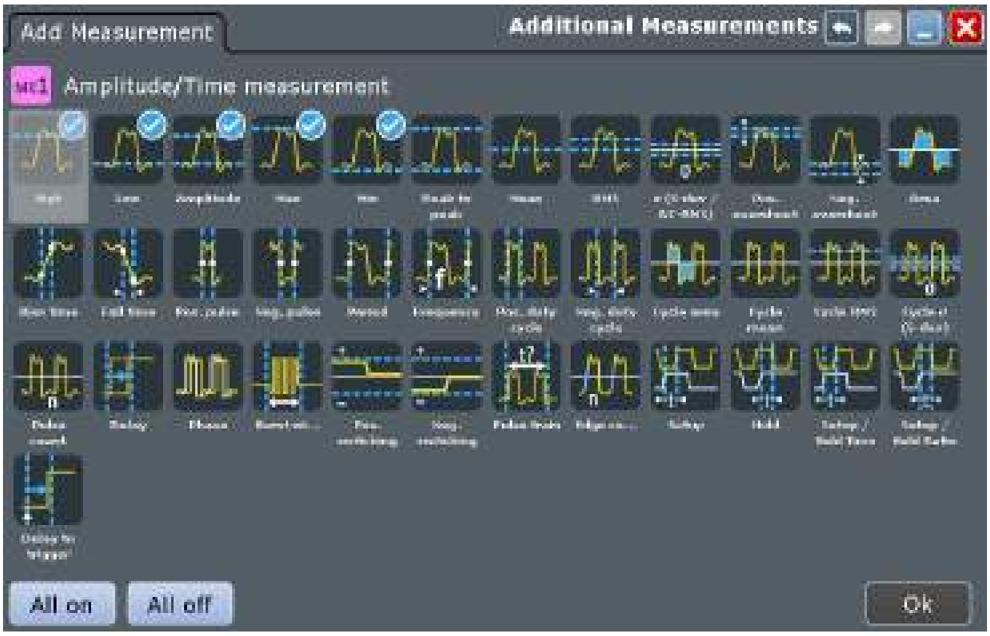
   The selected measurement types are enabled, using the selected (focused) waveform as the source. The "Measurements" result box shows the measured values.

5. To display statistical results for the measurement, tap 🔧 in the result box Alternatively, press the MEAS key in the ANALYSIS area of the front panel.
   The "Measurements" dialog box opens.
6. Enable the "Statistics" option.



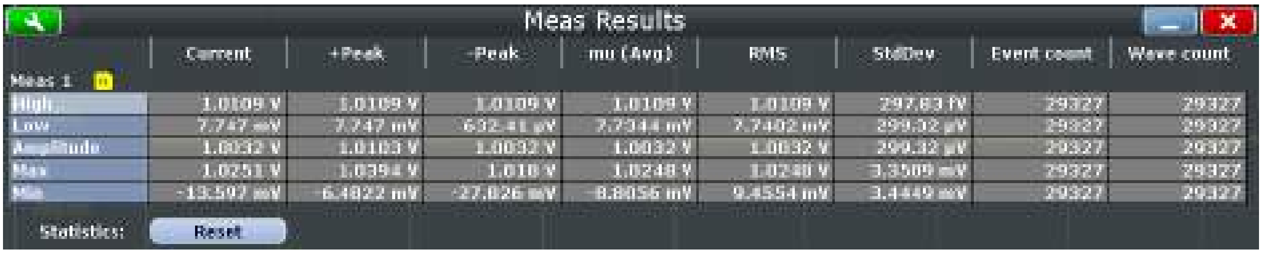
7. Tap "Additional Measurements".

8. Select the required measurement types. For example, select also "Min" and "Max" to display the minimum and maximum values.



9. Tap "OK". Close the dialog box.

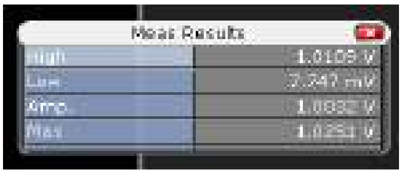
The result box displays all measurement results.



	Current	+Peak	-Peak	mu (Avg)	RMS	StdDev	Event count	Wave count
High	1.0109 V	1.0109 V	1.0109 V	1.0109 V	1.0109 V	297.83 fV	29327	29327
Low	7.747 mV	7.747 mV	632.41 µV	7.7344 mV	7.7402 mV	299.32 µV	29327	29327
Amplitude	1.0032 V	1.0103 V	1.0032 V	1.0032 V	1.0032 V	299.32 µV	29327	29327
Max	1.0251 V	1.0394 V	1.018 V	1.0248 V	1.0248 V	3.3509 mV	29327	29327
Min	-13.597 mV	-6.4822 mV	-27.026 mV	-8.8056 mV	9.4554 mV	3.4449 mV	29327	29327

10. To save space in the display, tap ▁ "Minimize" in the result box.

Now you see the first results in the result icon.

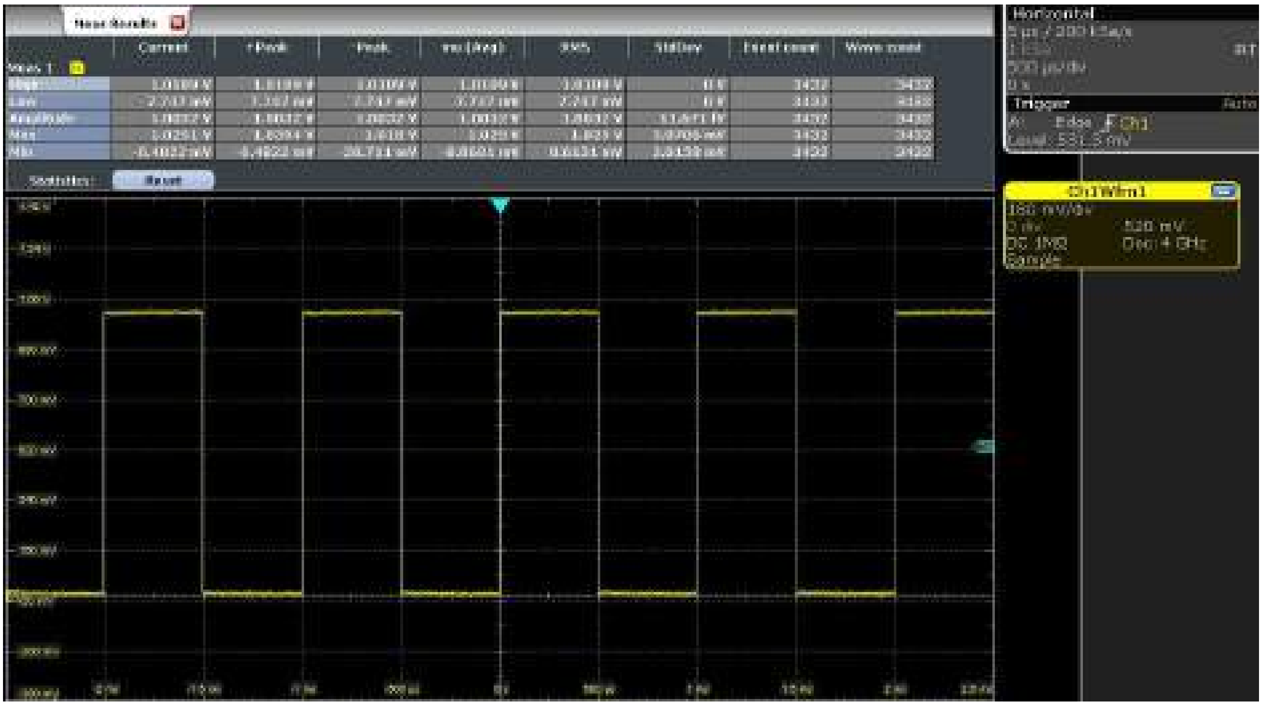


Meas Results

High	1.0109 V
Low	7.247 mV
Amp	1.0032 V
Max	1.0251 V

11. To view all measurement results without covering part of the waveform display, move the result table to its own diagram area:
    a) Drag the result icon to the diagram area.
    b) Drop the icon in the target area.

    Now you can see all measurement results and the waveform.



12. Minimize the measurement results display: touch the title of the results diagram, and drag it to the signal bar.
13. Close the result icon.

2.3.7.3 Performing and Configuring the Quick Measurement

A set of maximum eight different measurements on one source can be performed at once, simply by tapping the "Quick measurement" toolbar icon. You can configure the measurement types to be included in quick measurement. This way, you can repeat measurements quickly.

By default, the "Quick measurement" icon is not visible in the toolbar. Therefore, you first configure the toolbar content.

To add a function to the toolbar

1. On the right of the toolbar, tap the "Toolbar configuration" icon.
2. Enable "Quick meas".

3. Close the dialog box.

In the following examples, you start a quick measurement and change the measurement configuration.

To start the quick measurement

1. Press AUTOSET.
2. Tap the "Quick measurement" icon on the toolbar.
3. Tap the diagram.

   The result box shows the results of the default quick measurement.

Source C1

High	1.0038 V
Low	7.747 mV
Amplitude	996.05 mV
Max	1.018 V
Min	-0.4822 mV
Peak to peak	1.0215 V
Mean	507.05 mV

To configure the quick measurement

1. To open the "Measurements" dialog box, tap .
2. On the left, select the "Quick Meas" tab (lowest tab).
3. Scroll down in the table and disable the Mean and RMS measurements.

Amplitude/Time measurement	State
Max	✓
Min	✓
Peak to peak	✓
Mean	✓
RMS	✓

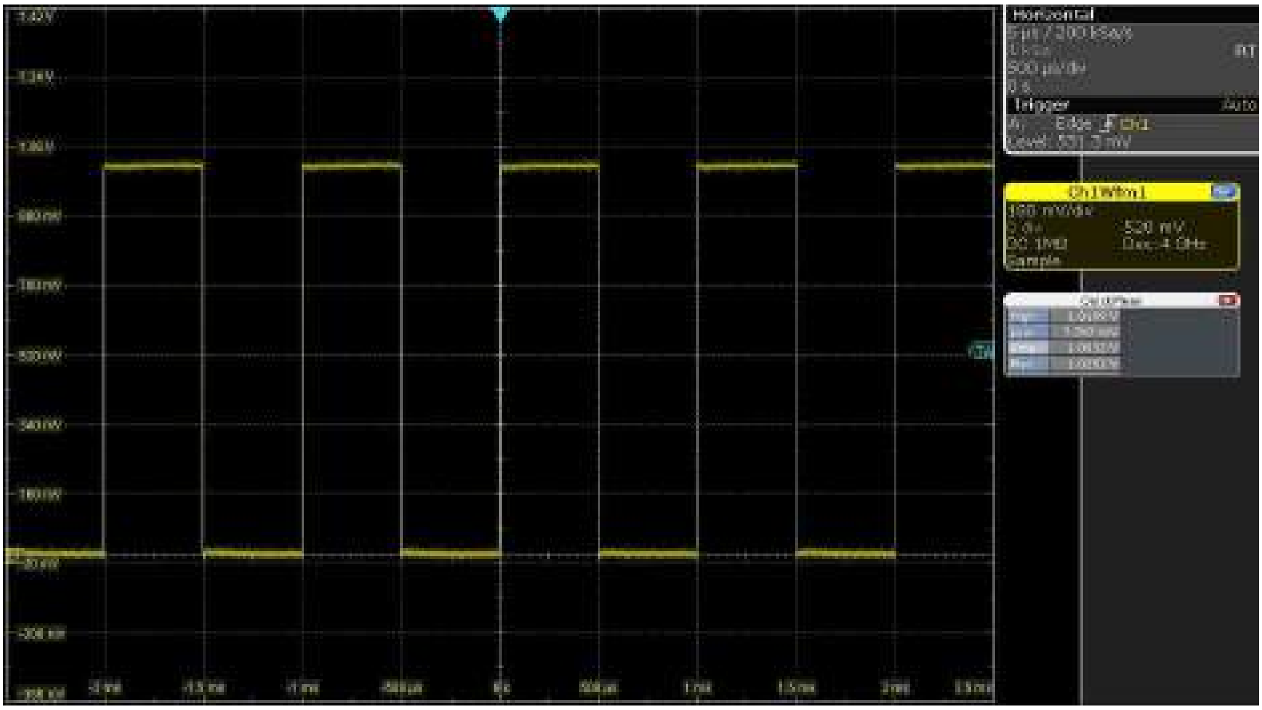
4. Tap "Activate" and select "Period".

   Now the result box also shows the result of the period measurement.
5. Tap "Activate" and select "Frequency".

Amplitude/Time measurement	State
Max	✓
Min	✓
Peak to peak	✓
Period	✓
Frequency	✓

   Now the result box also shows the result of the frequency measurements.
6. Tap "Set as QuickMeas".

   The current configuration is set as default quick measurement and can be repeated until you save another configuration.
7. Close the dialog box.
8. To save space in the display, minimize the result box:
   Do not close the result icon, as you need the results for the search example (see).



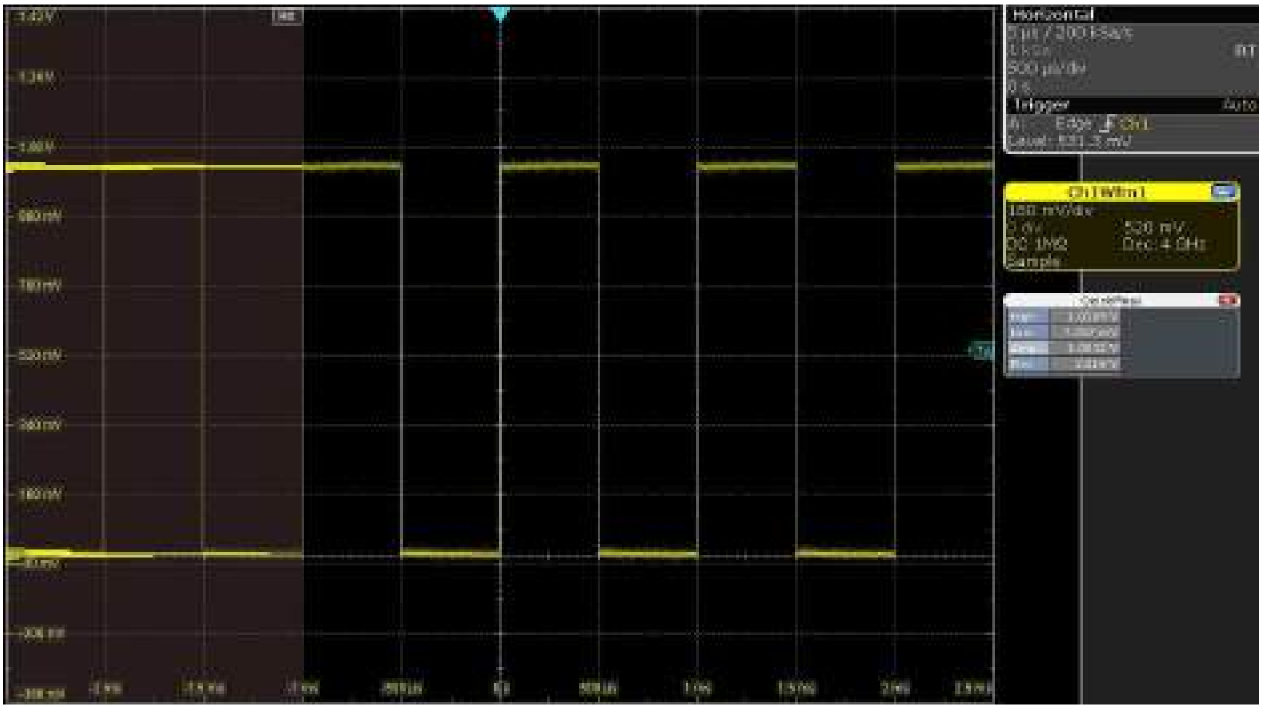
2.3.7.4 Displaying a Histogram

Histograms are useful to analyze the occurrence of measurement values statistically.

The usage of histograms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Histogram".

1. Tap the "Histogram" icon on the toolbar.
2. Tap the diagram in which you want to generate the histogram.

   A vertical histogram is defined and displayed.



Tip: You can also draw a rectangle on the screen to define the area on which the histogram is to be based. The histogram range is indicated in the diagram.

3. To perform measurements on the histogram, tap the "Measurement" icon on the toolbar.

4. Tap the histogram.

   The waveform count for the histogram is displayed.

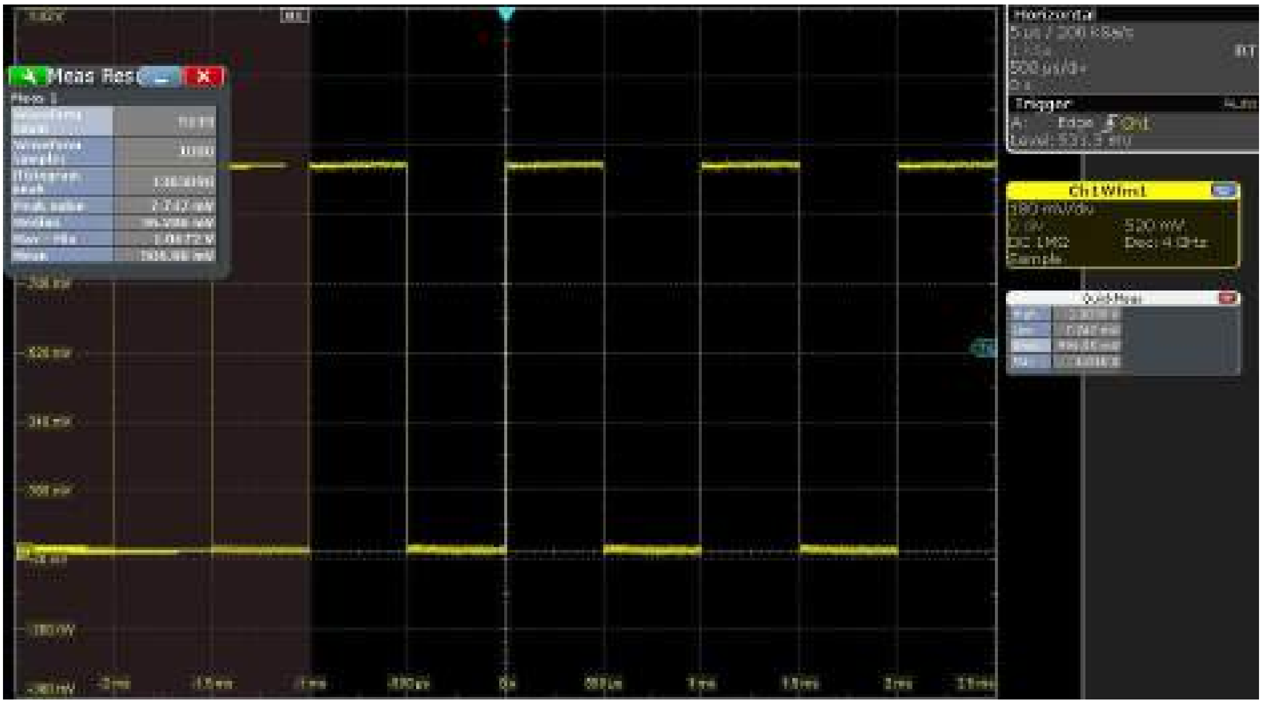
5. To display further measurement results for the histogram, tap 🔧 in the result box. Alternatively, you can press the MEAS key on the front panel.

6. In the "Measurements" dialog box, tap "Additional Measurements".

7. Select the required histogram measurement types.

8. Tap "OK". Close the dialog box.

   The histogram measurement results are displayed in the result box.



9. To remove the histogram, tap the "Delete" icon on the toolbar, and then tap the histogram.

   🗑

The histogram and any measurements based on that histogram are deactivated.

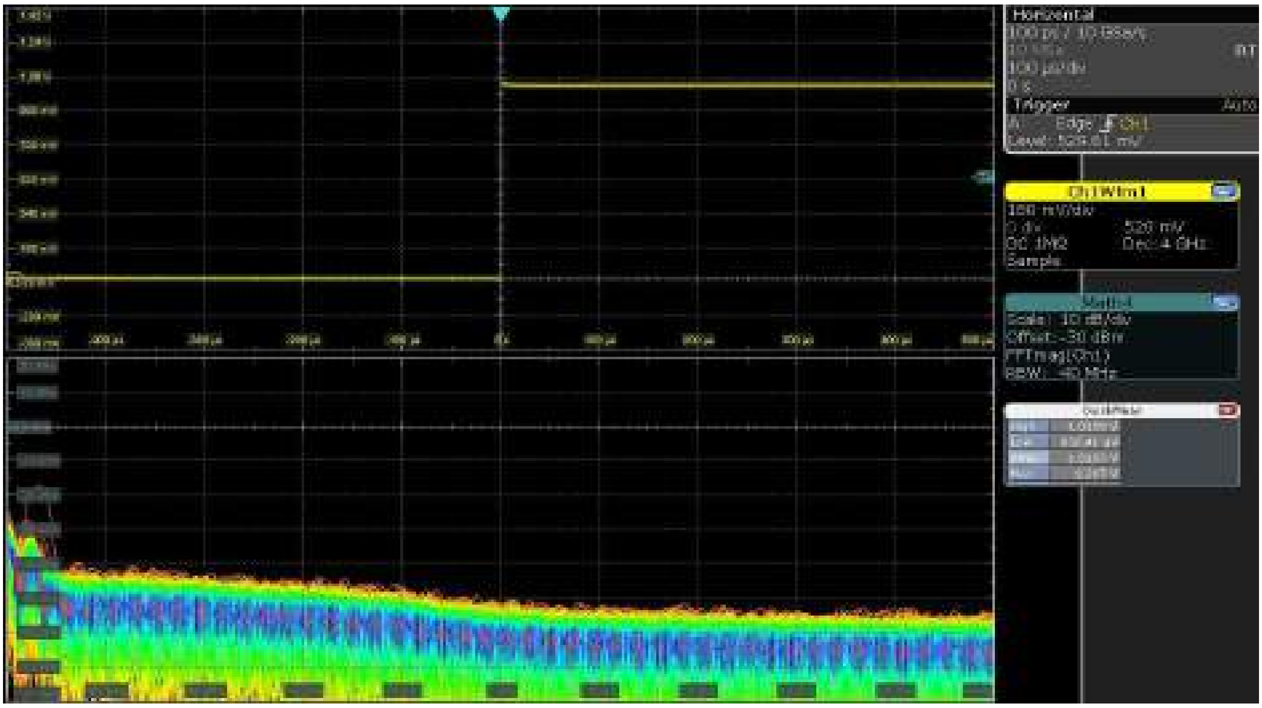
2.3.8 Performing a Basic FFT Analysis

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed quickly.

The usage of FFT is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > FFT".

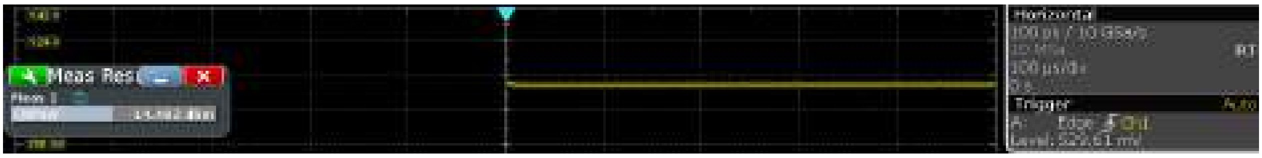
1. Restore the default signal channel settings by pressing the AUTOSET key.
2. Tap the "FFT" icon on the toolbar. Then tap the diagram.

   A math waveform is configured that uses the "Mag(FFT(x))" operator with "Ch1Wfm1" as source. The spectrum waveform is displayed in a new diagram.



3. To measure the spectrum on the math channel, tap the "Measurement" icon on the toolbar.
4. Tap the spectrum waveform.

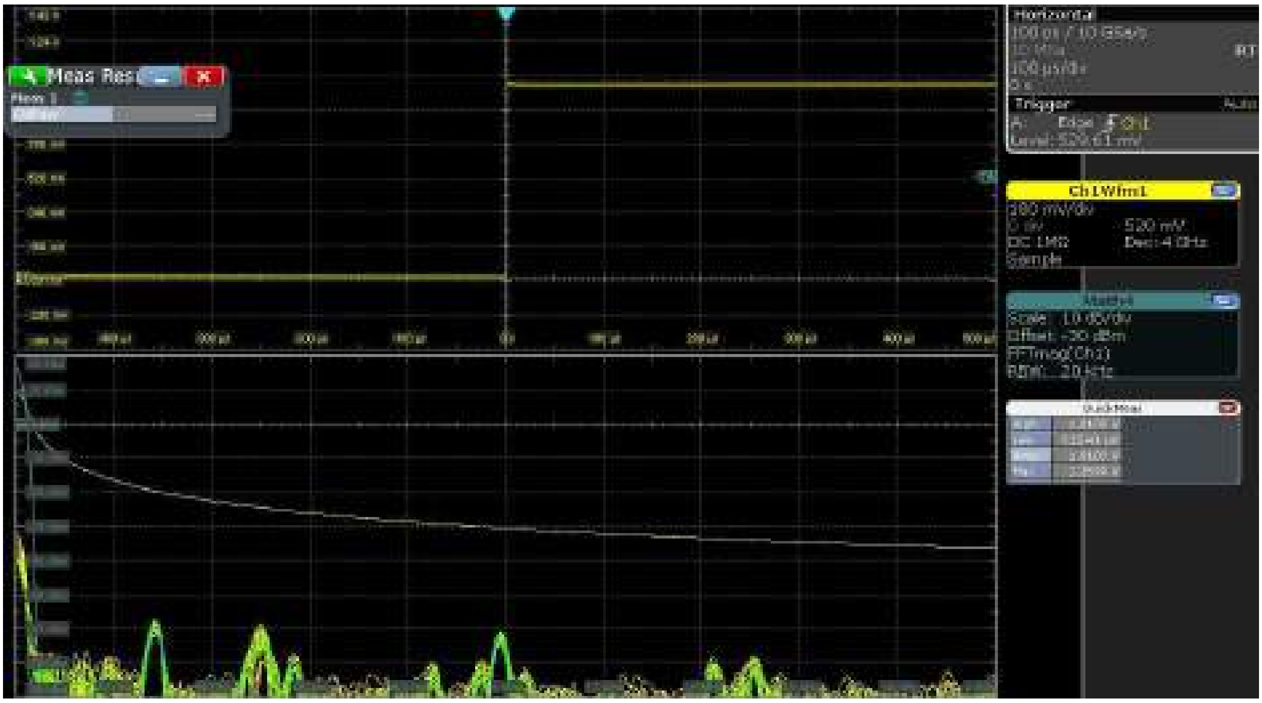
   The spectrum measurement results are displayed in a result box.



5. Double-tap the spectrum waveform.

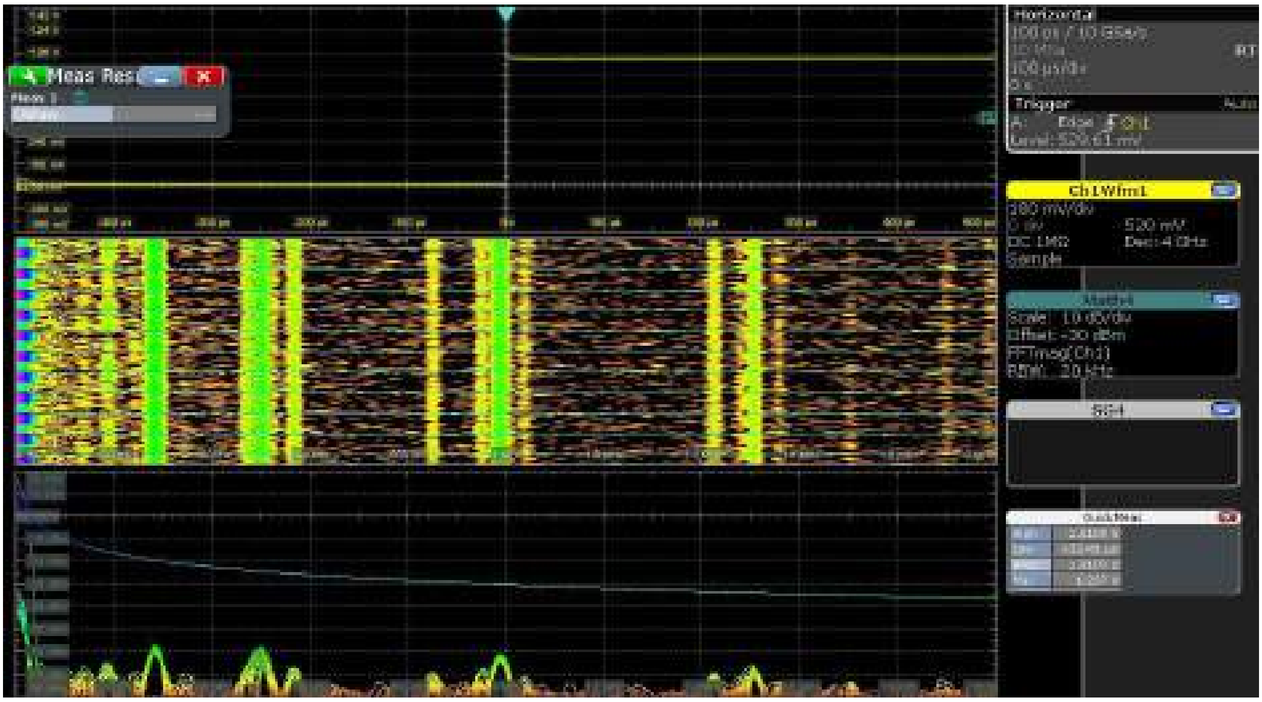
   The "FFT Setup" dialog box opens.

6. Set the "Center frequency" to *1 MHz*.
   The instrument adjusts the frequency span automatically.
   Close the dialog box.



7. If the spectrum analysis option R&S RTO-K18 is installed on your instrument, double-tap the spectrum waveform again.

8. Enable the spectrogram. Close the dialog box.



9. To remove the FFT results, tap the "Delete" icon and then the spectrum waveform.

10. Close the "Measurement" result box.

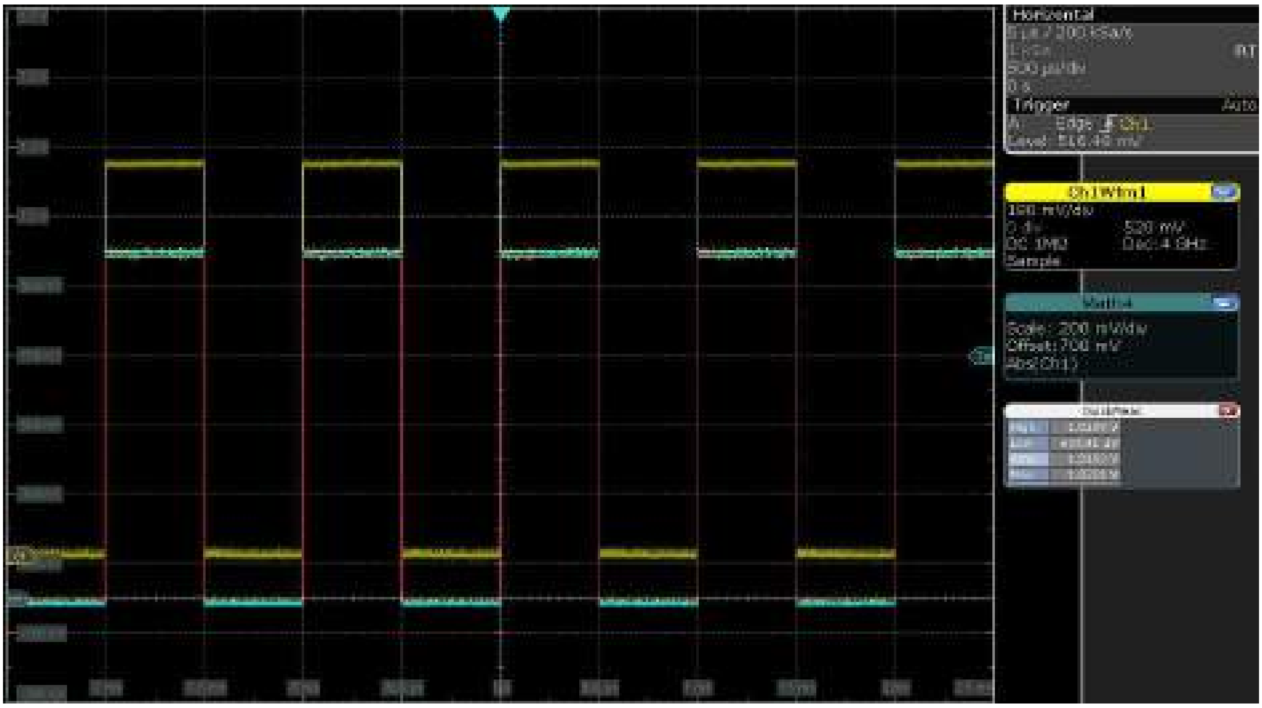
2.3.9 Performing Mathematical Calculations

In addition to the measured waveforms, you can display calculated data to compare the current measurement result with.

For example, you can display the absolute value if the waveform values as a math waveform.

1. Press AUTOSET.
2. Press the MATH key.
3. In the "Setup" tab, select the "Basic" subtab.
4. Tap the "Source1" icon and select "Ch1Wfm1".
5. Tap the "Operator" icon and select "|x|".
6. Tap "Enable" to display the math waveform.
7. Close the "Math" dialog box.

   The original and the math waveforms are displayed. The color of the math waveform is non-uniform because the instrument applied a color table to it.



8. Press the DISPLAY key.
9. Disable "Use color table" in the lower area of the dialog box.

Persistence

☑ Enable persistence

☐ Infinite persistence

Persistence time 50 ms

Reset

Signal style

Intensity 50 %

Style
Vectors
Dots

Color table assignment

Source M4

☐ Use color table

Color

Set to default color

10. Close the dialog box.

    Now the math waveform has blue color.
11. To remove the math waveform, tap the "Delete" icon and then the math waveform.

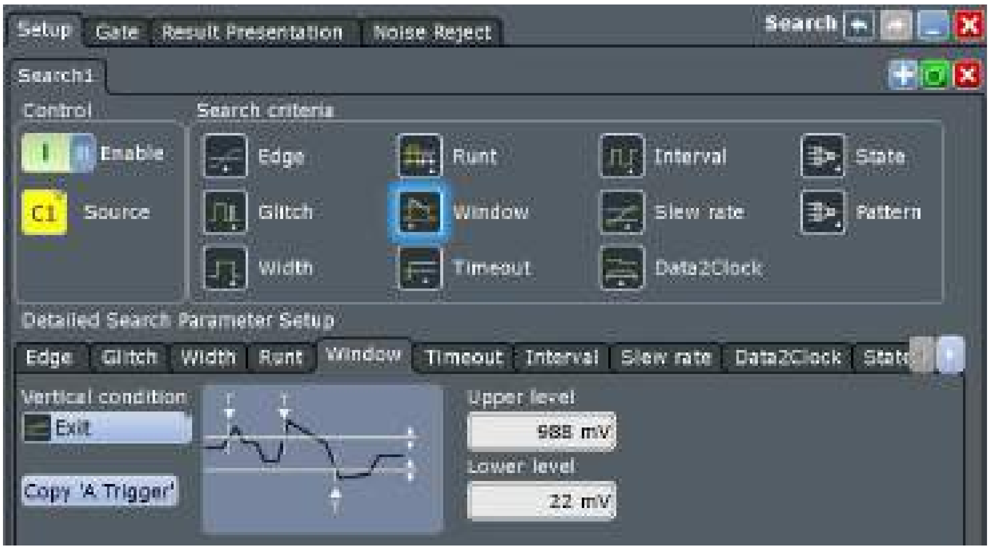
Alternatively, you can tap the signal icon of the math waveform to minimize the waveform. Then close the signal icon.

2.3.10 Performing a Search

In the following search, you detect positive and negative overshoots, i.e. values that exceed the high or low levels. To find these events, you can use the windows search.

To determine the search conditions, we use the results of the measurement example described in Chapter 2.3.7.3, "Performing and Configuring the Quick Measurement", on page 56.

1. Press the SEARCH key on the front panel (ANALYSIS area).
2. Select "C1" as "Source".
3. Select the search criteria: Enable "Window".
4. In the "Window" tab below, define the search conditions:
   a) In the "Upper level" field, enter the result of the "High" level measurement.
   b) In the "Lower level" field, enter the result of the "Low" level measurement.
   c) As "Vertical condition", select "Exit" to find values that are outside the range defined by the high and low levels.



Source: C1

Vertical condition: Exit

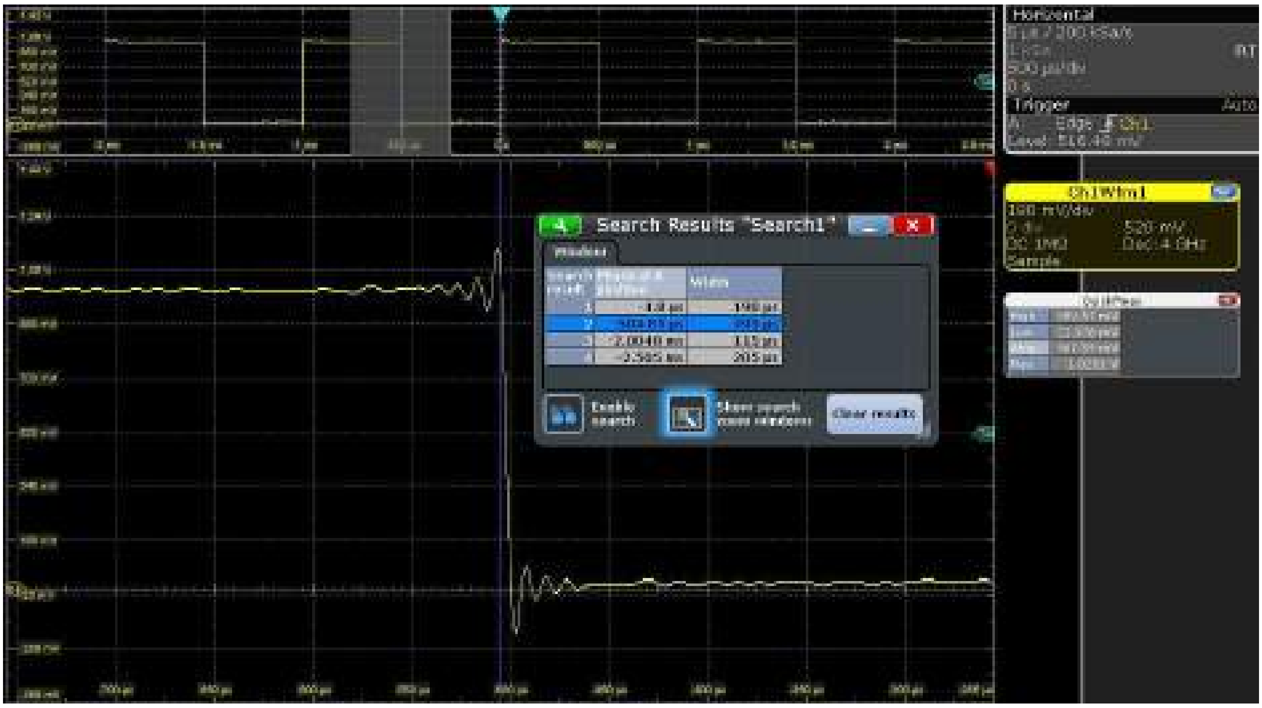
Upper level: 988 mV

Lower level: 22 mV

5. Select "Enable" to start the continuous search on the acquired data.
6. Close the "Search" dialog box.
7. In the "Search Results" box, select "Show search zoom windows".

   The acquisition stops, and the detected overshoots of the last acquisition are listed in the search result table. The search zoom window shows the last result that was found. Vertical lines indicate the time values for which a result was found.

8. In the results table, tap the row of the search result that you want to display in the search zoom diagram.



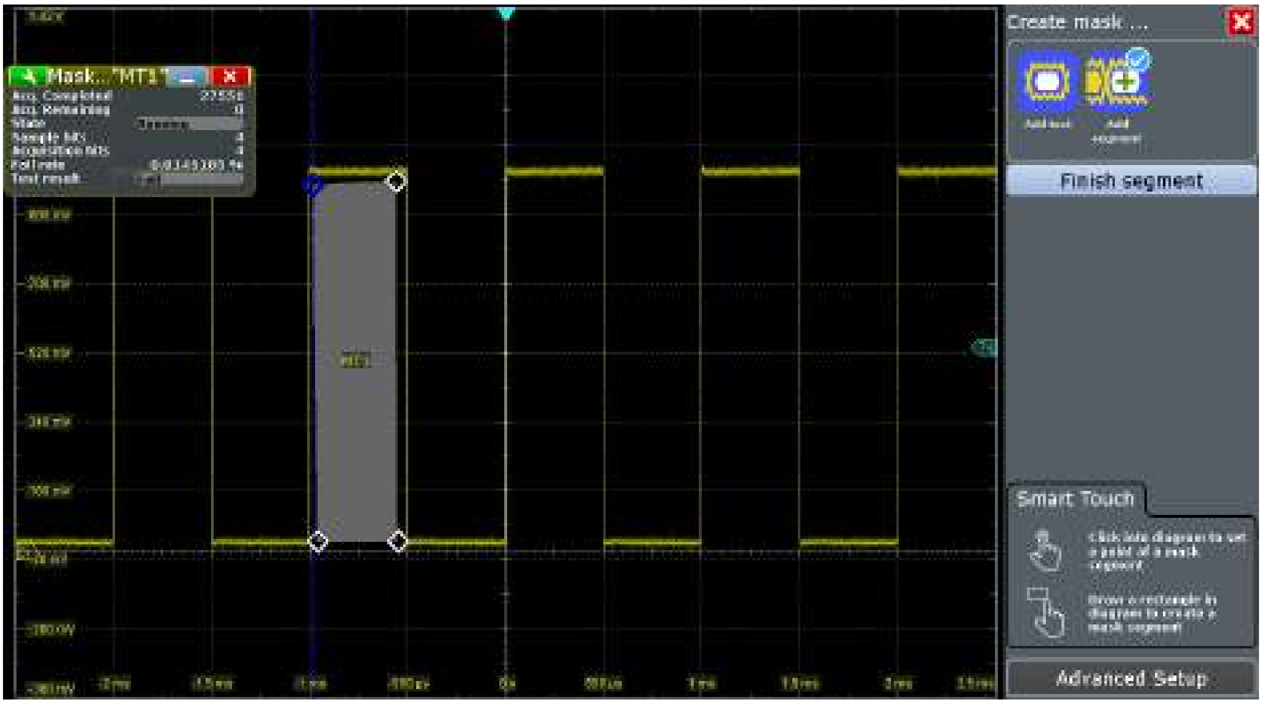
2.3.11 Performing a Mask Test

In the following example, you perform a mask test to determine whether the signal exceeds a rectangular area.

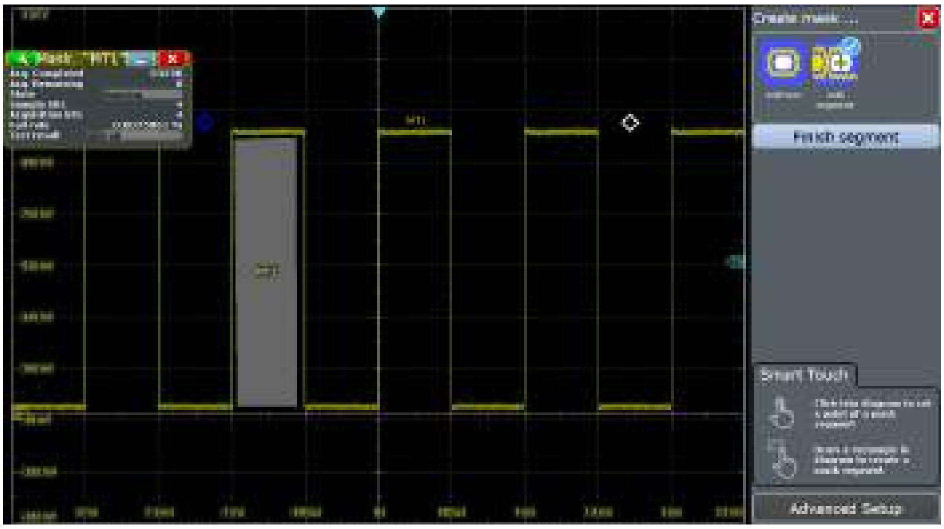
The usage of masks tests is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Mask Test".

1. To restore the default signal channel settings, press PRESET and AUTOSET.
2. Tap the "Masks" icon on the toolbar.
3. Tap the corner points of the first mask segment on the touchscreen. Select the corner points of one complete pulse, with a minor offset to the inside.

   Tip: To create an exact rectangle, draw the diagonal of the rectangle on the screen.
4. Tap "Finish segment" in the sidebar.

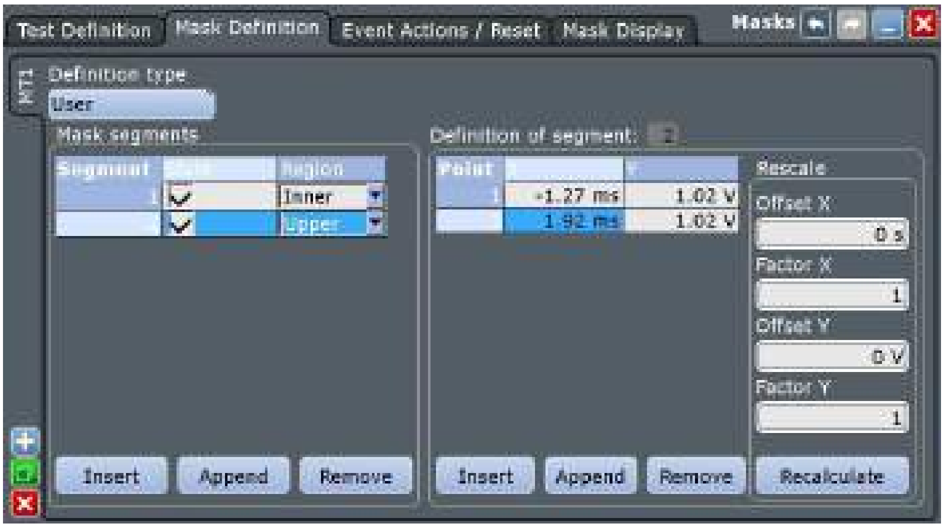


5. Add another mask segment above the positive pulse:
   a) Tap "Add segment" in the sidebar.
   b) Tap two points slightly above the pulse.
   c) Tap "Finish segment" in the sidebar.



   d) Tap 🟩 in the result box.
   e) Select the "Mask Definition" tab.

f) In the "Region" column of the second mask segment, select "Upper".



Definition type: User

Mask segments

Segment	[illegible]	Region
1	✓	Inner
	✓	Upper

Definition of segment: 2

Point	[illegible]	Y
1	-1.27 ms	1.02 V
	1.92 ms	1.02 V

Rescale

Offset X: 0 s

Factor X: 1

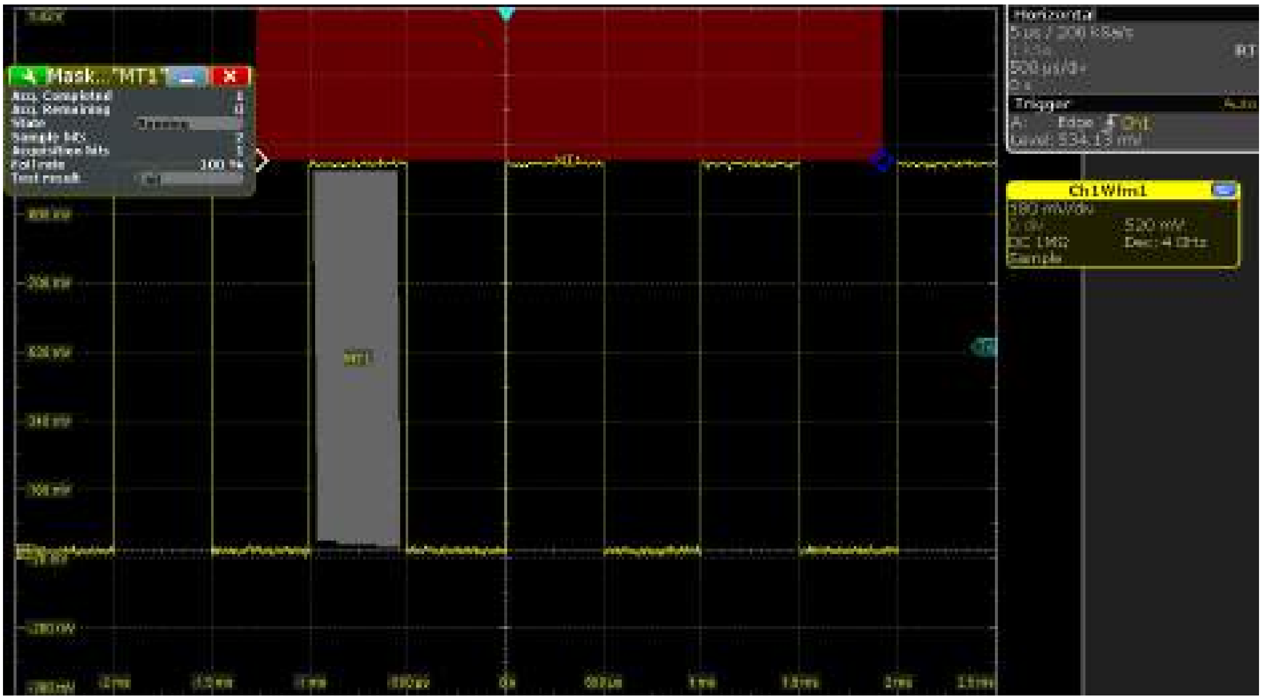
Offset Y: 0 V

Factor Y: 1

6. Select the "Test Definition" tab.
7. Select channel 1 as the "Source".
8. Define the number of tolerable sample hits in the "Violation tolerance" field.

   A test has failed if the number of sample hits exceeds the limit of "Violation tolerance".
9. Select the "Event Action / Reset" tab.
10. For the "Stop acquisition" action, select "On violation".

    When the violation tolerance is exceeded, the acquisition stops. The results of the mask test are shown in the "MaskTest" results box. Mask hits are also indicated as red points in the mask segment in the diagram.



11. Press RUN STOP to start the next acquisition and watch the screen.

12. To close the test, tap 🔧 in the "MaskTest" results box.

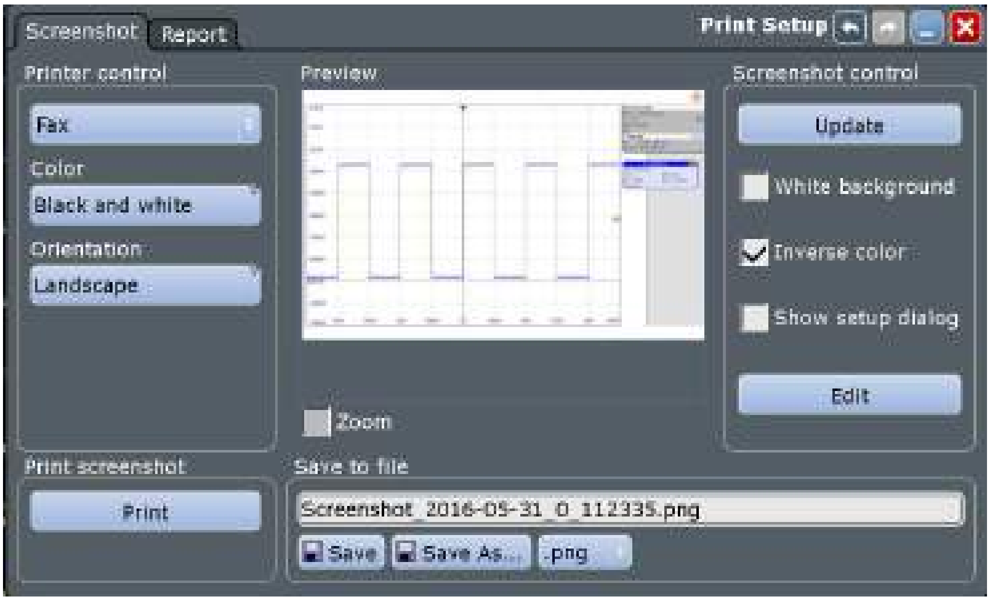
2.3.12 Printing and Saving Screenshots

You can print and save screenshots of the current display to document your results. In the following examples, you print the current display as a black and white graphic with inverted colors, i.e. a black waveform is printed on a white background. Then you save some screenshots using the Camera key.

To print a screenshot

You need a printer that is connected to the instrument. If the instrument is connected to the network, you can also use a network printer.

1. Open the "File" menu and tap "Print Setup".
2. Tap "Color" and select "Black and white".
3. Enable "Inverse color".



Fax

Color: Black and white

Orientation: Landscape

☐ White background

☑ Inverse color

☐ Show setup dialog

☐ Zoom

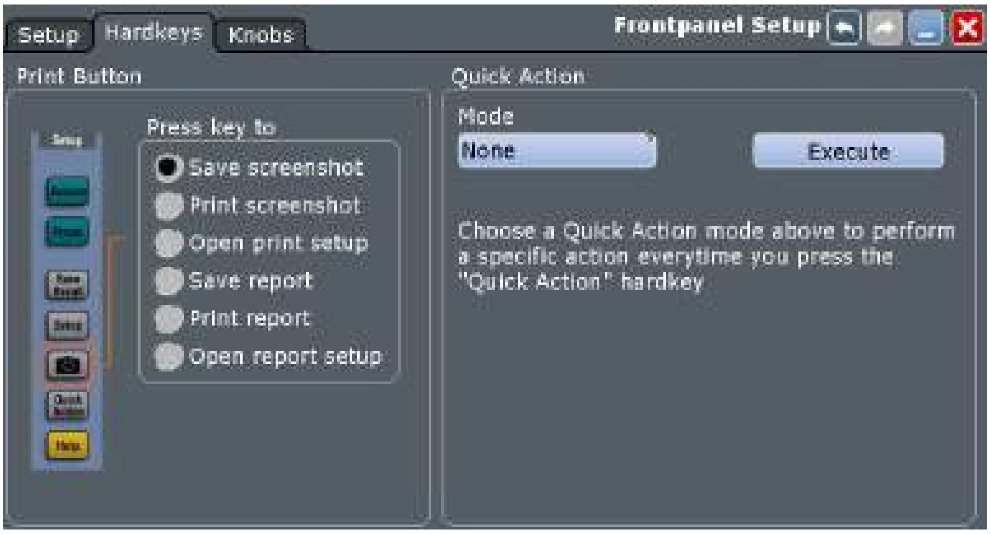
Screenshot_2016-05-31_0_112335.png

.png

4. Tap the upper left button and select the printer.
5. Tap "Print". The result is a monochrome image.
6. Close the dialog box.

To configure the Camera key

1. Open the "File" menu and tap "Frontpanel Setup".
2. Select the "Hardkeys" tab.
3. Select "Save screenshot".



Press key to
● Save screenshot
○ Print screenshot
○ Open print setup
○ Save report
○ Print report
○ Open report setup

Mode: None

Choose a Quick Action mode above to perform a specific action everytime you press the "Quick Action" hardkey

4. Close the dialog box.

To save screenshots

1. Press the 📷 key.
2. Change the horizontal scale.
3. Press the 📷 key.

   The files are saved to the following directory:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ScreenShots`
   The default file name is `Screenshot_<date>_<index>_<time>.png`.
4. To access the saved files, open the "File" menu and tap "Minimize Application".
5. Double-tap the "User" folder icon on the desktop.
6. Open the `ScreenShots` folder.

2.3.13 Saving Data

After a measurement with the R&S RTO, you can save the resulting waveform data for further evaluation or comparison. You can also save measurement results, and device settings in order to repeat or restore previous measurements.

- "Saving waveform data" on page 72
- "Saving data of an acquisition series" on page 73
- "Saving measurement results" on page 74
- "Saving and restoring device settings" on page 74

Saving waveform data

1. Press the SAVE RECALL key on the front panel (in the SETUP area on the left).
2. Select the "Waveforms/Results" tab.
3. Select the "Waveforms" tab.
4. Check the "Source".
5. Set "Scope" to "Full Waveform".

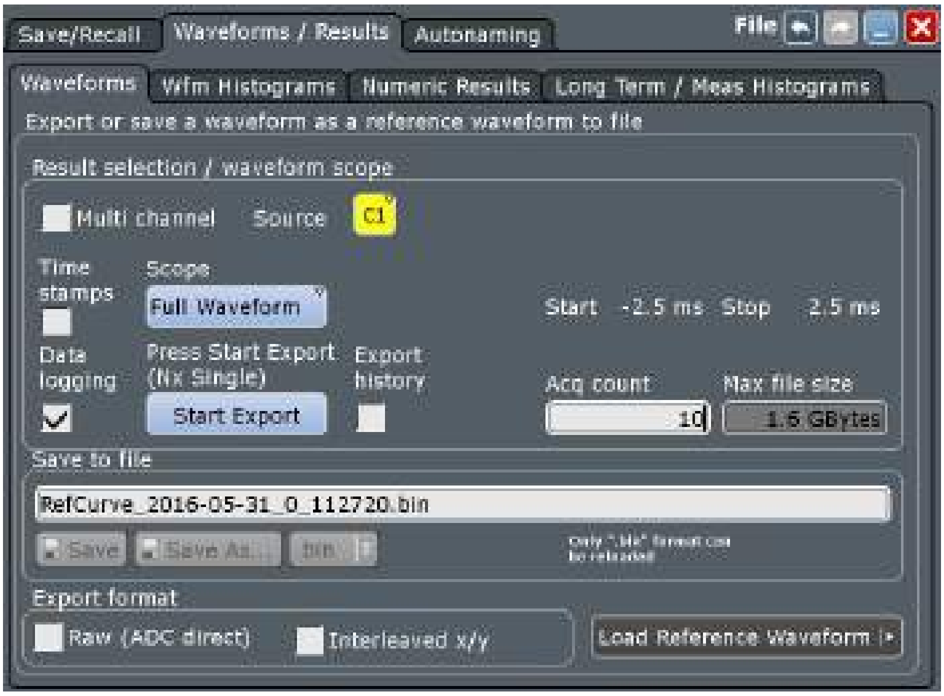
   Tip: If a cursor, zoom or measurement gate is defined, you can use these settings to export only a part of the waveform.
6. Under "Save to file", tap "Save As".
7. The file selection dialog box shows the default storage directory:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms`
8. Tap the keyboard icon on the right of the "File Name" field.

9. Enter *Waveform1* on the online keyboard
10. Tap "ENTER" to close the online keyboard.
11. Select the file type: "*.bin".
12. Tap "Save".

    The waveform data is saved to the files `Waveform1.Wfm.bin` and `Waveform1.bin` in the selected directory.

Saving data of an acquisition series

1. Press the SAVE RECALL key on the front panel.
2. Select the "Waveforms /Results" tab.
3. Set the export scope of the waveform:
    a) Check the "Source".
    b) Set "Scope" to "Full Waveform".
    c) Tap "Data logging" to enable export all waveforms of a running acquisition.
    d) Enter "Acq count" = *10*, the number of subsequent waveforms that the instrument acquires and saves.



Export or save a waveform as a reference waveform to file

☐ Multi channel Source C1

Scope: Full Waveform

Start -2.5 ms Stop 2.5 ms

Time stamps ☐

Data logging ☑

Acq count 10

Max file size 1.6 GBytes

RefCurve_2016-05-31_0_112720.bin

☐ Raw (ADC direct) ☐ Interleaved x/y

4. Tap "Start Export" to save the waveforms to file. You can change the file name in "Save to file".

Saving measurement results

1. Perform a measurement as described in Chapter 2.3.7.2, "Performing an Amplitude Measurement", on page 53.
2. Tap 🔧 in the result box.
3. Tap "Result Export" in the "Setup" tab.
4. Select the "Numeric Results" tab.
5. Select the results that you want to save.
6. For further usage of the results, select the "CSV-Delimiter" that is used to convert the values in columns. For MS Excel, the semicolon is recommended.
7. Tap "Save".

   The results are saved to the following folder:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ResultBoxExport`
   The file name is created according to the autonaming settings.

Saving and restoring device settings

1. Press the SAVE RECALL key on the front panel.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Save As". Enter the path and file name.
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\SaveSets\Settings_Meas1.dfl`
5. Tap "Save".
6. To restore the default instrument settings, press the PRESET key.
7. To repeat the initial measurement, tap the "Load saveset" icon on the toolbar.

   📂

8. Use the buttons on the left and the right to scroll the stored savesets. The file name and a screenshot help identify the correct saveset.
9. Tap "Load".

   The device and measurement settings are restored and you can repeat the measurement.

2.4 Operating the Instrument

There are three ways to operate the R&S RTO.

Manual operation

Use the touchscreen, keys and rotary knobs, or an optional mouse and/or keyboard. The principles of manual operation are explained in this section.

Remote control

Create programs to automatize repeating settings, tests, and measurements. The instrument is connected to a computer running the program.

This way of operation is described in: Chapter 20, "Remote Control Commands", on page 1154.

Remote operation

The remote desktop connection of Windows Embedded Standard 7 can be used for instrument control and file transfer. Even on computers with non-Windows operating systems, a remote desktop connection is possible using RDP applications.

See also: User Manual, chapter "Remote Desktop Connection".

Remote monitoring and control of the instrument from a connected computer is also possible with a standard web browser and a LAN connection using LXI.

See also: User Manual, chapter "Web Control".

Alternatively, you can use Virtual Network Computing (VNC), which requires installation of the VNC server on the R&S RTO. Installation and configuration are described in the Application Note "Remote Monitoring and Control of the R&S RTO with a Web Browser", available on the Rohde & Schwarz Internet.

2.4.1 Means of Manual Interaction

The R&S RTO provides the following means of manual interaction, which you can use alternatively or complementary:

- Touchscreen:
  Using the touchscreen is the most direct interaction way. Use your finger to place waveforms on the screen, mark areas for zoom and histograms, set parameters in dialog boxes, enter data, and much more. Most of the control elements and actions on the screen are based on common concepts, and you will easily become familiar with the user interface.

  Tapping the screen works like clicking mouse buttons:
  - Tap = click: Selects a parameter or provokes an action.
  - Double-tap = double-click has the same effect as touch and hold = right-click: Opens the on-screen keyboard or keypad, or a specific editor if available

  Use gestures to scale the waveform:
  - Spread or pinch two fingers horizontally to change the horizontal scale (time-base).
  - Spread or pinch two fingers vertically to change the vertical scale of the active waveform.
- Function keys and rotary knobs:

The front panel provides nearly all functions and controls to operate the instrument in the classic ways, without touchscreen. As an exception, the signal bar cannot be used with front panel controls.

- Optional mouse and/or keyboard:
  These devices work conform to Windows standards. The navigation keys on the front panel correspond to the keys on the keyboard.

The usage of the touchscreen and navigation keys is described in detail in the following sections.

2.4.2 Touchscreen Display

2.4.2.1 Information on the Display

The touchscreen display of the instrument shows not only waveforms and measurement results, but also information and everything that you need to control the instrument. All waveform-related display elements are shown in Figure 2-3. An overview of control elements - like dialog box, toolbar - is given in Figure 2-6 .

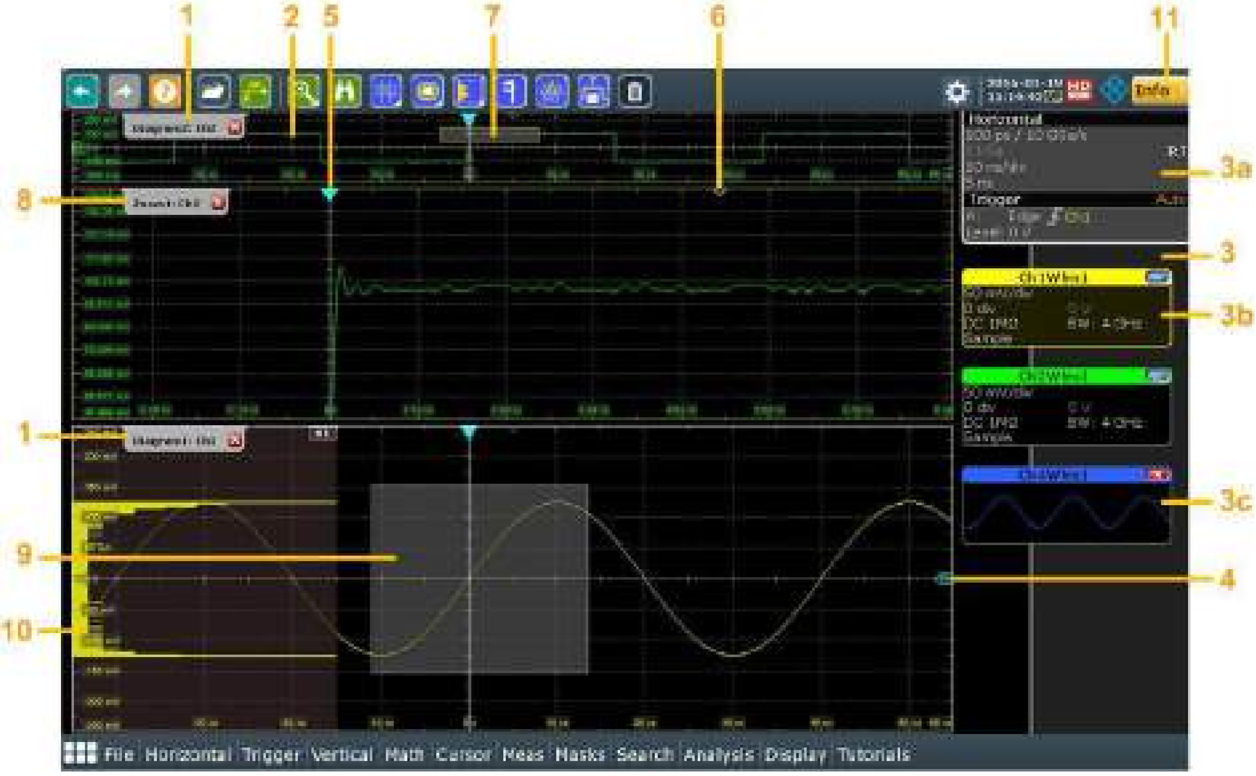


Figure 2-3: Display information

1 = Diagram
2 = Grid
3 = Signal bar with horizontal and trigger label (3a), signal icon with signal label (3b) and signal icon with minimized live waveform (3c)
4 = Trigger level

5 = Trigger position
6 = Reference point (distance from trigger position to reference point = horizontal position)
7 = Zoom area
8 = Zoom diagram
9 = Histogram area
10 = Histogram
11 = Messages

Diagram (1)

A diagram shows one or more waveforms: channel, reference, and math waveforms together with histograms, masks etc. Zoom details appear in separate zoom diagrams, also XY-waveforms appear in separate diagrams.

By default, the diagram name contains the diagram number and the short names of the waveforms shown inside. To change the diagram name, touch and hold the tab name. The on-screen keyboard opens to enter the new name. Names must be unique.

To arrange the diagrams on the screen, the Rohde & Schwarz SmartGrid function helps you to find the target place simply and quickly. A tabbed view is also possible, and you can adjust the diagram size.

For details, see "To arrange a waveform using the SmartGrid" on page 83.

Grid (2)

The grid shows the vertical and horizontal divisions. The division lines are labeled with the correspondent values. The grid labels have the color of the waveform to which they belong. If several waveforms are shown in one diagram, the grid has the color of the selected waveform.

Signal bar (3)

The signal bar is the control center for all enabled waveforms. On the top, the horizontal and trigger labels show the main timebase and trigger settings. If you tap a label, the relevant dialog box opens with the tab used at last.


Horizontal
100 ps / 10 GSa/s
1 kSa
RT
10 ns/div
0 s
Trigger Normal
A: Width Ch2
B: Edge Ch1
Level: 0 V

Figure 2-4: Horizontal and trigger label on top of the signal bar

1 = Resolution and sample rate
2 = Record length
3 = Timebase (horizontal scale)
4 = Horizontal position
5 = RT - real time, IT - interpolated time
6 = Trigger mode
7 = Trigger type, slope or polarity, source for A-event and B-event
8 = Trigger level

Below, each waveform is represented by a signal icon. For each waveform that is shown in a diagram, a signal icon displays the signal label with its main vertical and acquisition settings. If you tap the "Minimize" icon on the signal label, the waveform switches from the diagram area to the signal icon: the icon shows the real-time preview of the waveform. If you tap a label, the dialog box with vertical settings for this waveform opens. See Chapter 2.4.4, "Working with Waveforms", on page 81 for a detailed description.

In Figure 2-3, the signal icons Ch1Wfm1 and Ch2Wfm1 show the signal label, and the waveforms are displayed in diagrams. All other waveforms are minimized and shown in the signal view.

Ch1Wfm1
50 mV/div
0.2 div
0 V
DC 1MΩ
BW: 4 GHz
Peak detect

Figure 2-5: Signal label on the signal bar

1 = Vertical scale
2 = Vertical position
3 = Coupling
4 = Decimation
5 = Offset
6 = Actual bandwidth, can be less than the instrument bandwidth depending on the number of active channels and other settings

If the signal bar contains many icons and not all icons are visible, touch one of the icons and move it up or down until the required icon appears. You can also switch off the signal bar: "Display" menu > "Diagram Layout" > "Show signal bar".

Trigger position and trigger level (4, 5)
The blue markers show the horizontal position of the trigger and the vertical trigger level. You can touch and move the trigger markers in the diagram to set the positions. The trigger point is the zero point of the diagram.

The trigger position can be moved outside the diagram. A red trigger position marker indicates that the trigger position is not visible.

Reference point (6)
The reference point marks the rescaling center. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

You can define the position of the reference point (Horizontal), and its time distance from the trigger point of the diagram (Position).

Zoom diagram and zoom area (7, 8)
Zoomed waveforms are shown in separate zoom diagrams, in addition to the waveform diagrams. On the original waveform diagram, a rectangle indicates the zoomed section of the waveform - this is the zoom area. You can modify the zoom area by dragging the rectangle as a whole, and by dragging its edges. To toggle between these modes, tap the zoom area. You can also set exact positions.

The frames of the zoom area and of the associated zoom diagram have the same color, different zooms are marked with different colors. So it is easy to assign zoom area and zoom diagram.

As for waveform diagrams, you can change the name of the zoom diagram. A zoom in a zoom and coupled zooms are also possible.

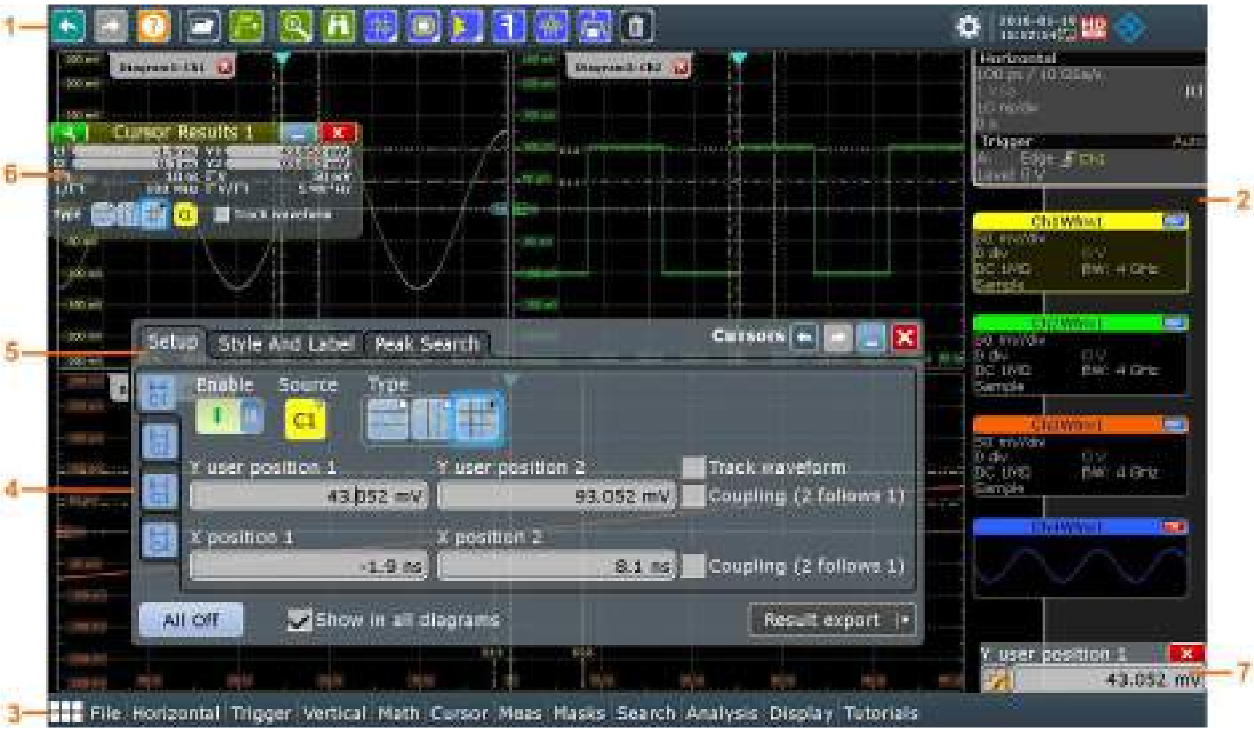
All zooming possibilities are described in detail in the "User Manual", chapter "Zoom".

Histogram and histogram area (9, 10)
A histogram shows the frequency of occurrence of voltage or time values in a bar chart directly in the diagram. The rectangular histogram area indicates the part of the waveform that is considered in the histogram. The vertical histogram counts the voltage values, and the horizontal histogram counts time values. You can switch between vertical and horizontal mode, and modify the histogram area by dragging the rectangle as a whole, by dragging its edges, or by setting exact positions.

Messages (11)
A yellow or red button on the toolbar points to the status messages of the instrument. To open the message box, tap the button. See also: Chapter 2.4.9, "Messages", on page 96.

2.4.2.2 Control Elements on the Touchscreen

The touchscreen provides everything you need to control the instrument, to analyze waveforms, and to get measurement results. Figure 2-6 shows the control elements on a glance.



Y user position 1: 43.052 mV
Y user position 2: 93.052 mV
X position 1: -1.9 ns
X position 2: 8.1 ns
☐ Track waveform
☐ Coupling (2 follows 1)
☐ Coupling (2 follows 1)
☑ Show in all diagrams
Y user position 1: 43.052 mV

Figure 2-6: Control elements on the touchscreen

1 = Toolbar
2 = Signal bar, see "Signal bar (3)" on page 77
3 = Menu bar
4 = Dialog box
5 = Tab in a dialog box
6 = Result box
7 = Input box

Toolbar (1)
The icons on the toolbar provide quick and easy access to the most important functionality. For a detailed description, refer to Chapter 2.4.5, "Toolbar", on page 84.

Menu bar (3)
The menus provide access to the complete functionality of R&S RTO.

Dialog box (4, 5)
The tabs of the dialog boxes contain all task-oriented settings and operations, and black buttons for calling related tabs. The usage of dialog boxes is described in Chapter 2.4.7, "Using Dialog Boxes", on page 92.

Result box (6)
If you perform manual or automatic measurements, mask testing, or a search, the result box shows the results of the action. Similar to waveform diagrams, you can minimize the result box to a result icon on the signal bar, and display results in a separate diagram on the screen. The 🔧 icon opens the corresponding dialog box to adjust the settings.

For details, see Chapter 2.4.6, "Displaying Results", on page 91.

Input box (7)
The input box appears if you adjust a value using one of the rotary knobs, or if you drag an element on the screen, for example, a cursor line. The input box shows the current value of the modified parameter. You can enter the exact numerical value, change the step size, and - if available - autoset the value directly in the input box. The box title shows the name of the currently adjusted parameter. The input box is helpful when using the multi-function rotary knobs, for example, INTENSITY, and RESOLUTION / RECORD LENGTH.

Horizontal position

-10 µs

See also: Chapter 2.4.8, "Entering Data", on page 94.

2.4.3 App Cockpit

The app cockpit provides fast access to all available applications.

► To open the app cockpit:

- Tap ▦ in the menu.
- R&S RTO2000 only: Press the ▦ key in the ANALYSIS section of the frontpanel.

2.4.4 Working with Waveforms

The R&S RTO can create and display several types of waveforms:

- Channel waveforms:
  Up to three waveforms per input channel can be shown. For a four-channel instrument, 12 channel waveforms are available.
- Reference waveforms:
  Four waveforms can be used as reference for comparison and analysis.
- Math waveforms:
  Four mathematic waveforms can be created with mathematic operations performed on channel, reference, and other math waveforms.
- Zoom waveforms:
  Show the details of waveforms.
- XY-waveforms:
  Four XY-waveforms can be created. Each XY-waveform is built from the voltage values of two source waveforms.
- Digital waveforms:
  The Mixed Signal Option R&S RTO-B1 provides 16 digital channels grouped in two logic probes (pods) with 8 channels each.

Waveform handling

The R&S RTO can show and analyze many waveforms. To handle this multitude while keeping track of it, the R&S RTO provides intelligent support:

- The color system helps to distinguish the waveforms. The color of the vertical rotary knobs indicates the signal that is focused (selected). The color of each waveform can be changed, the color of its signal icon and of the illuminated keys is adjusted to the new color. Alternatively, a color table can be assigned to a waveform. Settings: DISPLAY > "Signal Colors / Persistence" tab.

- Waveforms can be minimized to signal icons showing a small real-time signal view. Thus, more space in the diagram area is available without switching off waveforms.
- Diagrams are displayed on tabs – you can arrange them side by side or one above the other. To change the diagram name, double-tap the tab name.
- The Rohde & Schwarz SmartGrid function helps to arrange the diagrams.

Waveform states

Depending on its place on the screen and the effect of settings, a waveform has one of the following states:

- Off
- Active:
  The waveform is shown in a diagram
- Selected:
  One of the active waveforms that has the focus. In each diagram, one of the assigned waveforms is selected – it appears "on top" in the diagram, and the grid labels have the color of the selected waveform. Some of the toolbar functions, like cursor and histogram measurements are performed on the selected waveform. All waveform-specific settings are applied to the selected waveform of the selected diagram. The vertical POSITION and SCALE knobs, and the SIGNAL OFF key are illuminated with the color of the selected waveform.
  In Figure 2-3, "Ch1Wfm1" is the selected waveform: The frame of the diagram and the signal icon are highlighted.
- Minimized:
  The waveform is shown as real-time signal view in its signal icon.

To switch a waveform on

A channel waveform is activated as soon as you connect the probe. You can switch it on and off according to your needs.

► Choose one of the following ways:

  - Press the channel key.
  - In the "Vertical" dialog box, select the channel and tap the "Show channel" button.

The waveform is now active, selected, and is shown in the diagram.

To select a waveform

► Choose one of the following ways:

  - Tap the waveform in the waveform diagram.
  - To select a channel, reference, or math waveform, press the corresponding key.
  - Tap the signal icon.

Note: Zoom waveforms in zoom diagrams cannot be selected.

To minimize a waveform

► Choose on of the following ways:
  - Tap the "Minimize" icon in the upper right corner of the waveform's signal label in the signal bar.
  - Drag the waveform from the diagram to the signal bar.

The waveform disappears from the diagram and the minimized signal view is shown in the signal icon.

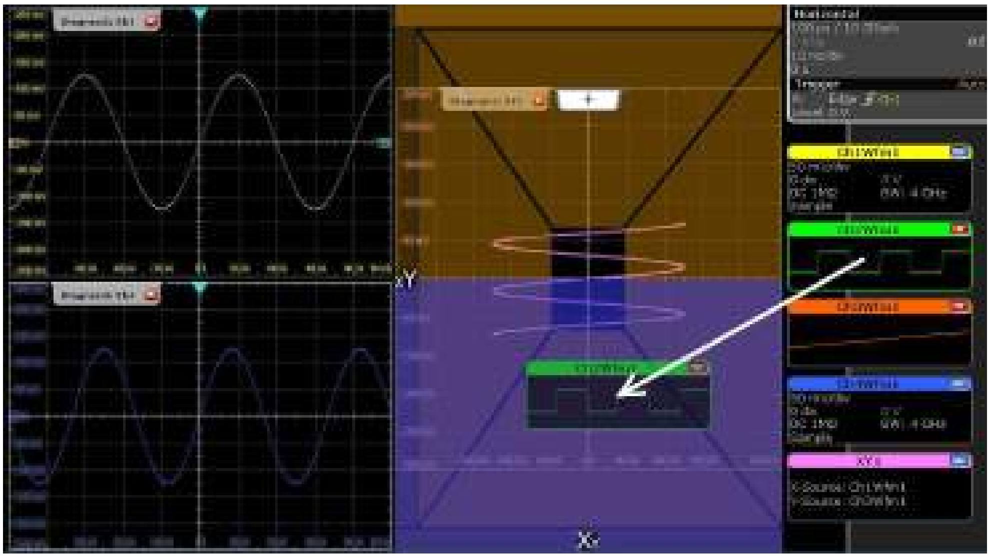
Tip: To set the waveform back to its previous diagram immediately, use "Undo".

To arrange a waveform using the SmartGrid

You can arrange waveforms in one of the existing diagrams, or in a new diagram.

The usage of the SmartGrid is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > SmartGrid".

1. Drag the signal icon to the diagram area, and move it around.
   The Rohde & Schwarz SmartGrid appears and a blue area shows where the waveform will be placed.
2. Drop the waveform in the target area.
   The waveform appears in an existing or in a new diagram, and it is selected for further actions.



3. To change the size of the new diagram, drag its edge to the required position.

The diagram layout depends on the position where you drop the signal view, in relation to an existing diagram.

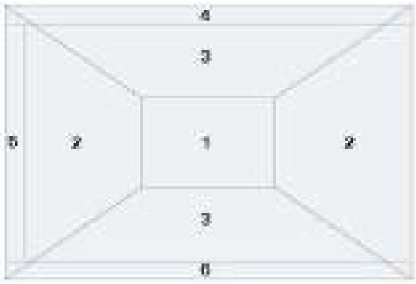


Figure 2-7: SmartGrid positions

1 = In the existing diagram, overlay of signal
2 = New diagram on the left or right
3 = New diagram above or below
4 = New diagram on top of the existing diagram
5 = XY-diagram
6 = YX-diagram

To switch off a waveform

► Do one of the following:

- Select the waveform, and then press the SIGNAL OFF key.
- To switch off a minimized waveform, tap the "Close" icon in the upper right corner of the minimized signal view.
- Disable "Show channel" in the "Vertical" > "Channels" tab.
- Tap the "Delete" icon (Recycle bin) in the toolbar, and then the waveform.
  If several waveforms overlap or lie close together, the upper (selected) waveform is switched off.

2.4.5 Toolbar

The toolbar provides direct access to important control and measurement functions. It shows current date and time, and a message button. The selected function is highlighted.

This chapter describes the toolbar usage at R&S RTO2000 instruments. For information on other instrument types, refer to the help system on the instrument.

By default, the toolbar shows the most frequently used functions. You can configure the content of the toolbar and hide the date/time display, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.

2.4.5.1 Using the Toolbar

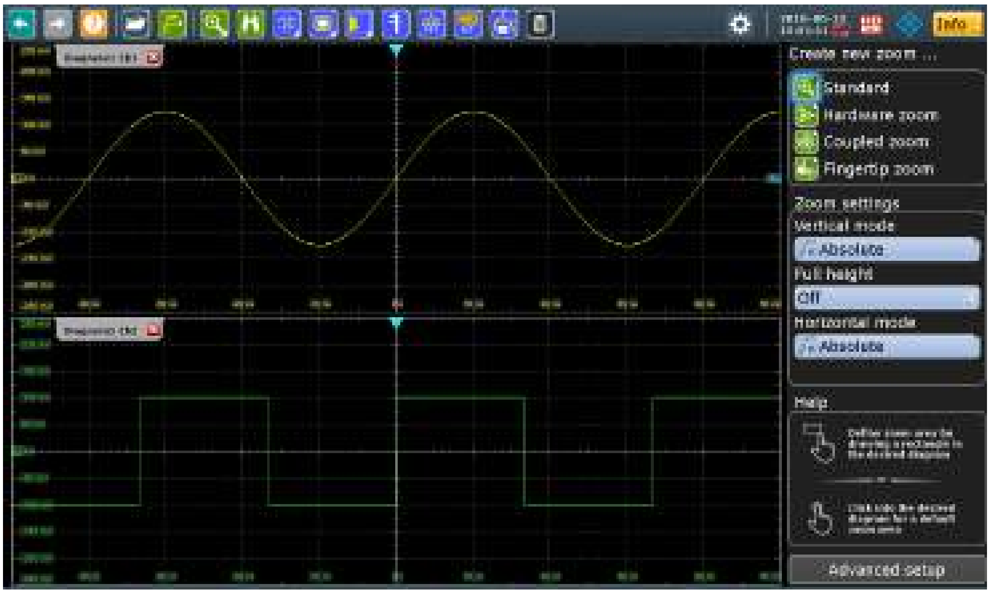
Using the toolbar is easy and straightforward.

Some of the toolbar functions are one-click actions. These actions are performed immediately when you tap the icon.

Other toolbar functions are analyzing functions. These actions are interactive actions.

To use analyzing functions (interactive actions)

1. If several waveforms are shown in the diagram, select the waveform that you want to analyze.
   See: "To select a waveform" on page 82
2. Tap the icon of the function in the toolbar.
3. Check and adjust the settings in the sidebar on the right.



Vertical mode: Absolute
Full height: Off
Horizontal mode: Absolute

4. To define the analyzed area, do one of the following:
   - Tap the required diagram.
   - Drag a rectangle on the diagram.

The toolbar handling is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Toolbar".

2.4.5.2 Configuring the Toolbar

You can configure the contents of the toolbar so that only the required functions are displayed. Furthermore, date and time can be hidden. The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. To open the toolbar configuration, choose one of the following ways:
   - Tap the icon in the toolbar:

- On the "Display" menu, select "Toolbar".

2. Select the functions to be displayed:
    - Disable the functions that you do not need. Tap the functions that you want to add to the toolbar.
    - To display all available toolbar icons, tap "Show All".
    - To hide all toolbar icons, tap "Hide All".
3. To hide the current date and time on the toolbar, disable "Show date and time".

A detailed description of the toolbar functions is given in Chapter 2.4.5.3, "Toolbar Functions", on page 86.

2.4.5.3 Toolbar Functions

This chapter describes all toolbar functions in detail.

One-click actions	Interactive actions
Undo	Zoom
Redo	Search
Show Help	Cursor
Graphical Recall (load saveset)	Mask
Find Trigger Level	Histogram

One-click actions	Interactive actions
Save Settings	Measurement
Save Screenshot	Quick meas
Create Report	FFT
Clear Screen	Delete
Autoset and Preset	Label
Run / Stop and Run Single	Update Ref Waveform
	Save Waveform
	Spectrogram (option R&S RTO-K18)
	Zone trigger (option R&S RTO-K19)

You can configure the content of the toolbar and hide the date/time display, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.

The following list describes at first the default toolbar functions and then the additional functions.

Undo
Undoes the last setting actions step by step. Some actions cannot be revoked: locking the touchscreen with TOUCH LOCK, and saving data. The undo stack is deleted during the following actions: Reloading settings from file, and reference waveform actions (save, load and preset with active reference waveform).

Redo
Recovers the undo steps in reverse order.

Show Help
Enables the tooltip display. A short description appears when you tap a parameter in a dialog or result box. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip. See also: Chapter 2.4.10, "Getting Information and Help", on page 96.

Graphical Recall (load saveset)
Opens a window to select and load instrument settings that were previously stored in a saveset. A graphical preview helps you to find the required settings.

Find Trigger Level
Analyses the signal and sets the trigger level to the middle of the signal peaks.

Zoom
The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom.

To use another zoom type, select it in the sidebar.

Standard zoom ← Zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 1297

Hardware zoom ← Zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom ← Zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

Remote command:
`LAYout:ZOOM:ADDCoupled` on page 1297

Fingertip zoom ← Zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

Search
Performs a search. Tap the icon and adjust the settings in the sidebar. Tap the diagram with the waveform to be searched, or drag a rectangle to define a search gate. The search is performed on the selected waveform.

Cursor
The cursor icon shows the last selected cursor type. A short tap on the icon activates the selected cursor.

To use another cursor type, select it in the sidebar, and adjust the settings.

Tap the diagram where you want to set the cursors, or draw a rectangle in the diagram to position the cursor lines. The resulting cursor lines measure the selected waveform. The results appear in the "Cursor Results" box. You can adjust the cursor source, type and position in the result box. Move the cursor lines by dragging them in the diagram, or by turning the navigation knob. Pressing the knob switches the parameter to be changed.

Mask
Starts the on-screen mask definition and the testing against the defined mask.

Tap the icon and then tap the points that build the mask. Double-tap the last point to finish mask definition. To create a rectangular mask, draw a rectangle on the screen. You can move the mask on the screen.

To configure the mask test settings, tap the 🔧 icon in the "Mask" result box.

Histogram
The histogram icon on the toolbar shows the last selected histogram type. A short tap on the icon activates the selected histogram.

To use another histogram type, select it in the sidebar, and adjust the settings.

Tap the icon and then drag a rectangle on the diagram to mark the histogram area. The histogram for the selected waveform appears.

Touch and hold the histogram area to open the "Histogram" dialog box.

Measurement
Starts an automatic measurement.

You can start up to 8 automatic measurements to run in parallel. The "Automatic measurment" icon starts the measurements one after the other.

Tap the icon and select the measurement type in the sidebar. Tap the diagram with the waveform to be measured. To define a measurement gate, draw a rectangle on the screen.

To configure the measurement or select a different measurement type, tap the 🔧 icon in the "Measurement" result box.

Quick meas
Performs a set of measurements on the selected waveform. You can configure up to 8 measurement types to be included in quick measurement.

Tap the icon and then tap the diagram with the waveform to be measured.

FFT
Transforms a waveform to the frequency spectrum by fast Fourier transform (FFT). The FFT trace is shown in a new diagram.

Tap the icon and adjust the settings in the sidebar. Tap diagram with the waveform to be transformed. The FFT diagram is created from the selected waveform.

To adjust FFT settings, double-tap the FFT diagram.

Delete
Removes zoom and histogram areas and their diagrams; measurement areas and their associated results; and mask segments. The icon also switches off a waveform.

Tap the icon and then tap the area or diagram to be deleted, or the waveform to be switched off.

Save Settings
Saves the current instrument settings in a saveset. The filename is created according to the autonaming pattern. You can reload the saveset using the "Load saveset (Graphical recall)" toolbar icon, or using SAVE RECALL > "Save/Recall" > "Settings".

Save Screenshot
Saves a screenshot of the current display using the settings defined in "File" menu > "Print Setup".

Create Report
Creates a report of the current measurement settings and results using the settings defined in "File" menu > "Report Setup".

Clear Screen
Deletes all measurement results including long term measurement and statistic results. Also deletes the current measurement and channel waveforms.

Auto
Preset

Autoset and Preset
Performs an autoset, or a preset to a default state. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Run Cont
Single

Run / Stop and Run Single
Starts and stops the continuous acquisition, or starts a defined number of acquisition cycles. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Label
Defines a waveform label that names or explains the waveform. Tap the icon and then tap the waveform to be labeled. If you tap the display background, the label is assigned to the selected waveform. Enter the label text using the onscreen keyboard. The text is shown in the same color as the waveform. You can drag the label to another position.

Ref 1

Update Ref Waveform
Copies the selected source waveform with all its settings to the reference waveform. If the acquisition is running, the reference waveform is a snapshot. You can configure up to four reference waveforms.

Select the required reference waveform (R1 to R4) in the sidebar.

Save Waveform
Exports the waveform data to file using the settings defined in SAVE RECALL > "Waveforms / Results" > "Waveforms". The filename is created according to the autonaming pattern.

Tap the icon and then tap the waveform to be exported. If you tap the display background, the selected waveform is exported, or a multichannel export is performed if configured.

FFT

Spectrogram (option R&S RTO-K18)
Starts an FFT and the spectrogram. The FFT trace and the spectrogram are shown in separate diagrams.

Tap the icon and adjust the settings in the sidebar. Tap diagram with the waveform to be transformed. The diagrams are created from the selected waveform.

T

Zone trigger (option R&S RTO-K19)
Defines a zone trigger, which combines the trigger condition with the intersection or non-intersection of one or more zones or masks.

Tap the icon and then tap the corner points of the zone on the screen.

Only available on R&S RTO2000 oscilloscopes.

2.4.6 Displaying Results

The results of automatic and cursor measurements, mask tests, and searches are displayed immediately in a result box.

There are three ways to display the results:

- In a floating result box in front of the diagrams, which you can move on the display
- In a minimized view (result icon) on the signal bar
- In a diagram

The default position and the font size can be adjusted.

To arrange a result box on the display

► Touch the title of the result box and drag the box on the screen. The SmartGrid indicates where the result box will be placed.

  - If you drop the box on one of the buttons, the results are shown in a diagram.
  - If you drop the box on the signal bar, a result icon is created.
  - If you drop the box somewhere else, a floating result box is created.

1 = Floating result box
2 = Table in a diagram on the left or right
3 = Table in a diagram above or below
4 = New tab

To open the corresponding setup dialog box

► In the result box, tap the 🔧 icon.

The dialog box with corresponding settings opens.

To define the default position of results

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Under "Result box", select the "Default position":
   - "Preview": result icon on the signal bar
   - "Floating": floating result box in front of the diagrams

To adjust the font size in result boxes

1. Press the SETUP key.
2. Select the "Screen" tab.
3. Set the "Result dialog font size".

2.4.7 Using Dialog Boxes

All functionality is provided in dialog boxes as known from computer programs. You can control the instrument intuitively with the touchscreen. This section provides an overview of the accessing methods and describes how to use the dialog boxes.

Each dialog box has four icons in the upper right corner:

↶	Go back: opens the previously opened dialog box.
↷	Go forward: opens the next dialog box.
–	Minimizes the dialog box to a small box that only contains the last selected function.
✕	Closes the dialog box.

For direct access to important control and measurement functions use the toolbar, see Chapter 2.4.5, "Toolbar", on page 84.

To open a dialog box

► Perform one of the following actions:
- Tap the required menu, and then the menu entry.
- Press the function key on the front panel.
- If a results box is open, tap the 🔧 icon to open the corresponding dialog box.

- To open the "Vertical" dialog box of a waveform, tap its signal icon. For XY-waveforms, the "XY Diagram" tab opens.
- Tap the horizontal or trigger label to open the "Horizontal" or "Trigger" dialog box, respectively.

To minimize a dialog box

If you want to change only one setting during analysis, and you need to change it often, you can display a small box that only contains the required setting.

1. Tap the function that you need to modify.
2. Tap the "Minimize" icon in the upper right corner of the dialog box.

   The dialog box turns into a small box that contains only the "Wfm Arithmetic" setting.

3. To restore the complete dialog box, tap the "Maximize" icon in the small box.

To close a dialog box

► Tap the "Close" icon in the upper right corner.
Or:
Press the ESC key on the front panel.

To select an option in a dialog box

► Tap the required option.
Or:
Press the ⇤ and ⇥ keys to navigate to the required option. Then press the ☑ key.

To select an option in a list

If many options are available - for example, for the trigger type - the options are provided in a list. The current selection is shown on the list button.

► Tap the list button. Then tap the required option.
Or:
Use the front panel keys:

a) Press the ⇤ and ⇥ keys to navigate to the list button.
b) Press the ☑ key to open the list.
c) Press the ▲ and ▼ keys to navigate to the required option in the list.
d) Press the ☑ key to select the marked option.

2.4.8 Entering Data

Most important parameters have their own rotary knobs on the front panel. When you turn a knob, the input box appears the lower right corner of the screen, showing the parameter name and current value.

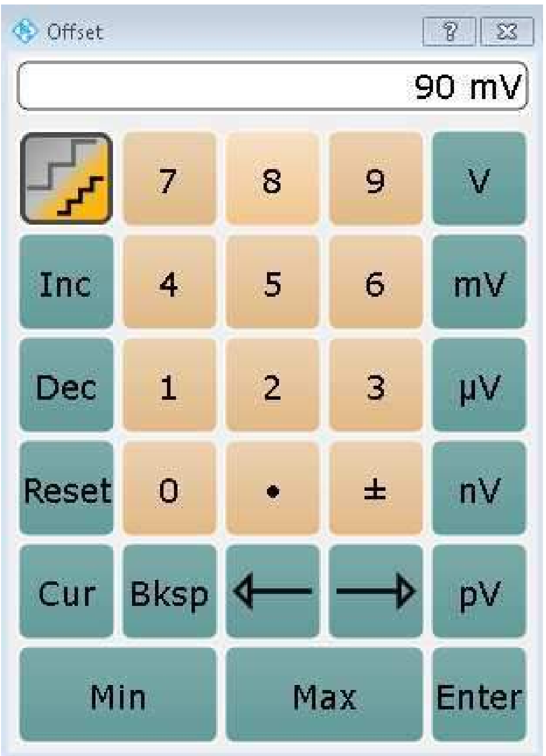
Using rotary knobs

1. Turn the knob to change the value.
2. To toggle the increment, tap the "Steps" icon in the input box.
3. To set the parameter to the autoset value (if available), tap the "RESET" icon.

For data input in dialog boxes, the touchscreen provides an on-screen keypad to enter numeric values and units. For text input, the on-screen keyboard with English key layout is used.

To enter values with the on-screen keypad

1. Double-tap the entry field.
   The on-screen keypad opens.



2. Enter the numeric value using the following methods:
   - To use the default value, tap "Reset" (if available).
   - To use the minimum or maximum value, tap "Min" or "Max", respectively.

- To increase the displayed value in fixed steps, tap "Inc".
  To decrease the value in fixed steps, tap "Dec".
  To toggle between small steps and large steps, tap the "Steps" icon.
- To get the value that was used before the keypad was displayed, tap "Cur".
- To enter a user-defined value, tap the numbers and complete the entry by tapping the unit button.
  - The arrow buttons move the cursor left or right.
  - "Bksp" deletes the last character before the cursor.
  - ± changes the sign of the value.

To enter data with the on-screen keyboard

1. Double-tap the entry field to open the on-screen keyboard.
   If available, you can also tap the keyboard icon on the right of the entry field.

New text: First

2. Enter the text as you would on a normal keyboard.
   - To enter a series of capital characters, tap "Caps".
     To enter one capital character, tap "Shift".
   - To use the currently defined value, tap "Cur". This is the value that was used before the keyboard was displayed.
   - The arrow buttons move the cursor left or right.
   - "Bksp" deletes the last character before the cursor.
3. Tap "Enter" to complete the entry.

To enter numeric data in a dialog box with navigation controls

1. To navigate to the entry field, press the ⇤ and ⇥ keys.
2. To change the value with a small step size, turn the rotary knob.
   Alternatively, press the ▲ and ▼ keys for a larger step size.

If you edit numeric data in tables, the entry field must be in edit mode. To activate the edit mode, press ENTER, or the ☑ key, or the navigation rotary knob.

2.4.9 Messages

Status messages of the instrument are displayed for a few seconds. Then they are saved in a message box in the upper right corner of the screen. By default, the message box is closed. You can open it to read the messages and to delete them.

► To open and close the message box, tap the "Info" button.

Invalid trigger position detected. Current acquisition is not valid (Message id: 2)

Remove all info messages

If no messages are available, the "Info" button is hidden.

Important messages are indicated by a red "Info" button. These messages cannot be deleted, they remain until the problem is solved.

2.4.10 Getting Information and Help

In many dialog boxes, graphics are included to explain the way a setting works. For further information, you can use the following sources:

- Tutorials demonstrate the general usage of the R&S RTO, for example, how to use the SmartGrid.
- Tooltips give a short description of the parameter.
- The context help provides functional description on a setting, and the corresponding remote command.
- The general help explains a dialog box, provides instructions, and general information.

2.4.10.1 Displaying Tutorials

Tutorials are silent movies, which are available directly on the instrument, on the Documentation CD-ROM on the "Movies" tab, and on the Internet. They show basic usage aspects.

To see a tutorial on the instrument

1. On the menu, tap "Tutorials".
2. Tap "Getting Started".
3. Tap the tutorial that you want to see.

2.4.10.2 Displaying Help

To display tooltips and context help

1. Enable the "Tooltip" icon on the toolbar.
2. Tap the parameter for which you need information.

   The tooltip opens.
3. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command. You can browse the help for further information.

   Note: The tooltip icon disables automatically when you tap a parameter. To show another tooltip, tap the tooltip icon again.

To open general help

► Press the yellow HELP button on the left side of the screen.

If a dialog box is open, the help topic for the current tab is shown. Otherwise the "Contents" page appears.

2.4.10.3 Using the Help Window

The Help window contains several tabs:

- "View" - shows the selected help topic
- "Contents" - contains a table of help contents
- "Index" - contains index entries to search for help topics
- "Search" - provides text search

The Help toolbar provides some buttons:

- To browse the topics in the order of the table of contents: Up arrow = previous topic, Down arrow = next topic
- To browse the topics visited before: Left arrow = back, Right arrow = forward
- To increase or decrease the font

To navigate the Help, use the touchscreen. Alternatively, you can also use the navigation keys on the front panel.

To search for a topic in the index

The index is sorted alphabetically. You can browse the list, or search for entries in the list.

1. Switch to the "Index" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the first characters of the keyword you are interested in.

   The entries containing these characters are displayed.
4. Double-tap the suitable index entry.

   The "View" tab with the corresponding help topic is displayed.

To search topics for a text string

1. Switch to the "Search" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the string you want to find.
   If you enter several strings with blanks between, topics containing all words are found (same as AND operator).

   For advanced search, consider the following:
   - To find a defined string of several words, enclose it in quotation marks. For example, a search for *"trigger qualification"* finds all topics with exactly *"trigger qualification"*. A search for *trigger qualification* finds all topics that contain the words *trigger* and *qualification*.
   - Use "Match whole word" and "Match case" to refine the search.
   - Use operators AND, OR, and NOT.

To close the Help window

► Select the "Close" icon in the upper right corner of the help window.
Or: Press the ESC key.

3 Instrument Setup

You can adapt various instrument settings to your requirements, such as language, display appearance, and assign functions to some keys.

The chapter describes also the handling of software options.

The following setup procedures are described in other chapters of the documentation:

- Chapter 2.1.4, "Connecting External Devices", on page 21
- Chapter 19.3, "Web Interface (LXI)", on page 1139
- Chapter 19.6, "Remote Settings", on page 1150
- The firmware update is described in the release notes.

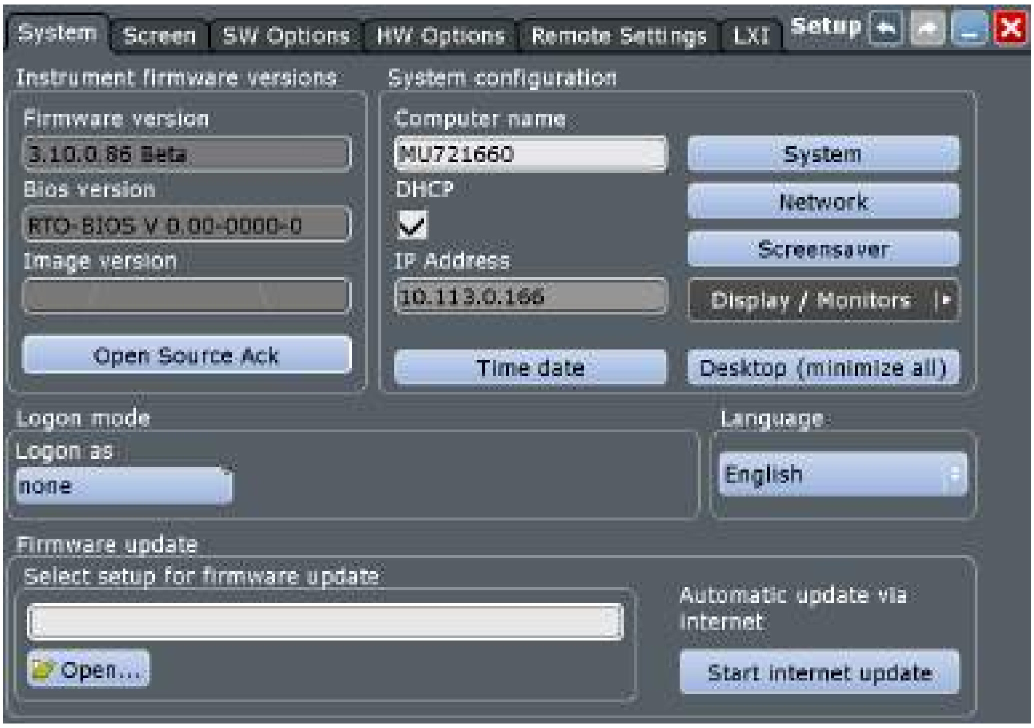
The following settings and procedures are described in the current chapter:

3.1 System Setup

3.1.1 System Settings

Access: SETUP > "System" tab

The settings on this tab are related to the basic instrument and system configuration.



Firmware version: 3.10.0.86 Beta

Bios version: RTO-BIOS V 0.00-0000-0

Computer name: MU721660

DHCP: ☑

IP Address: 10.113.0.166

Logon as: none

Language: English

Firmware version

Indicates the firmware version currently installed on the instrument.

Remote command:

`DIAGnostic:SERVice:FWVersion?` on page 1186

Bios version

Indicates the BIOS version currently installed on the instrument.

Image version

Indicates the image version currently installed on the instrument.

Desktop (minimize all)
Minimizes all displayed application windows on the instrument, so that the desktop becomes visible on the screen to access the Windows functionality.

This function is also available from the "File" menu.

Computer name, IP Address, DHCP
Indicates the currently defined computer name, the defined IP address and DHCP address enabling. These values are required to configure the instrument for work in a network.

NOTICE! Risk of network problems. All parameters can be edited here; however, beware that changing the computer name has major effects in a network. For details, see Chapter 19.2, "Setting Up a Network (LAN) Connection", on page 1135.

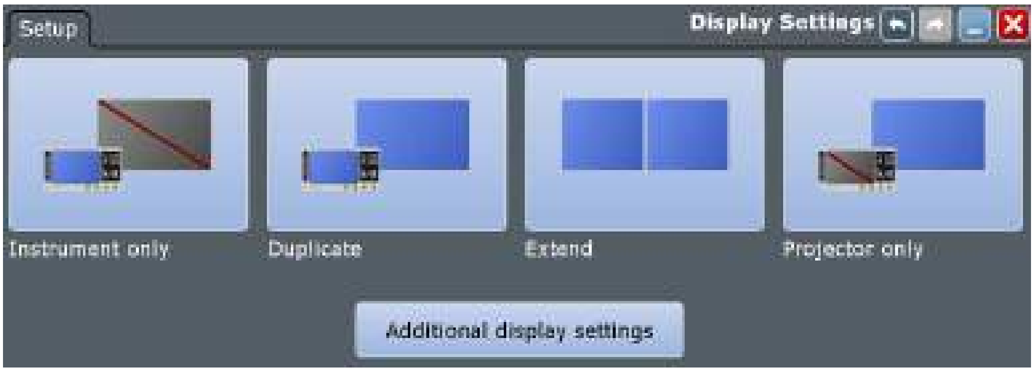
Remote command:
`DIAGnostic:SERVice:COMPutername` on page 1186

System
Opens the standard Windows "System Properties" dialog box to configure system settings.

Network
Opens the standard Windows "Network Connections" dialog box to configure a network.

Screensaver
Opens the standard Windows "Display Properties" dialog box to configure a screen saver.

Display / Monitors: Display Settings
The "Display / Monitors" button opens the "Display Settings" dialog box, where you can extend or duplicate the instrument display to a second monitor or projector (external display).



"Instrument only"	The instrument display is on, the external display is off.
"Duplicate"	The external display shows the same content as the instrument display.

"Extend"	The instrument display and the external display show different content.
"Projector only"	The instrument's user interface is only shown on the external display, the instrument display is off.
"Additional display settings"	Opens the Windows configuration for display settings.

Time, date
Opens the standard Windows "Date and Time Properties" dialog box to set the correct date and time.

Note: Usually date and time are set correctly. To adjust your regional time, select the correct time zone rather than changing the time.

Remote command:
`SYSTem:DATE` on page 1185
`SYSTem:TIME?` on page 1186

Log on as
Sets the user that is automatically logged on during the startup process of the instrument. The change of this setting takes effect at the next instrument startup

"User autologon"	Auto-logon as standard user with limited access. Enter the "User name" and "Password" of the user who will log on at the next instrument startup.
"Admin autologon"	Auto-logon with unrestricted access to the instrument and network. The setting is only available for administrators. Enter the administrator "Password" to enable the auto-logon.
"None"	No auto-logon, user name and password are requested at instrument startup.

Language
Selects the language in which the dialog boxes, result boxes and other screen information is displayed.

Select setup for firmware update
Your instrument is delivered with the latest firmware version.

Firmware updates and the "Release Notes" describing the improvements and modifications are provided on the Internet at www.rohde-schwarz.com/ product/rto.html > "Downloads" > "Firmware".

How to update the firmware is described in the "Release Notes" of the R&S RTO.

"Load"	Loads the specified file.
"Open"	Opens a file selection dialog box and loads the selected file.
"Explore"	Opens the Windows file explorer where you can navigate and search for files and folders by means of the operating system.

Start internet update
Starts the "RTxUpdater", which connects to the internet, checks for newer versions, downloads the firmware file, and installs the firmware.

Make sure that your device is connected to the Internet. If your corporate network uses a proxy server, enter the proxy settings in "Settings" menu > "Proxy Settings". Ask your administrator for correct proxy settings.

A short instruction is available under "Help" > "Help".

3.1.2 Setting the Display Language

You can change the language in which the dialog boxes, result boxes and other screen information is displayed. A reboot of the instrument is not necessary.

1. Press the SETUP key.
2. Select the "System" tab.
3. Tap the "Language" button. The button shows the current language.
4. Select the required language.

   The instrument changes the language after a few seconds.

3.2 Screen Setup

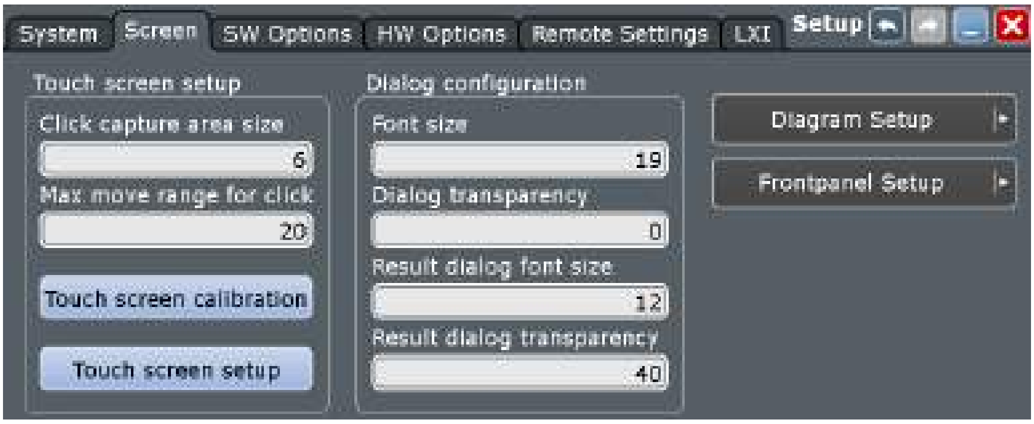
3.2.1 Screen Settings

Access: SETUP > "Screen" tab

The settings on this tab are related to the screen display.

Note for "Dialog configuration", "Front panel setup" and "Navigation rotary knob" settings:

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using SAVE RECALL > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



Click capture area size

Defines the number of pixels around each element (e.g. button, icon, data point) that create a capture area. If you tap your finger or click the mouse pointer within this capture area, this element is considered to be selected. If you tap or click outside this area, a different or no element is selected.

The larger the area, the easier is it to select an element. However, when selecting data points, for example, a large frame does not allow you to select precisely.

Max move range for click

Defines the maximum number of pixels around an element (e.g. data point) within which your pointing device must stay in order to "click" the element. When you tap or click a specific element and move your finger or the mouse outside this range, it is considered to be a "moving" or "dragging") operation.

Touchscreen calibration

Opens the touchscreen calibration application, see Chapter 3.2.2, "Aligning the Touchscreen", on page 105.

Touchscreen setup
Opens the touchscreen configuration application for advanced touchscreen setup and more sophisticated calibration. The application is available on R&S RTO1000 instruments.

Font size
Defines the font size of the text in dialog boxes.

Dialog transparency
Defines the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

Result dialog font size
Defines the font size of the text in result boxes. The size of the result box is adapted to the font size.

Result dialog transparency
Defines the transparency of the measurement result boxes in the same way as Dialog transparency.

3.2.2 Aligning the Touchscreen

When the device is delivered, the touchscreen is initially calibrated. However, to ensure that the touchscreen responds to the finger contact correctly, a touchscreen alignment is required.

Alignment of the touchscreen is useful:

- At first use
- If the position of the instrument has been changed and you cannot look straight on the screen
- If another person operates the instrument
- If you notice that touching a specific point on the screen does not achieve the correct response

1. Press the SETUP key.
2. Select the "Screen" tab.
3. Tap "Touchscreen Calibration".

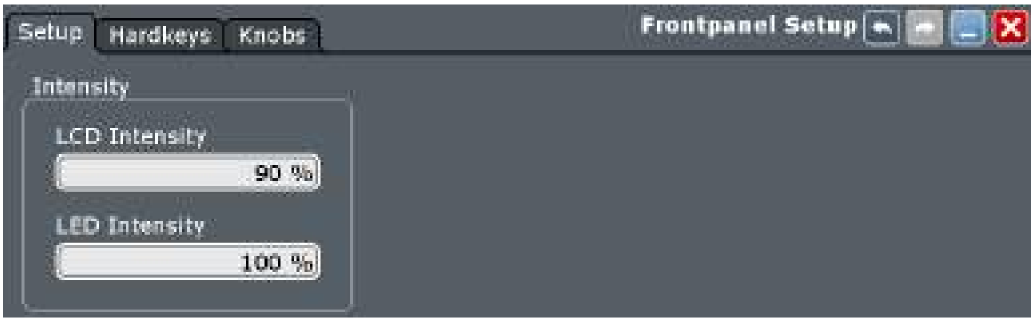
   A blinking cross appears in the lower left corner of the screen.
4. Touch and hold the cross until "OK" is shown.
5. Repeat this action for the crosses in the other corners.
6. Tap the R&S logo button in the task bar to display the instrument's user interface.

3.3 Frontpanel Setup

In the "Frontpanel Setup" dialog box, you can adjust the luminosity of the screen and luminous keys, assign functions to keys and knobs, and adjust the Navigation knob.

3.3.1 Setup: Luminosity Settings

Access: "File" menu > "Frontpanel Setup" > "Setup"



LCD Intensity: 90 %

LED Intensity: 100 %

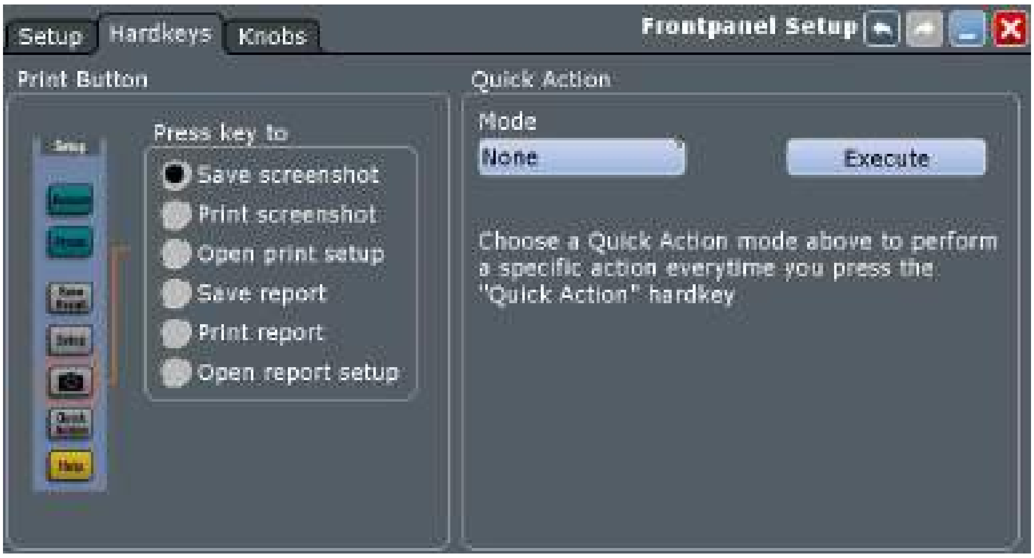
LCD Intensity
Changes the background luminosity of the touchscreen.

LED Intensity
Defines the luminosity of illuminated front panel keys and rotary knobs.

3.3.2 Hardkeys: Function Assignment

Access: "File" menu > "Frontpanel Setup" > "Hardkeys"

You can configure the function of some controls on the front panel to your needs.



Print Button

Press key to

● Save screenshot
○ Print screenshot
○ Open print setup
○ Save report
○ Print report
○ Open report setup

Quick Action

Mode: None

Choose a Quick Action mode above to perform a specific action everytime you press the "Quick Action" hardkey

Print Button

The Camera key on the left side of the display is a shortcut key that initiates an associated action.

You can assign one of the following actions to the Camera key:

- Save a screenshot
- Print a screenshot
- Open print setup
- Save a report
- Print a report
- Open report setup

Configure the settings for the selected action.

- Screenshots: "File" menu > "Print Setup", see Chapter 11.3.1, "Screenshot Settings", on page 469.
- Report: "File" menu > "Report Setup", see Chapter 11.4.1, "Report Settings", on page 474.

Quick Action

This setting is only available on R&S RTO2000 instruments.

The Quick Action key on the left side of the display is a shortcut key that initiates an associated action. To test the setup, tap "Execute".

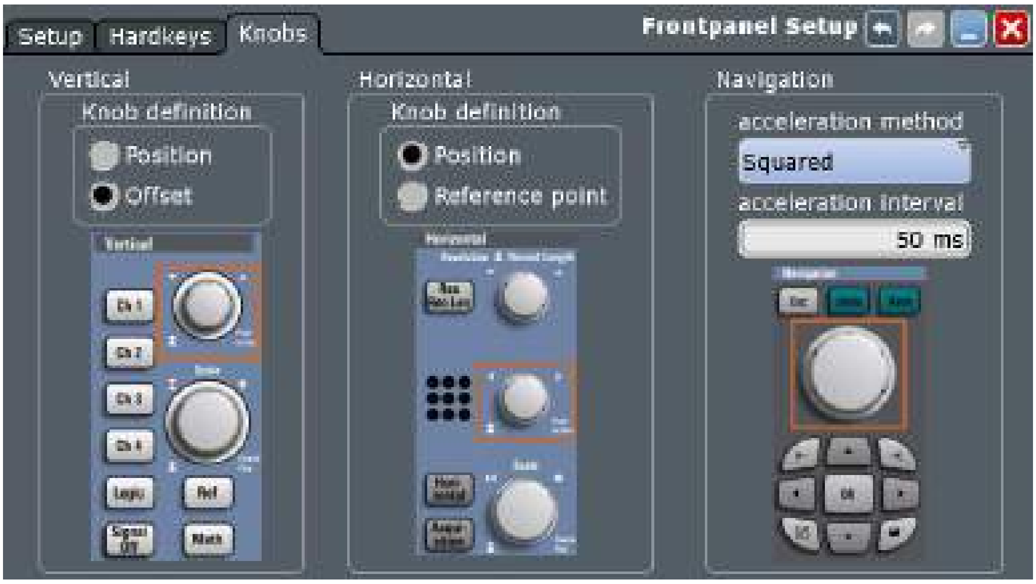
You can assign one of the following actions to the Quick Action key:

"Application"	Starts an external application. Select the path of the application executable, additional parameters, and the working directory as in a Windows shortcut definition.
"Graphical Recall"	Opens the "Load saveset" window to select and load instrument settings that were previously stored in a saveset. See also: "Graphical Recall (load saveset)" on page 87.

"Clear Screen"	Deletes the measurement results and waveforms on the display. See also: "Clear Screen " on page 90

3.3.3 Knobs

Access: "File" menu > "Frontpanel Setup" > "Knobs"



Vertical
Knob definition
○ Position
● Offset

Horizontal
Knob definition
● Position
○ Reference point

Navigation
acceleration method: Squared
acceleration interval: 50 ms

Vertical
The vertical Position knob can change the waveform position or the offset of the selected waveform. Select the action that you want to perform.

See also: "POSITION (upper knob)" on page 29.

Horizontal
The horizontalPosition knob can change the horizontal position or the reference point. Select the action that you want to perform.

See also: "POSITION" on page 27.

Rotary knob acceleration method
Selects a method to accelerate the movement of the element on the screen compared to the actual movement of the rotary knob. Acceleration is useful if you need to move from one end of the screen to the other, for example. Without acceleration, you have to turn the knob quite a while to reach the other end. On the other hand, acceleration can make precise selection difficult, since a small movement of the knob causes a relatively large movement on the screen.

"None"	No acceleration method used.

"Squared"	Moderate acceleration method used.
"Exponential"	Strong acceleration method used.

Rotary knob acceleration interval
Defines the delay time during which the movement of the rotary knob is analyzed before acceleration is applied. For short intervals, acceleration sets in quickly, but is not as effective. For long intervals, acceleration is more effective. However, it takes longer until the instrument reacts on the knob's input. Furthermore, when you turn the knob slowly during fine-tuning, subsequent movements that occur during the same interval are accelerated, making precise selection difficult.

3.4 Display Configuration

3.4.1 Adjustable Display Elements

You can customize the various elements on the screen according to your needs:

Signal bar

The signal bar contains signal icons (mini windows) that display either real-time views of minimized waveforms, or labels with setting information for displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

The signal bar can be manually switched on and off, it can be automatically hided, and you can adjust color and transparency of the bar.

In addition, you can define the signal behavior when tapping a signal icon.

Toolbar

The toolbar contains icons that start frequently used functions. You can define which tools are displayed on the toolbar.

Diagrams

The basic diagram elements can be shown or hidden: grid, crosshair, label, and tab titles. You can also enter user-defined diagram names.

Waveforms

For waveforms, you can adjust the persistence, the waveform style, and color. You can also annotate the waveforms by adding screen texts.

To set the color, you can select it from a color palette or assign color tables defining the color of waveform pixels depending on the cumulative occurrence of the associated values. You can assign a different color or color table to each waveform.

The following default color tables are provided:

- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"

Dialog boxes and result boxes

You can configure the font size, contrast and transparency in dialog and result boxes. Thus, you can optimize readability or keep track of the waveforms while changing settings in dialog boxes.

Clear screen results

To delete all results and waveforms, select "Display" menu > "Clear screen results".

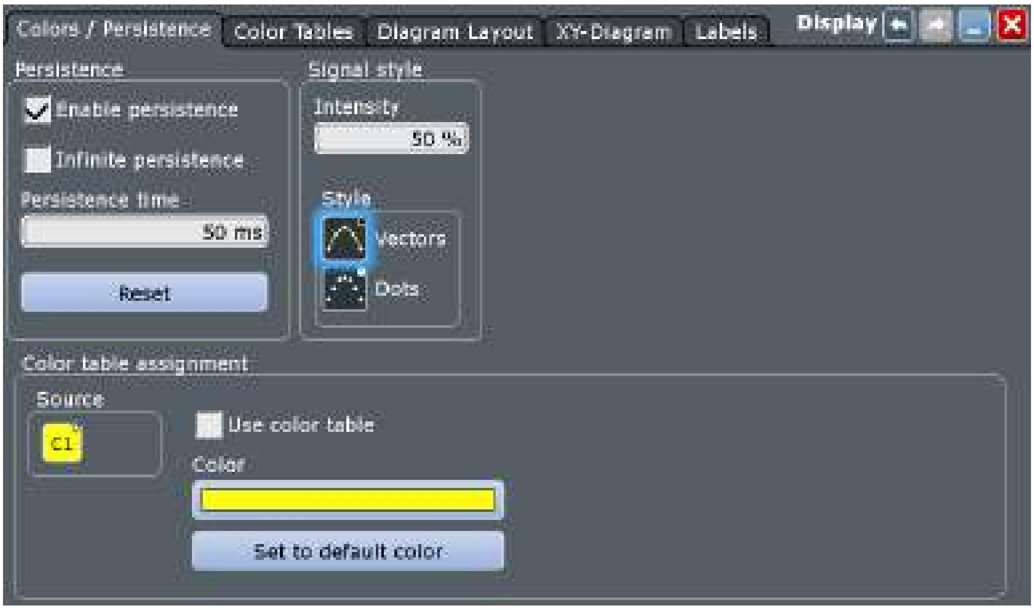
3.4.2 Display Settings

Display settings are configured in the "Display" dialog box, which is opened when you press the DISPLAY key or select an item from the "Display" menu.

3.4.2.1 Colors / Persistence

Access: DISPLAY > "Colors / Persistence" tab

The "Colors / Persistence" tab contains settings for the general display of waveform data.



Enable persistence

If enabled, each new data point in the diagram area remains on the screen for the duration that is defined using Persistence time, or as long as Infinite persistence is selected.

If disabled, the waveform points are displayed only for the current acquisition.

Remote command:
`DISPlay:PERSistence[:STATe]` on page 1189

Infinite persistence

If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled.

Remote command:
`DISPlay:PERSistence:INFinite` on page 1190

Persistence time

Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the R&S RTO emulates the persistence of analog phosphor screens.

Remote command:
`DISPlay:PERSistence:TIME` on page 1190

Reset
Resets the display, removing persistent all waveform points.

Remote command:
`DISPlay:PERSistence:RESet` on page 1190

Intensity
This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (strong). The default value is 50%.

You can also use the INTENSITY knob on the left side of the screen to adjust the waveform intensity directly.

Note: Use of color tables. The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal. See also: Chapter 3.4.3.1, "Editing Waveform Colors", on page 122.

Remote command:
`DISPlay:INTensity` on page 1190

Style
Select the style in which the waveform is displayed:

"Vectors"	The individual waveform points are connected by a line. Define the strength of the line using the INTENSITY knob on the left side of the screen.
"Dots"	Only the individual waveform points are displayed. Waveform sample points are the ADC sample points and additional interpolated points if "Interpolated time" is used for resolution enhancement. To see the dots of one waveform, perform one acquisition with SINGLE and N=1 ("Average count" = 1). During continuous acquisition, or a SINGLE acquisition with N > 1, the dots of multiple subsequent waveforms are displayed on the screen. Thus, the waveform on the screen might look like a line. Consider also the "Interpolation" on page 152.

Remote command:
`DISPlay:DIAGram:STYLe` on page 1190

Color
Shows the current color of the selected waveform. To change the color, tap the button and select a color. The color of the waveform, its signal icon, channel icon, and of the illuminated keys is adjusted to the new color.

Remote command:
`DISPlay:COLor:SIGNal<m>:COLor` on page 1191

Set to default color
Resets the color of the selected waveform to the factory default.

Use color table

If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the selected color is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Remote command:
`DISPlay:COLor:SIGNal<m>:USE` on page 1191

Source

Selects the waveform to which the color table and the labels are assigned.

Option R&S RTO-K18: A spectrogram always has the same color as the math (spectrum) waveform from which it is created.

Assigned color table

Adjust the waveform colors to suit your preferences. For each of the following waveform types you can assign a suitable color table:
- Analog and digital channels
- Reference waveforms
- Results of a mathematical function, also for FFT and derived spectrogram.
- Measurements and tracks
- XY-traces
- Serial buses if a protocol option is activated
- Parallel buses if MSO option is installed

See also: Chapter 3.4.2.2, "Color Tables", on page 113.

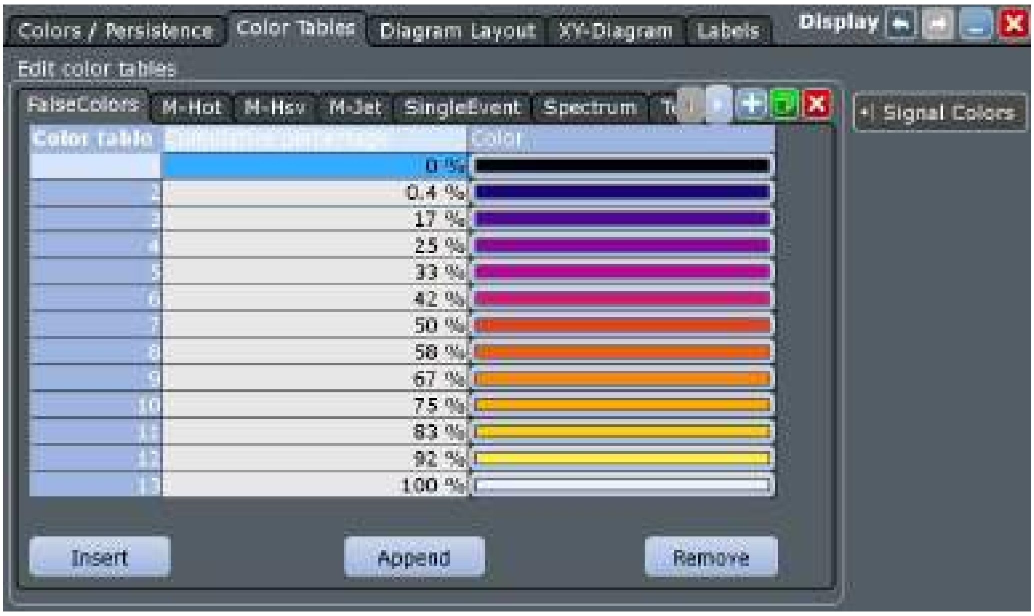
Remote command:
`DISPlay:COLor:SIGNal<m>:ASSign` on page 1191

3.4.2.2 Color Tables

Access: DISPLAY > "Color Tables" tab

Color tables define the color of the waveform pixels depending on the cumulative occurrence of the associated values. By default, the intensity of the specific waveform color varies according to the cumulative occurrence of the values. The more often a value occurs, the darker the color of the data point is displayed.

The following default color tables are provided:
- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"



Color table	[illegible]	Color
1	0 %	■
2	0.4 %	■
3	17 %	■
4	25 %	■
5	33 %	■
6	42 %	■
7	50 %	■
8	58 %	■
9	67 %	■
10	75 %	■
11	83 %	■
12	92 %	■
13	100 %	□

The editing table allows you to edit existing color tables or add new ones that can then be assigned to the waveforms. To assign a color table to a waveform, use the "Signal colors / Persistence" tab.

See also:

- Chapter 3.4.3.1, "Editing Waveform Colors", on page 122
- Assigned color table

Remote commands

The following remote commands are used to configure color tables:

`DISPlay:COLor:PALette:COUNt?` on page 1192

`DISPlay:COLor:PALette:ADD` on page 1192

`DISPlay:COLor:PALette:REMove` on page 1192

`DISPlay:COLor:PALette:POINt:INSert` on page 1192

`DISPlay:COLor:PALette:POINt:ADD` on page 1192

`DISPlay:COLor:PALette:POINt[:VALue]` on page 1193

`DISPlay:COLor:PALette:POINt:COUNt?` on page 1193

`DISPlay:COLor:PALette:POINt:REMove` on page 1193

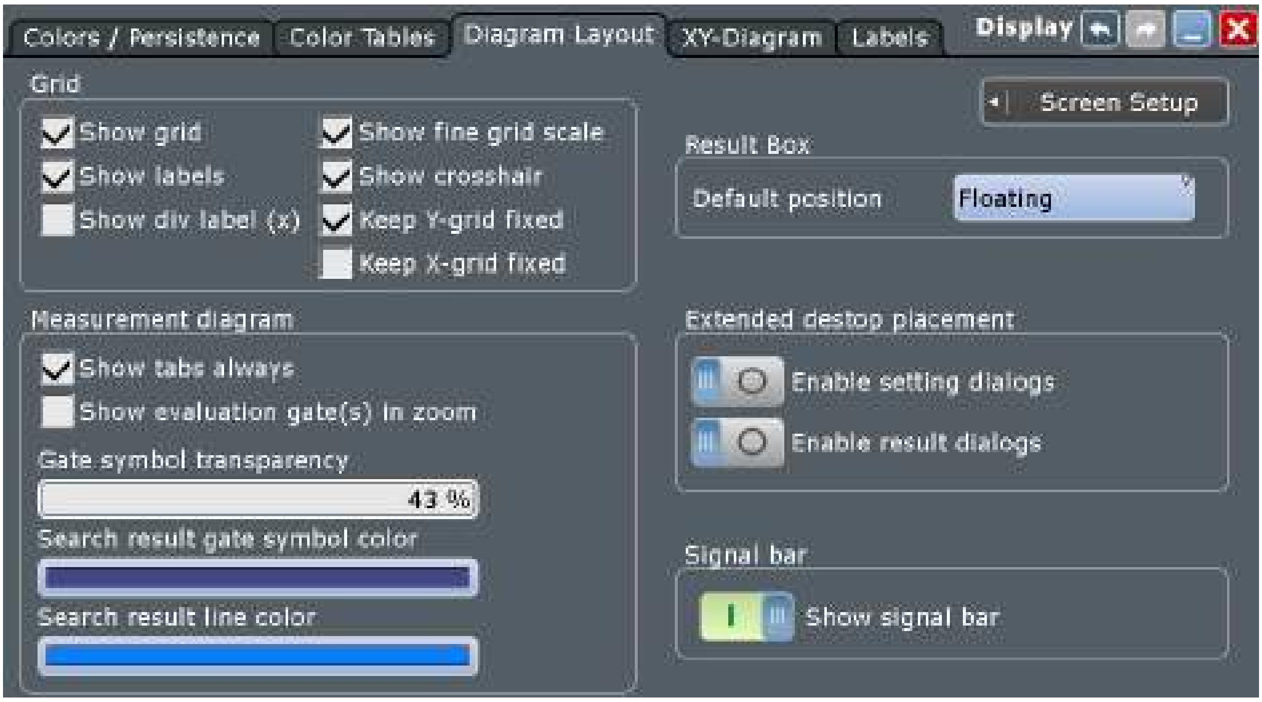
`DISPlay:COLor:PALette:COUNt?` on page 1192

3.4.2.3 Diagram Layout

Access: DISPLAY > "Diagram Layout" tab

On the "Diagram Layout" tab, you define the basic diagram layout and the appearance and behavior of the signal bar.

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using SAVE RECALL > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



☑ Show grid
☑ Show labels
☐ Show div label (x)
☑ Show fine grid scale
☑ Show crosshair
☑ Keep Y-grid fixed
☐ Keep X-grid fixed
☑ Show tabs always
☐ Show evaluation gate(s) in zoom
Gate symbol transparency: 43 %
Search result gate symbol color
Search result line color
Default position: Floating
Enable setting dialogs
Enable result dialogs
Show signal bar

Show grid
If selected, a grid is displayed in the diagram area. A grid helps you associate a specific data point to its exact value on the x- or y-axis.

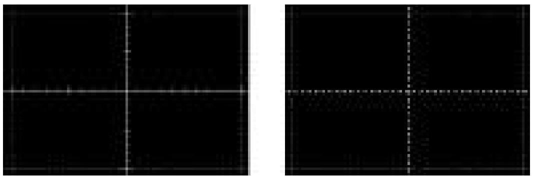
Remote command:
`DISPlay:DIAGram:GRID` on page 1194

Show labels
If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

Remote command:
`DISPlay:DIAGram:LABels` on page 1195

Show div label (x)
If selected, the time scale value is shown at the diagram bottom instead of the horizontal grid labels. For example, 10 ns/div is shown instead of the values 0, 10, 20, 30... ns.

Show fine grid scale
If selected, the crosshair is displayed as a ruler with scale markers. If disabled, the crosshair is shown as dashed lines.



Remote command:
`DISPlay:DIAGram:FINegrid` on page 1194

Show crosshair
If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Remote command:
`DISPlay:DIAGram:CROSshair` on page 1194

Keep Y-grid fixed
If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Remote command:
`DISPlay:DIAGram:YFIXed` on page 1195

Keep X-grid fixed
If enabled, the vertical grid lines remain in their position when the horizontal position is changed. Only the values at the grid lines are adapted.

Show tabs always
If selected, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If cleared, the tab titles are not shown except for titles in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Remote command:
`DISPlay:DIAGram:TITLe` on page 1195

Show evaluation gate(s) in zoom
If enabled, the available histogram areas, masks, and measurement gates are shown in the zoom diagrams. If the evaluation gate is within the zoom area, the display helps to move or modify the evaluation gates in the zoom window.

Make sure that the option is disabled if the zoom area and the evaluation gate are of nearly the same size to avoid conflicts in operation.

Gate symbol transparency
Sets the transparency of the area that is defined as measurement or search gate. The setting only takes effect if "Show gate" is enabled.

Remote command:
`DISPlay:GATE:TRANsparency` on page 1195

Search result gate symbol color
Sets the color of the search zoom area. The search zoom area is displayed if "Show search zoom windows" is enabled. See also: "Search zoom window" on page 438.

Search result line color
Sets the color of the search result markers. The markers are displayed if "Show search zoom windows" is enabled.

Result Box: Default position
Defines where a new result box opens.

"Floating"	The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.
"Preview"	The result box opens as a minimized result icon on the signal bar. It shows only two columns and a few rows of the results.

Remote command:
`DISPlay:RESultboxes:DEFaultpos` on page 1196

Extended desktop placement
If an external monitor is connected to the instrument, you can enable these settings to display dialog boxes and/or result boxes on the external monitor. Thus, the boxes do not cover the waveforms on the instrument display.

Show signal bar
If enabled, the signal bar is displayed on the right of the diagram area.

The signal bar contains signal icons (mini windows) that display either real-time views of minimized waveforms, or labels with setting information for displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

Remote command:
`DISPlay:SIGBar[:STATe]` on page 1195

Signal bar

The settings for the signal bar are only relevant for R&S RTO1000 oscilloscopes.

You can adjust the position and appearence of the signal bar in various ways.

Enable ← Signal bar

If enabled, the signal bar is displayed in the diagram area.

The signal bar contains signal icons (mini windows) that display either real-time views of minimized waveforms, or labels with setting information for displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

Remote command:
`DISPlay:SIGBar[:STATe]` on page 1195

Position ← Signal bar

The signal bar can be placed vertically at the right (default position), or at the left to ensure best visibility of the waveforms.

Remote command:
`DISPlay:SIGBar:POSition` on page 1198

Auto-hide ← Signal bar

If selected, the signal bar disappears automatically after some time, similar to the Windows task bar. With the settings below "Auto hide", you can define when and how the signal bar hides.

The signal bar reappears if you tap it, or if an action changes the content of the bar.

Remote command:
`DISPlay:SIGBar:HIDE[:AUTO]` on page 1199

Hide head also ← Signal bar

If selected, the "Auto hide" function hides also the horizontal and trigger label at the top of the signal bar.

Remote command:
`DISPlay:SIGBar:HIDE:HEAD` on page 1199

Hide bar after ← Signal bar

Sets the time when the signal bar is faded out with "Auto-hide".

Remote command:
`DISPlay:SIGBar:HIDE:TIME` on page 1199

Hiding transparency ← Signal bar

Sets the transparency of the signal bar when the signal bar is faded out with "Auto-hide". The maximum value is 70%, the signal bar is always slightly visible. The minimum value 20% applies the best visibility of the signal bar.

Remote command:
`DISPlay:SIGBar:HIDE:TRANsparency` on page 1199

Click on signal icon ← Signal bar
Defines what happens when you tap or click a signal icon.

"Minimize"	The waveform is minimized, it switches from the diagram to the signal icon and is shown as small real-time preview.
"Hardkey logic"	The waveform is selected and gets the focus. This behavior has been introduced with firmware version 1.50 and has the same effect as pressing the corresponding channel key.

Border color ← Signal bar
Opens a color selection dialog box to define the color of the signal bar border.

For details, see "To change the colors" on page 125.

Remote command:
`DISPlay:SIGBar:COLor:BORDer` on page 1199

Fill color ← Signal bar
Opens a color selection dialog box to define the fill color of the signal bar.

For details, see "To change the colors" on page 125.

Remote command:
`DISPlay:SIGBar:COLor:FILL` on page 1200

3.4.2.4 Waveform Labels

Access: DISPLAY > "Labels" tab

Using labels, you can annotate the waveforms to name or explain each waveform. The text is shown in the same color as the assigned waveform. Each label has its individual position. You can enter exact positions in the dialog box, or drag the labels on the screen to the required position. The position can be a fixed one (relative to the screen), or a flexible position (absolute, assigned to the axes).

To add labels quickly, you can add the "Label" icon to the toolbar and use it.

Make sure that the correct waveform tab is selected before you enter the labels.

Labels

For each waveform, the "Labels" table shows the assigned texts and their positions. Enter the label text and the horizontal and vertical positions for each label.

"Add"	Adds a line at the end of the list.
"Copy"	Copies the selected line in a new line.
"Remove"	Deletes the selected line. Only single lines can be removed. You can also delete a label by using the toolbar: Tap the "Delete" icon and then the label.

Remote command:
`DISPlay:SIGNal:LABel:ADD` on page 1200
`DISPlay:SIGNal:LABel:REMove` on page 1201
`DISPlay:SIGNal:LABel:TEXT` on page 1202
`DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition` on page 1203
`DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition` on page 1203
`DISPlay:SIGNal:LABel:HORizontal:RELative:POSition` on page 1203
`DISPlay:SIGNal:LABel:VERTical:RELative:POSition` on page 1203

Show labels

Enables or disables the label display.

Position mode

Defines the label position either relative to the diagram or with absolute values according to the units of the waveform. Relative positions are fixed, whereas absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.

The position mode applies to all labels of the selected waveform. For different waveforms, different position modes can be selected.

"Relative"	Sets a fixed position in percent of the screen counting from the upper left corner.
"Absolute"	Sets the position in time and voltage values, or in other units depending on the waveform character.

Remote command:
`DISPlay:SIGNal:LABel:POSMode` on page 1202

Label font size

Defines the size of the labels in the diagram.

3.4.2.5 Performance

Access: "Display" menu > "Show Performance"

The "Performance" result box shows information on the current acquisition performance values of the R&S RTO.

Performance

Acquisition per frame	5
Acquisition per second	165.9
Time per frame	0.03014

The instrument groups acquired waveforms together in a frame, and displays the frame content. The maximum number of frames displayed per second is about 30. The current number of frames per second is indicated as reciprocal "Time per frame". If the time scale decreases, and thus the number of acquisitions per second also decreases, the number of acquisitions per frame can drop to 1.

3.4.2.6 Clear Screen Results

"Display" menu > "Clear screen results"

"Clear screen results" resets all results in all measurement result boxes including long-term measurement and statistic results and deletes the current measurement waveforms. If you need this function frequently, you can add the correspondent icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.

3.4.3 Adjusting the Display

To change the diagram name

► Double-tap the diagram tab name. The on-screen keyboard opens to enter the new name.

3.4.3.1 Editing Waveform Colors

For each waveform, you can set a waveform color, or you define a color table that specifies which waveform points are displayed in which color. You can use one of the default color tables, or define your own table according to your needs. You can also edit the default color tables.

After you define a color table, you must assign it to the waveform it is to be used for, and enable its use.

The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: "Intensity" on page 112.

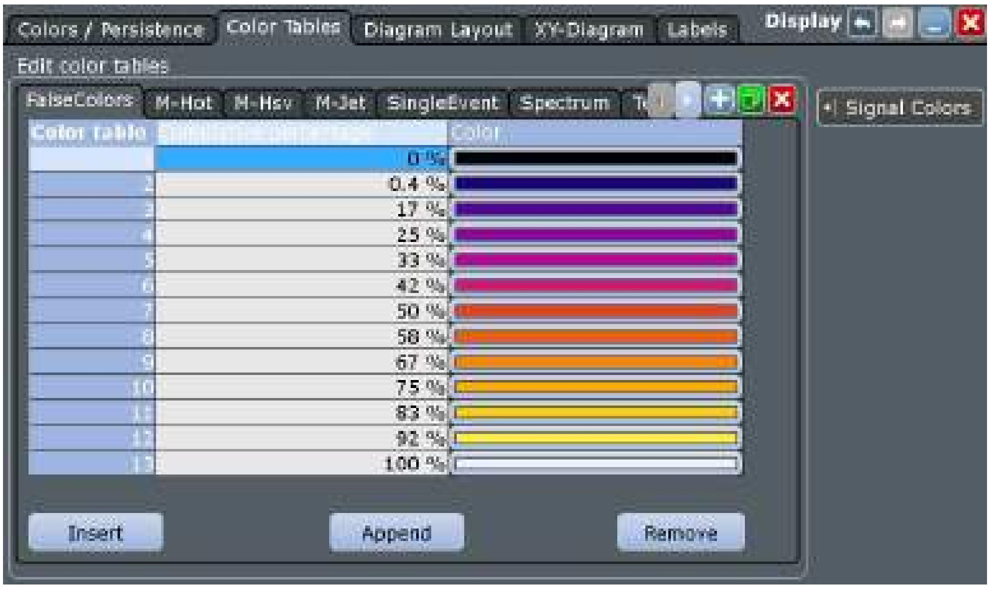
For details on signal color settings, see Chapter 3.4.2.2, "Color Tables", on page 113.

To change a waveform color

1. On the "Display" menu, tap "Signal Colors / Persistence".
2. Under "Color table assignment", select the waveform for which you want to change the color.
3. Tap the "Color" button.
4. In the "Adjust Colors" dialog box, select a predefined color, or define any other RGB color with "User defined Colors".

To edit a color table

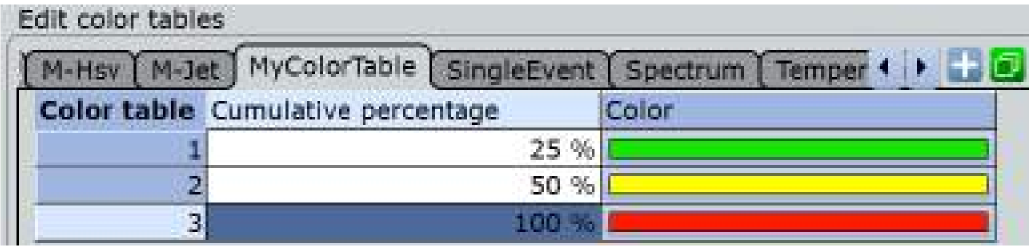
1. On the "Display" menu, tap "Color Tables".
2. Under "Edit Color Tables", select the color table you want to edit.



Color table	Cumulative percentage	Color
	0 %	⬛
2	0.4 %	🟦
3	17 %	🟪
4	25 %	🟪
5	33 %	🟪
6	42 %	🟥
7	50 %	🟥
8	58 %	🟧
9	67 %	🟧
10	75 %	🟧
11	83 %	🟨
12	92 %	🟨
13	100 %	⬜

3. For each range of cumulative occurrence of the values, insert an entry in the color table:
   - To insert an entry at the end of the color table, tap "Append".
   - To insert an entry before an existing entry, tap the existing row. Then tap "Insert".
   - To remove an entry, tap the entry. Then tap "Remove".
4. Assign a color to each entry: Tap the "Color" cell.
   Select a predefined color, or define your own color.

Example:



Color table	Cumulative percentage	Color
1	25 %	🟩
2	50 %	🟨
3	100 %	🟥

In this example, values with a cumulative occurrence under 25% (very short or rare display) are displayed green. Values with an occurrence of 40% are yellow-green. Values with an occurrence of 90% (displayed almost for the entire duration of the signal) are a deep shade of orange.

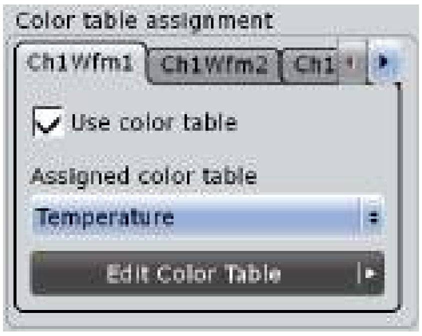
To create a color table

1. On the "Display" menu, tap "Signal Colors".
2. **To create an empty color table:** tap the "Add" button and enter a name for the new color table using the on-screen keyboard.

To copy an existing color table: select the color table you want to copy, and tap the "Copy" button. Enter a name for the new color table using the on-screen keyboard.

To assign the color table and enable its use

1. Open the "Signal Colors/ Persistence" tab of the "Display" dialog box.
2. Under "Color Table Assignment", select the tab for the waveform.
3. Enable "Use Color table".



☑ Use color table

Assigned color table: Temperature

4. Under "Assign color table", select the color table you want to assign to the waveform.

   The waveform colors are displayed according to the definition in the color table.

3.4.3.2 Using the Signal bar

This section is relevant only for R&S RTO1000 oscilloscopes.

The signal bar can hold a large number of signal and result icons. Signal icons represent the waveforms, serial buses and parallel buses, while result icons are minimized result boxes showing measurement and search results.

To scroll the signal bar

If the signal bar contains more than four icons, not all icons are visible on the display.

► Touch one of the signal icons and move it up or down until the required icon appears.

To switch on and off the signal bar

If you need the complete screen to see the diagrams and results, you can switch off the signal bar completely.

► Tap the "Show signal bar" icon on the toolbar.

Alternatively, tap "Signal Bar" on the "Display" menu.

To change the position of the signal bar

► Touch the "Horizontal" label on the top of the signal bar and drag it to the opposite side of the screen.

To set the action on tapping the signal icon

You can define what happens when you tap a signal icon: Either the waveform is minimized, or it is selected (gets the focus).

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Under "Signal bar", tap "Click on signal icon".
4. Select the action on clicking/tapping:
    - "Minimize": The waveform switches from the diagram to the signal icon.
    - "Hardkey logic": Selects the waveform for further operation.

To configure auto-hide

The signal bar can be hidden if the displayed information has not changed for a defined time, and is displayed again automatically when a setting in the signal bar changes. The signal bar does not hide entirely, it simply fades and becomes less visible in the display.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Select "Auto-hide".
4. Define the hiding properties:
    - "Hide bar after": the time after which the bar is hidden if no changes occur
    - "Hiding transparency": Transparency of the hidden signal bar on a scale from 20% (low transparency) to 70% (high transparency)
    - Hide head also: the horizontal and trigger labels are also faded

To change the colors

If you want to highlight the signal bar, you can change the "Fill color" and "Border color" of the bar.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Tap "Border color" to change the color of the signal bar frame, or "Fill color" to change the fill color of the bar.
4. In the "Adjust Colors" dialog box, select the color.
5. To use a color that is not yet defined, tap "Userdefined Colors". Define the new color settings.

To see the effect of a setting change in the "Preview" area, enter the value and press the OK key.

6. Tap "OK."

   The signal bar is displayed in the new colors.

3.4.3.3 Configuring the Toolbar

You can configure the contents of the toolbar so that only the required functions are displayed. Furthermore, date and time can be hidden. The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. To open the toolbar configuration, choose one of the following ways:
   - Tap the icon in the toolbar:
   - On the "Display" menu, select "Toolbar".
2. Select the functions to be displayed:
   - Disable the functions that you do not need. Tap the functions that you want to add to the toolbar.
   - To display all available toolbar icons, tap "Show All".
   - To hide all toolbar icons, tap "Hide All".
3. To hide the current date and time on the toolbar, disable "Show date and time".

A detailed description of the toolbar functions is given in Chapter 2.4.5.3, "Toolbar Functions", on page 86.

3.4.3.4 Configuring Dialog Boxes and Result Boxes

You can optimize the display of dialog and result boxes so they do not interfere with the waveform display and you can still analyze the results and settings.

To change the font size in dialog and result boxes

1. Press SETUP.
2. Select the "Screen" tab.
3. To set the font size in points for text in all dialog boxes, change "Font size". Most dialog boxes are optimized for a font size of 19 pt.
4. To set the font size in points for result boxes, change "Result dialog font size". The default is 12 pt.

To change the transparency of dialog boxes and result boxes

The transparency of the dialog box background lets you see the waveforms behind the box. You can configure the transparency separately for dialog boxes and result boxes.

1. Press SETUP.
2. In the "Screen" tab, in the "Dialog box transparency" field, enter the transparency value for dialog boxes.
   For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.
3. In the "Result box transparency" field, enter the transparency value for result boxes.

Alternatively, you can press the INTENSITY knob until the required parameter is shown in the data input box, and then turn the knob to set the transparency.

To change the color theme and contrast for dialog boxes

When you print a screenshot of the display, it is helpful to use dark-colored text on a light-colored background. For improved readability, different settings are required, depending on the transparency value.

1. Press SETUP.
2. In the "Screen" tab, select the color theme suitable for the current operating situation.

3.5 Self-Alignment

When data from several input channels is displayed at the same time, it may be necessary to align the data vertically or horizontally in order to synchronize the time bases or amplitudes and positions. This is the case, for example, when strong temperature changes occur (> 5°).

3.5.1 Control

Access: "File" menu > "Selfalignment"

Before the start of the selfalignment procedure remove all probes from the input connectors.

Overall alignment state: Passed

Start Alignment
Starts the self-alignment procedure for all channels.

Remote command:
`*CAL?` on page 1176

Date / Time / Overall alignment state
Show the date and the summary result of the self-alignment process: Passed or Failed. Detailed results are provided on the "Results" tab.

3.5.2 Results

For each channel, the results of the individual aligment steps are shown for all technical channel component. In case you require support, you may be asked to provide this information.

Self alignment step	Alignment step results
THA offset	Ok
THA gain	Ok
Spc	Ok
Deskew	Ok
Deskew interleaved	Ok
VarGain 50	Ok
FixGain 50	Ok
Offset 50	Ok
BufFixGain	Ok
BufVarGain 1M	Ok
BufVarGain20dB1M	Ok
FixGain 1M	Ok
Offset 1M	Ok

3.5.3 Performing a Self-alignment

The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions. The self-alignment process includes a basic hardware check.

Recommendation on performing the self-alignment:

- When putting the instrument into operation for the first time
- After a firmware update
- Once a week
- When major temperature changes occur (> 5°)

NOTICE

Warm-up and prepare the instrument

Make sure that the instrument has been running and warming up before you start the self-alignment. The minimum warm-up time is indicated in the data sheet.

Remove the probes from the input connectors.

---

1. On the "File" menu, select "Selfalignment".
2. On the "Control" tab, tap "Start Alignment".

   The alignment is performed, the process might take several minutes. A message box informs you about the running process, wait until this message box closes. The overall pass/fail result is shown in the "Overall alignment state" field. The results of the individual alignment steps for each input channel are indicated in the "Results" tab. This information is required if problems arise.

3.6 Options

Additional options for the R&S RTO can be enabled using a license key. To obtain the license key, consult your sales representative.

The license type defines the duration of applicability and the portability of a license. The following license types are provided: evaluation, permanent, portable, quantified, timed with duration of 1, 3, 6 or 12 months. A license can also be in the states deactivated and expired.

Unregistered licenses

Unregistered licenses are not assigned to a particular instrument. The instrument accepts only registered licenses. If your license is delivered unregistered, use the online tool R&S License Manager to register the license for your instrument. The registration of a permanent license is irreversible, so ensure that you register it for the correct instrument. The address of the tool is https://extranet.rohde-schwarz.com/service.

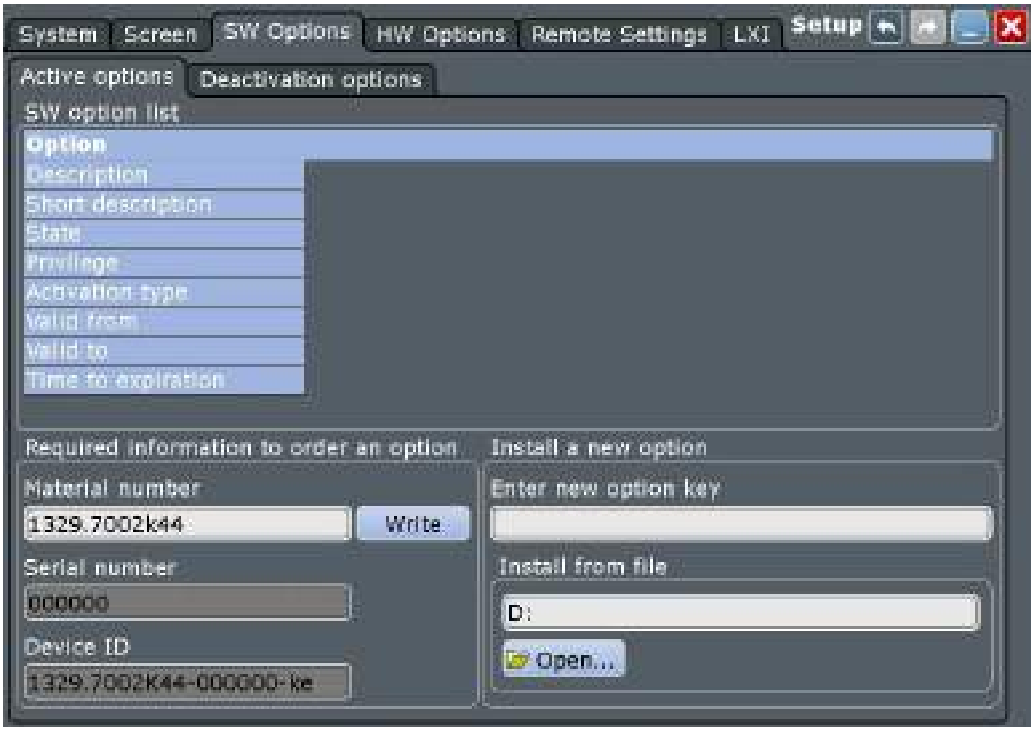
The R&S License Manager also allows you to move a portable license to another instrument.

3.6.1 SW Options

3.6.1.1 Active Options Settings

Access: SETUP > "SW Options" tab > "Active options" subtab

The "Active options" tab provides information on installed software options. Here you can install new options or deactivate existing options using license keys.



Material number: 1329.7002k44

Serial number: 000000

Device ID: 1329.7002K44-000000-ke

Install from file: D:

SW option list

Shows the activated options. This information provided for administration and troubleshooting purposes. If you need support for an option, provide this information to the service representative.

The "State" of the option indicates whether the installed option is a normal or a beta-release version. Beta-release versions must be activated explicitly in the "Mode" dialog box (see Chapter 3.6.5, "Options in Beta State", on page 134).

Material number, Serial number, Device ID

Indicates the material number, serial number and the device identification string (device ID) of your instrument. These numbers, in particular the device ID, are required to order a new option, or to move a portable option.

Remote command:
`DIAGnostic:SERVice:PARTnumber` on page 1186
`DIAGnostic:SERVice:SERialnumber?` on page 1187
`SYSTem:DEVice:ID?` on page 1186

Enter new option key

Enter the license key here to activate the option. For license keys delivered as a file, use Install from file.

Install from file

If you got a license file, install the license here. Tap "Open" to open the file selection dialog, or enter the complete path and filename. For details, see Chapter 11.6, "File Selection Dialog", on page 478.

When you move a portable license, use this function to import the deactivation key that is generated by the "R&S License Manager". See also Chapter 3.6.4, "Moving a Portable License", on page 133.

3.6.1.2 Deactivation Options

Access: SETUP > "SW Options" tab > "Deactivation options" subtab

The "Deactivation options" tab shows all deactivated options and provides a function to export the deactivation response.

Export deactivation key
When you move a portable license, or deactivate an option, you have to note the response key, or to save the response to a file. The "R&S License Manager" needs the response key.

See also Chapter 3.6.4, "Moving a Portable License", on page 133.

3.6.2 HW Options

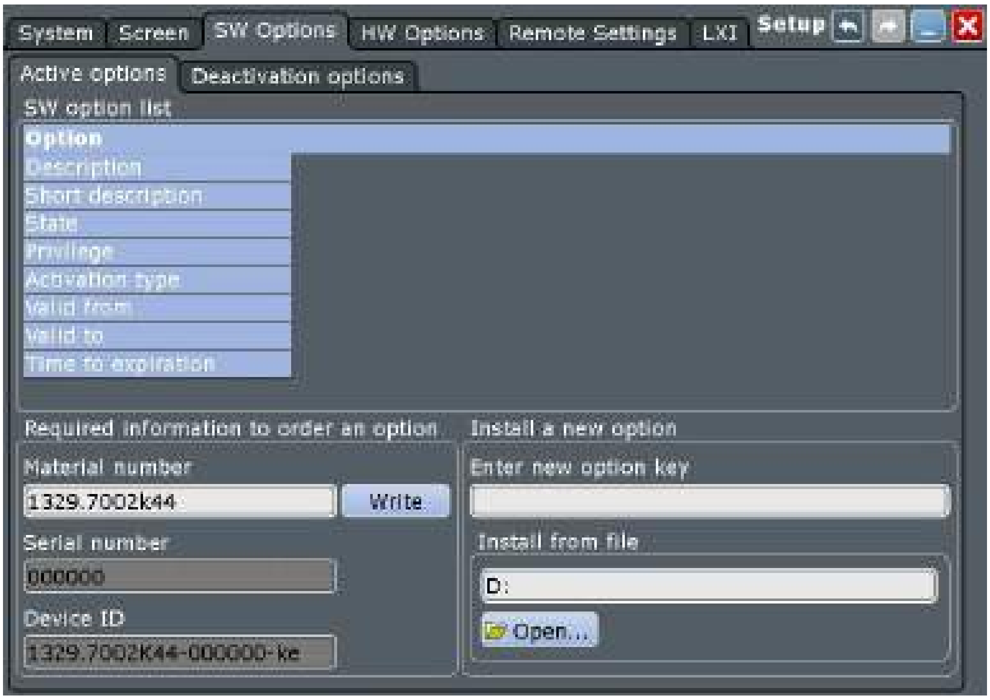
This tab informs about the availability of hardware options.

3.6.3 Activating Options

Options are activated by license keys. No additional installation is required. Consult your sales representative and provide the material number and serial number (or the device ID) of your instrument to get a license key. The license key is provided in written form or in a file. Unregistered licenses must be registered in the R&S License Manager before they can be activated on the instrument.

If the option has a portable license, keep the license file or option key at a save place. You need the license to move it to another instrument.

1. Press the SETUP key and select the "SW options" tab.



Material number: 1329.7002k44

Serial number: 000000

Device ID: 1329.7002K44-000000-ke

Install from file: D:

2. If you received a key in written form, enter the key in the "Enter new option key" field.
   If you received a key in digital form as a file, tap "Open", navigate to the directory that contains the file, and select the option key file.
3. If you want to activate several options, repeat step 3 for each option.
4. Restart the instrument or the firmware.

See also: Chapter 3.6.1, "SW Options", on page 130

3.6.4 Moving a Portable License

The following procedure describes how to move an active portable license to another instrument. Each instrument is identified by its individual device ID.

The procedure involves the transfer of files between the R&S License Manager web tool and the instruments (source and target). For file transfer, you can use a USB flash drive, or store the files in a LAN directory that can be accessed by both instruments and by the device that runs the R&S License Manager.

1. Make sure that the license file or written option key that is installed on the source instrument is available.

2. On the source and target instruments:
   Select SETUP > "SW Options" tab > "Active options" subtab and note the device IDs of both instruments.
3. In the R&S License Manager:
   1. a) Open the R&S License Manager: https://extranet.rohde-schwarz.com/service.
   2. b) Select "Move Portable License".
   3. c) Enter the device identifications of the source and target instruments.
4. In the R&S License Manager:
   1. a) Open the portable license file of the source instrument, or enter the license key (option key).
   2. b) Generate the deactivation key and store it to a file.
5. On the source instrument:
   1. a) On the "Active options" subtab, use "Install from file" to install the deactivation key file generated in the previous step.
   2. b) Select the "Deactivation options" subtab and note the "Response" key.
6. In the R&S License Manager:
   1. a) Enter the deactivation response key generated in the previous step.
      As a result, a portable license file registered for the target is generated.
   2. b) Store the new license file.
7. On the target instrument:
   On the "Active options" subtab, use "Install from file" to install the license generated in the previous step.
8. Reboot the source and the target instruments.

   The portable license is now active on the target instrument, and it is not any more available an the source instrument.

3.6.5 Options in Beta State

Options may be released in beta state. These options require a license key and an additional activation.

To activate a beta option:

1. On the "File" menu, select "Mode".
2. Select the "Operating Mode" tab.
3. Enable "Enable options in beta state".

The activation is effective immediately until the next shut-down of the firmware.

☐ Enable options in beta state

4 Acquisition and Waveform Setup

This chapter describes the horizontal and vertical settings as well as the acquisition and probe setup.

4.1 Basics

This chapter provides background information on the essential settings in the vertical and horizontal systems, on acquisition setup and probing.

4.1.1 Vertical System

The controls and parameters of the vertical system are used to scale and position the waveform vertically.

4.1.1.1 Input Coupling

The input coupling influences the signal path between input connector and the following internal signal stage. The coupling can be set to DC, AC, or ground.

- DC coupling shows all of an input signal. DC coupling is available with 1 MΩ input impedance to connect standard passive probes. DC coupling is the default for 50 Ω input impedance.
- AC coupling is useful if the DC component of a signal is of no interest. AC coupling blocks the DC component of the signal so that the waveform is centered around zero volts.
- Ground coupling disconnects the input signal from the vertical system to see the ground level (zero volts) on the screen. Ground coupling is useful for reference purposes.

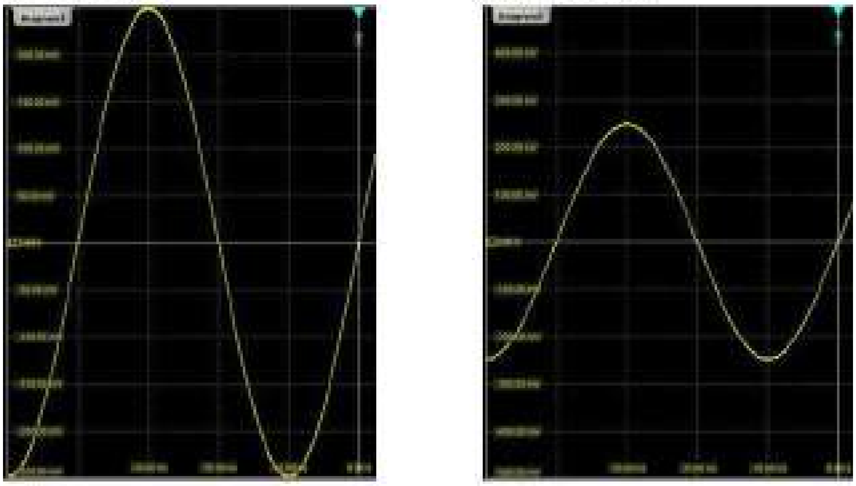
4.1.1.2 Vertical Scale and Position

Vertical scale and vertical position directly affect the resolution of the waveform amplitude. The vertical scale corresponds to the ADC input range. To get the full resolution of the ADC, set up the waveforms to cover most of the height of the diagram.

Signal amplitude = 0.5 V

Scale = 50 mV/div

Scale = 100 mV/div



Best signal resolution
8 bit → 2 mV steps

Reduced signal resolution
8 bit → 4 mV steps

Figure 4-1: Input range and resolution of the ADC

With R&S RTO, you can work with multiple diagrams, and each diagram obtains the full vertical resolution, no matter where the diagram is placed. Therefore, use a separate diagram for each waveform instead of the traditional setup that arranges the waveforms side by side in one diagram.

Signal amplitude: 0.5 V
Scale/div = 100 mV/div
Reduced signal resolution: 4 mV steps

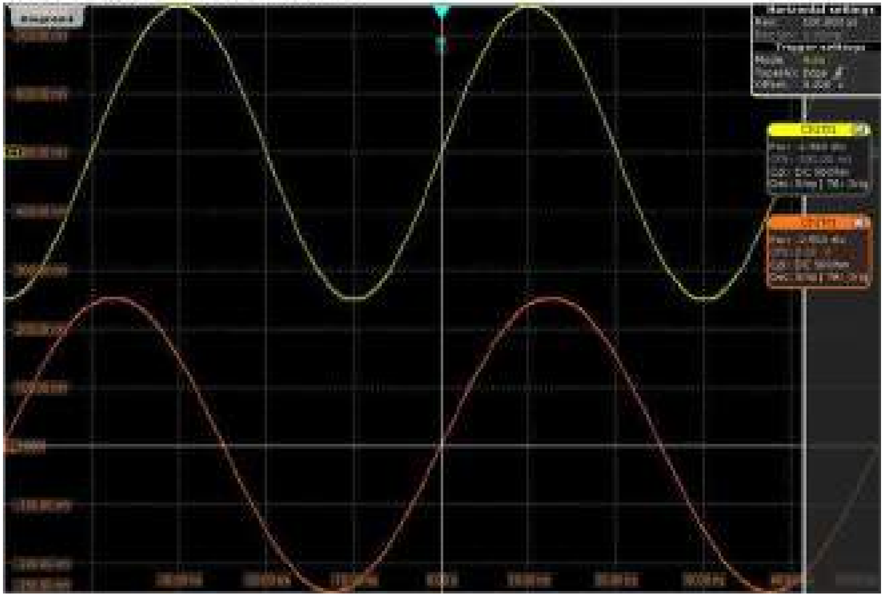
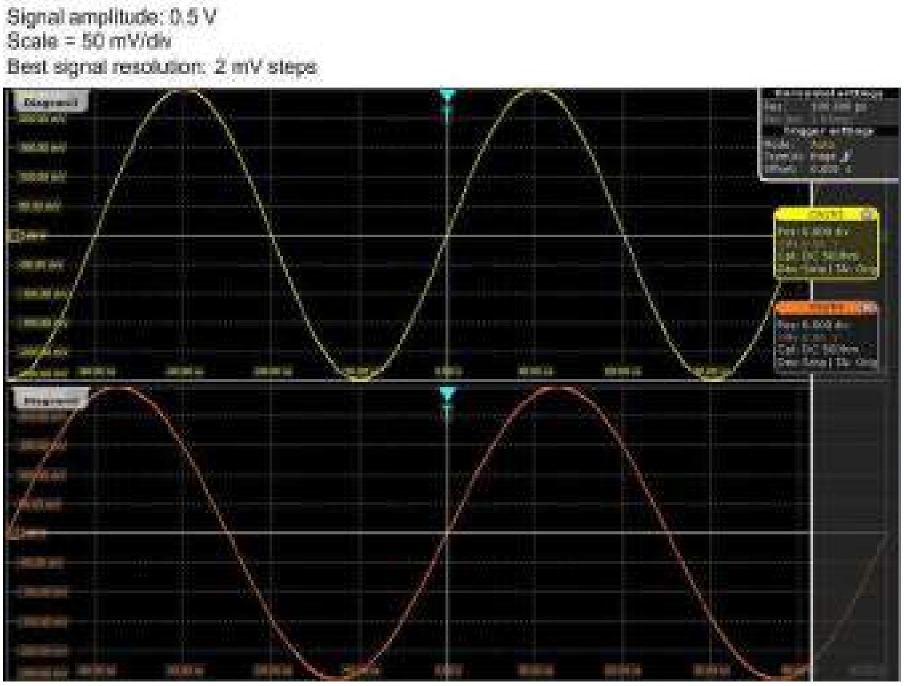


Figure 4-2: Traditional setup of multiple waveforms in one diagram: reduced resolution



Signal amplitude: 0.5 V
Scale = 50 mV/div
Best signal resolution: 2 mV steps

Figure 4-3: R&S RTO setup of multiple waveforms in separate diagrams: best resolution

4.1.1.3 Bandwidth

For analog applications, the highest signal frequency determines the required oscilloscope bandwidth. The oscilloscope bandwidth should be slightly higher than the maximum frequency included in the analog test signal to measure the amplitude with very little measurement error.

Most test signals are more complex than a simple sine wave and include several spectral components. A digital signal, for example, is built up of several odd harmonics. As a general rule, for digital signals the oscilloscope bandwidth should be 5 times higher than the clock frequency to be measured.

The oscilloscope is not a stand-alone system. You need a probe to measure the signal of interest, and the probe has a limited bandwidth, too. The combination of oscilloscope and probe creates a *system bandwidth*. To reduce the effect of the probe on the system bandwidth, the probe bandwidth must exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

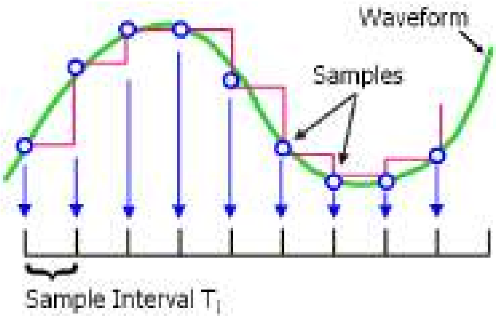
See also: Chapter 4.1.4.1, "Voltage Probes", on page 144

4.1.2 Sampling and Acquisition

The vertical system of a digital oscilloscope conditions the test signal in a way that the following A/D Converter (ADC) can transform the measured voltage into digital data.

4.1.2.1 Sampling and Processing

The A/D converter samples the continuous signal under test at specific points in time and delivers digital values called **ADC samples**. The rate at which the converter is working is the **ADC sample rate**, a constant value specified in GHz: $f_{ADC} = 1 / T_I$



The digital ADC samples are processed according to the acquisition settings. The result is a waveform record that contains **waveform samples** and is stored in the **waveform memory**. The waveform samples are displayed on the screen and build up the waveform.

The number of waveform samples in one waveform record is called **record length**. The rate of recording waveform samples - the number of waveform samples per second - is the **sample rate**. The higher the sample rate, the better is the resolution and the more details of the waveform are visible.

Maximum sample rate on R&S RTO1044/2044/2064

R&S RTO1044/2044/2064 can work with double maximum realtime sample rate compared to other R&S RTO instruments. This high sample rate is achieved by interleaving two channels: channels 1 and 2 are interleaved, and also channel 3 and 4. Interleaving assumes that only one of the paired channels can be used - either channel 1 or channel 2, and either channel 3 or 4. If the second channel of a pair is used (on display, or as trigger source, math source, or measurement source), the interleaving mode is disabled and the realtime sample rate is limited to the usual value of 10 GSa/s. Interleaved mode is also disabled in IQ mode, if NFC or TV trigger is selected, and for most serial protocols.

Preset sets the R&S RTO1044/2044 to 10 GSa/s (non-interleaved mode), while the R&S RTO2064 is set to 20 GSa/s (interleaved mode).

Minimum sample rate and aliasing

A sufficient resolution is essential for correct reconstruction of the waveform. If the signal is undersampled, aliasing occurs - a false waveform is displayed. To avoid aliasing and accurately reconstruct a signal, Nyquist theorem postulates that the sample rate must be at least twice as fast as the highest frequency component of the signal. However, the theorem assumes ideal conditions, so the Nyquist sample rate is usually not sufficient.

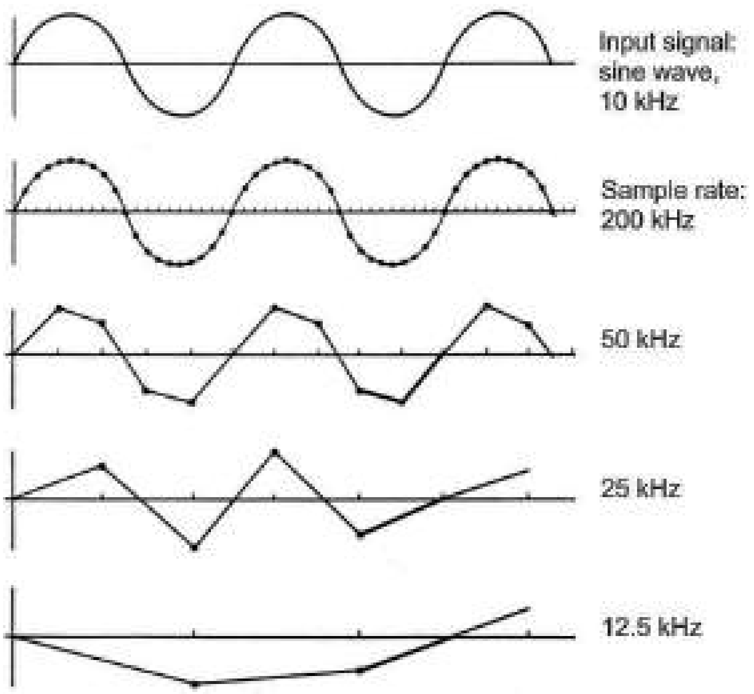


Figure 4-4: Waveforms acquired with different sample rates

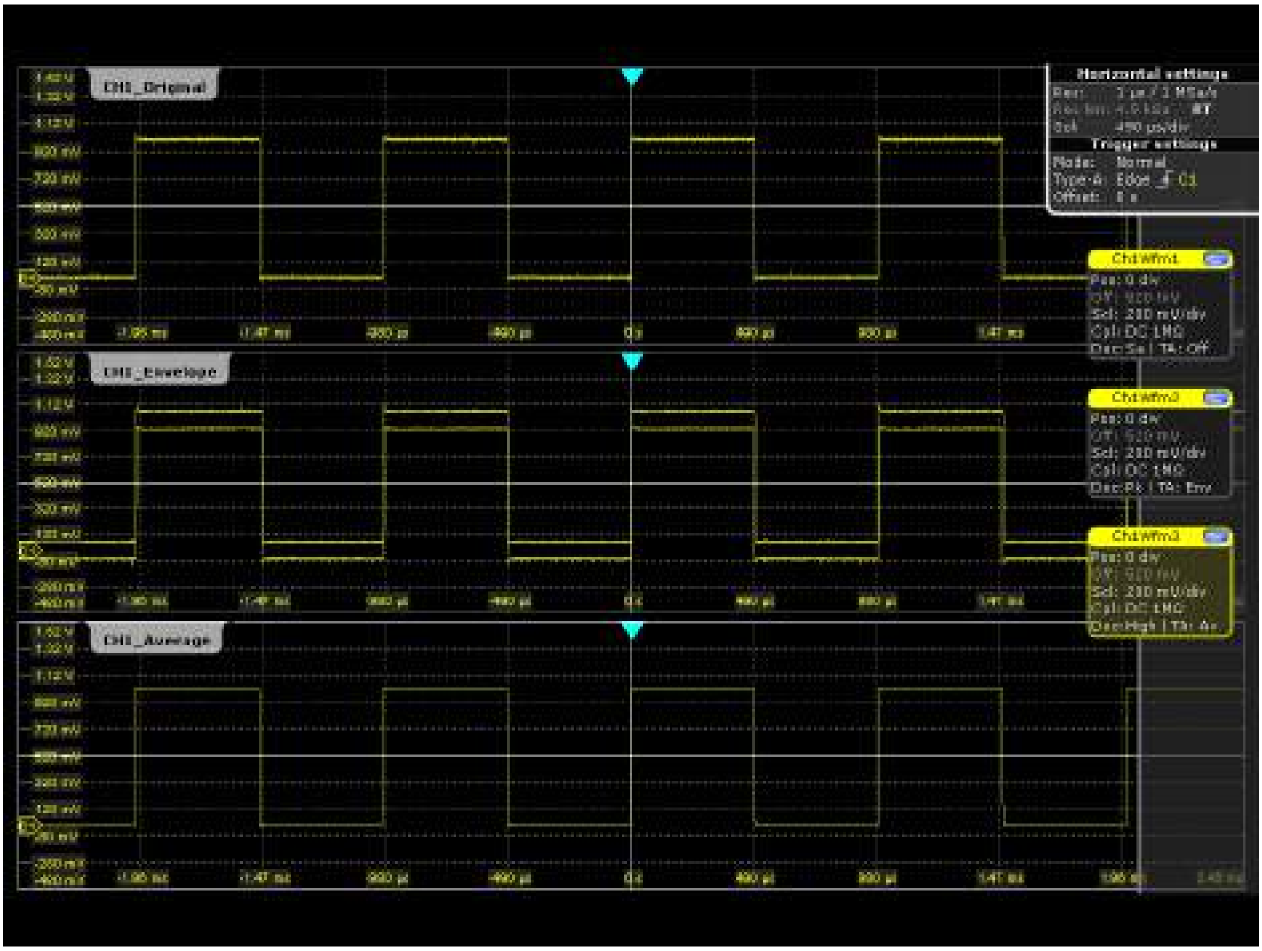
To avoid aliasing, the sample rate must be set to a value 3 to 5 times the fastest frequency component of the signal. A higher sample rate increases signal fidelity, increases the chance to capture glitches and other signal anomalies, and improves the zoom-in capabilities.

4.1.2.2 Acquisition Settings

The sample rate can be the same as the constant ADC sample rate, or higher, or lower. To get a higher sample rate, interpolation as method of **resolution enhancement** is used. To reduce the sample rate, **decimation** methods help: sample, peak detect, high resolution and RMS.

As digital waveform data is stored in the memory, and the memory can save many waveform records, further **waveform arithmetic** processing is possible: average and envelope waveforms are resulting waveforms, created from a composite of sample points taken from multiple acquisitions.

You can display up to three waveforms from one input signal and apply different decimation and arithmetic to each waveform.



4.1.2.3 Acquisition Control

You can run the R&S RTO in two ways:

- Run Stop: the instrument acquires data until you stop it manually.
- Single: the instrument samples and processes a specified number of acquisitions.

The determining point of an acquisition is the trigger. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete.

The trigger modes define how the instrument triggers:

- Normal: The instrument acquires a waveform only if a real trigger occurs, that is, if all trigger conditions are fulfilled.
- Auto: The instrument triggers repeatedly after a fixed time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. If the real trigger is faster than the auto trigger, both modes are virtually the same.

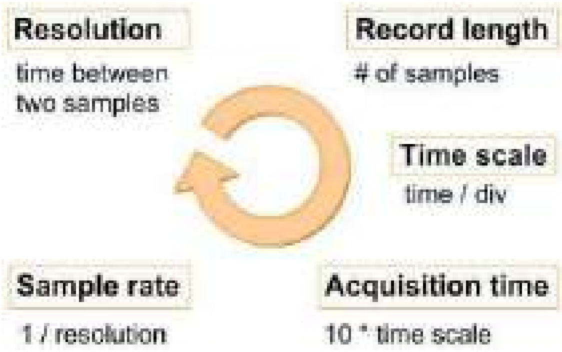
In practice, both trigger modes are useful: The auto mode lets you see the signal with little adjustment, while the normal mode selects the interesting part of the waveform. If you want to acquire a specified number of waveforms, make sure to select the normal trigger mode. Thus you get only the required number of interesting acquisitions.

See also: Chapter 5, "Triggers", on page 202

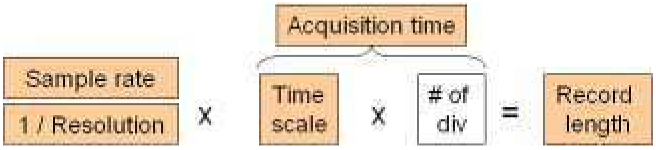
4.1.3 Horizontal System

4.1.3.1 Parameters of the Horizontal System

The control parameters of the horizontal system are tightly connected. Thus, changing one parameter affects the other parameters as well.



The mathematical dependencies can be summarized as follows:



The number of divisions is 10, this is the only constant parameter.

When you set up horizontal parameters, you can choose whether the record length or the resolution remains constant.

- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

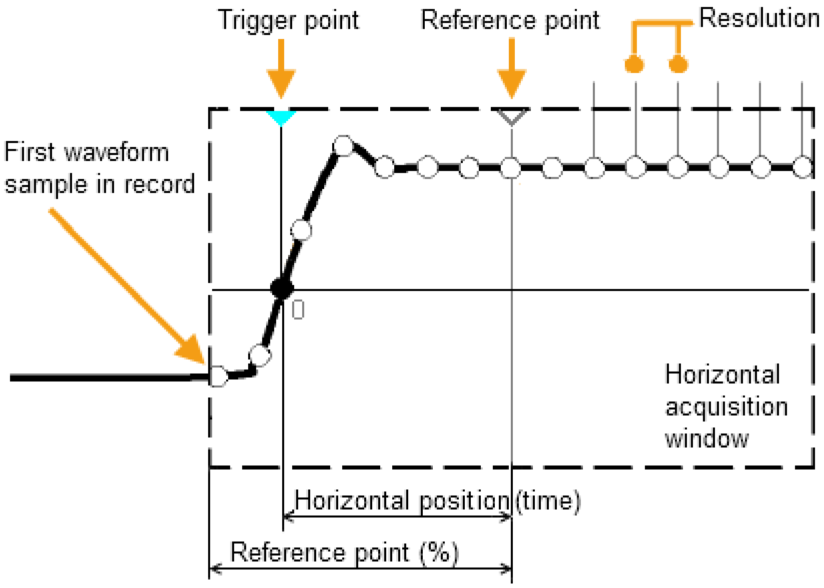
For both settings, the "Auto adjustment" ensures a sufficient resolution to prevent undersampling.

4.1.3.2 Horizontal Position

As described before in Chapter 4.1.2.3, "Acquisition Control", on page 141, the trigger is the determining point of the waveform record.

In many scenarios, you might want to analyze the waveform some time before or after the trigger. To adjust the horizontal acquisition window to the waveform section of interest, you can use the following parameters:

- The **horizontal position** defines the time distance from the trigger point (the zero point of the diagram) to the reference point. Changing the horizontal position, you can move the trigger point, even outside the screen.
- The **reference point** is the rescaling center of the time scale.on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.



4.1.4 Probes

A probe connects the signal source (DUT) to the oscilloscope, and delivers the signal to be measured. It is the essential first link in the measurement chain.

An ideal probe fulfills the following requirements:

- Safe and reliable contacts
- Infinite bandwidth
- The probe should not load the signal source and thus impact the circuit operation.
- The connection should not introduce or suppress signal components (hum, noise, filter) and thus degrade or distort the transferred signal.

In reality, the probe can never be an ideal one, it always affects the signal transmission and the signal source, and thus the measured signal. It depends on the frequency to be measured and on the signal source to determine the acceptable loading, and to determine which kind of probe delivers good results.

The solution depends on the quantity to be measured with respect to:

- Signal type: voltage, current, power, pressure, optical, etc.

- Signal amplitude: The oscilloscope itself can only display voltages in a limited range. Most probes can adjust the dynamic range to amplitudes from a few mV to 10 V. Smaller or much larger signals require specialized equipment.
- Signal frequency: High frequencies require advanced equipment in order to get correct results.
- Source characteristic: The source impedance is the decisive factor when choosing the suitable connection.

4.1.4.1 Voltage Probes

The following table provides an overview on common voltage probes and their usage.

Table 4-1: Voltage probes overview

Probe type	Attenuation	Typical bandwidth range	Oscilloscope input	Usage
Passive, high impedance	1:1	10 MHz	1 MΩ	Low speed, low level signals
Passive, high impedance	10:1	500 MHz	1 MΩ	General purpose
Passive, low impedance	10:1	up to 10 GHz	50 Ω	High frequency
Active, single-ended	10:1	up to 10 GHz	50 Ω	High speed
Active, differential	10:1		50 Ω	Floating

For a list of recommended probes refer to the R&S RTO product brochure.

Besides the possible input voltage range, two factors are important when selecting a voltage probe: Bandwidth and impedance over frequency.

- **Bandwidth:**
  The combination of probe and oscilloscope builds up a system. The resulting system bandwidth is approximately determined with:

  $$\frac{1}{BW_{system}} = \sqrt{\left(\frac{1}{BW_{probe}}\right)^2 + \left(\frac{1}{BW_{scope}}\right)^2}$$

  To measure the signal with low measurement error, the system bandwidth should be higher than the highest frequency component of the signal. The probe bandwidth must be even higher than the system bandwidth.
- **Impedance:**
  A minimum impedance is required to keep the circuit loading low. Over frequency, the impedance decreases, in particular with passive probes. The probe impedance should be approximately 10 times the impedance of the circuit test point at the highest signal frequency.

Passive voltage probes

Passive probes have the following qualities:

- No active components inside

- BNC connector for universal use
- Compensate the probe when it is connected to a scope input: LF compensation matches the probe (mainly cable) capacitance to the oscilloscope input capacitance.
- With high impedance probes, the impedance varies significantly over frequency.
- With low impedance probes, the impedance variation over frequency is low, but the load on the source is high.

If you use passive probes, remember some recommendations:

- Use a probe recommended for your oscilloscope model.
- Use a ground lead as short as possible to minimize the effect of ground lead inductance. The resonance frequency can be much lower than the system bandwidth and thus can affect the measurement results, in particular, if you measure steep edge rise times.
- Select a probe that has a bandwidth of 5 to 10 times the highest frequency being measured. This preserves the harmonics and thus the waveform integrity.

Active voltage probes - General

Active probes require operating power from the instrument and have a proprietary interface to the instrument. Their main qualities are:

- Low loading on signal source
- The probe is automatically recognized by the instrument, no adjustment is required.
- Adjustable DC offset at probe tip allows for high resolution on small AC signals which are superimposed on DC levels.
- Connections should be as short as possible to keep the usable bandwidth high.
- Observe the operating voltage range.
- The probe impedance depends on the signal frequency.

RT-ZS single-ended active probes and RT-ZD differential active probes provide special features for easier use and precise measurements. These special features are not available on RT-ZSxxE probes.

- The micro button on the probe head remotely controls important functions on the instrument, like running and stopping the acquisition, autoset, AutoZero and setting the offset to mean value.
- The R&S ProbeMeter measures DC voltages between the probe tip and the ground connection with very high precision. The result is displayed on the instrument's screen. So you can check DC voltages with different levels without having to adjust the measurement range of the oscilloscope. The R&S ProbeMeter also measures the zero error of the probe to optimize measurement results at small signal levels.

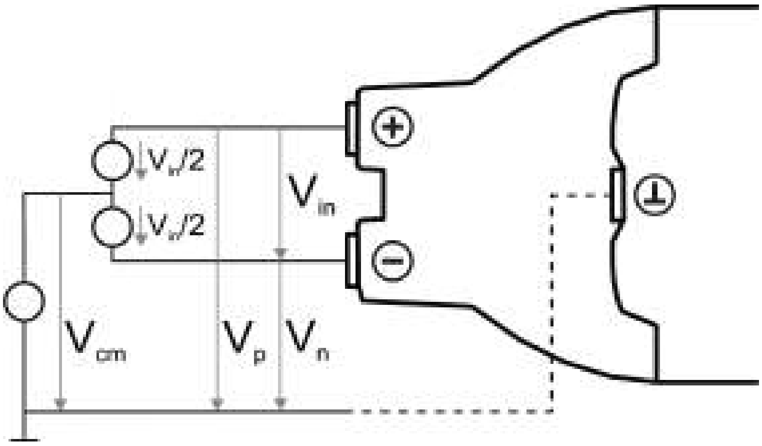
When you connect an R&S RT-ZSxx active probe to a channel input of the R&S RTO, the oscilloscope recognizes the probe. It reads the identification and calibration data from the probe box and shows the result in the "Setup" and "Probe Attributes" tabs. This data together with the deskew time for a given channel is stored and processed by the R&S RTO. If you connect the probe the next time to the same channel, the information is fetched and used.

Differential Active Probes

Differential active probes are designed to measure signals that are referenced against each other, and voltages that are not references to ground, for example twisted-pair signal lines. The R&S RT-ZD probes are differential probes with high input impedance, they can be used to measure voltages between any two test points.

Compared with two-channel measurement setup with single-ended probes, the measurement with differential probes is symmetric due to the same amplification and cable length on both paths. It is also immune to interference and noise and occupies only one input channel.

A differential probe has three sockets: the positive signal socket (+), the negative signal socket (-), and the ground socket.



Multiple input voltages can be defined for a differential probe:

- Differential mode input voltage (V_{in}, V_{dm})
  Voltage between the positive and negative signal sockets
- Positive single-ended input voltage (V_p)
  Voltage between the positive signal socket and the ground socket
- Negative single-ended input voltage (V_n)
  Voltage between the negative signal socket and the ground socket
- Common mode input voltage (V_{cm})
  Mean voltage of positive and negative signal sockets referred to the ground socket, respectively

Two of these voltages are independent values, the other two can be calculated:

$$V_{in} = V_p - V_n$$

$$V_{cm} = \frac{V_p + V_n}{2}$$

R&S RT-ZD probes detect only differential input voltages and provide it to the oscilloscope. Common mode signals are suppressed by the probe. This characteristic is described by the Common Mode Rejection Ratio (CMRR):

$$CMRR = \frac{DifferentialGain}{CommonModeGain}$$

In addition, the R&S ProbeMeter of R&S RT-ZD differential probes can measure differential and common mode DC voltages. The measurement result is displayed on the oscilloscope's screen. The common mode measurement of the R&S ProbeMeter allows you to check the input voltage relative to ground. Thus, the CM measurement is a convenient way to detect breaches of the operating voltage window, and the reason of unwanted clippings.

4.2 Horizontal Settings

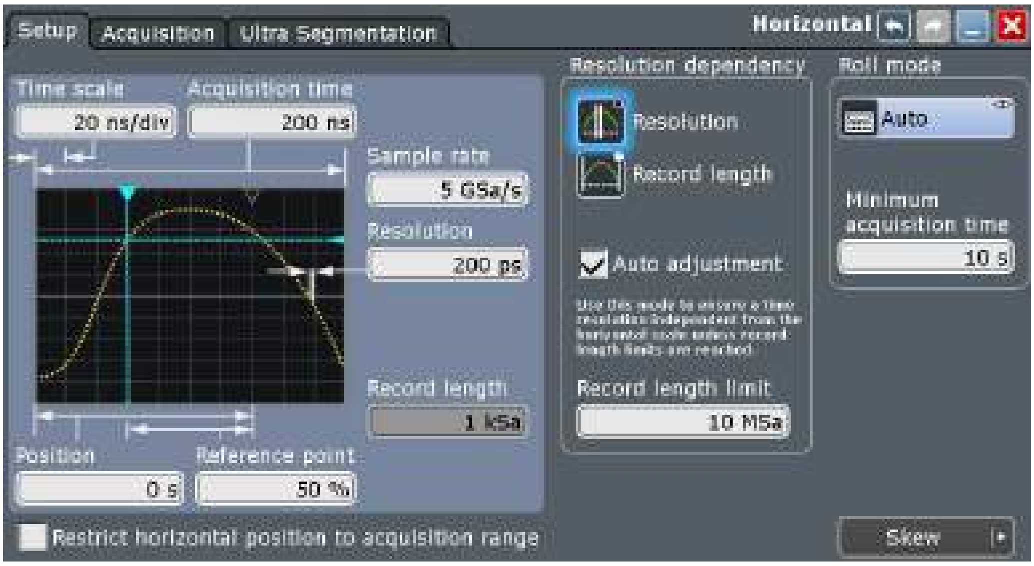
The "Horizontal" menu provides the time base and acquisition configuration for channel and spectrum waveforms:

4.2.1 Setup

Access: Horizontal key

The "Setup" tab in the "Horizontal" dialog box provides the settings for the time axis and the roll mode.

For background information, see Chapter 4.1.3, "Horizontal System", on page 142.



Time scale: 20 ns/div
Acquisition time: 200 ns
Sample rate: 5 GSa/s
Resolution: 200 ps
Record length: 1 kSa
Position: 0 s
Reference point: 50 %
☑ Auto adjustment
Record length limit: 10 MSa
Roll mode: Auto
Minimum acquisition time: 10 s
☐ Restrict horizontal position to acquisition range

Time scale

Sets the horizontal scale for all channel and math waveforms in seconds per division. Increase the scale to see a longer time interval of the waveform. Decrease the scale to see it in more detail. The scale has a point that remains fixed on the screen when the scale value is changing - the reference point.

Remote command:
`TIMebase:SCALe` on page 1205

Acquisition time

Shows the time of one acquisition, that is the time across the 10 divisions of the diagram:

Acquisition time = Time scale * 10 divisions

Changing the acquisition time changes the time scale too.

Remote command:
`TIMebase:RANGe` on page 1205

Position

Defines the time distance between the reference point and the trigger point (the zero point of the diagram). If you want to see a section of the waveform some time before or after the trigger, enter this time as horizontal position. The requested waveform section is shown around the reference point. Use positive values to see waveform sections after the trigger - the waveform and the diagram origin move to the left.

See also "Reference point" on page 148.

Remote command:
`TIMebase:HORizontal:POSition` on page 1206

Reference point

Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. It is indicated by a grey triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

Remote command:
`TIMebase:REFerence` on page 1206

Restrict horizontal position to acquisition range
If enabled, the horizontal position cannot be set outside the visible waveform diagram.

Remote command:
`TRIGger<m>:OFFSet:LIMited` on page 1206

Sample rate
Sets the number of captured waveform points per second. It considers the samples of the ADC, and the reduction of waveform points by decimation.

If interpolation is not active, the sample rate is the reciprocal value of the resolution and thus also depends on the acquisition time and the record length.

If interpolation is active, the sample rate is limited to the ADC sample rate.

See also:
- Chapter 4.1.2, "Sampling and Acquisition", on page 138
- Chapter 4.1.3, "Horizontal System", on page 142

Remote command:
`ACQuire:SRReal` on page 1208

Resolution
Sets the time between two waveform samples. A fine resolution with low values produces a more precise waveform record.

Remote command:
`ACQuire:RESolution` on page 1209

Record length
Indicates the number of waveform samples that build the waveform across the acquisition time.

Remote command:
`ACQuire:POINts[:VALue]` on page 1209

Resolution / Record length (Resolution dependency)
You can choose to keep constant either the resolution or the record length when you adjust the time scale or acquisition time.
- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

Remote command:
`ACQuire:POINts:AUTO` on page 1207

Auto adjustment (Resolution dependency)
Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the "Resolution / Record length" setting.

See also: Resolution / Record length (Resolution dependency)

Remote command:
`ACQuire:POINts:AADJust` on page 1207

Record length limit (Resolution dependency)
Sets a limit for the record length to prevent very large records. This value is only available if "Auto adjustment" is on and a constant resolution is selected. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

See also:
- Resolution / Record length (Resolution dependency)
- Auto adjustment (Resolution dependency)

Remote command:
`ACQuire:POINts:MAXimum` on page 1208

Roll mode
In roll mode, the instrument shows the waveforms immediately, without waiting for the complete acquisition of the waveform record. If the time base is slow - at long time scale values - the roll mode saves waiting for the waveform display. The instrument displays newly acquired waveform points at the right edge of the display and moves the waveform to the left.

The roll mode has following restrictions:
- Roll mode disables persistence
- History is not available

The instrument activates the roll mode automatically if the following conditions are fulfilled:

- Acquisition time exceeds the defined "Minimum acquisition time"
- Waveform arithmetic is disabled ("Off")
- Only one waveform per channel is active
- All channel waveforms are set to the same decimation mode, and only to one of these values: "Sample", "Peak detect", or "High res"
- All mask tests are disabled
- Ultra segmentation is disabled
- FFT is disabled
- All serial buses are disabled
- All digital channels are disabled (MSO option R&S RTO-B1)
- All XY-diagrams are disabled
- No CDR jitter data is acquired
- No zone trigger is active (only R&S RTO2000)

The roll mode depends also on sample rate and record length. In roll mode, the sample rate limit is 20 MSample/s. At 50 s, the resulting record length limit is 1000 MSample.

If the acquisition time is >50 s, the record length limit is effective, and the maximum sample rate depends on the acquisition time:

Sample rate ≤ 1000 MSample / Acquisition time.

If the acquisition time is <50 s, the maximum sample rate in roll mode depends on the number of active channels:

Sample rate = 20 MSample/s / Number of active wfms.

The corresponding maximum record length is:

*Record length ≤ 20 MSample/s * Acquisition time / Number of active wfms*.

Note for R&S RTO1000 instruments: The sample rate limit is 2 MSample/s, and the record length limit is 100 MSample.

Thus, the roll mode switches off, or it does not activate automatically if:

- The record length exceeds the limit at acquisition times >50 s.
- The sample rate exceeds the limit.
- To many waveforms are active.

Remote command:
`TIMebase:ROLL:ENABle` on page 1209
`TIMebase:ROLL:STATe?` on page 1209

Minimum acquisition time ← Roll mode
The instrument can activate the roll mode automatically if the Acquisition time exceeds the value given here.

Remote command:
`TIMebase:ROLL:MTIMe` on page 1210

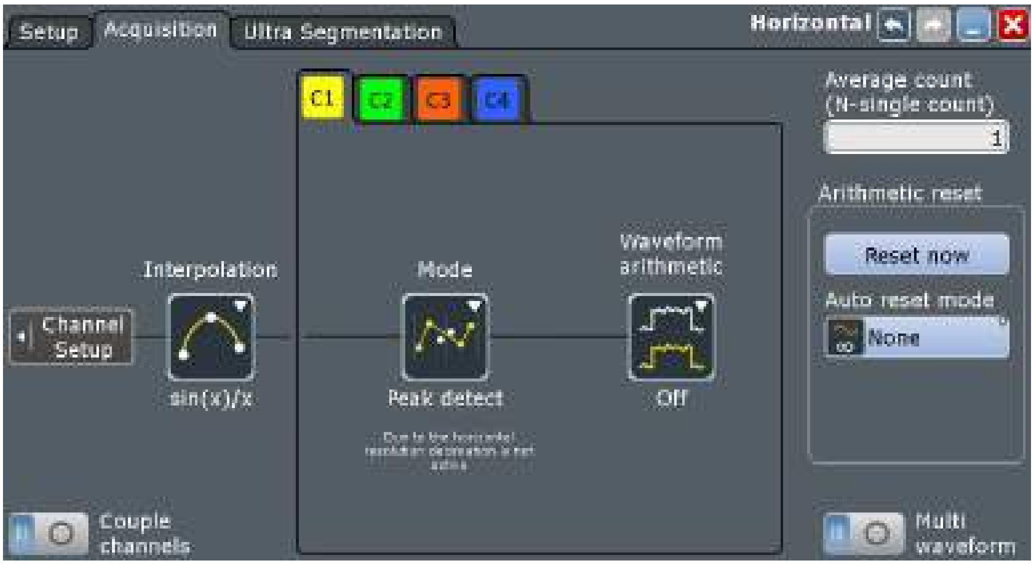
4.2.2 Acquisition

Access: Acquisition key

Acquisition settings control how the waveform is built from the acquired samples.

You can display up to three waveforms from one input signal and apply different decimation and arithmetic to each waveform.

For background information, see Chapter 4.1.2, "Sampling and Acquisition", on page 138.



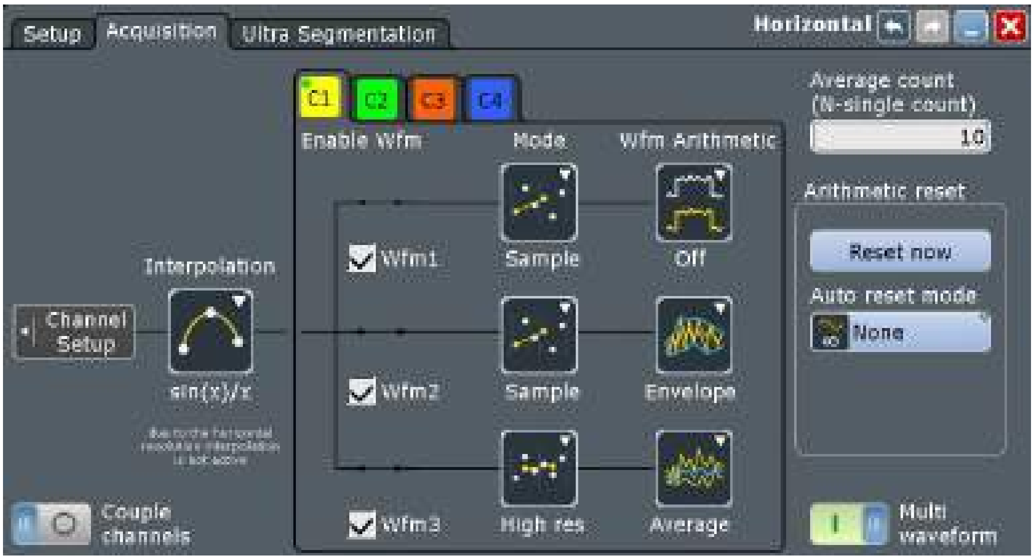
Interpolation: sin(x)/x

Mode: Peak detect

Waveform arithmetic: Off

Average count (N-single count): 1

Auto reset mode: None



The acquisition "Mode" and "Waveform arithmetic" are specific for each waveform. Make sure to select the channel tab first, then set up the waveforms.

Interpolation

Selects the interpolation method. If the defined "Sample rate" is higher than the ADC sample rate, interpolation adds points between the captured samples of the waveform by various mathematic methods.

"Linear"	Two adjacent ADC sample points are connected by a straight line, the interpolated points are located on the line. You see a polygonal waveform similar to the real signal, and also the ADC sample points as vertexes.
"sin (x)/x"	Two adjacent ADC sample points are connected by a sin(x)/x curve, and also the adjoining sample points are considered by this curve. The interpolated points are located on the resulting curve. This interpolation method is very precise and shows the best signal curve.
"Sample/Hold"	The ADC sample points are displayed like a histogram. For each sample interval, the voltage is taken from the sample point and considered as constant, and the intervals are connected with vertical lines. Thus, you see the discrete values of the ADC - the measured samples.

Remote command:
`ACQuire:INTerpolate` on page 1211

Couple channels
Sets the acquisition mode and the waveform arithmetic of all channels to the last set value.

If the acquisition settings are coupled, "Multi waveform" is not available, only one waveform per channel can be used.

Remote command:
`ACQuire:CDTA` on page 1212

Multi waveform
For each channel, up to three waveforms can be shown and analyzed. The decimation mode and the waveform arithmetic are specific for each waveform. So you can analyze several aspects of the signal: For example, waveform1 shows the peaks, and waveform2 shows the average of the signal.

Remote command:
`ACQuire:MUWaveform` on page 1212

Enable Wfm
Activates or deactivates the individual waveforms of the selected channel.

Remote command:
`CHANnel<m>[:WAVeform<n>][:STATe]` on page 1211

Mode
Selects the decimation mode. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution. The R&S RTO uses decimation, if the waveform "Sample rate" is less than the ADC sample rate. In this case, interpolation is not possible.

The decimation mode is waveform-specific, you can select another mode for each waveform.

There are different methods to define the recorded waveform point out of a number of n sample points:

"Sample"	One of n samples in a sample interval of the ADC is recorded as waveform point, the other samples are discarded. The time between the two adjacent waveform points is exactly the resolution. Very short glitches might remain undiscovered by this method.
"Peak detect"	The minimum and the maximum of n samples in a sample interval are recorded as waveform points, the other samples are discarded.
"High res"	The average of n sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution.
"RMS"	The waveform point is the root mean square of n sample values. Thus, the RMS value reflects the instantaneous power. This arithmetic mode is used to average a measured power waveform. Linear averaging of power signals causes an error dependent on the noise of the signal to be averaged.

Remote command:
`CHANnel<m>[:WAVeform<n>]:TYPE` on page 1211

Wfm Arithmetic
Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. The arithmetic works with interpolated and decimated waveforms.

This setting is waveform-specific.

The methods are:

"Off"	The data of only one acquisition is recorded according to the decimation settings. In effect, no waveform arithmetic is processed.
"Envelope"	Detects the minimum and maximum values in a sample interval over a number of acquisitions. Each acquisition is done in the "Peak detect" decimation mode, and the most extreme values for all acquisitions build the envelope. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof). The envelope is built until the restart criterion is reached, see "Auto reset mode / Reset mode" on page 155. **Note:** If you change from "Envelope" to "Off", make sure to set also the "Mode" to the required value.
"Average"	The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function. The number of acquisitions for average calculation is defined with "Average count" The "Auto reset mode" defines the restart condition.

Remote command:
`CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 1212

Acquisition/average count
Access:
- Trigger > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with SINGLE
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with SINGLE.

If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 157.

- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 1213

Reset now

Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 1213

Auto reset mode / Reset mode

Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1213
`ACQuire:ARESet:TIME` on page 1214
`ACQuire:ARESet:COUNt` on page 1214

Resolution enhancement

This setting is only available on R&S RTO1000 instruments.

If the ADC sample rate is too slow to capture sufficient samples to achieve the required resolution, the sample rate can be increased by adding calculated points to the waveform record. The enhancement method is the same for all channel waveforms. As long as the waveform sample rate is not higher than the ADC sample rate, the instrument works automatically in real time mode, enhancement settings are ignored. Otherwise - for resolutions faster than 100 ps - the instrument changes to interpolated time mode. If enhancement is done, the instrument ignores the decimation settings.

The methods are:

"Real time"	The sampled points of the input signal are used directly to build the waveform. Actually, the real time mode is not an enhancement mode. The maximum "Sample rate" is the "ADC sample rate". In this mode, decimation can be set to reduce the amount of data. The real time mode is used to acquire non-repetitive and transient signals.
"Interpolated time"	If the "Sample rate" is higher than the "ADC sample rate", interpolation adds points between the ADC samples of the waveform by various mathematic methods, see Interpolation.

"Equivalent time"	This method requires repetitive, stable signals and is not suitable for random and non-repetitive signals. It is used to capture fast signals whose frequency components are higher than the "ADC sample rate". Equivalent-time sampling constructs a picture of a repetitive signal by capturing part of information from each repetition. Each sample is taken with some time difference after the trigger, and the time difference varies with each repetition of the signal. After a number of acquisitions, the oscilloscope builds the waveform from the sampled points. The R&S RTO uses the sequential equivalent-time sampling method. When a trigger occurs, a sample is taken after a very short delay time. At the next trigger, this delay time is incremented by a precisely defined Δt, and the next sample is taken. This process is repeated until the waveform is complete. Sequential equivalent-time sampling provides good time resolution and accuracy. Equivalent-time sampling is not available, if digital channels are active (requires option R&S RTO-B1, MSO).

Remote command:
`ACQuire:MODE` on page 1210

4.2.3 Ultra Segmentation

In normal acquisition mode, only a short time is used for sampling; processing and display take most of the time. The processing and display time is blind time causing a gap in the recorded signal. The normal acquisition mode may miss very short time and infrequent events occurring during the dead time.

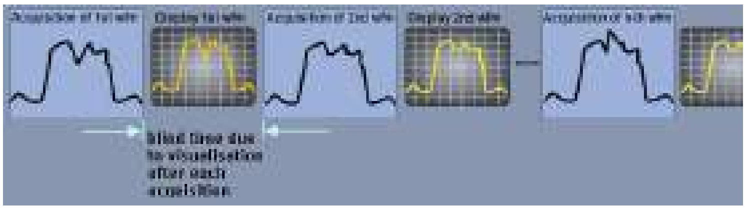


Figure 4-5: Normal acquisition with blind time

With ultra segmentation, a number of triggered acquisitions are captured very fast, with hardly any dead time between the acquisitions. The data is processed and the waveforms are displayed when the acquisition of the series has been completed.

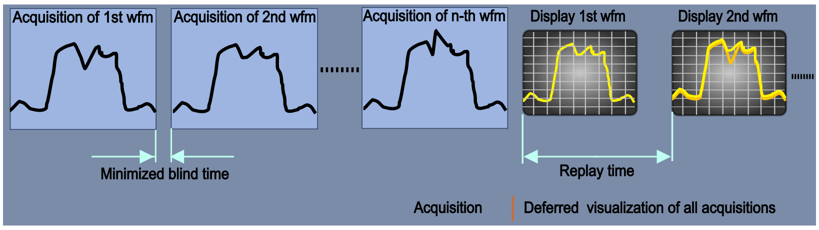


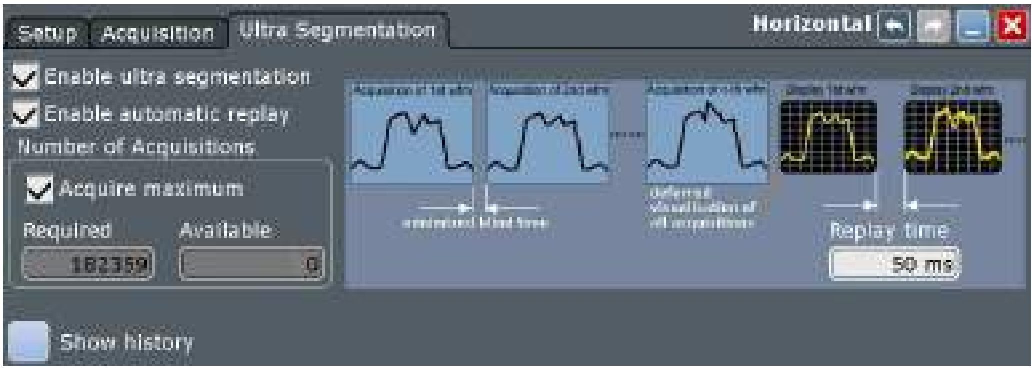
Figure 4-6: Ultra segmentation with deferred processing and display

Ultra segmentation and history

The acquisition series is written in the sample memory, thus the memory size limits the number of acquisitions in a series. This memory is the memory that is accessed by the history, thus the history function is used to read out the contents of the sample memory.

To use the history functionality, enable "Show history" in the "Ultra Segmentation" tab. The history viewer settings are displayed directly in the "Ultra Segmentation" tab.

See also: Chapter 6.4, "History", on page 281.



☑ Enable ultra segmentation
☑ Enable automatic replay
Number of Acquisitions
☑ Acquire maximum
Required: 182359
Available: 0
Replay time: 50 ms
☐ Show history

Enable ultra segmentation

Switches the ultra segmentation mode on and off.

Remote command:
`ACQuire:SEGMented:STATe` on page 1215

Enable automatic replay

If enabled, the instrument starts processing and displaying the data as soon as the acquisition series is captured completely. Depending on the number of acquisitions, it may take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Remote command:
`ACQuire:SEGMented:AUToreplay` on page 1215

Number of acquisitions

You can define the number of acquisitions to be stored in an ultra segmentation acquisition series:

- Acquire the maximum number of acquisitions that can be stored in the sample memory.
  To acquire the maximum number, enable "Acquire maximum". The maximum number of acquisitions is shown in the "Required" field.
- Acquire a given number of acquisitions.
  Enter the number in the "Required" field.

The acquisition count (Acquisition/average count) is always set to the required number of acquisitions. Thus you can acquire exactly one ultra segmentation acquisition series with SINGLE. The RUN STOP key works in the same way as SINGLE, it stops acquisition when the series is completed.

You can stop the running acquisition before the series is completed.

The number of acquired waveforms is shown in "Available" and can be displayed with "Show history".

Remote command:
`ACQuire:SEGMented:MAX` on page 1215

Replay time
Defines the display speed of the ultra segmentation acquisition series. Display starts after the series has been captured completely.

See also: "Replay time per acq." on page 284

Show history
Enables the history mode and displays the history viewing functions in the "Ultra Segmentation" tab.

See also: Chapter 6.4.2.1, "Viewer", on page 283.

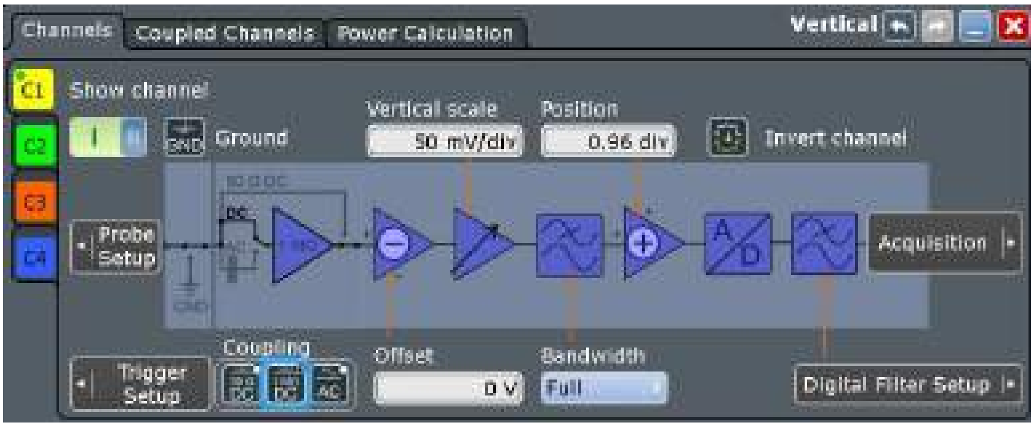
4.3 Vertical Settings

The "Vertical" menu contains all channel-dependent settings and information.

4.3.1 Channels

Access: "Vertical" menu > "Channels"

The "Channels" tab provides all basic vertical settings. The channels are listed in vertical tabs at the left side of the dialog box.



Vertical scale: 50 mV/div
Position: 0.96 div
Offset: 0 V
Bandwidth: Full

Make sure that the correct channel tab is selected. The vertical rotary knobs are illuminated in the color of the selected channel.

Show channel

Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:

`CHANnel<m>:STATe` on page 1216

GND

Ground

Connects the input to the ground.

Remote command:

`CHANnel<m>:GND` on page 1216

Vertical scale

Defines the vertical scale in Volts per division. Increasing the scale compresses the display of the signal.

Remote command:

`CHANnel<m>:SCALe` on page 1216

Position

Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset but the waveform is adjusted later in the signal flow. While the offset sets a voltage, position is a graphical setting given in divisions.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

Remote command:

`CHANnel<m>:POSition` on page 1217

Invert channel

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

You can use inversion, for example, to switch the polarity of a differential signal without changing the probe connections.

Remote command:

`CHANnel<m>:INVert` on page 1218

50 Ω DC

1 MΩ DC

AC

Coupling

Selects the connection of the channel signal determining what part of the signal is used for waveform analysis and triggering.

In addition to coupling, the signal can be filtered for high frequency rejection, see Chapter 4.7, "Digital Filter Setup", on page 193.

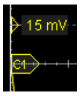
"DC 50 Ω"	Connection with 50 Ω termination, passes both DC and AC components of the signal.
"DC 1 MΩ"	Connection with 1 MΩ termination, passes both DC and AC components of the signal.
"AC"	Connection with 50 Ω termination through DC capacitor, removes DC and very low-frequency components.

Remote command:
`CHANnel<m>:COUPling` on page 1216

Offset

The offset voltage is subtracted to correct an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram area. Negative offset values move up the waveform, positive values move it down.

The offset of a signal is determined and set by the autoset procedure. The current value is shown in the waveform label, and it is marked by a small triangle in the grid.



If a Rohde & Schwarz differential probe is connected, the offset is the differential offset.

If a Rohde & Schwarz modular probe is connected, the offset of the selected probe mode is used. For example, in CM mode, the offset is the common mode offset.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

Remote command:
`CHANnel<m>:OFFSet` on page 1218

Bandwith

Selects the bandwidth limit.

The specified full bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3dB attenuation. The probe has also a limited bandwidth and thus affects the resulting system bandwidth.

The current bandwidth is shown on the signal icon. At full bandwidth, the displayed bandwidth can be less than the instrument bandwidth depending on the number of active channels and other settings.

See also: Chapter 4.1.1.3, "Bandwidth", on page 138

"Full"	At full bandwidth, all frequencies in the specified range are acquired and displayed. Full bandwidth is used for most applications.

"20 MHz, 200 MHz, 800 MHz"	Frequencies above the selected limit are removed to reduce noise at different levels. The "800 MHz" filter is available for 50 Ω coupling on scopes with ≥ 1 GHz instrument bandwidth.

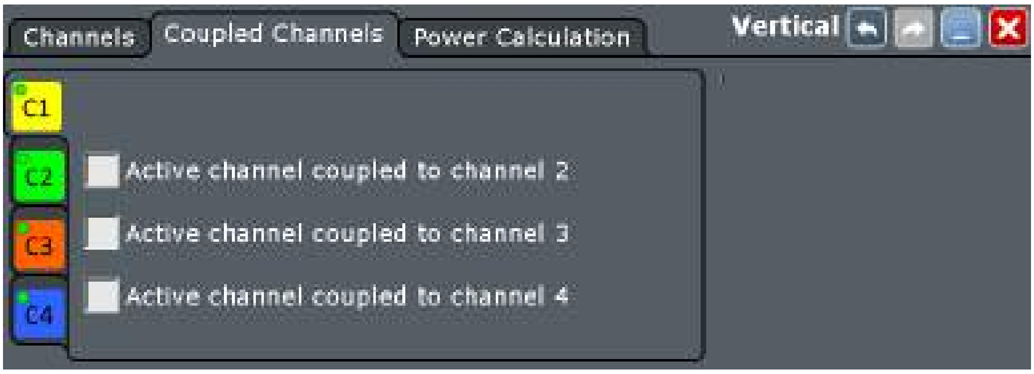
Remote command:
`CHANnel<m>:BANDwidth` on page 1218

4.3.2 Coupled Channels

Access: "Vertical" menu > "Coupled Channels"

Channel coupling sets the vertical settings of the coupled channels to the values of the active channel. If you want to have the same vertical settings for two or more channels , you can set them at once by coupling these channels.

Channel coupling affects all vertical settings that are adjusted in the "Channels" tab: vertical scale, position, offset, bandwidth, coupling, and ground.

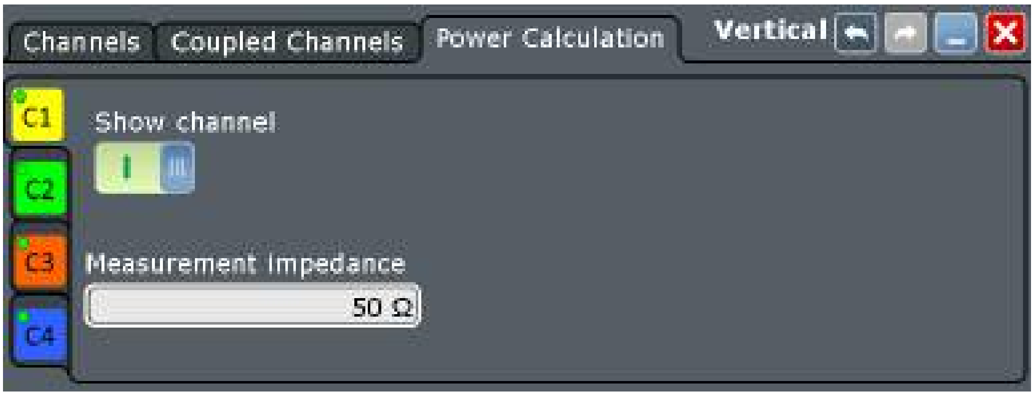


☐ Active channel coupled to channel 2
☐ Active channel coupled to channel 3
☐ Active channel coupled to channel 4

4.3.3 Power Calculation

Access: "Vertical" menu > "Power Calculation"

Make sure that the correct channel tab is selected.



Show channel
Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 1216

Measurement impedance
Sets the impedance of the channel for power calculations and measurements.

Remote command:
`CHANnel<m>:IMPedance` on page 1219

4.4 High Definition (Option R&S RTO-K17)

The high definition mode offers up to 16 bits of vertical resolution. Higher vertical resolution reduces quantization noise and acquires waveforms of higher accuracy with finer details of the signal to be seen.

The number of vertical resolution bits defines the number of vertical levels that the acquisition samples are mapped to (quantization). 16 bits of resolution represent 65536 voltage quantization levels, while 8 bits of resolution represent only 256 voltage levels. The waveform values are recorded with 16 bit word length, except for peak detect decimation.

The higher vertical resolution is achieved by applying a digital low pass filter (DSP filter) to the output of the ADC, which reduces the bandwidth of the signal. Increasing the bandwidth reduces the resulting digital resolution. The high definition is also applied to the digital trigger, thus the R&S RTO can trigger with the same high resolution with which they can display signals.

High definition can be used, for example, to measure slow pulses with high accuracy, or to analyze AM signals with very low modilation index, as used in radar.

See also:

- Chapter 4.1.1, "Vertical System", on page 136
- Chapter 4.1.2, "Sampling and Acquisition", on page 138

4.4.1 High Definition Settings

Access: "App Cockpit" menu > "HD"

High definition is a special acquisition mode of the oscilloscope. This mode has only one setting - the filter bandwidth.

Option Mode: High definition
Bandwidth: 20 MHz
Resolution in bits: 16

Figure 4-7: Setting the instrument into high definition mode

Option mode
Sets the operation mode of the instrument.

"Normal"	Usual oscilloscope mode
"IQ"	I/Q mode to record I/Q data, requires option R&S RTO-K11. The analyzing tools on the toolbar are deactivated, and the magnitude of the I/Q vector is displayed.
"High definition"	Mode with higher digital resolution, up to 16 bit. Requires option R&S RTO-K17.

Remote command:
`IQ:STATe` on page 2135
`HDEFinition:STATe` on page 1249

Bandwidth
Sets the filter bandwidth for the high definition mode.

The maximum filter bandwidth depends on the instrument bandwidth.

Instrument bandwidth	Maximum filter bandwidth
600 MHz	500 MHz
≥ 1 GHz	1 GHz

Remote command:
`HDEFinition:BWIDth` on page 1249

Resolution in bits
Shows the resulting vertical resolution in high definition mode. The higher the filter bandwith, the lower the resolution. For details, refer to the R&S RTO Specifications.

Remote command:
`HDEFinition:RESolution?` on page 1250

4.4.2 Effects of the High Definition Mode

The high definition mode has several effects:

Acquisition

The active high definition mode is indicated by "HD" in the horizontal label.

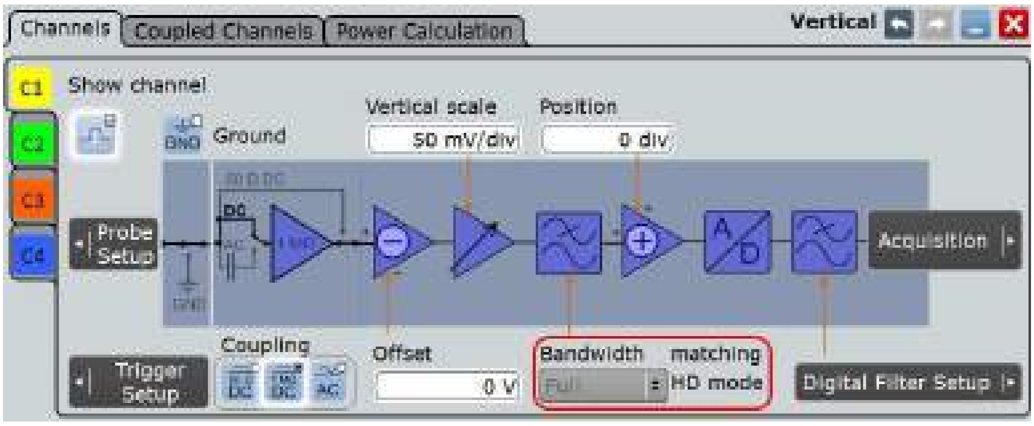
The high definition mode works with half the realtime sample rate. For FFT, the instrument halves this sample rate again.

The waveform values are recorded with 16 bit word length, except for peak detect decimation (2 values with 8 bit).

Vertical system

The current bandwidth is shown in the channel label.

In the "Channels" dialog box (CH<x>), the "Bandwidth" setting is not available because the bandwidth is set by the high definition filter.



Vertical scale 50 mV/div

Position 0 div

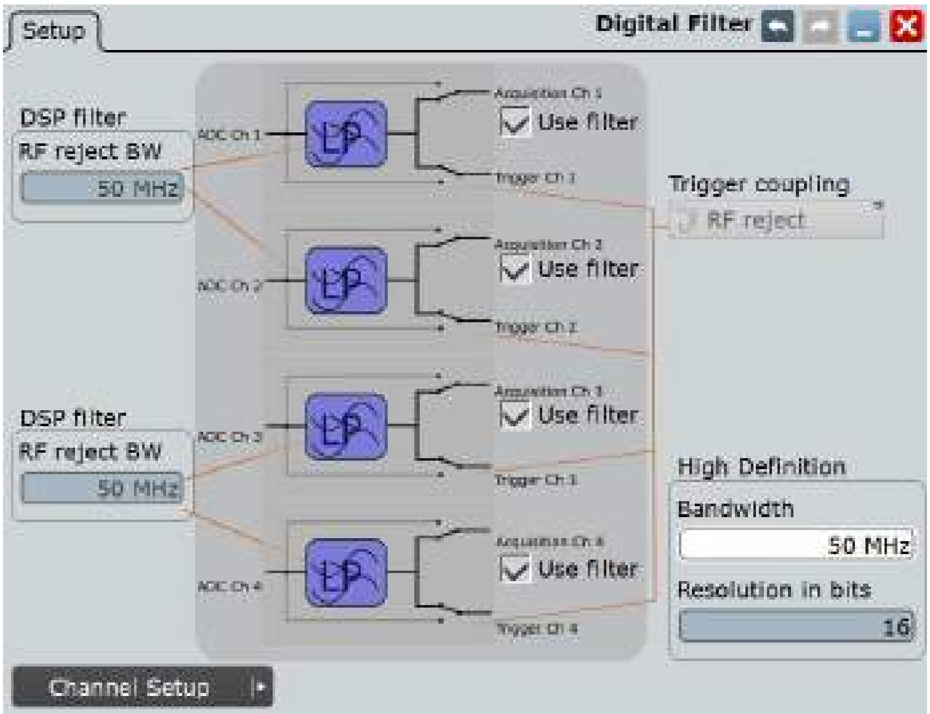
Offset 0 V

Bandwidth Full matching HD mode

The minimum vertical scale is 500 µV/div instead of 1 mV in normal mode.

Digital filter

The digital filter settings are set automatically. You can change the high definition "Bandwidth" in the "Digital Filter Setup".



DSP filter
RF reject BW: 50 MHz

DSP filter
RF reject BW: 50 MHz

☑ Use filter
☑ Use filter
☑ Use filter
☑ Use filter

Trigger coupling: RF reject

High Definition
Bandwidth: 50 MHz
Resolution in bits: 16

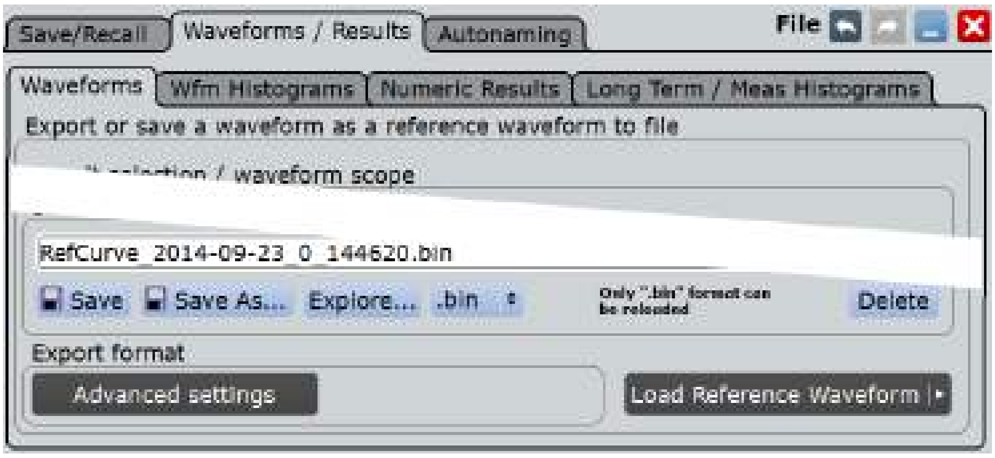
History

Due to the 16 bit word length, the history depth is reduced, less waveforms are saved than in normal mode

Export

In high definition mode, waveform data in raw format is exported to file with 16 bit word length, except for peak detect decimation (2 values with 8 bit). In addition, you can define the byte order of the data words.

To define additional export settings, tap "Advanced Settings" in the SAVE RECALL > "Waveforms" tab.



Export or save a waveform as a reference waveform to file

waveform scope

RefCurve_2014-09-23_0_144620.bin

Only "*.bin" format can be reloaded

Export format

See:

- "Raw (ADC direct)" on page 460
- "Interleaved x/y" on page 460
- "Byte order" on page 460

If you use remote control commands to transfer data to a controlling computer, set the data format to `INT,16` to transfer the complete data words (see `FORMat[:DATA]` on page 1181).

Further restrictions

The IQ mode (option R&S RTO-K11) is not available if high definition mode is active.

4.5 Probes

With R&S RTO digital oscilloscopes, you can use various probe types. Mostly these probes are passive and active voltage probes. The "Probes" dialog box provides all probe-relevant information.

The instrument can detect many probes and read out the probe-specific parameters, for example, bandwidth and attenuation.

In the "Setup" tab, you find all settings that are relevant for the connected probe.

Access: "Vertical" menu > "Probe Setup"

The functionality on the "Setup" tab changes according to the type of the attached probe. Probes with Rohde & Schwarz probe interface (probe box), and also many other passive voltage probes, are recognized by the instrument. The R&S RTO reads out the main characteristics of the probe and displays them. Other probes cannot be detected, but their characteristics are known to the instrument. These known probes are called "Predefined probes". Probes that are not recognized automatically and not predefined are unknown probes, they require manual setting of measurement unit and attenuation.

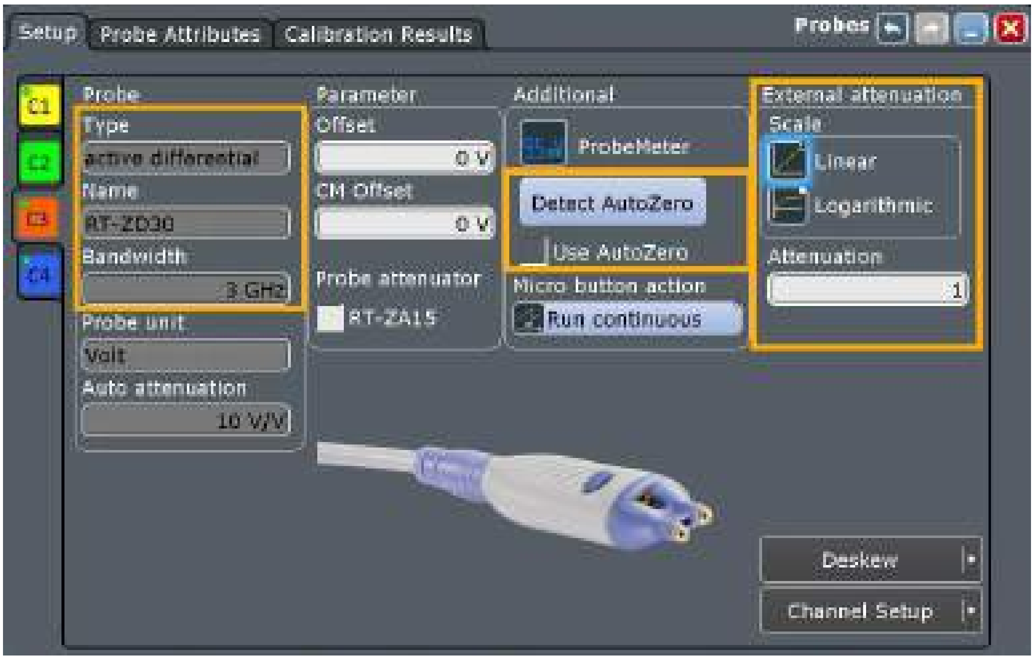
Before you adjust the settings, select the correct channel tab on the left.

Additional information is given in the "Probe Attributes" and "Calibration Results" tabs. For background information, see Chapter 4.1.4, "Probes", on page 143.

This chapter has the following sections:

4.5.1 Shared Probe Settings

Some of the settings in the "Pobes Setup" tab are available for all probes.



Type: active differential
Name: RT-ZD30
Bandwidth: 3 GHz
Probe unit: Volt
Auto attenuation: 10 V/V
Offset: 0 V
CM Offset: 0 V
Probe attenuator: RT-ZA15
Micro button action: Run continuous
Scale: Linear, Logarithmic
Attenuation: 1

The shared probe settings are:

Type, Name, Bandwidth
The fields show the characteristics of a recognized or predefined probe for information. If the instrument cannot recognize the probe, and the probe is not known, the "Type" is "None", and the other fields are empty.

Remote command:
`PROBe<m>:SETup:TYPE?` on page 1222
`PROBe<m>:SETup:NAME?` on page 1222
`PROBe<m>:SETup:BANDwidth?` on page 1222

Detect AutoZero, Use AutoZero
Differences in DUT and oscilloscope ground levels may cause larger zero errors, which affect the waveform. If the DUT is ground-referenced, the AutoZero function corrects the zero error of the probe to optimize measurement results at small signal levels. The validation limit depends on the probe attenuation because probes with high attenuation often have to compensate high offsets. AutoZero detects offset values even when the signal is out of the current measurement range.

To correct the zero error of voltage probes, short the signal pin and the ground pin together and connect them to the ground of the DUT. Then tap "Detect AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To include the measured offset in measurement results, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position. See "Detect AutoZero" on page 182.

Remote command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 1223
`PROBe<m>:SETup:OFFSet:USEautozero` on page 1223

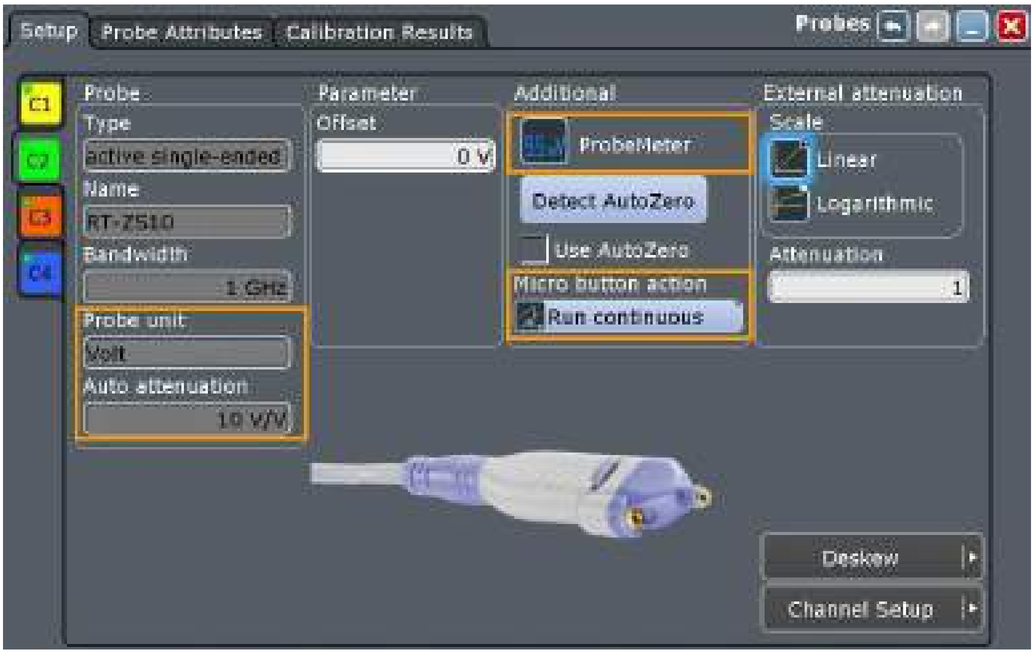
External attenuation: Scale, Attenuation
Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

"Scale"	Select linear or logarithmic attenuation scale.
"Attenuation"	Enter the attenuation of the voltage divider according to the selected scale. The conversion from linear to logarithmic values depends on the "Vertical unit" of the probe: For voltage-based unit (V and A): $attenuation\ (dB) = 20 * \log_{10}(attenuation\ factor)$ For power-based unit (W): $attenuation\ (dB) = 10 * \log_{10}(attenuation\ factor)$

Remote command:
`CHANnel<m>:EATScale` on page 1223
`CHANnel<m>:EATTenuation` on page 1224

4.5.2 Settings for the R&S Probe Interface (Voltage Probes)

Active voltage probes with Rohde & Schwarz probe interface provide special features: the micro button and the ProbeMeter. Furthermore, the R&S RTO can read out the attenuation of the probe.



The settings for active voltage probes with Rohde & Schwarz probe interface are:

Probe unit, Auto attenuation

If the probe is recognized by the R&S RTO, the instrument reads the attenuation unit and value from the probe an displays them.

Remote command:

`PROBe<m>:SETup:ATTenuation[:AUTO]?` on page 1223

Micro button action

Active voltage probes with Rohde & Schwarz probe interface have a configurable micro button on the probe head. Pressing this button, you start an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self-alignment, autoset, and find level.

Select the action that you want to start from the probe:

"Run Continuous"	Is the default assignment. Starts or stops the acquisition (same as Run Stop key).
"Run single"	Starts a defined number of acquisitions (same as SINGLE key).
"Auto set"	Starts the autoset procedure (same as Autoset key).
"AutoZero"	Starts an auto zero measurement, see "Detect AutoZero, Use AutoZero" on page 168.
"Set offset to mean"	Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. See: "Offset to mean" on page 180.
"Print"	Prints the current display according to the "Printer control" settings in the "Print" dialog box. Depending on the selected printer, you can print to a local or network driver, or save to a file. See also: Chapter 11.3, "Screenshots", on page 468.
"Save image to file"	Saves the current display as image according to the image settings in the "Print" dialog box. See also Chapter 11.3, "Screenshots", on page 468.
"No action"	Select this option to prevent unwanted actions due to unintended usage of the micro button.
"Find trigger level"	Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.
"Create report"	Creates and saves a report using the settings defined in "File" menu > "Report Setup".
"Probe mode"	Only available if a R&S RT-ZM modular probe is connected. Sets the measurement mode of the modular probe. See also "Probe Mode" on page 177.
"Probe Setup"	Opens the "Probes Setup" dialog box.

Remote command:
`PROBe<m>:SETup:MODE` on page 1224

ProbeMeter
The integrated R&S ProbeMeter of active voltage probes with Rohde & Schwarz probe interface is a voltmeter. It measures DC voltages between the probe tip and ground connection or between the probe tips with very high precision. The R&S ProbeMeter enables ground-referenced measurements of voltages. The measurement is performed continuously and in parallel to the measurements of the oscilloscope.

- **"Probemeter"**
  Select "Probemeter" to activate the integrated R&S ProbeMeter of active R&S probes. The measured voltages are displayed in the "ProbeMeter" result box on the screen.
- **ProbeMeter measurement results of single-ended active R&S probes**
  Measures the voltage between the probe tip and the ground.

- **ProbeMeter measurement results of differential and modular R&S probes**
  You can select the voltage to be measured by the differential active probe:
  - "Differential / Common Mode":
    Differential voltage is the voltage between the positive and negative signal sockets.
    Common mode voltage is the mean voltage between the signal sockets and the ground socket. It measures the voltage level relative to ground, for example, to check the operating voltage window.

  - "Single Ended Pos/Neg": Measures the voltage between the positive/negative signal socket and the ground.

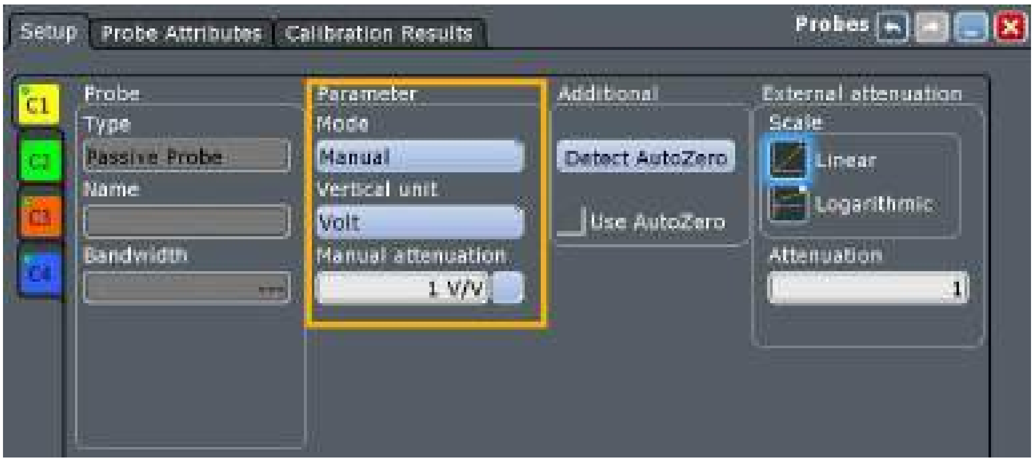
    

    The ProbeMeter always measures the common mode and differential voltages. Single-ended voltages are calculated values:
    $V_p = V_{cm} + 0.5 * V_{in}$ and $V_n = V_{cm} - 0.5 * V_{in}$

Remote command:
`PROBe<m>:PMETer:VISibility` on page 1226
`PROBe<m>:SETup:DISPlaydiff` on page 1225
`PROBe<m>:PMETer:RESults:SINGle?` on page 1226
`PROBe<m>:PMETer:RESults:POSitive?` on page 1228
`PROBe<m>:PMETer:RESults:NEGative?` on page 1227
`PROBe<m>:PMETer:RESults:DIFFerential?` on page 1227
`PROBe<m>:PMETer:RESults:COMMon?` on page 1226

4.5.3 Setup for Passive Probes

Passive probes are the most widely used probes for oscilloscope measurements. Passive probes require compensation.



Type: Passive Probe
Name:
Bandwidth:
Mode: Manual
Vertical unit: Volt
Manual attenuation: 1 V/V
Use AutoZero
Scale: Linear
Attenuation: 1

Figure 4-8: Probe setup for passive probe R&S RT-ZP10

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168

If a passive probe is connected, the probe attenuation is read out and shown in the "Setup" tab:

- "Probe unit, Auto attenuation" on page 169

If you need to change the unit or attenuation, change the "Mode" to "Manual" and enter the correct values.

Mode

Defines how the attenuation of a passive probe is set.

"Auto"	The instrument uses the values that are read out from the probe.
"Manual"	You can define the attenuation unit and value. See: "Vertical unit, Attenuation, Gain" on page 172

Remote command:
`PROBe<m>:SETup:ATTenuation:MODE` on page 1228

Vertical unit, Attenuation, Gain

If a predefined probe is connected and selected, the attenuation or gain values are shown.

For unknown probes and passive probes in manual mode, you can set user-defined values for unit, gain and attenuation.

Remote command:
`PROBe<m>:SETup:ATTenuation:UNIT` on page 1228
`PROBe<m>:SETup:ATTenuation:MANual` on page 1229
`PROBe<m>:SETup:GAIN:MANual` on page 1229

4.5.4 Setup for Active Voltage Probes

Active voltage probes with Rohde & Schwarz probe interface have an integrated data memory that contains identification data and individual probe correction parameters. The R&S RTO can detect these probes and read out the data. Furthermore, these probes have a micro button and a ProbeMeter.

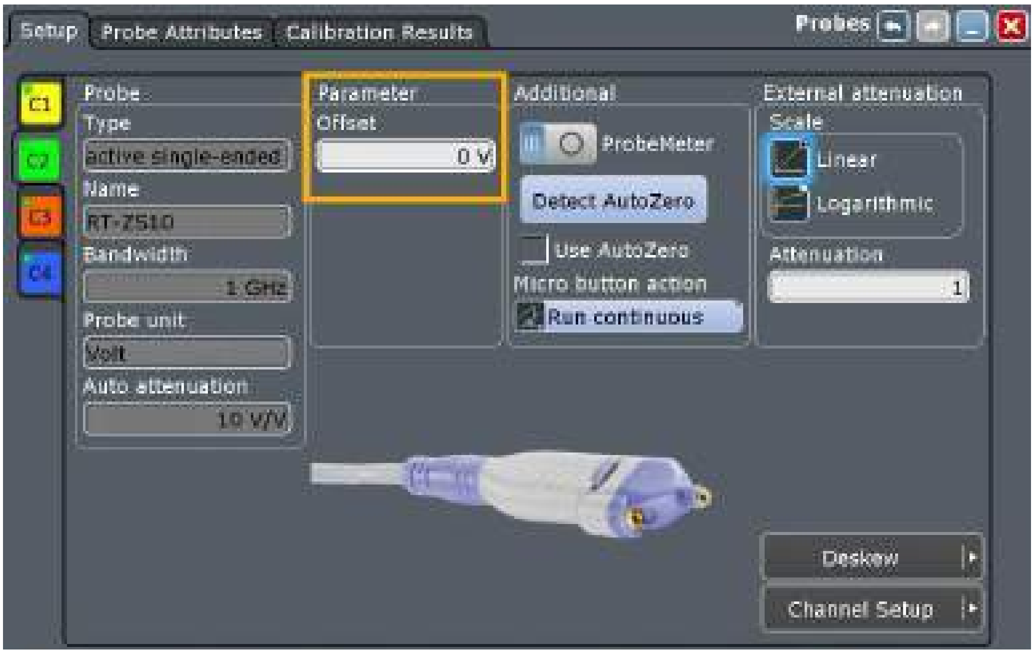
Active voltage probes that are offered by Rohde & Schwarz but not equipped with a Rohde & Schwarz probe interface are known to the R&S RTO as predefined probes, see Chapter 4.5.6, "Setup for Predefined Probes", on page 179.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168

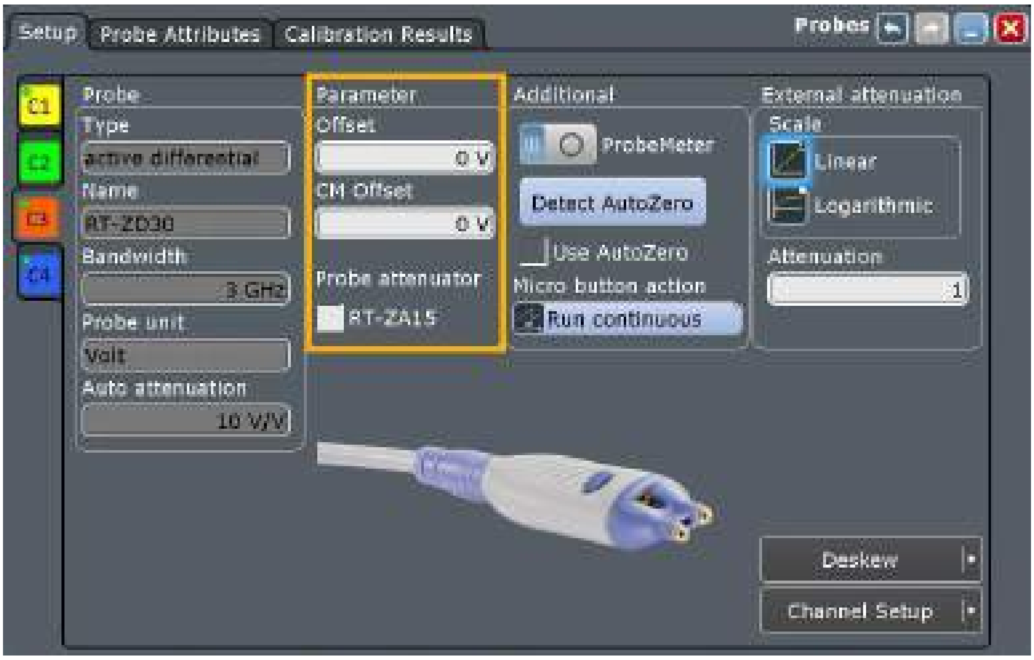
Special features of the Rohde & Schwarz probe interface are described in these sections:

- "Probe unit, Auto attenuation" on page 169
- "Micro button action" on page 169
- "ProbeMeter" on page 170



Type: active single-ended
Name: RT-ZS10
Bandwidth: 1 GHz
Probe unit: Volt
Auto attenuation: 10 V/V
Offset: 0 V
Micro button action: Run continuous
Attenuation: 1

Figure 4-9: Probe setup for active single-ended probe R&S RT-ZS10



Type: active differential
Name: RT-ZD30
Bandwidth: 3 GHz
Probe unit: Volt
Auto attenuation: 10 V/V
Offset: 0 V
CM Offset: 0 V
Micro button action: Run continuous
Attenuation: 1

Figure 4-10: Probe setup for active differential probe R&S RT-ZD30

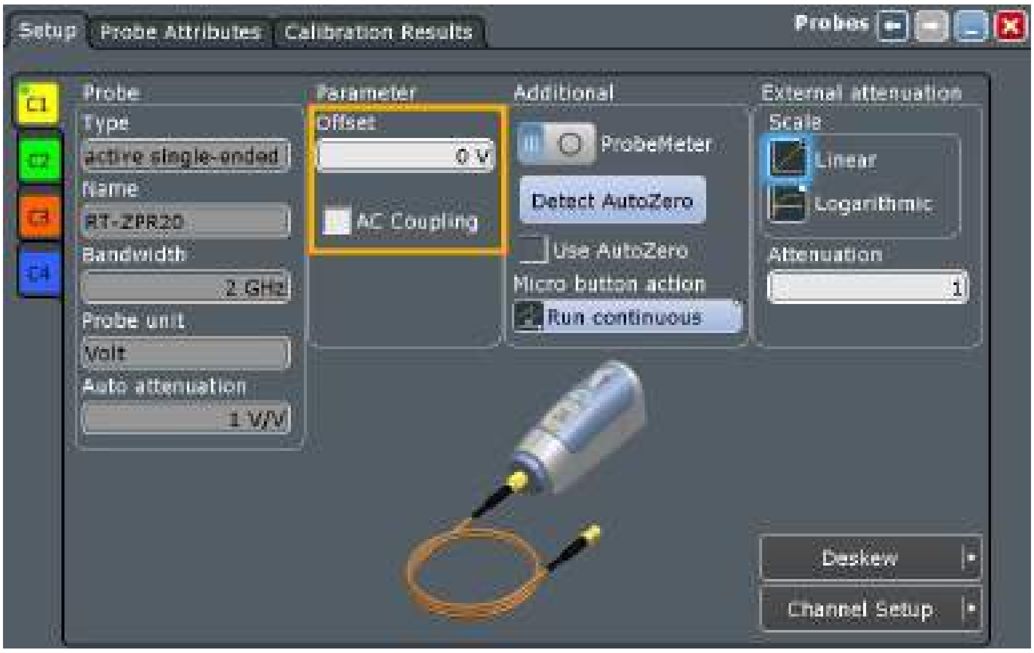


Figure 4-11: Probe setup for power rail probe R&S RT-ZPR20

Specific settings for active single-ended and differential probes with Rohde & Schwarz probe interface are the following:

Offset

For differential probes, this offset is the differential offset.

See "Offset" on page 160.

CM offset

Sets the common-mode offset to compensate for a common DC voltage applied to both input sockets (referenced to the ground socket). Offset compensation is particularly helpful for measurements on differential signals with high common mode levels, for example, current measurements using a shunt resistor. You can measure the common mode input voltage using the R&S ProbeMeter.

The setting is available for Rohde & Schwarz differential probes, and for modular probes in DM or CM mode (see "DM Offset, CM Offset, P Offset, N Offset" on page 177).

Remote command:

`PROBe<m>:SETup:CMOFfset` on page 1229

Probe attenuator RT-ZA15

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable RT-ZA15 to include the external attenuation in the measurements.

Remote command:
`PROBe<m>:SETup:ZAXV` on page 1230

AC Coupling
Enables AC coupling in the R&S RT-ZPR20 probe, which removes DC and very low-frequency components. The R&S RT-ZPR20 probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Remote command:
`PROBe<m>:SETup:ACCoupling` on page 1230

4.5.5 Setup for Modular Probes

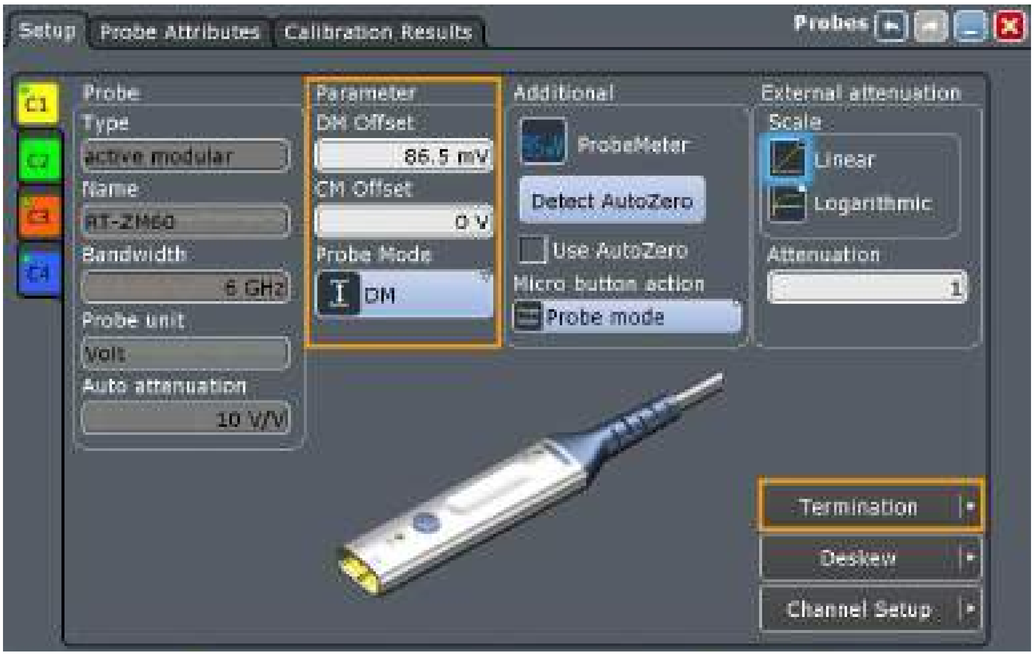
The probes of the R&S RT-ZM family are modular probes. They have a probe amplifier and various probe tip modules and tip cables for different applications. R&S RT-ZM probes are equipped with Rohde & Schwarz probe interface, and provide special features: ProbeMeter, micro button, and a wide offset compensation range.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168

Special features of the Rohde & Schwarz probe interface are described in these sections:

- "Probe unit, Auto attenuation" on page 169
- "Micro button action" on page 169
- "ProbeMeter" on page 170



Type: active modular
Name: RT-ZM60
Bandwidth: 6 GHz
Probe unit: Volt
Auto attenuation: 10 V/V
DM Offset: 86.5 mV
CM Offset: 0 V
Probe Mode: DM
☐ Use AutoZero
Micro button action: Probe mode
Scale: ● Linear ○ Logarithmic
Attenuation: 1

Specific settings for modular probes are the following:

Probe Mode

Sets the measurement mode of modular probes.

The modular probes of the R&S RT-ZM family have a multi-mode function. You can switch between single-ended, differential and common mode measurements without reconnecting or resoldering the probe. You can set the probe mode in the dialog box, and you can assign the probe mode setting to the micro button.

If you use the R&S RT-ZMA30 browser module, only DM measurements are possible because this module has no ground connector.

The measurement modes are:

"DM"	Differential mode input voltage (V_{dm}), the voltage between the positive and negative input terminal. $V_{dm} = V_p - V_n$
"CM"	Common mode input voltage (V_{cm}) , the mean voltage between the positive and negative input terminal vs. ground. $V_{cm} = \frac{V_p + V_n}{2}$
"P"	Positive single-ended input voltage (V_p). The voltage between the positive input terminal and ground.
"N"	Negative single-ended input voltage (V_N). The voltage between the negative input terminal and ground.

Remote command:
`PROBe<m>:SETup:PRMode` on page 1230

DM Offset, CM Offset, P Offset, N Offset

Compensate offset voltages. Available offsets depend on the selected probe mode.

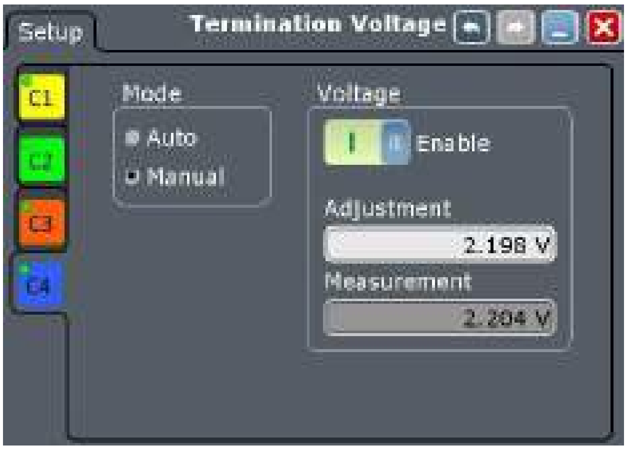
The offset of the selected probe mode is used as channel offset and considered automatically for correction. For example, in CM mode, the common mode offset is used as channel offset. See also: "Offset" on page 160.

"DM Offset"	Compensates a DC voltage applied between the positive (V_p) and the negative (V_n) input terminal at the probe tip.
"CM Offset"	Compensates a DC voltage applied to both input terminals referenced to ground. See also: "CM offset" on page 175.
"P Offset"	Compensates a DC voltage applied to the positive input terminal (V_p) referenced to ground.
"N Offset"	Compensates a DC voltage applied to the negative input terminal (V_n) referenced to ground.

Remote command:
`PROBe<m>:SETup:DMOFfset` on page 1231
`PROBe<m>:SETup:CMOFfset` on page 1229
`PROBe<m>:SETup:NOFFset` on page 1232
`PROBe<m>:SETup:POFFset` on page 1232

Termination Voltage
Termination voltage is relevant if you use the R&S RT-ZMA40 SMA module. The SMA module applies a termination voltage (±4 V) to the DUT to enable measurements against a common mode DC voltage instead of ground. This measurement is required for many digital signal standards.

The termination voltage can be controlled by the oscilloscope. Therefore, connect the V_T terminal of the R&S RT-ZM probe amplifier to the V_T terminal of the R&S RT-ZMA40 SMA module using the red DC lead (see R&S RT-ZMUser Manual). The required termination voltage is measured and adjusted automatically, but can also be set manually.



Adjustment 2.198 V
Measurement 2.204 V

"Mode"	In "Auto" mode, the instrument uses the measured common mode voltage for termination. In "Manual" mode, you can enter the voltage to be used for termination. Use the manual mode if you know the common mode voltage of the DUT.
"Enable"	Activates control of the termination voltage.
"Adjustment"	Voltage to be used for termination to DC voltage.
"Measurement"	Shows the measured common mode voltage.

Remote command:
`PROBe<m>:SETup:TERM:MODE` on page 1232
`PROBe<m>:SETup:TERM:STATe` on page 1232
`PROBe<m>:SETup:TERM:MEASure?` on page 1233
`PROBe<m>:SETup:TERM:ADJust` on page 1233

4.5.6 Setup for Predefined Probes

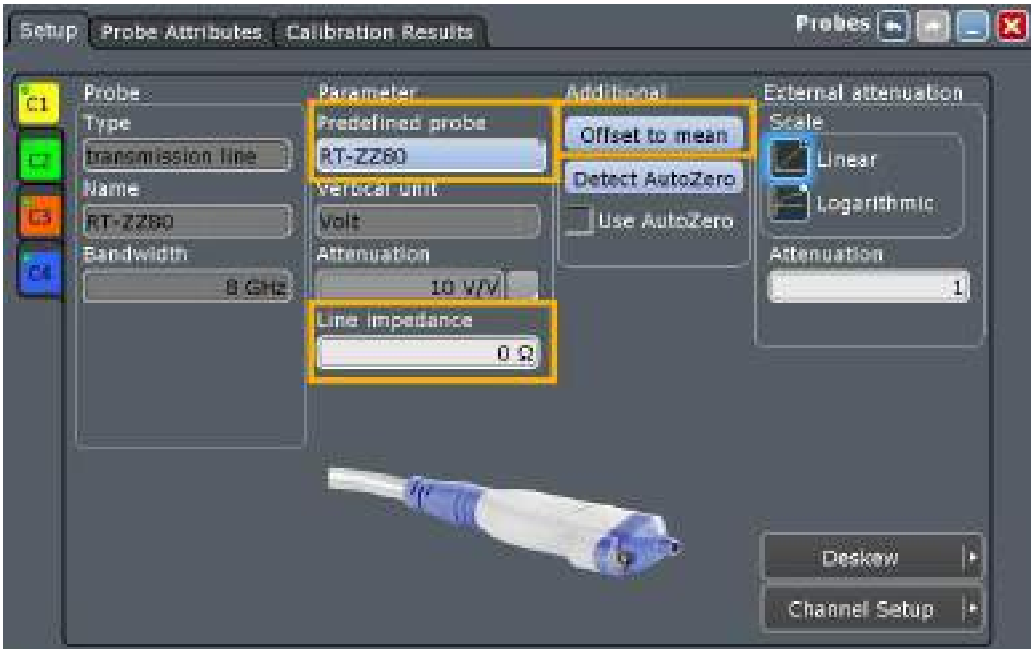
Probes that cannot be detected, but their characteristics are known to the R&S RTO are called "Predefined probes".

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168

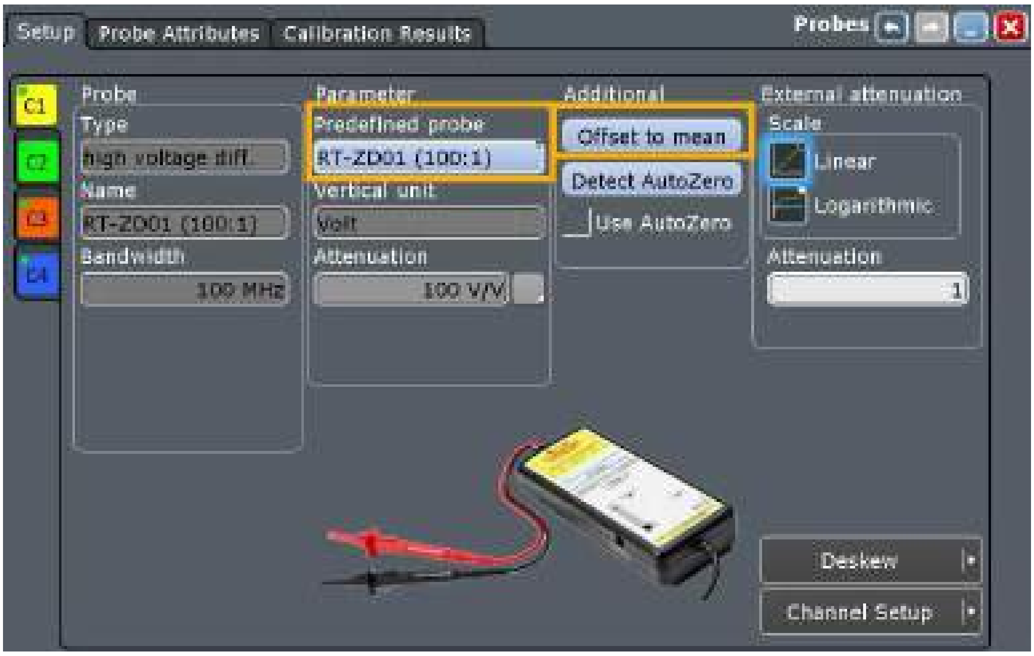
The probe attenuation of the selected probe is also shown in the "Setup" tab:

- "Probe unit, Auto attenuation" on page 169



Type: transmission line
Name: RT-ZZ80
Bandwidth: 8 GHz
Predefined probe: RT-ZZ80
Vertical unit: Volt
Attenuation: 10 V/V
Line impedance: 0 Ω
Attenuation: 1

Figure 4-12: Probe setup for transmission line probe R&S RT-ZZ80



Type: high voltage diff

Name: RT-ZD01 (100:1)

Bandwidth: 100 MHz

Predefined probe: RT-ZD01 (100:1)

Vertical unit: Volt

Attenuation: 100 V/V

Scale: Linear

Attenuation: 1

Figure 4-13: Probe setup for R&S RT-ZD01

Specific settings for predefined probes are the following:

Predefined probe

List of probes that are known to the instrument. Select the used probe on the list. The corresponding "Vertical unit" and the "Attenuation" or "Gain" are shown.

All other unrecognized probes that are not listed, are unknown probes. For these probes, set "Predefined probe" to "None". See Chapter 4.5.8, "Setup for Unknown Probes", on page 183.

Remote command:

`PROBe<m>:SETup:ATTenuation:DEFProbe` on page 1234

Offset to mean

Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. The result is shown in "Offset". The function is probe-independent and supports quick and convenient measurements of input signals with different DC offsets. It detects offset values even when the signal is out of the current measurement range. It also sets the zero level to the determined DC offset in the middle of the screen and thus prevents clipping of the waveform.

Remote command:

`PROBe<m>:SETup:OFFSet:TOMean` on page 1234

Line impedance

If the transmission line probe R&S RT-ZZ80 is selected, enter the impedance of the measured line.

The actual attenuation of the transmission line probe depends on the impedance of the line Z_0:

$\mathit{Attenuation} = 10 + Z_0 / 100$

The instrument uses the actual attenuation to determine the measurement values.

4.5.7 Setup for Current Probes

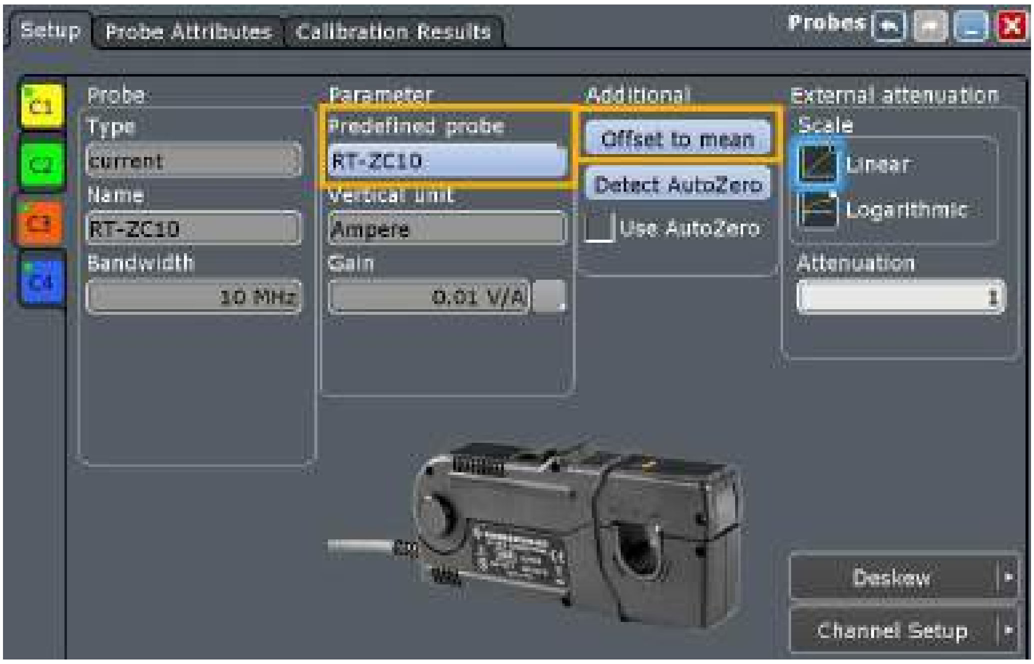
The setup and adjustment of current probes depends on the output connector of the probe: BNC or Rohde & Schwarz probe box.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168

Current probes R&S RT-ZCxx

The current probes **R&S RT-ZCxx** have BNC connectors. They are known to the R&S RTO as predefined probes, see Chapter 4.5.6, "Setup for Predefined Probes", on page 179. Demagnetizing and zero adjustment is done on the probe, see the probe's User Manual for details. Make sure to demagnetize and adjust the probe before taking measurements.



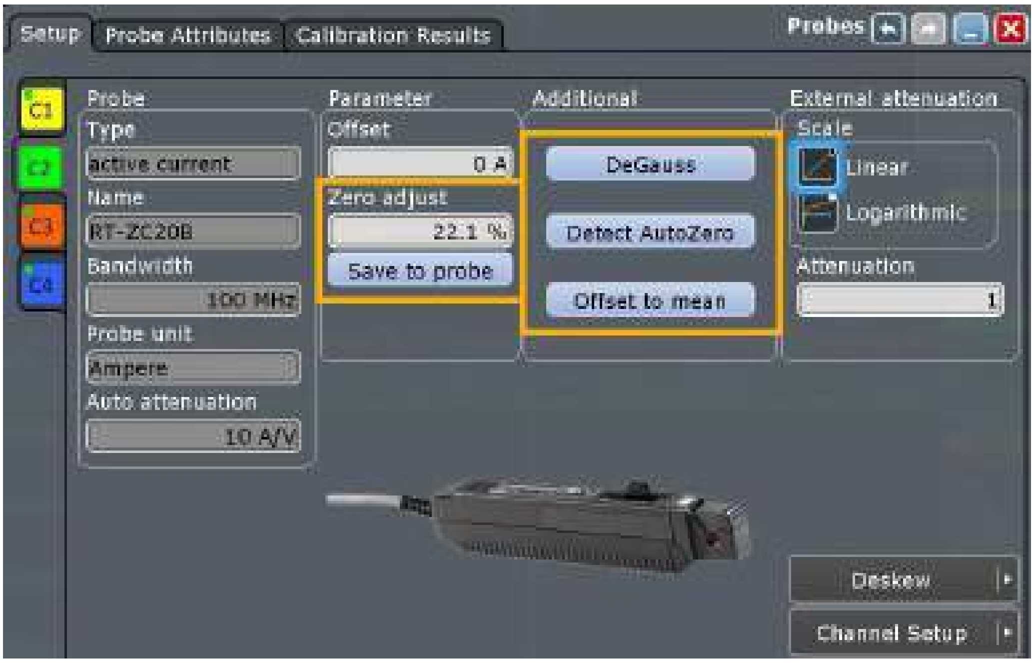
Type: current
Name: RT-ZC10
Bandwidth: 10 MHz
Predefined probe: RT-ZC10
Vertical unit: Ampere
Gain: 0.01 V/A
Attenuation: 1

Figure 4-14: Probe setup for current probes R&S RT-ZC10

Current probes R&S RT-ZCxxB

Current probes **R&S RT-ZCxxB** have a Rohde & Schwarz probe interface; they are powered and remotely controlled by the oscilloscope.

When the probe is connected, demagnetization is performed automatically.



Type: active current
Name: RT-ZC20B
Bandwidth: 100 MHz
Probe unit: Ampere
Auto attenuation: 10 A/V
Offset: 0 A
Zero adjust: 22.1 %
Attenuation: 1

Figure 4-15: Probe setup for current probes R&S RT-ZC20B

For all current probes, attenuation or gain is shown in the "Setup" tab, and you can set the offset to mean:

- "Probe unit, Auto attenuation" on page 169
- "Offset to mean" on page 180

Current probes R&S RT-ZCxxB are adjusted by the following functions:

DeGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

The demagnetizing process takes about one second. During demagnetizing, a demagnetizing waveform is displayed.

Demagnetizing is done automatically when R&S RT-ZCxxB is connected to the oscilloscope, or when "Detect AutoZero" is performed.

Remote command:
`PROBe<m>:SETup:DEGauss` on page 1235

Detect AutoZero

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position to correct the error offset. Thus, it compensates for the remanence and offset caused by temperature drift.

For R&S RT-ZCxxB probes, the determined "Zero adjust" value is displayed and can be saved in the probe head.

See also "Detect AutoZero, Use AutoZero" on page 168.

Remote command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 1223

Zero adjust
Zero adjust corrects the effect of an offset caused by temperature drift, and compensates for the remanence. The setting is only available if DC coupling is set.

To set the waveform to zero level by the instrument, use "Detect AutoZero". The detected value is displayed.

Alternatively, you can adjust the value manually until the waveform is set to zero level. Make sure to demagnetize the probe before zero adjustment.

The value is given in percent of the maximum range, which is internally defined. The actual setup range depends on the temperature drift, the measured current and other variables, and it may change over time. If you measure high currents, the probe core magnetizes, which impairs the measurement results. Therefore, repeat "Detect AutoZero" before the measurement.

Remote command:
`PROBe<m>:SETup:OFFSet:ZADJust` on page 1235

Save to probe
Saves the "Zero adjust" value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again, and you can use the probe without further adjustment.

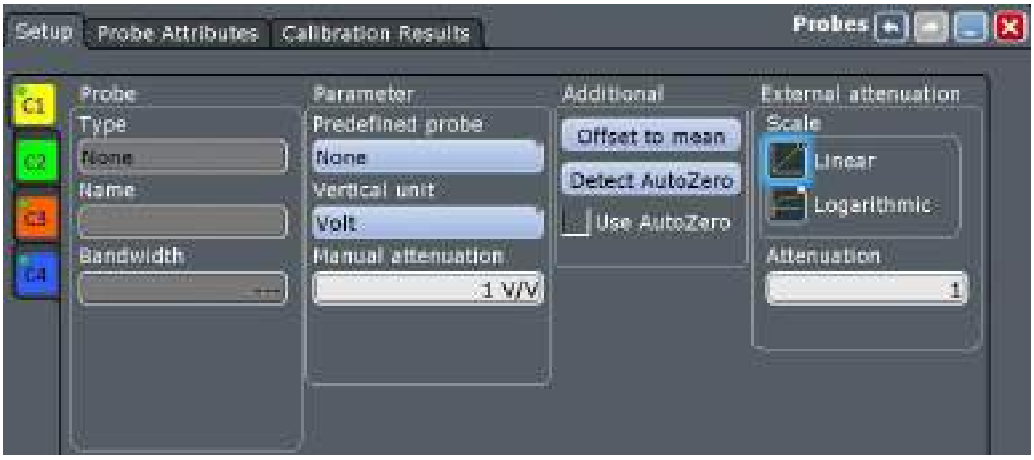
Remote command:
`PROBe<m>:SETup:OFFSet:STPRobe` on page 1235

4.5.8 Setup for Unknown Probes

If the R&S RTO cannot detect the probe, and the probe is not a predefined one, you can set the probe parameters manually.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 167
- "Detect AutoZero, Use AutoZero" on page 168
- "External attenuation: Scale, Attenuation" on page 168



Probe
Type
None
Name
Bandwidth

Parameter
Predefined probe
None
Vertical unit
Volt
Manual attenuation
1 V/V

Additional

Attenuation
1

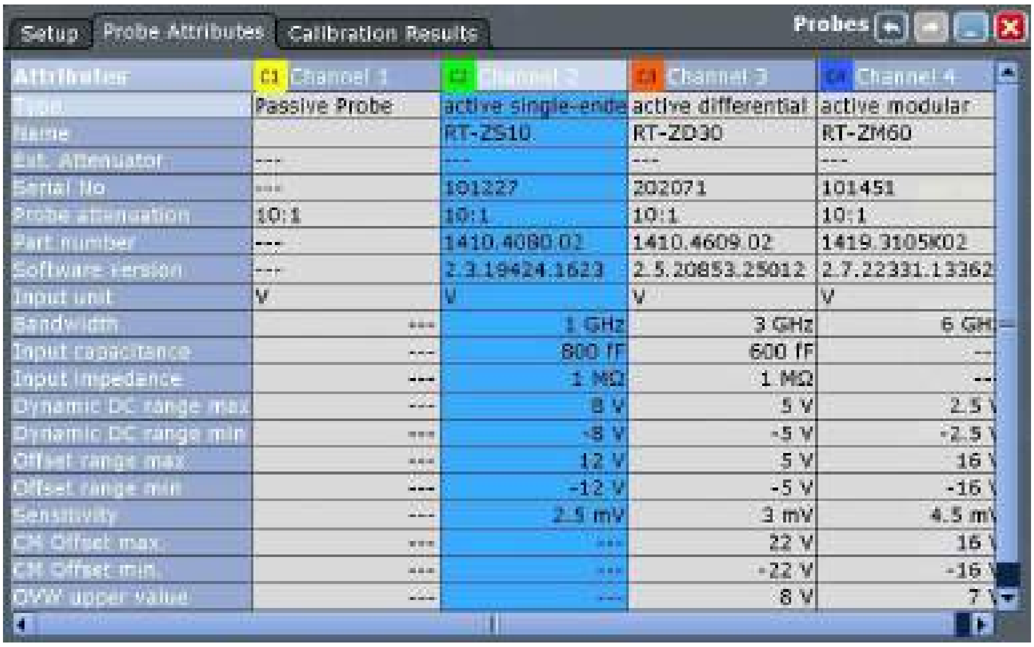
Figure 4-16: Probe setup for an unknown probe

Set the unit and the attenuation or gain of the probe: "Vertical unit, Attenuation, Gain" on page 172.

4.5.9 Probe Attributes

The "Probe Attributes" tab provides an overview of all R&S probes connected to an input channel.

For a specification of the probe parameters, refer to the data sheet.



Attributes	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Type	Passive Probe	active single-ende	active differential	active modular
Name		RT-ZS10	RT-ZD30	RT-ZM60
Ext. Attenuator	---	---	---	---
Serial No	---	101227	202071	101451
Probe attenuation	10:1	10:1	10:1	10:1
Part number	---	1410.4080.02	1410.4609.02	1419.3105K02
Software version	---	2.3.19424.1623	2.5.20853.25012	2.7.22331.13362
Input unit	V	V	V	V
Bandwidth	---	1 GHz	3 GHz	6 GH
Input capacitance	---	800 fF	600 fF	---
Input impedance	---	1 MΩ	1 MΩ	---
Dynamic DC range max	---	8 V	5 V	2.5
Dynamic DC range min	---	-8 V	-5 V	-2.5
Offset range max	---	12 V	5 V	16
Offset range min	---	-12 V	-5 V	-16
Sensitivity	---	2.5 mV	3 mV	4.5 m
CM Offset max	---	---	22 V	16
CM Offset min	---	---	-22 V	-16
OVW upper value	---	---	8 V	7

Remote commands:

- `PROBe<m>:ID:SWVersion?` on page 1236
- `PROBe<m>:ID:PRDate?` on page 1236

- `PROBe<m>:ID:PARTnumber?` on page 1236
- `PROBe<m>:ID:SRNumber?` on page 1236
- `PROBe<m>:SETup:CAPacitance?` on page 1236
- `PROBe<m>:SETup:IMPedance?` on page 1237

4.5.10 Calibration Results

The "Calibration Results" tab provides the calibration data stored in the probe for all R&S probes connected to an input channel.

Calibration	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Probe group delay	---	5.4758 ns	5.2678 ns	5.7158 ns
Probe internal offset	---	-112.3 µV	90 µV	720 µV
Attenuation	10:1	10.7695887:1	10.24402:1	10.760730:1

4.6 R&S RT-ZVC Probe

With the R&S RTO and option R&S RTO-B1E, you can use the R&S RT-ZVC multi-channel high accuracy power probe. It has an integrated 2- or 4-channel amperemeter and 2- or 4-channel voltmeter. The probe provides parallel measurements of analog or digital, voltage/current signals with excellent 18-bit resolution.

For more information on the R&S RT-ZVC probe, see also its user manual.

Source Channels

You can simultaneously connect a R&S RT-ZVC and a R&S RT-ZL04 to the R&S RTO, but no parallel operation on screen is possible.

You can acquire and measure the R&S RT-ZVC or R&S RT-ZL04 together with the analog input channels. They are running on the same horizontal scale.

If an amperemeter or voltmeter channel is activated, it can be displayed on the screen and used as a source for:

- Waveform measurements
- Mask testing
- Waveform math
- Search and mark function
- Display characteristics

All features of the base unit, the R&S RTO-K18 option and R&S RTO-K19 option are supported.

Also, if a R&S RT-ZVC probe is connected, its amperemeter and voltmeter channels can be used as a source for Trigger type "Edge".

Data export

You can save the data of the amperemeter and voltmeter channels to an XML, CSV, or BIN file. One channel per file can be saved. Files in BIN format can be reloaded to the R&S RTO as reference waveforms.

See also:

- Chapter 11.2.6, "Saving and Loading Waveform Data", on page 466
- Chapter 11.2.2, "Waveforms - Export Settings", on page 456

Remote commands for export to file:

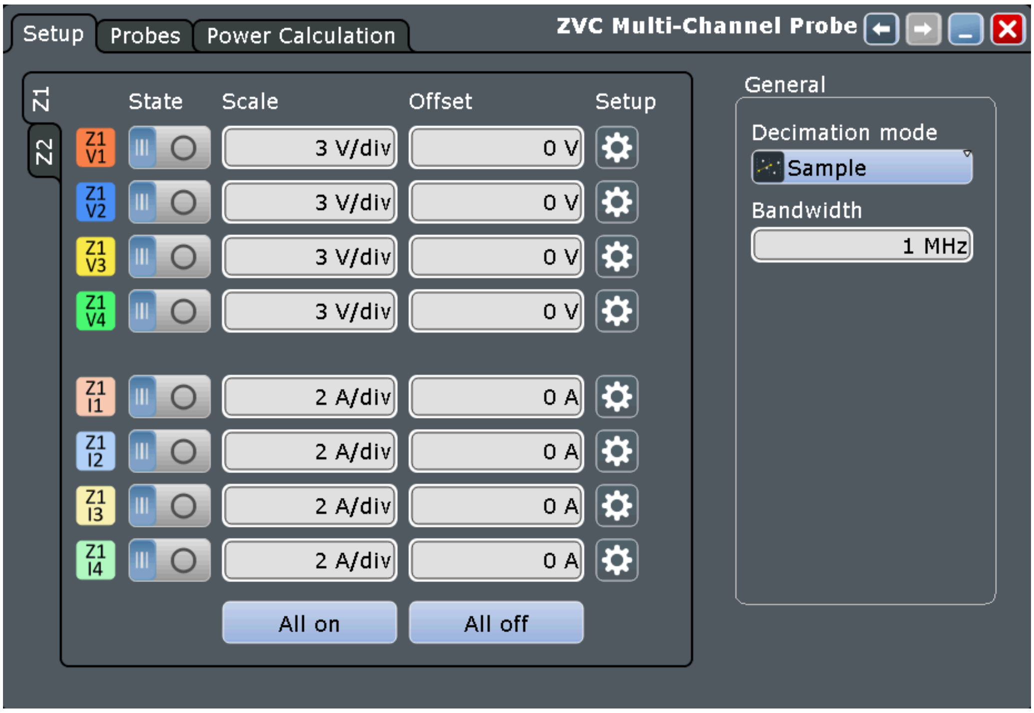
- `EXPort:WAVeform:SOURce` on page 1478
- `EXPort:WAVeform:NAME` on page 1479
- `EXPort:WAVeform:SAVE` on page 1480

4.6.1 R&S RT-ZVC Overview

4.6.1.1 Setup

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" tab

Make sure that the tab of the correct probe is selected on the left side.



	State	Scale	Offset	Setup
Z1 V1		3 V/div	0 V	
Z1 V2		3 V/div	0 V	
Z1 V3		3 V/div	0 V	
Z1 V4		3 V/div	0 V	
Z1 I1		2 A/div	0 A	
Z1 I2		2 A/div	0 A	
Z1 I3		2 A/div	0 A	
Z1 I4		2 A/div	0 A	

Decimation mode: Sample
Bandwidth: 1 MHz

State

Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1245
`ZVC:Z<m>:I<n>[:STATe]` on page 1243

Vertical Scale

Defines the vertical scale for the channel in Volts per division. Increasing the scale compresses the display of the signal. Within a given operation range, modifying the scale is equivalent to scaling a display range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:SCALe` on page 1245
`ZVC:Z<m>:I<n>:SCALe` on page 1240

Offset

The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram area. Negative offset values move up the waveform, positive values move it down.

Within a given operation range, modifying the offset is equivalent to moving vertically the display range. The offset can only be modified such that the display range reaches at most the limits of the operation range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:OFFSet` on page 1243
`ZVC:Z<m>:I<n>:OFFSet` on page 1239

All on

Enables all available channels.

All off

Disables all available channels.

Decimation mode

Selects the decimation mode for all R&S RT-ZVC probes. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution.

"Sample"	One of n samples in a sample interval of the ADC is recorded as waveform point, the other samples are discarded. The time between the two adjacent waveform points is exactly the resolution. Very short glitches might remain undiscovered by this method.
"Peak detect"	The minimum and the maximum of n samples in a sample interval are recorded as waveform points, the other samples are discarded.

"High res"	The average of n sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution. The high measurement resolution is suitable for high accuracy measurements of instantaneous values.

Remote command:
`ZVC:TYPE` on page 1238

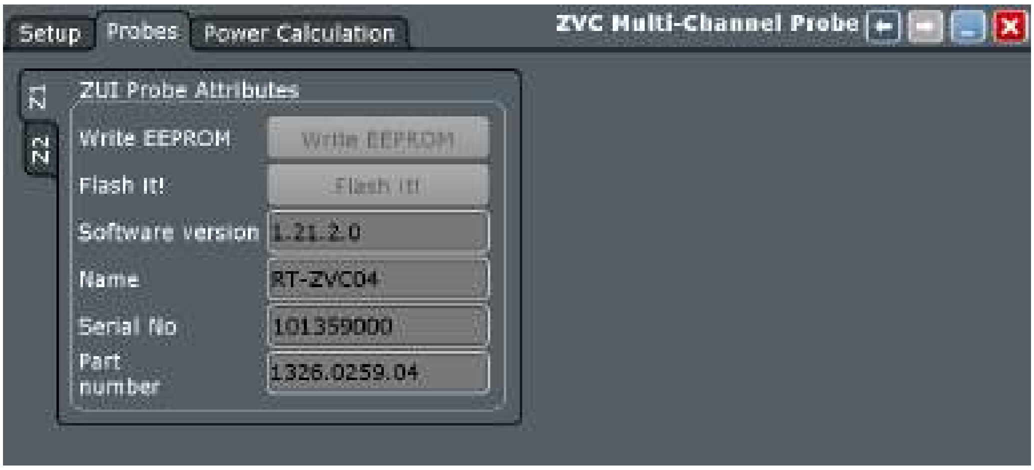
Bandwidth
Sets the bandwidth limit of all R&S RT-ZVC probes. The bandwidth specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 89 % (0.1 dB) of its amplitude.

The bandwidth of some current channels is restricted to 300 KHz due to their vertical settings.

Remote command:
`ZVC:BANDwidth` on page 1238

4.6.1.2 Probes

Access: "Vertical" menu > "ZVC Multi-Channel Probe"> "Probes" tab



Software version: 1.21.2.0
Name: RT-ZVC04
Serial No: 101359000
Part number: 1326.0259.04

Software version
Displays the software version of the probe.

Remote command:
`ZVC:Z<m>:ID:SWVersion?` on page 1246

Name
Displays the name of the probe.

Remote command:
`ZVC:Z<m>:ID:NAME?` on page 1246

Serial no
Displays the serial number of the probe.

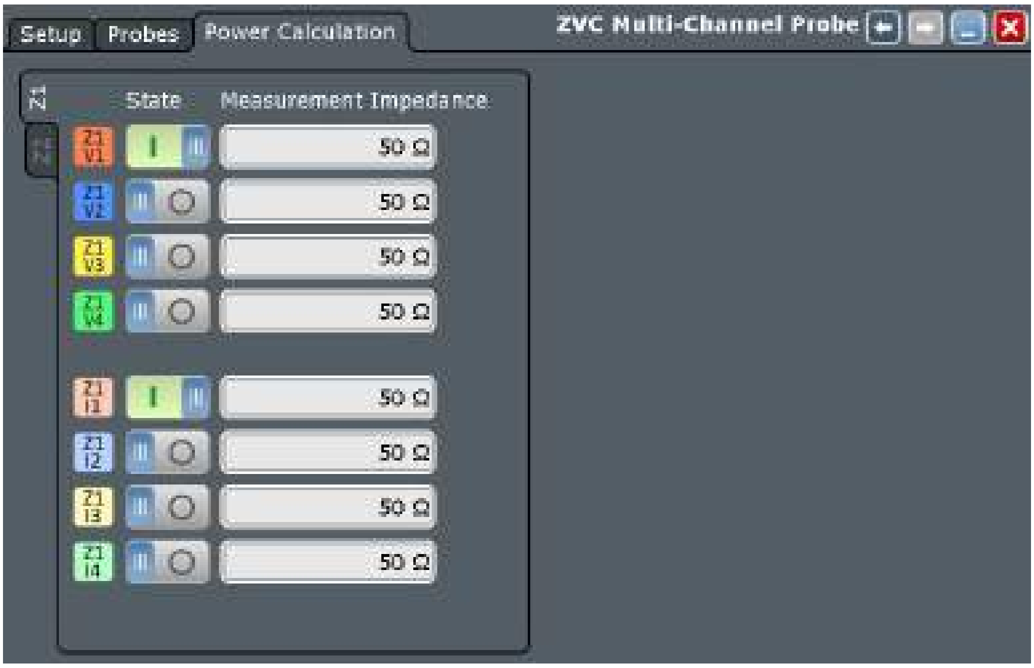
Remote command:
`ZVC:Z<m>:ID:SRNumber?` on page 1246

Part number
Displays the part number of the probe.

Remote command:
`ZVC:Z<m>:ID:PARTnumber?` on page 1246

4.6.1.3 Power Calculation

Access: "Vertical" menu > "ZVC Multi-Channel Probe"> "Power Calculation" tab



State
Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1245
`ZVC:Z<m>:I<n>[:STATe]` on page 1243

Measurement Impedance
Sets the impedance of the probe channel for power calculations and measurements.

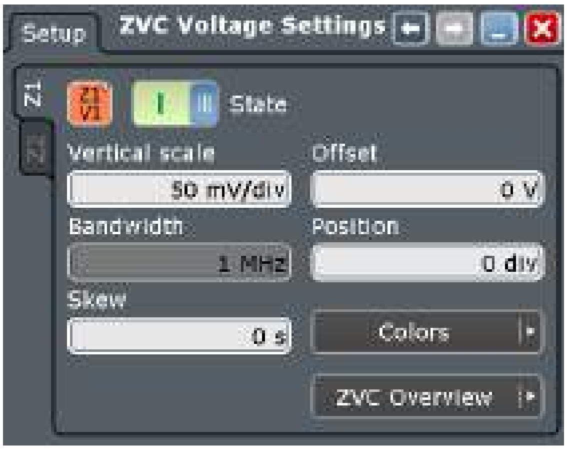
Remote command:
`ZVC:Z<m>:V<n>:IMPedance` on page 1243
`ZVC:Z<m>:I<n>:IMPedance` on page 1239

4.6.2 ZVC Voltage Setup Settings

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" dialog > "Setup" of voltage channel

See also:

- Vertical Scale
- Offset



Vertical scale: 50 mV/div
Offset: 0 V
Bandwidth: 1 MHz
Position: 0 div
Skew: 0 s

Channel
Selects the voltmeter channel to be configured.

State
Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1245
`ZVC:Z<m>:I<n>[:STATe]` on page 1243

Bandwidth
Displays the bandwidth of the current channel. You can set the probe bandwidth in the "Setup" dialog.

Remote command:
`ZVC:Z<m>:V<n>:BANDwidth?` on page 1243

Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset. While the offset sets a voltage, position is a graphical setting given in divisions. Within a given operation range, modifying the position is equivalent to moving vertically the display range. The position can only be modified such that the display range reaches at most the limits of the operation range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:POSition` on page 1244

Skew
Sets the skew, a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

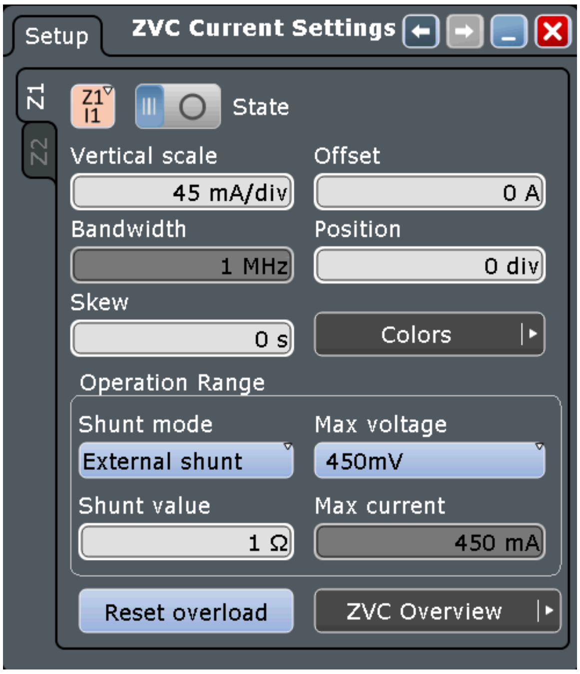
Remote command:
`ZVC:Z<m>:V<n>:SKEW` on page 1245

4.6.3 ZVC Current Setup Settings

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" dialog > "Setup" of current channel

See also:

- Vertical Scale
- Offset



Vertical scale: 45 mA/div
Offset: 0 A
Bandwidth: 1 MHz
Position: 0 div
Skew: 0 s
Shunt mode: External shunt
Max voltage: 450mV
Shunt value: 1 Ω
Max current: 450 mA

Channel
Selects the amperemeter channel to be configured.

State
Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1245
`ZVC:Z<m>:I<n>[:STATe]` on page 1243

Bandwidth
Displays the bandwidth of the current channel. You can set the probe bandwidth in the "Setup" dialog.

Remote command:
`ZVC:Z<m>:I<n>:BANDwidth?` on page 1238

Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset. While the offset sets a current, position is a graphical setting given in divisions. Within a given operation range, modifying the position is equivalent to moving vertically the display range. The position can only be modified such that the display range reaches at most the limits of the operation range.

Remote command:
`ZVC:Z<m>:I<n>:POSition` on page 1240

Skew
Sets the skew, a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Remote command:
`ZVC:Z<m>:I<n>:SKEW` on page 1242

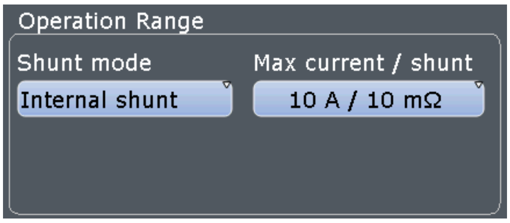
Shunt mode
Selects the internal or external shunt mode.

Regarding the shunt selection, i.e. the burden voltage level, there is a trade-off between the burden of the circuit under test and the SNR at the front-end input. The burden voltage is the DUT circuit loading caused by leads, connectors and the amperemeter circuit.

From the DUT perspective, the burden voltage has to be kept low not to distort the device operation. In contrast, from the probe's view the voltage has to be as large as possible to obtain a good SNR. For that reason, the external shunt can be applied to get the best compromise of both for a specific measurement range.

Remote command:
`ZVC:Z<m>:I<n>:SHUNt:MODE` on page 1241

Internal Shunt Mode
If Shunt mode is set to "Internal shunt", includes the settings for the internal shunt mode.



Shunt mode: Internal shunt
Max current / shunt: 10 A / 10 mΩ

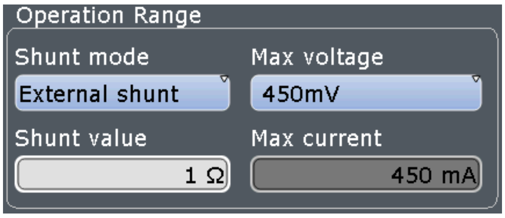
Max current / shunt ← Internal Shunt Mode
Selects the maximum current and the internal shunt value.

With the maximum current and the internal shunt selection, the operating range of the amperemeter is specified. At the same time, the burden voltage at the amperemeter input can be estimated. For values of the total round-trip resistance that can be seen at the test lead ends, consider the data sheet.

For using internal shunts, the circuit under test needs to be interrupted so that the current can flow through the probe.

Remote command:
`ZVC:Z<m>:I<n>:SHUNt:MAXCurrent` on page 1241

External shunt mode
If Shunt mode is set to "External shunt", includes the settings for the external shunt mode.



Operation Range
Shunt mode: External shunt
Max voltage: 450mV
Shunt value: 1 Ω
Max current: 450 mA

Maximum voltage ← External shunt mode
Selects the maximum voltage at the external shunt.

Remote command:
`ZVC:Z<m>:I<n>:SHUNt:MAXVoltage` on page 1242

Shunt value ← External shunt mode
Sets the shunt value of the external shunt resistor.

Remote command:
`ZVC:Z<m>:I<n>:SHUNt:EVALue` on page 1241

Max current ← External shunt mode
Displays the maximum current.

Remote command:
`ZVC:Z<m>:I<n>:SHUNt:MXCValue?` on page 1242

Reset Overload ← External shunt mode
Resets the overload indication at the probe.

Remote command:
`ZVC:Z<m>:I<n>:OVERload:RSTO` on page 1239

4.7 Digital Filter Setup

After processing by the A/D converter, the channel and trigger signals are digitized signals. These digitized signals can be filtered to reject high frequency - also known as Digital Signal Processing (DSP). You can filter the acquisition channels as well as the trigger channel signal.

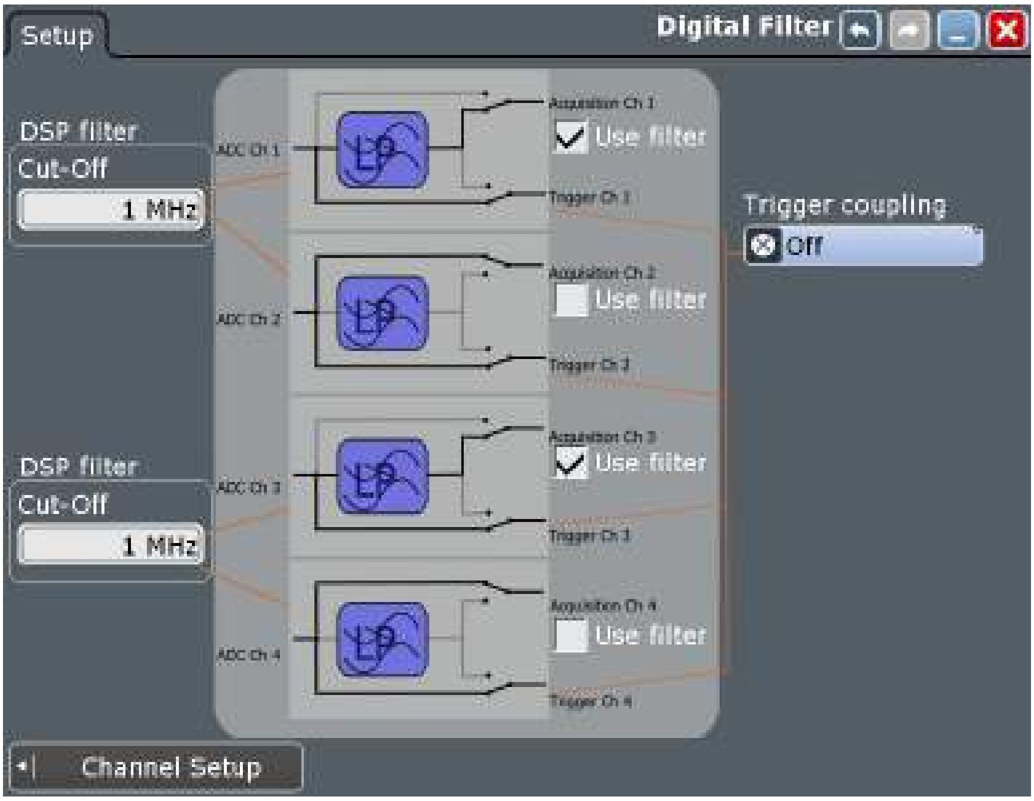
One filter is applied to a pair of channels. If you filter only the input channels, you can apply different filters to the channels - one filter for channels 1 and 2 and - for 4-channel models - another filter for channels 3 and 4.

If you filter the trigger channel, the same filter must be used for the input channels to ensure that all signals suit for analysis. The instrument offers only permitted combinations and triggers on the filtered signal.

If High Definition mode (option R&S RTO-K17), digital filter settings are enabled automatically. You can change the high definition bandwidth in the Digital Filter Setup, which is applied to the channels.

Example:

RF reject for the trigger signal ensures that triggering will not be caused by unexpected glitches.



DSP filter
Cut-Off: 1 MHz

☑ Use filter
☐ Use filter

DSP filter
Cut-Off: 1 MHz

☑ Use filter
☐ Use filter

Trigger coupling: Off

Use filter
Enables the DSP filter for the correspondig input channel.

Remote command:
`CHANnel<m>:DIGFilter:STATe` on page 1247

Cut-off
Sets the limit frequency of the lowpass filter for input channels. One filter is applied to a pair of channels.

Remote command:
`CHANnel<m>:DIGFilter:CUToff` on page 1247

Trigger coupling
Selects the filter for the trigger channel(s). Other channels must use the same filter, or proceed unfiltered.

"Off"	The trigger signal is not filtered, and the acquisition channels can be filtered independently.
"RF reject"	Frequencies higher the "RF reject BW" are rejected, lower frequencies pass the filter.

Remote command:
`TRIGger<m>:COUPling` on page 1247

RF reject BW
Sets the limit frequency for "RF reject" trigger coupling. This limit is applied to the trigger channel and to the input channels enabled for filtering.

Remote command:
`TRIGger<m>:RFReject` on page 1248

4.8 Horizontal Accuracy

The "Horizontal Accuracy" dialog box contains standard and optional settings to improve measurement and analysis accuracy and to reduce jitter effects.

4.8.1 Reference Clock (OCXO, Option R&S RTO-B4)

The option RTO-B4 provides an oven controlled crystal oscillator (OCXO), which produces a 10 MHz internal reference signal with precise and stable frequency. With this option, you can also use an external reference signal. The input and output connectors for the external reference signal are located on the rear panel alongside the external trigger input.

Detected
Indicates if the OCXO option is installed and detected by the instrument.

Oven hot
Indicates when the oven has reached its nominal temperature and is operating with the specified accuracy.

External reference
Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel of R&S RTO. A frequency range from 1 MHz to 20 MHz is supported.

Remote command:
`SENSe[:ROSCillator]:EXTernal:FREQuency` on page 1251

Use external reference
Enables the use of the external reference signal instead of the internal OCXO reference.

If an external reference is used, the frequency of the reference output signal is the same as of the reference input signal. Otherwise, the frequency of the reference output signal is 10 MHz, that is the frequency of the OCXO.

Remote command:
`SENSe[:ROSCillator]:SOURce` on page 1250

4.8.2 Skew

Skew compensates signal propagation differences between channels caused by the different length of cables, probes, and other sources. Correct skew values are important for accurate triggering and timing relations between channels.

☑ Use skew offset

Skew offset: 100 ps

Active probe: RT-ZM60

Probe group delay: 5.7158 ns

Total skew offset: -5.616 ns

Make sure that the correct channel tab is selected.

Show channel
Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 1216

Use skew offset
If enabled, the "Skew offset" value is used for compensation, which improves horizontal and trigger accuracy.

Remote command:
`CHANnel<m>:SKEW:MANual` on page 1248

Skew offset
Sets a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

Remote command:
`CHANnel<m>:SKEW:TIME` on page 1248

Probe skew offset
Measures the skew of all connected active probes and includes it in the total skew offset.

"Use probe group delay ..."	If enabled, the skew of all connected active probes is measured, displayed, and used for deskewing. The setting affects all active channels.
"Active probe"	Shows the type of the probe that connected to the selected channel.
"Probe group delay"	Shows the result of the probe skew measurement.

Total skew offset
Shows the effective skew offset, the sum of the measured "Probe group delay" and the "Skew offset". If "Use skew offset" is disabled, the skew offset is ignored.

4.8.3 AUX OUT

1 GHz Reference ON
Enables the 1 GHz reference signal and sends it to the AUX OUT connector at the front panel. The signal is required for performance test to measure the frequency internal calibration signal.

Remote command:
`CALibration:SOURce:FREQuency` on page 1249
`CALibration:SOURce:STATe` on page 1249

4.9 Setting Up the Waveform

This chapter contains the fundamental procedures for setting up the acquisition and adjusting the channel waveforms.

4.9.1 Adjusting Passive Probes

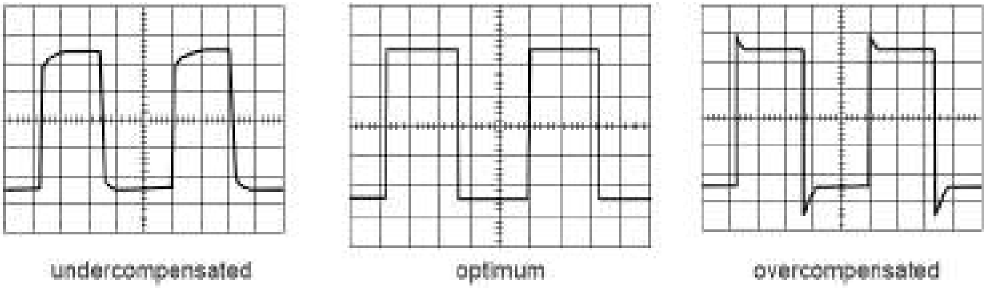
R&S RT-ZP10 passive probes are already pre-compensated to the R&S RTO front-end characteristics, and a compensation procedure is not required.

If you use other passive probes, the R&S RTO allows you to compensate it when it is connected to the instrument the first time. Compensation matches the probe cable capacitance to the oscilloscope input capacitance to assure good amplitude accuracy from DC to upper bandwidth limit frequencies. A poorly compensated probe reduces the performance of the probe-oscilloscope system and introduces measurement errors resulting in distorted waveforms and inaccurate results.

Two connector pins are located on the front panel. The right pin is on ground level. The left pin supplies a square wave signal with 1 kHz for low frequency probe compensation.

1. Connect the BNC connector of the probe to input CH1.
2. Connect the probe's ground connector to the right compensation pin, and the tip with the left pin.
3. Press AUTOSET.

   A square wave appears on the display.
4. Adjust the compensation trimmer of the probe to optimum square wave response. For details, refer to the documentation of your probe.



4.9.2 Setting Up the Signal Input with Autoset

Autoset is the solution for the major part of routine test-setup. It is also a good start if you need to use more complex trigger settings. Autoset finds appropriate horizontal and vertical scales, vertical offset, and trigger conditions to present a stable waveform.

1. Connect the probe to the input connector CH <N>.

   The instrument recognizes the probe and turns the channel on.
2. Press the AUTOSET button on the left of the display.

4.9.3 Adjusting the Signal Input Manually

1. Connect the probe to the input connector CH <N>.

   The instrument recognizes the probe and turns the channel on.
2. On the "Horizontal" menu, tap "Setup".
3. Set the "Time scale".

4. If you want to analyze the signal some time before or after the trigger, use the "Position" and "Reference point" to adjust the visible section of the waveform.
5. Select to set either the resolution or the record length and enter the required value.
6. Press the channel button corresponding to the input channel. It is illuminated with the color of the channel waveform.
7. In the "Channels" tab, select the "Coupling".
8. Adjust the vertical "Scale", and the vertical "Position".
9. Tap "Acquisition" to proceed with the acquisition setup.

4.9.4 Setting the Acquisition

Prerequisites:

- Probes are connected.
- Vertical and horizontal settings are adjusted.

The settings are described in Chapter 4.2.2, "Acquisition", on page 151.

1. On the "Horizontal" menu, tap "Acquisition".
2. To configure the waveform-specific acquisition settings, Enable "Multi channel". Select the "Channel" subtab and activate the waveform.
   You can set up and display up to three waveforms per channel.
3. Select the "Mode" - for example, Peak detect or High res.
4. Select the "Wfm Arithmetic" - for example, Average or Envelope.
   The instrument precludes incompatible combinations, like "Peak detect" with "Average".
5. If "Average" is selected for a waveform, enter the "Average count", that is the number of waveforms used for average calculation.
6. Set the reset condition for the average and envelope calculation:
   a) If "Time" is selected, enter the "Reset time".
   b) If "Waveforms" is selected, enter the "Reset count".

4.9.5 Starting and Stopping Acquisition

You can control the acquisition in two ways:

- Running continuous acquisition until you stop it.
- Running one acquisition or a given number of acquisitions.
  If "Envelope" or "Average" is selected in the "Acquisition" tab, one acquisition means a cycle containing as many acquired waveforms as required to satisfy the reset conditions.

Prerequisites:

- Probes are connected.
- Vertical and horizontal settings are adjusted.
- Triggering is set.
- Channels to be acquired are turned on.

To start and stop continuous acquisition

1. Check if the trigger mode is set to "Normal". The trigger mode is shown in the trigger label in the upper right edge of the screen.
   If not, press the trigger MODE key on the front panel to toggle the setting.
2. Press the RUN STOP key to start acquisition.

   The acquisition starts if a trigger occurs.
3. To stop , press the RUN STOP key again.

   The acquisition stops immediately.

To acquire a limited number of acquisitions

1. Press the Trigger key and tap the "Control" tab.
2. In the "Control" area, select the "Normal" trigger mode.
3. Enter the number of acquisitions in the "Average count" field.
4. Press the SINGLE key on the front panel.
   You can stop the running acquisition before it is finished by pressing the key again.

4.9.6 Using the Roll Mode

The roll mode can be used if the acquisition process is slow - that is if the time scale is large. In roll mode, the instrument shows the waveform immediately and saves waiting for the waveform display. The roll mode can be activated by the instrument if several conditions are fulfilled.

To set the roll mode manually

1. Make sure that all requirements for the roll mode are fullfilled: see "Roll mode" on page 150.
2. Press the HORIZONTAL key.
3. In the "Roll mode" section of the "Setup" tab, set "Mode" to "Auto".
4. In the "Min roll mode gain" field, enter the acquisition time at which the instrument starts the roll mode.

4.9.7 Using Ultra Segmentation

Ultra Segmentation reduces the dead time between two waveform acquisition cycles.

The settings are described in Chapter 4.2.3, "Ultra Segmentation", on page 156.

1. On the "Horizontal" menu, tap "Ultra Segmentation".
2. Tap "Enable" to activate the Ultra Segmentation mode.
3. If you want to sample the maximum number of acquisitions in a series, select "Acquire maximum".
   If you want to capture a defined number of acquisitions, disable "Acquire maximum" and enter the "Required" number of acquisitions.
4. Set the "Replay time", the display time of each acquisition.

4.9.8 Using Digital Filters

Before using digital filters, you determine if you want to filter input channels only or if the trigger signal will be filtered too. The filter settings depend on this decision.

For details on filter settings and dependencies, see Chapter 4.7, "Digital Filter Setup", on page 193.

To filter the input channels only

1. On the "Vertical" menu, tap "Digital Filter Setup".
2. Set the "Trigger coupling" to "Off".
3. Enter the "Cut-off" frequency for each filter.
4. Enable "Use filter" for each channel to be filtered.

To filter the trigger signal

1. On the "Vertical" menu, tap "Digital Filter Setup".
2. Set the "Trigger coupling" to "RF Reject".
3. Set the frequency limit for the filter: "RF reject BW".
4. To filter the input channels too, enable "Use filter" for each channel to be filtered.
   The trigger filter settings are applied also to these input channels.

5 Triggers

5.1 Basics of Triggering

Triggering means to capture the interesting part of the relevant waveforms. Choosing the right trigger type and configuring all trigger settings correctly allows you to detect various incidents in analog, digital, and protocol signals.

Trigger

A trigger occurs if the complete set of trigger conditions is fulfilled. The trigger is the determining point in the waveform record. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger setup

A simple trigger setup includes:

- Source of the trigger signal, its coupling and filtering
- Trigger type selection and setup
- Horizontal position of the trigger: see: Chapter 4.1.3.2, "Horizontal Position", on page 142
- Trigger mode

The R&S RTO provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, pattern trigger, and much more.

For complex tasks like verifying and debugging designs, advanced trigger settings are available:

- Hysteresis, that is the rejection of noise to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event causes the trigger
- Qualification to consider the states of digital signals on other input channels and their logical combination
- Trigger sequences to combine two trigger type conditions

Action on trigger

A trigger can initiate one or more actions, for example, saving a screenshot or saving waveform data. All available actions can be initiated at the same time.

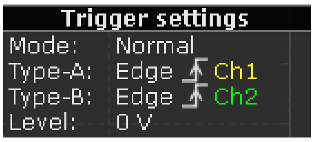
Trigger sequence

A complex trigger sequence joins two separate trigger type conditions with an optional delay time and a reset time or reset condition. This combination is called "A → B → R" trigger sequence. Similar setups are also known as multi-step trigger or A/B trigger.

Trigger information

Information on the most important trigger settings is shown in the trigger label on top of the signal bar. If you double-tap the trigger label, the "Trigger" dialog box opens. The label shows:

- Trigger mode
- Trigger type, edge/polarity and trigger source, for A- and B-trigger
- Trigger level



Trigger settings

Mode:	Normal
Type-A:	Edge ↑ Ch1
Type-B:	Edge ↑ Ch2
Level:	0 V

When no trigger has been found for longer than one second, a message box appears that shows the current state of the trigger. For long timebases, the state indicates the remaining pretrigger time, the waiting time if no trigger occurs, and after the trigger the time until the acquisition is completed. While waiting for the trigger, the "Force trigger" button is available to get a waveform quickly. You can also drag the message box to the signal bar.

External trigger input

If the trigger source is a channel input, the trigger system uses the digitized signal. The trigger system of the instrument is a separate system, thus the signal processing by enhancement, decimation and arithmetic has no impact on the trigger signal. Most of the R&S RTO trigger types use the digitized trigger signal.

If the trigger source is the external trigger input, the trigger comparator uses the analog input signal. For the external trigger signal, only the edge trigger of the A-trigger is available. Trigger sequence is not supported.

Qualification of the external trigger signal is not available.

5.2 Setting Up the Trigger

This chapter provides step-by-step procedures for the important stages of trigger setup.

5.2.1 Configuring a Simple Trigger

Prerequisites:

- Horizontal and vertical settings are set appropriately to the signals.
- The acquisition is running, the RUN STOP key lights green.

For details on settings, see Chapter 5.3, "Trigger Types", on page 206.

Proceed as follows:

1. Press the TRIGGER key on the front panel.

   The "Trigger" dialog box opens with the "Setup" tab.
2. At the left hand-side, select the "A" vertical sub tab.
3. Tap the "Source" button and select the trigger source.
4. Check the trigger coupling and filter settings. To change the settings, tap the "Channel Setup" button and "Digital Filter" button.
   If the trigger source is "Extern", you can adjust the coupling and filters directly in the "Setup" tab.
5. Tap the "Type" button and select the trigger type.
6. Under "Trigger type dependent settings", configure the settings for the selected trigger type.
   See: Chapter 5.3, "Trigger Types", on page 206
7. To let the instrument find the trigger level, tap "Find level".
8. Set the normal trigger mode. Do either of the following:
   - Press the MODE key on the front panel until "Normal" is shown in the trigger label.
   - Tap the "Normal" trigger mode option in the "Ctrl/Action" tab.

5.2.2 Positioning the Trigger

By positioning the trigger on the time axis, you define which part of the waveform is displayed: mainly the pre-trigger part, or the post-trigger part, or the part around the trigger point.

For details on position settings, see Chapter 4.2.2, "Acquisition", on page 151.

1. Press the HORIZONTAL key.
   Alternatively, tap the "Horizontal" menu and then "Setup".
2. Set the "Reference point" and the "Position".
   If you want to set the trigger position outside the waveform display, make sure that "Restrict horizontal position to acquisition range" is disabled.

5.2.3 Using Holdoff

For details on holdoff settings, see Chapter 5.5, "Holdoff", on page 235.

1. Press the TRIGGER key and select the "Holdoff" tab.
   Alternatively, tap the "Trigger" menu and then "Holdoff".
2. Select the "Holdoff mode".
3. Enter the "Holdoff settings" belonging to the selected mode.

5.2.4 Setting Up a Trigger Sequence

The complete configuration of a complex "A → B → R" trigger sequence consists of:

- A-trigger condition
- B-trigger condition in the same way as for the A-trigger, and optional delay time between the two triggers
- Optional reset by timeout and/or R-trigger

For details on sequence settings, see Chapter 5.8, "Sequence", on page 241.

1. Press the TRIGGER key and select the "Setup" tab.
2. Select the type of the "Sequence": "A → B → R".
3. Tap the "A" subtab and configure the first condition.
   See: Chapter 5.2.1, "Configuring a Simple Trigger", on page 204.
4. Select the "B" subtab and configure the B-trigger condition.
5. Optionally, set the "Delay A -> B" that the instrument waits after an A-trigger until it recognizes B-triggers.
6. Set the "B event count". The last B-trigger causes the trigger.
7. You can also define a reset condition. The sequence restarts with the A-trigger if no B-trigger occurs and the reset condition is fulfilled.
   a) Select the "R" subtab.
   b) To specify a reset by timeout, enable "Reset timeout", and enter the time in "Timeout".
   c) To specify a reset trigger type condition, enable "Reset event" and configure the reset trigger type.
      The trigger types and settings are restricted dependent on the A and B trigger settings. The instrument provides only possible, reasonable combinations.

5.2.5 Qualifying the Trigger

Qualification considers the states of digital signals on other input channels and their logical combination as an additional trigger condition. For example, an edge trigger is configured for channel 1, and the instrument triggers only if the signal on channel 2 is high.

For details on qualification settings and restrictions, see Chapter 5.4, "Qualification", on page 233.

1. Press the TRIGGER key and select the Qualification tab.
   Alternatively, tap the "Trigger" menu and then "Qualification".
2. At the left hand-side, select the vertical tab of the trigger you want to qualify: "A".
   Qualification is not available for the B- and R-triggers.
3. Select the channel(s) with the digital input signal to be used as qualifying signal(s).
   Channels used as trigger source for the current trigger condition cannot be used for qualification and appear dimmed.
4. Check and set the trigger levels for all used channels, that is, the thresholds for digitization of analog signals.
   You can set all levels to the currently selected value if you select "Couple levels".
5. Set the boolean operation for each channel.
6. If more than one channel is selected, set the logical combination of the channel states.
7. Tap "Qualify" to enable the qualification.

5.3 Trigger Types

The setup of the trigger type is the most important part of the trigger definition. It determines the method to identify specific signal phenomena. Almost all trigger types are available for all conditions in a trigger sequence, that is, you can combine different types in the sequence. The instrument checks the trigger settings for compatibility and feasibility, and disables settings that do not fit the previous settings in the sequence.

Make sure that the correct trigger tab is selected on the left before you enter the settings.

The settings in the "Setup" tab are:

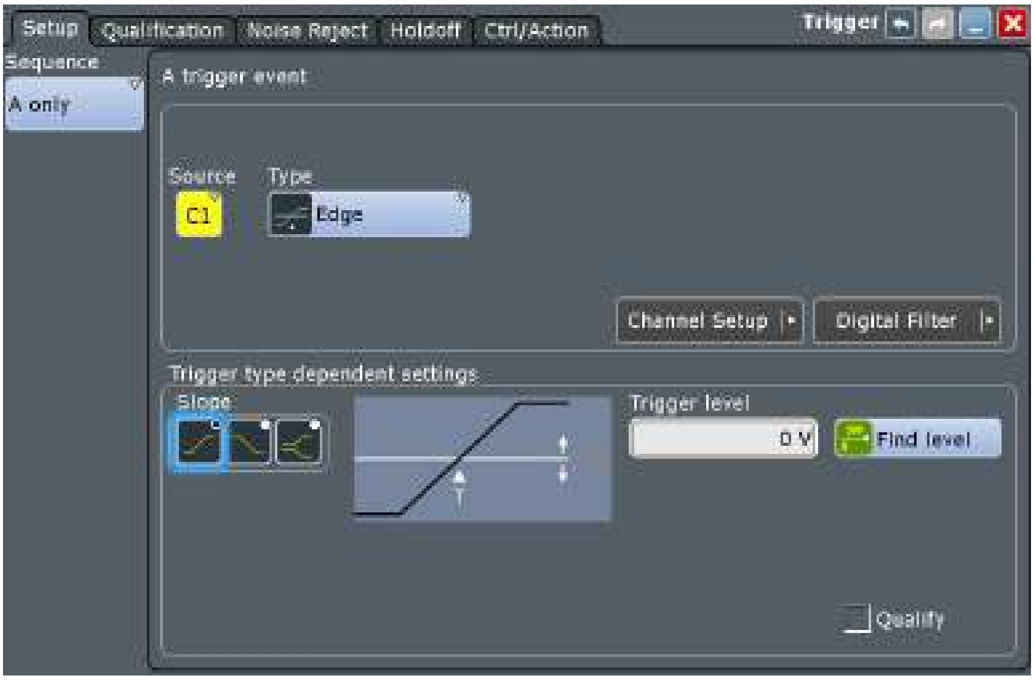
5.3.1 Basic Trigger Settings

Access: TRIGGER > "Setup" tab

The basic trigger settings are the trigger source and the trigger type, including the trigger level. These settings are specific for each condition in a trigger sequence "A → B → R". For the trigger source, the current ground/coupling settings are displayed, filtering is also possible.

Depending on the trigger type, additional settings are available. These settings are located under "Trigger type dependent settings".

- Let the R&S RTO find the trigger level: "Find level".
- Set the trigger levels to the same value for all channels.
- Enable trigger qualification.



Sequence: A only
Source: C1
Type: Edge
Trigger level: 0 V

C1 **Source**
Selects the source of the trigger signal for the current trigger condition. The trigger source works even if it is not displayed in a diagram. It must be synchronized to the signal to be displayed and analyzed.

The trigger source can be:

- Channel 1...4: An analog input channel
- Extern: External analog signal connected to the external trigger input
  The external trigger source is supported for the "A only" sequence. It is not available if a longer trigger sequence is selected, or if qualification is enabled.
- Line: The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency. Use this source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.
  Only available on R&S RTO2000 instruments, depending on the integrated power supply unit.
- Serial bus, D0...D15, Logic, Parallel bus 1...4:
  If options with trigger functionality are installed, the variety of trigger sources of the A-setup is enhanced with specific trigger sources.

Available sources depend on the trigger sequence setting. If "A only" is selected, all inputs (analog input channels, serial and parallel buses, digital channels) can be used as trigger source. If any other trigger sequence is selected, only channel inputs Ch1...4 can be set as trigger source, and all other input sources are disabled. See also: Chapter 5.8, "Sequence", on page 241

Remote command:
`TRIGger<m>:SOURce` on page 1252

Type
Selects the trigger type specific for each condition in a trigger sequence. The current trigger type is shown on the button.

The following trigger types are available:

- Edge, see page 210
- Glitch, see page 213
- Width, see page 214
- Runt, see page 215
- Window, see page 217
- Timeout, see page 218
- Interval, see page 219
- Slew Rate, see page 221
- Data2Clock, see page 222
- State, see page 224
- Pattern, see page 225
- Serial Pattern, see page 226
- TV/Video Trigger, see page 228
- NFC Trigger, see page 1033 (requires option R&S RTO-K11)
- CDR Trigger, see page 1051 (requires option R&S RTO-K13)

Restrictions:

- If the external trigger input is used as trigger source, the analog edge trigger is the only available trigger type.
- For the R-trigger (reset), the trigger types and settings are restricted dependent on the A and B trigger settings. The instrument provides only possible, reasonable combinations.

Remote command:
`TRIGger<m>:TYPE` on page 1252

Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source and the TV trigger.

Remote command:
`TRIGger<m>:FINDlevel` on page 1254

Qualify
Enables the settings for trigger qualification that are defined in the "Qualification" tab. Qualification adds additional trigger conditions considering the logic states of other digital channel signals.

The checkmark is only active if at least one qualification channel is selected.

Qualification is available for many trigger types: Edge, Glitch, Width, Runt, Window, Timeout, and Interval.

Qualification is not possible for the R-event.

See also: Chapter 5.4, "Qualification", on page 233.

Robust trigger
The "Robust trigger" setting is relevant for all trigger types with an event condition that is based on the time difference between a rising and a falling edge. These trigger types are: glitch, width, runt, timeout, window, data2clock, pattern, and serial pattern. It avoids an undefined state of the trigger system that might occur due to hysteresis, for example, when triggering on the envelope of a modulated signal.

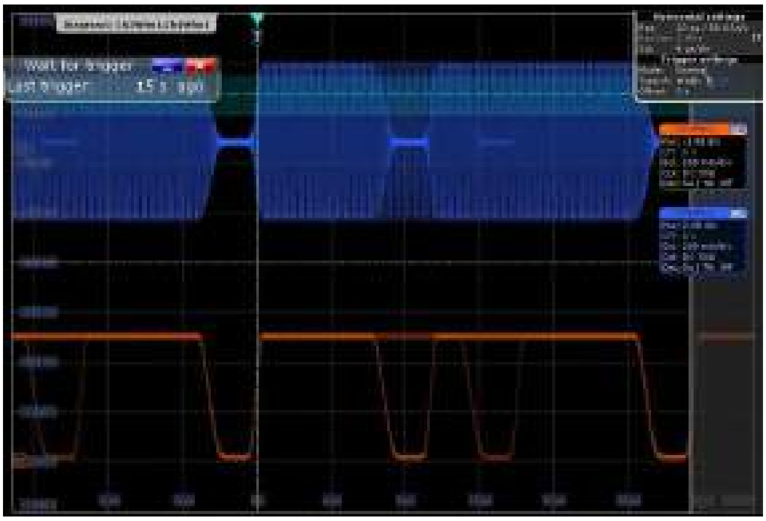


Figure 5-1: Width trigger (negative polarity) on modulated signal - no trigger occurs

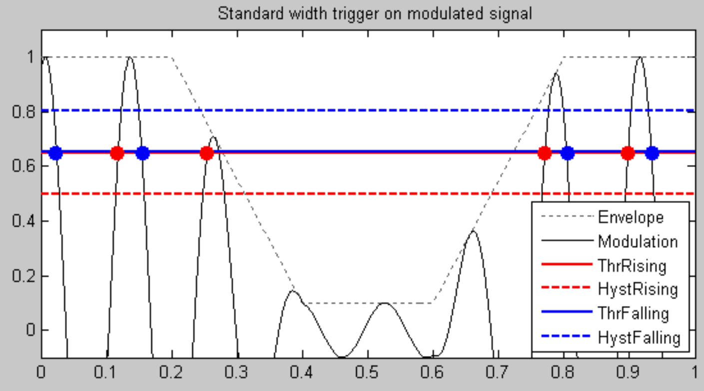


Figure 5-2: Standard width trigger

ThrRising = ThrFalling = Trigger thresholds for rising and falling edge are the same. The instrument misses the falling edge at T=0,27 because the signal stays below the hysteresis threshold. No trigger occurs due to an undefined state of the trigger system.

The robust trigger inserts a shift by the hysteresis value between the trigger threshold for the falling edge and the trigger threshold for the rising edge. Thus, the trigger cannot "hang" inside the hysteresis, triggering is always ensured.

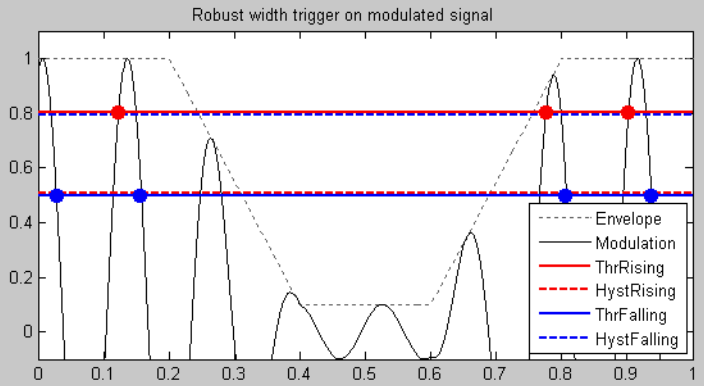


Figure 5-3: Robust width trigger

ThrRising = HystFalling, ThrFalling = HystRising = Rising and falling edge are detected by turns, noise is rejected, less accuracy in trigger measurement

The disadvantage of the robust trigger is a slight inaccuracy in the trigger measurements, because different trigger levels are used. For steep edges, the inaccuracy can be ignored.

See also: Chapter 5.6, "Noise Reject", on page 236

Remote command:
`TRIGger<m>:ROBust` on page 1254

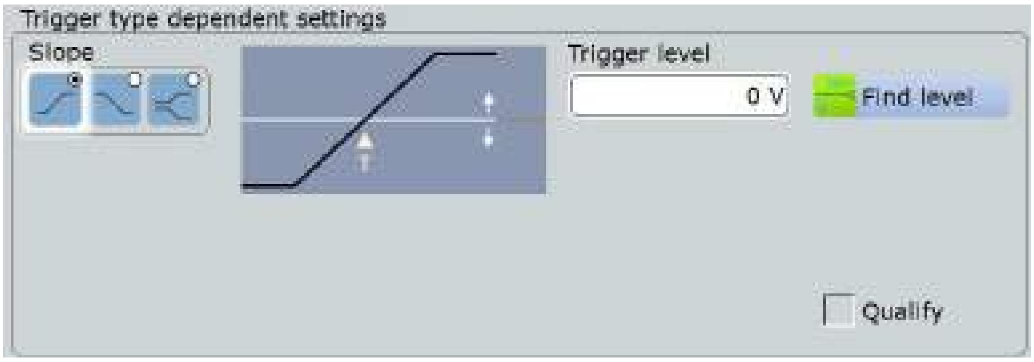
5.3.2 Edge

Access: TRIGGER > "Setup" tab > "Type = Edge"

The edge trigger is the most common trigger type. It is well-known from analog oscilloscopes; and you can use it for analog and digital signals.

The trigger condition is fulfilled when the signal from the trigger source passes the specified threshold voltage in the specified direction (slope).

If the trigger source is a channel signal, the edge trigger uses the digitized trigger signal. This signal can be qualified and filtered with the DSP filter. If the trigger source is the external trigger input, the coupling and filter for this signal is set directly in the trigger setup.



Slope
Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
`TRIGger<m>:EDGE:SLOPe` on page 1255
`TRIGger<m>:ANEDge:SLOPe` on page 1257
`TRIGger<m>:SLEW:SLOPe` on page 1267

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

5.3.3 Analog Edge

Access: TRIGGER > "Setup" tab > "Source = Extern" > "Type = Analog edge"

This edge trigger is available for trigger signals connected to the external trigger input.

The "Find level" function is not available for external trigger signals.

See also: "External trigger input" on page 203

Ground
If the selected trigger source is the external trigger input, you can connect the trigger input to the ground.

Remote command:
`TRIGger<m>:ANEDge:GND` on page 1257

Coupling
If the selected trigger source is the external trigger input, you can set the coupling directly in the trigger configuration.

"DC 50 Ω"	Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.
"DC 1 MΩ"	Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.
"AC"	Connection through capacitor, removes unwanted DC and very low-frequency components.

Remote command:
`TRIGger<m>:ANEDge:COUPling` on page 1255

Filter
If the selected trigger source is "Extern" (external trigger input), you can directly select a filter to reject high or low frequencies.

For all other trigger sources, you can add a digital filter using the Digital Filter Setup.

"Off"	The trigger signal is not filtered.
"Highpass"	Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.
"Lowpass"	Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.

Remote command:
`TRIGger<m>:ANEDge:FILTer` on page 1256
`TRIGger<m>:ANEDge:CUToff:HIGHpass` on page 1256
`TRIGger<m>:ANEDge:CUToff:LOWPass` on page 1256

Slope
Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
`TRIGger<m>:EDGE:SLOPe` on page 1255
`TRIGger<m>:ANEDge:SLOPe` on page 1257
`TRIGger<m>:SLEW:SLOPe` on page 1267

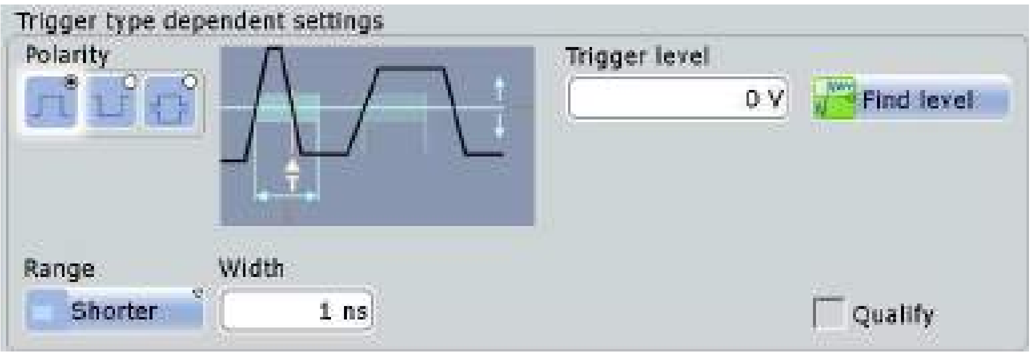
Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

5.3.4 Glitch

Access: TRIGGER > "Setup" tab > "Type = Glitch"

The glitch trigger detects pulses shorter or longer than a specified time. It identifies deviation from the nominal data rate and helps to analyze causes of even rare glitches and their effects on other signals.



Trigger level: 0 V

Range: Shorter

Width: 1 ns

☐ Qualify

Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 1258
`TRIGger<m>:RUNT:POLarity` on page 1260

Range
Selects which glitches are identified: shorter or longer than the specified "Width".

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 1258

Width
Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value. The minimum width is 100 ps.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Remote command:
`TRIGger<m>:GLITch:WIDTh` on page 1258

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

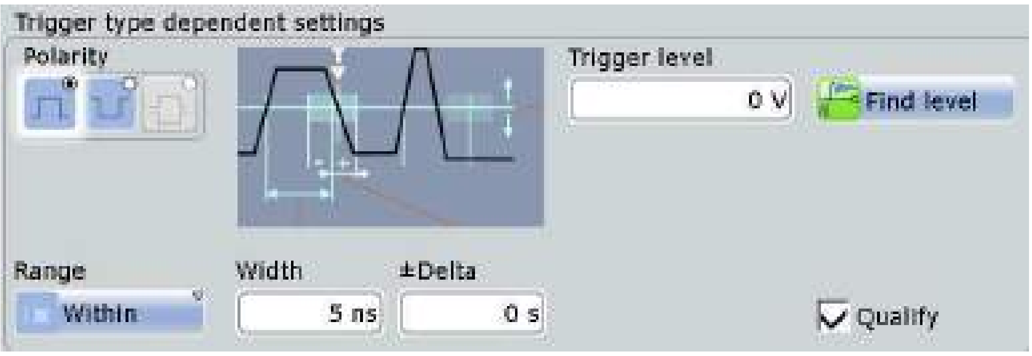
Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

5.3.5 Width

Access: TRIGGER > "Setup" tab > "Type = Width"

The width trigger compares the pulse width (duration of a pulse) with a given time limit. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, and pulses inside or outside the allowable time range. The pulse width is measured at the trigger level.

Using the width trigger, you can define the pulse width more precisely than with the glitch trigger. However, using the range settings "Shorter" and "Longer", you can also trigger on glitches.



Trigger level: 0 V
Range: Within
Width: 5 ns
±Delta: 0 s
☑ Qualify

While the width trigger can only analyze **either** positive **or** negative polarity, searching for a width is also possible for both polarities at the same time ("Either").

Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Triggers on positive going pulses.
"Negative"	Triggers on negative going pulses.

Remote command:
`TRIGger<m>:WIDTh:POLarity` on page 1259

Range
Selects how the range of a pulse width is defined:

"Within"	Triggers on pulses inside a given range. The range of the pulse width is defined by "±Delta" related to "Width".
"Outside"	Triggers on pulses outside a given range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on pulses shorter than the given "Width".
"Longer"	Triggers on pulses longer than the given "Width".

Remote command:
`TRIGger<m>:WIDTh:RANGe` on page 1259

Width
For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits ±Delta.

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Remote command:
`TRIGger<m>:WIDTh:WIDTh` on page 1259

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

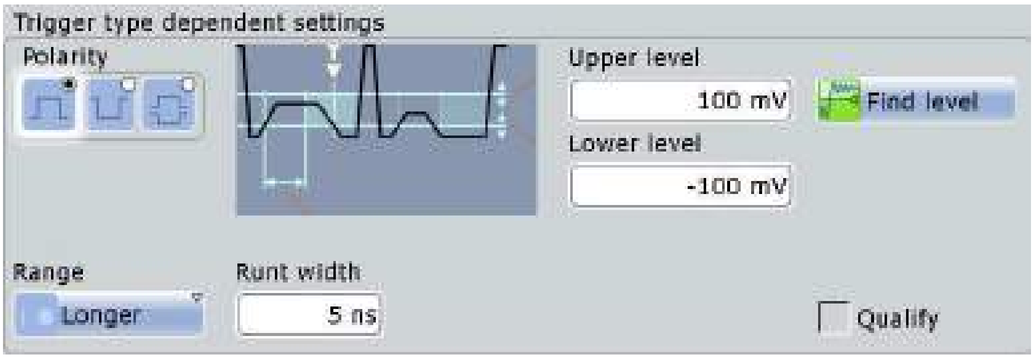
Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

5.3.6 Runt

Access: TRIGGER > "Setup" tab > "Type = Runt"

A runt is a pulse lower than normal in amplitude. The amplitude crosses the first threshold twice in succession without crossing the second one. In addition to the threshold amplitudes, you can define a time limit for the runt in the same way as for width triggers. For example, this trigger can detect logic, digital, and analog signals remaining below a specified threshold amplitude because I/O ports are in undefined state.



Trigger type dependent settings

Polarity

Upper level: 100 mV

Find level

Lower level: -100 mV

Range: Longer

Runt width: 5 ns

☐ Qualify

Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 1258
`TRIGger<m>:RUNT:POLarity` on page 1260

Upper level
Sets the upper voltage threshold.

Remote command:
`TRIGger<m>:LEVel<n>:RUNT:UPPer` on page 1261

Lower level
Sets the lower voltage threshold.

Remote command:
`TRIGger<m>:LEVel<n>:RUNT:LOWer` on page 1261

Range
Selects how the time limit of the runt pulse is defined:

"Any runt"	Triggers on all runts fulfilling the level condition, without time limitation.
"Longer"	Triggers on runts longer than the given "Runt width".
"Shorter"	Triggers on runts shorter than the given "Runt width".
"Within"	Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".
"Outside"	Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

Remote command:
`TRIGger<m>:RUNT:RANGe` on page 1261

Runt width
For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

Remote command:
`TRIGger<m>:RUNT:WIDTh` on page 1261

±Delta
Defines a range around the given runt width.

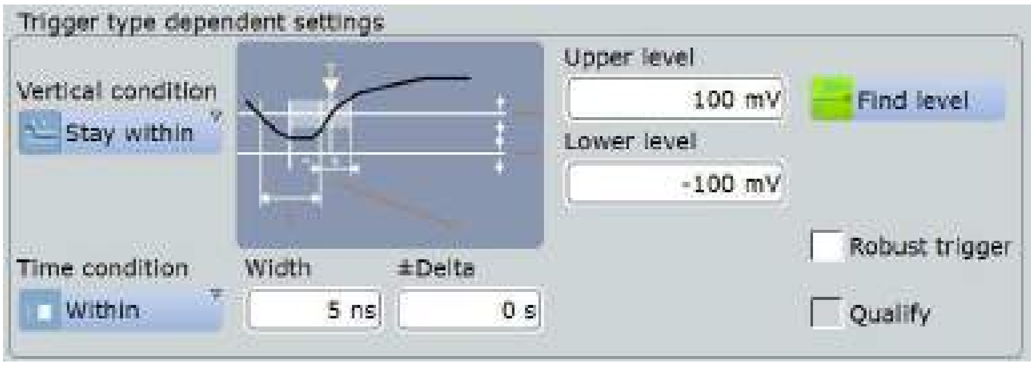
Remote command:
`TRIGger<m>:RUNT:DELTa` on page 1262

5.3.7 Window

Access: TRIGGER > "Setup" tab > "Type = Window"

The window trigger checks the signal run in relation to a "window". The window is formed by the upper and lower voltage levels. The trigger condition is fulfilled, if the waveform enters or leaves the window, or if the waveform stays inside or outside for a time longer or shorter than specified.

With the window trigger, you can display longer transient effects.



Trigger type dependent settings

Vertical condition: Stay within

Upper level: 100 mV

Lower level: -100 mV

Time condition: Within

Width: 5 ns

±Delta: 0 s

☐ Robust trigger

☐ Qualify

Vertical condition
Selects how the signal run is compared with the window:

"Enter"	Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.
"Exit"	Triggers when the signal leaves the window.
"Stay within"	Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the Time condition.
"Stay outside"	Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the "Time condition".

Remote command:
`TRIGger<m>:WINDow:RANGe` on page 1263

Upper level
Sets the upper voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:UPPer` on page 1262

Lower level
Sets the lower voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:LOWer` on page 1262

Time condition
Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "Stay within" and "Stay outside".

"Within"	Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width* - *Delta* and for *Width* + *Delta* at the most.
"Outside"	"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width* - *Delta* or longer than *Width* + *Delta*.
"Shorter"	Triggers if the signal crosses vertical limits before the specified "Width" time is reached.
"Longer"	Triggers if the signal crosses vertical limits after the specified "Width" time is reached.

Remote command:
`TRIGger<m>:WINDow:TIME` on page 1263

Width
For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Remote command:
`TRIGger<m>:WINDow:WIDTh` on page 1264

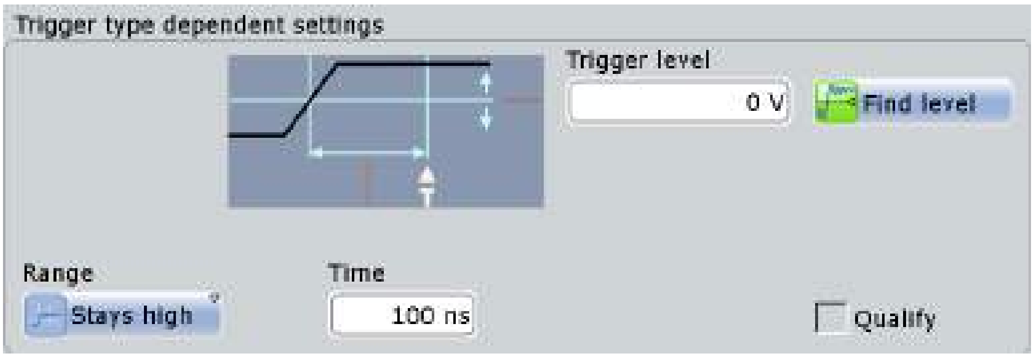
±Delta
Defines a range around the "Width" value.

Remote command:
`TRIGger<m>:WINDow:DELTa` on page 1264

5.3.8 Timeout

Access: TRIGGER > "Setup" tab > "Type = Timeout"

The timeout trigger checks if the signal stays above or below the threshold voltage for a specified time lapse. In other words, the trigger occurs if the trigger source does not have the expected transition within the specified time.



Trigger type dependent settings

Trigger level: 0 V

Range: Stays high

Time: 100 ns

☐ Qualify

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Range
Selects the relation of the signal level to the trigger level:

"Stays high"	The signal level stays above the trigger level.
"Stays low"	The signal level stays below the trigger level.
"High or low"	The signal level stays above or below the trigger level.

Remote command:
`TRIGger<m>:TIMeout:RANGe` on page 1265

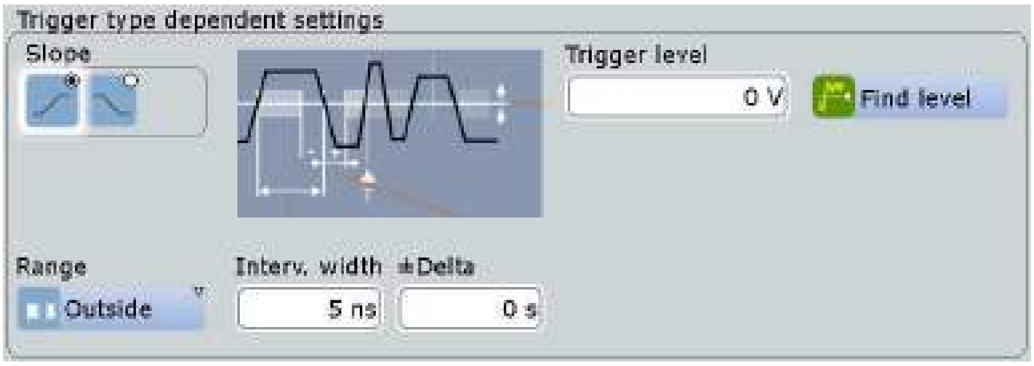
Time
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:TIMeout:TIME` on page 1265

5.3.9 Interval

Access: TRIGGER > "Setup" tab > "Type = Interval"

The interval trigger analyzes the time between two pulses.


Trigger type dependent settings
Slope
Trigger level: 0 V

Range: Outside
Interv. width: 5 ns
±Delta: 0 s

While the interval trigger can only analyze **either** rising **or** falling edges, searching for an interval is also possible for both edges at the same time ("Either").

Slope
Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Remote command:
`TRIGger<m>:INTerval:SLOPe` on page 1266

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Range
Selects how the range of an interval is defined:

"Within"	Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".
"Outside"	Triggers on intervals outside a given range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on intervals shorter than the given "Interv. width".
"Longer"	Triggers on intervals longer than the given "Interv. width".

Remote command:
`TRIGger<m>:INTerval:RANGe` on page 1266

Interv. width
Defines the time between two pulses.

Remote command:
`TRIGger<m>:INTerval:WIDTh` on page 1266

±Delta

Defines a range around the "Interval width" value.

Remote command:

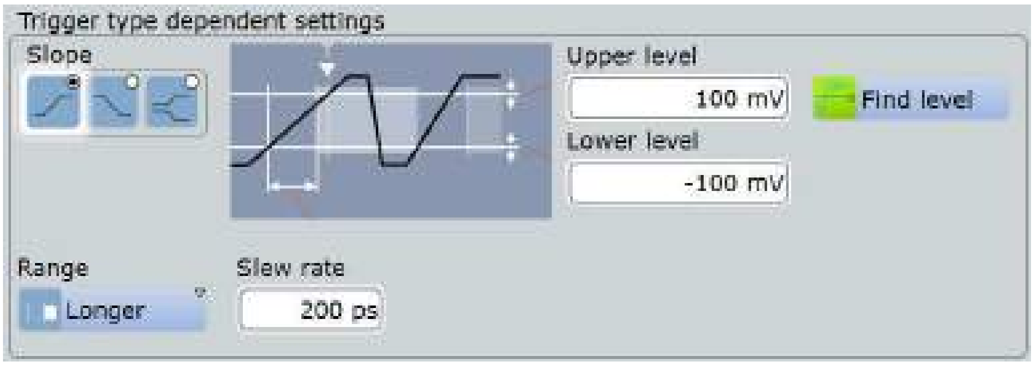
`TRIGger<m>:INTerval:DELTa` on page 1267

5.3.10 Slew Rate

Access: TRIGGER > "Setup" tab > "Type = Slew rate"

The slew rate trigger is also known as transition trigger. It triggers if the transition time from the lower to higher voltage level (or vice versa) is shorter or longer as defined, or outside or inside a specified time range.

The slew rate trigger finds slew rates faster than expected or permissible to avoid overshooting and other interfering effects. It also detects slow edges violating the timing in pulse series.



Trigger type dependent settings

Slope

Upper level: 100 mV

Find level

Lower level: -100 mV

Range: Longer

Slew rate: 200 ps

Slope

Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:

`TRIGger<m>:EDGE:SLOPe` on page 1255
`TRIGger<m>:ANEDge:SLOPe` on page 1257
`TRIGger<m>:SLEW:SLOPe` on page 1267

Upper level

Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:

`TRIGger<m>:LEVel<n>:SLEW:UPPer` on page 1268

Lower level
Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
`TRIGger<m>:LEVel<n>:SLEW:LOWer` on page 1268

Range
Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope. the measurements stops when the signal crosses the second level.

"Within"	Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".
"Outside"	Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on slew rates shorter than the given "Slew rate" limit.
"Longer"	Triggers on slew rates longer than the given "Slew rate" limit.

Remote command:
`TRIGger<m>:SLEW:RANGe` on page 1268

Slew rate
For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

Remote command:
`TRIGger<m>:SLEW:RATE` on page 1269

±Delta
Defines a time range around the given slew rate.

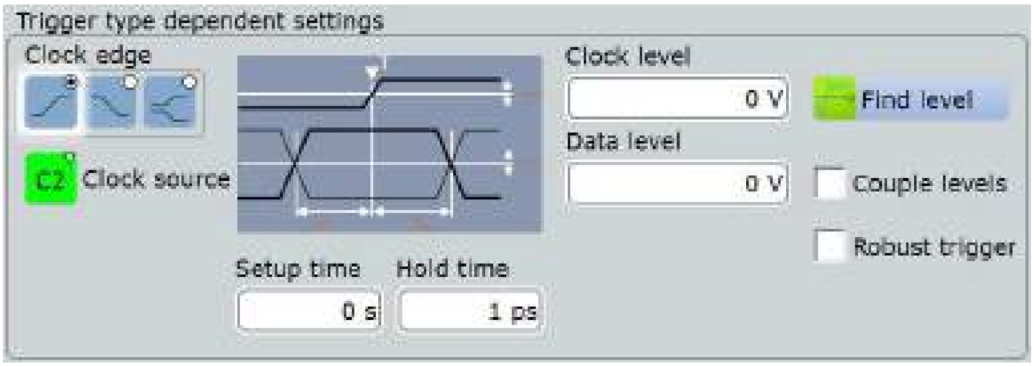
Remote command:
`TRIGger<m>:SLEW:DELTa` on page 1269

5.3.11 Data2Clock

Access: TRIGGER > "Setup" tab > "Type = Data2Clock"

With the Data2Clock trigger - also known as setup/hold trigger - you can analyze the relative timing between two signals: a data signal and the synchronous clock signal. Many systems require, that the data signal must be steady for some time before and after the clock edge, for example, the data transmission on parallel interfaces. With this trigger type, you can also test the time correlation of sideband and in-band signals.

The trigger occurs if the data signal crosses the data level during the setup and hold time. The reference point for the time measurement is defined by clock level and clock edge.



Clock level 0 V

Data level 0 V

☐ Couple levels

☐ Robust trigger

Setup time 0 s

Hold time 1 ps

Clock source

Selects the input channel of the clock signal.

Remote command:

`TRIGger<m>:DATatoclock:CSOurce[:VALue]` on page 1269

`TRIGger<m>:SPATtern:CSOurce[:VALue]` on page 1274

Clock edge

Sets the edge of the clock signal to define the time reference point for the setup and hold time:

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:

`TRIGger<m>:DATatoclock:CSOurce:EDGE` on page 1270

Clock level

Sets the voltage level for the clock signal. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:

`TRIGger<m>:DATatoclock:CSOurce:LEVel` on page 1270

Data level

Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

Remote command:

`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Couple levels (Trigger level and hysteresis coupling)

Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:

`TRIGger<m>:SCOupling` on page 1270

Setup time

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. If you set a negative setup time, the hold time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:STIMe` on page 1271

Hold time

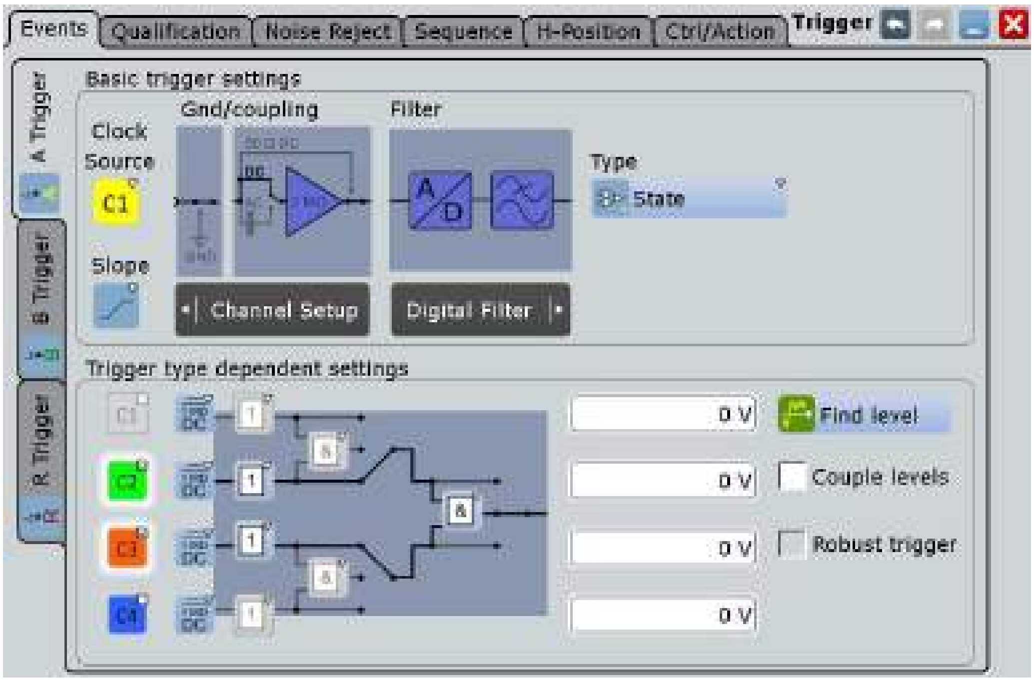
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. If you set a negative hold time, the setup time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:HTIMe` on page 1271

5.3.12 State

The state trigger is a qualified edge trigger. It combines the edge trigger settings with trigger qualification.



The individual settings are:

- "Slope" on page 211
- "Pattern" on page 225
- "Trigger Levels" on page 234
- "Find level" on page 209

- "Couple levels (Trigger level and hysteresis coupling)" on page 223

Robust triggering is not relevant for the state trigger.

5.3.13 Pattern

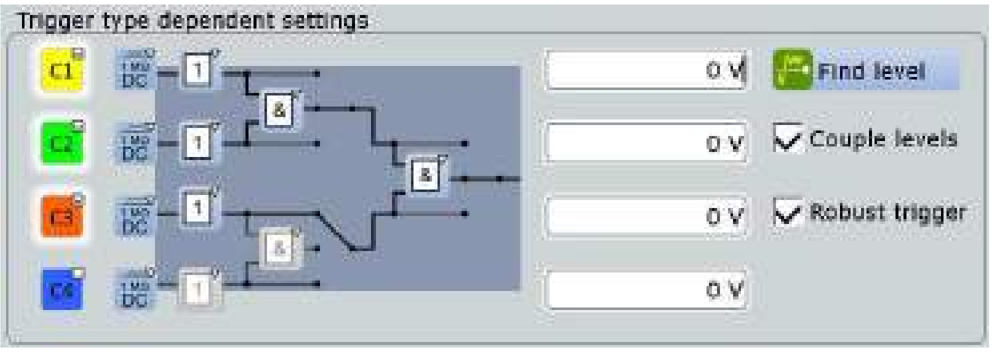
Access: TRIGGER > "Setup" tab > "Type = Pattern"

The pattern trigger is a logic trigger. It provides logical combinations of the input channels and supports you in verifying the operation of digital logic.

The setup of the pattern trigger is similar to trigger qualification. In addition to the pattern and the trigger levels, you can define a timing condition. The complete settings for the pattern trigger are provided in the "Qualification" tab.

Pattern

The pattern contains the channel selection, and the logical operations structure of hardware based boolean logic.



"Channel"	Select the channels to be considered. For qualification, you can select all channel signals except for the trigger source. In Pattern trigger setup, the trigger source channel is selected by default, and you can select all other channel signals.
"Coupling"	The current coupling or ground connection is shown for each channel and can be changed directly in the pattern, if necessary.
"Boolean operator"	Defines the logical operation on the digital signal resulting from the comparison with the trigger level. • 1 "Direct": leaves the input value unchanged • 1 "NOT": inverts the input value
"Logical operator"	defines the logic combination of two sources. The sources are channel 1/2 and channel 3/4 on the first step, and in the second step the logical combination resulting from the first step. • & "AND": logical AND, conjunctive combination • & "NAND": logical NOT AND • ≥1 "OR": logical OR, disjunctive combination • ≥1 "NOR": logical NOT OR

Remote command:
`TRIGger<m>:QUALify<n>:A:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:A[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:AB:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:ABCD:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:B:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:B[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:C:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:C[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:CD:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:D:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:D[:ENABle]` on page 1282

Additional settings: Timing
"State timing" adds time limitation to the state pattern. You find this setting in the "Qualification" tab.

"Off"	No time limitation. The trigger occurs if the pattern condition is fulfilled.
"Timeout"	Defines how long the result of the state pattern condition must be true or false.
"Width"	Defines a time range for keeping up the true result of the state pattern condition. The range is defined in the same way as for width and interval triggers, see "Range" on page 215.

Remote command:
`TRIGger<m>:PATTern:MODE` on page 1272
`TRIGger<m>:PATTern:TIMeout:MODE` on page 1272
`TRIGger<m>:PATTern:TIMeout[:TIME]` on page 1273
`TRIGger<m>:PATTern:WIDTh:DELTa` on page 1274
`TRIGger<m>:PATTern:WIDTh:RANGe` on page 1273
`TRIGger<m>:PATTern:WIDTh[:WIDTh]` on page 1274

5.3.14 Serial Pattern

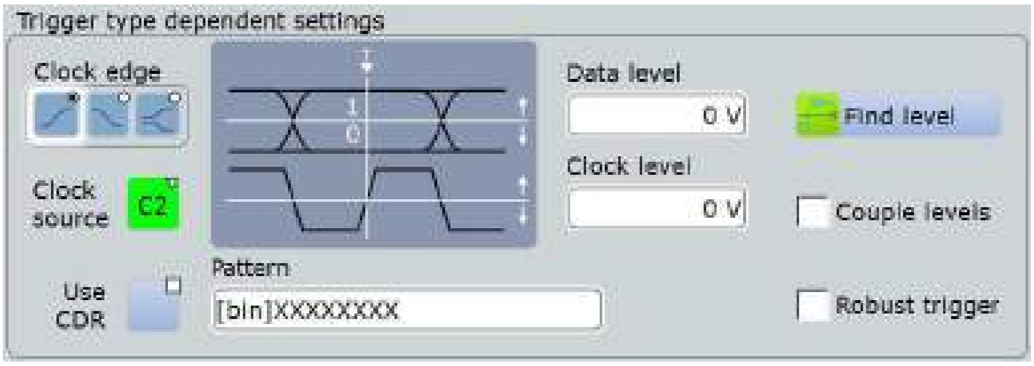
Access: TRIGGER > "Setup" tab > "Type = Serial Pattern"

The serial pattern is used to trigger on signals with serial data patterns in relation to a clock signal - for example, on bus signals like the I²C bus.

The instrument expects the bits coming in LSB first order. A triggered waveform in the diagram shows the LSB on the left and the MSB on the right side.

For convenient and comprehensive triggering on specific serial data, options for serial protocol analysis are provided, see Chapter 12, "Protocol Analysis", on page 480.

If option R&S RTO-K13 is installed, you can use the recovered clock signal for the serial pattern trigger instead of a real clock signal, see Chapter 16.2.2.3, "Serial Pattern Trigger Using CDR", on page 1052.



Trigger type dependent settings

Clock source: C2

Data level: 0 V

Clock level: 0 V

Pattern: [bin]XXXXXXXX

☐ Couple levels

☐ Robust trigger

Clock source

Selects the input channel of the clock signal.

Remote command:

`TRIGger<m>:DATatoclock:CSOurce[:VALue]` on page 1269

`TRIGger<m>:SPATtern:CSOurce[:VALue]` on page 1274

Clock edge

Together with the clock level, the clock edge sets the point in time when the state of the data signal is checked:

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:

`TRIGger<m>:SPATtern:CSOurce:EDGE` on page 1275

Clock level

Sets the voltage level for the clock signal.

Remote command:

`TRIGger<m>:SPATtern:CSOurce:LEVel` on page 1275

Data level

Sets the voltage level for the data signal.

If the signal value is higher than the data level, the state is 1. Below the level, the signal state is 0.

Remote command:

`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Couple levels (Trigger level and hysteresis coupling)

Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:

`TRIGger<m>:SCOupling` on page 1270

Pattern
The pattern contains the bits of the serial data to be found in the data stream. The maximum length of the pattern is 128 bit. Touch and hold the "Pattern" field to open the "Bit Pattern Editor" where you can enter the pattern in various formats.

See also: Chapter 12.1.4, "Bit Pattern Editor", on page 488.

In binary format, an *X* indicates that the logical level for the bit is not relevant (don't care).

Remote command:
`TRIGger<m>:SPATtern:PATTern` on page 1275

5.3.15 TV/Video Trigger

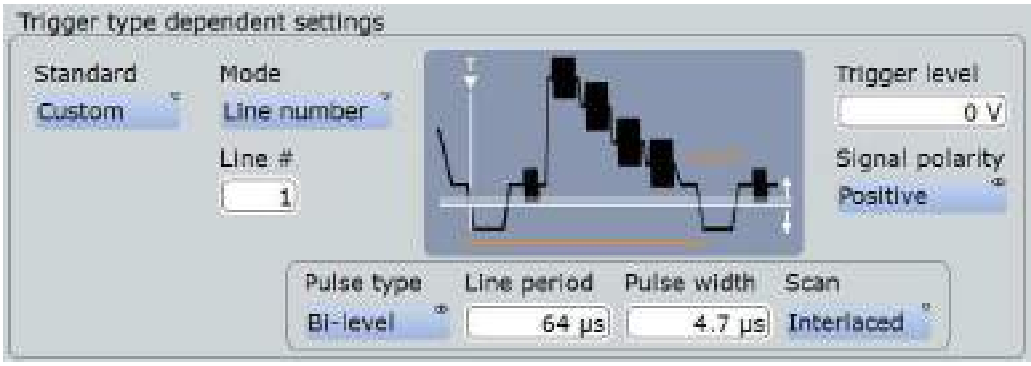
Access: TRIGGER > "Setup" tab > "Type = TV"

The TV or video trigger is used to analyze analog baseband video signals. You can trigger on baseband video signals from standard definition and high definition standards, and also on user defined signals.

The instrument triggers on the line start - the horizontal sync pulse. You can trigger on all lines, or specify a line number. You can also trigger on the field or frame start.

Additionally, a delay can be set: Set the "Holdoff events" in the "Holdoff" tab to the number of fields to be skipped. See also: Chapter 5.5, "Holdoff", on page 235.

Make sure that the trigger level crosses the synchronizing pulses of the video signal, see "Trigger level" on page 230.



Trigger type dependent settings

Standard: Custom
Mode: Line number
Line #: 1
Trigger level: 0 V
Signal polarity: Positive
Pulse type: Bi-level
Line period: 64 µs
Pulse width: 4.7 µs
Scan: Interlaced

Most video signals have an output impedance of 75 Ω. The channel inputs of the R&S RTO have an input impedance of 50 Ω or 1 MΩ. Make sure to provide the adequate matching to ensure amplitude fidelity. A simple 75 Ω feed-through termination combined with 1 MΩ oscilloscope inputs is suitable for most applications.

Once the trigger is set correctly, you can use cursor and automatic measurements to perform amplitude and timing measurements.

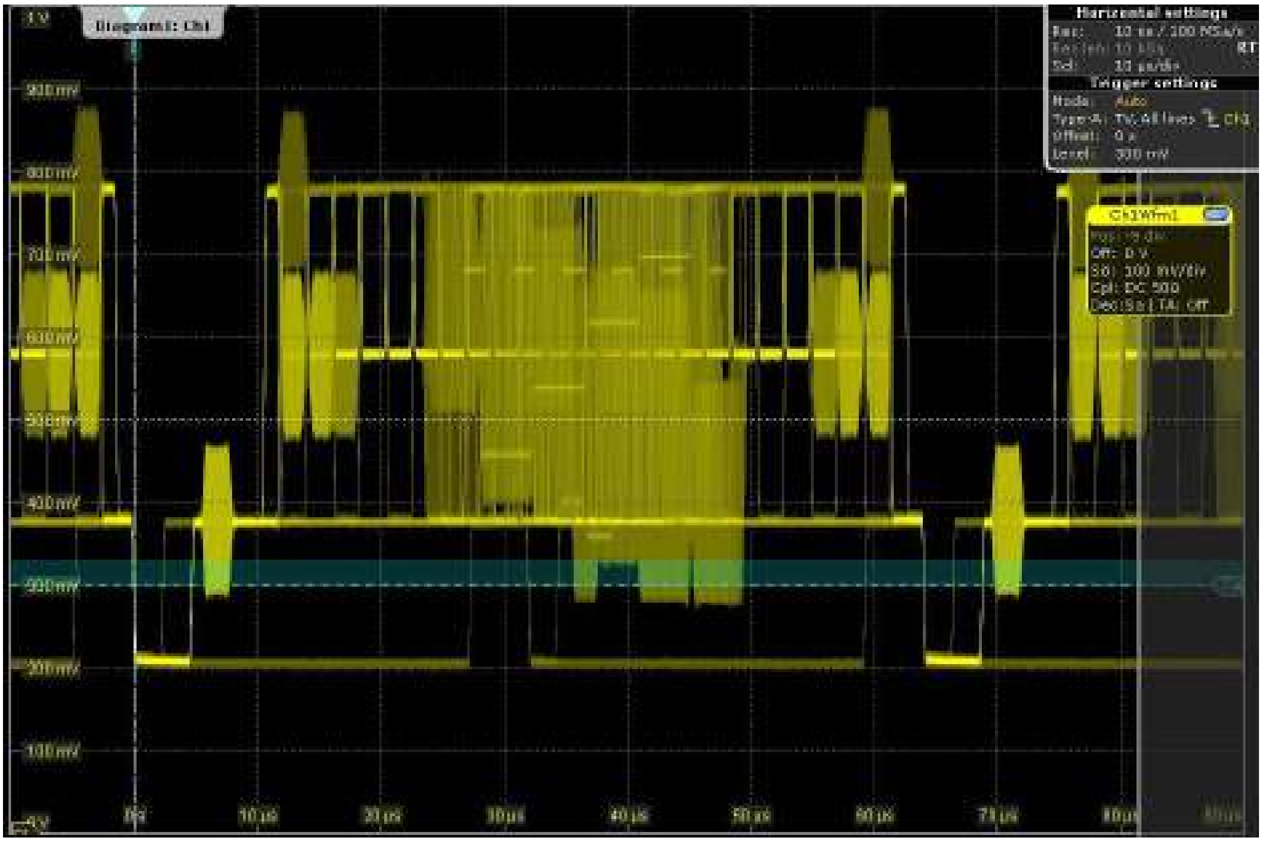


Figure 5-4: Trigger on all lines of a PAL signal with positive signal polarity, trigger level = 300 mV

Standard

Selects the TV standard or "Custom" for user-defined signals.

HDTV standards are indicated by the number of active lines, the scanning system (p for progressive scanning, i for interlaced scanning) and the frame rate. For interlaced scanning, the field rate is used instead of the frame rate. 1080p/24sF is an HDTV standard using progressive segmented frame scanning.

"Custom" can be used for signals of other video systems, for example, medical displays, video monitors, and security cameras. To trigger on these signals, you have to define the pulse type and length of the sync pulse, the scanning system and the line period.

Remote command:
`TRIGger<m>:TV:STANdard` on page 1276

Mode

Selects the lines or fields on which the instrument triggers. Available modes depend on the scanning system of the selected standard.

"All fields"	Triggers on the first video line of the frame (progressive scanning) or field (interlaced scanning), for example, to find amplitude differences between the fields.

"Odd fields / Even fields"	Triggers on the first video line of the odd or even field. These modes are available for interlaced scanning (PAL, PAL-M, SECAM, NTSC, 1080i) and progressive segmented frame scanning (1080p/24sF). They can be used, for example, to analyze the components of a video signal.
"All lines"	Triggers on the line start of all video lines, for example, to find maximum video levels.
"Line number"	Triggers on a specified line. Enter the line number in "Line #".

Remote command:
`TRIGger<m>:TV:MODE` on page 1277

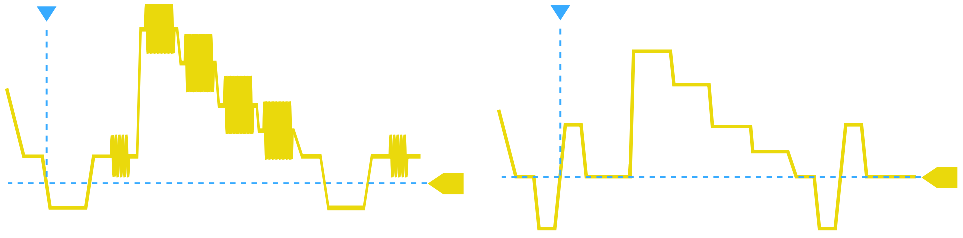
Line #
Sets the number of the line to be triggered on if "Mode" is set to "Line number". Usually the lines of the frame are counted, beginning from the frame start.

For NTSC signals, the lines are counted per field, not per frame. Therefore, you have to set the "Field" (odd or even), and the line number in the field.

Remote command:
`TRIGger<m>:TV:LINE` on page 1277
`TRIGger<m>:TV:LFIeld` on page 1278

Trigger level
Sets the trigger level as threshold for the sync pulse. Make sure that the trigger level crosses the synchronizing pulses of the video signal.

The hysteresis is set according to the settings in the "Noise Reject" tab.



Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Signal polarity
Sets the polarity of the signal. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

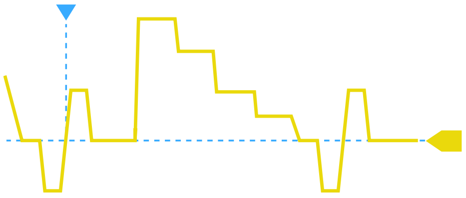


Figure 5-5: Signal with positive polarity and tri-level sync pulse

Remote command:

`TRIGger<m>:TV:POLarity` on page 1277

Pulse type

Sets the type of the sync pulse, either bi-level sync pulse (used in SDTV signals), or tri-level sync pulse (used in HDTV signals).

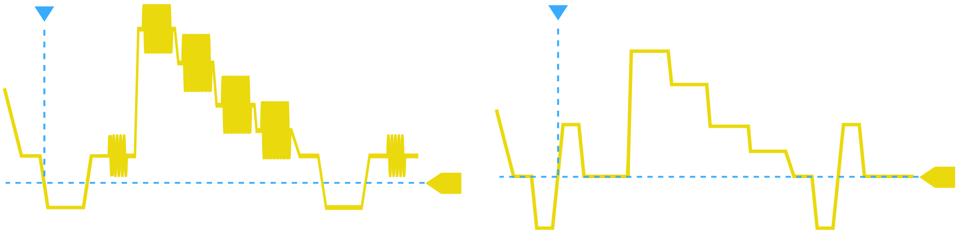


Figure 5-6: Bi-level (left) and tri-level (right) sync pulses

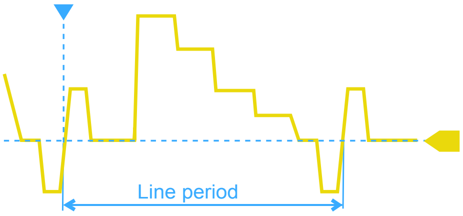
This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:

`TRIGger<m>:TV:CUSTom:STYPe` on page 1279

Line period

Sets the duration of a single video line, the time between two successive sync pulses.



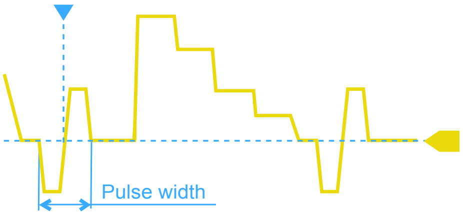
This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:

`TRIGger<m>:TV:CUSTom:LDURation` on page 1279

Pulse width

Sets the width of the sync pulse.



This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:

`TRIGger<m>:TV:CUSTom:SDURation` on page 1280

Scan

Sets the scanning system.

This setting is available for user-defined video signals if "Standard" is set to "Custom".

"Interlaced"	Interlace scanning uses two fields to create a frame. One field contains all the odd lines (odd, first, or upper filed), the other contains all the even lines of the image (even, second, or lower field). First the lines of the odd filed are processed, then the lines of the even field.
"Progressive"	Progressive scanning is a method to capture, transmit and display all lines of a frame in sequence.
"Segmented"	Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display.

Remote command:

`TRIGger<m>:TV:CUSTom:SCANmode` on page 1279

5.3.16 NFC Trigger

The Near Field Communication (NFC) trigger triggers on characteristic events of NFC signals. This trigger type requires option R&S RTO-K11 "I/Q Software Interface".

For details, see Chapter 15.4, "NFC Trigger", on page 1033

5.3.17 CDR Trigger

The clock data recovery (CDR) trigger triggers on the edges of a clock edge stream that is recovered from a data signal using the hardware CDR. This trigger type requires option R&S RTO-K13 "CDR".

For details, see Chapter 16.2.2.2, "CDR Trigger", on page 1051.

5.3.18 Triggering on Serial Buses

Protocol analysis including configuration, triggering, and decoding is described in Chapter 12, "Protocol Analysis", on page 480

For information on triggering on serial buses, see:

- Chapter 12.2.3, "I²C Trigger", on page 493
- Chapter 12.3.3, "SPI Trigger", on page 511
- Chapter 12.4.3, "UART Trigger", on page 523
- Chapter 12.6.3, "LIN Trigger", on page 568
- Chapter 12.5.2, "CAN / CAN FD Trigger", on page 531
- Chapter 12.7.2, "FlexRay Trigger", on page 582
- Chapter 12.9.3, "MIL-STD-1553 Trigger ", on page 622
- Chapter 12.10.3, "ARINC 429 Trigger", on page 641
- Chapter 12.13.3, "RFFE Trigger", on page 706

- Chapter 12.19.3, "USB Trigger", on page 847

5.3.19 Triggering on Parallel Buses and Digital Channels

Triggering on digital signals requires the Mixed Signal Option. The option is described in Chapter 13, "Mixed Signal Option (MSO, R&S RTO-B1)", on page 972.

For information on triggering, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 983.

5.4 Qualification

By qualifying a trigger event, you can logically combine the trigger signal with the state of other analog channel signals.

The instrument triggers if both of the following apply:

- The basic conditions of the trigger event definition are fulfilled.
- The logical conditions of the trigger qualification are true.

Qualification is only available for the A-event. for

Qualification is not supported if:

- The trigger source is "Extern".
- One of the following trigger types is selected: slew rate, Data2Clock, serial pattern, TV, and NFC.

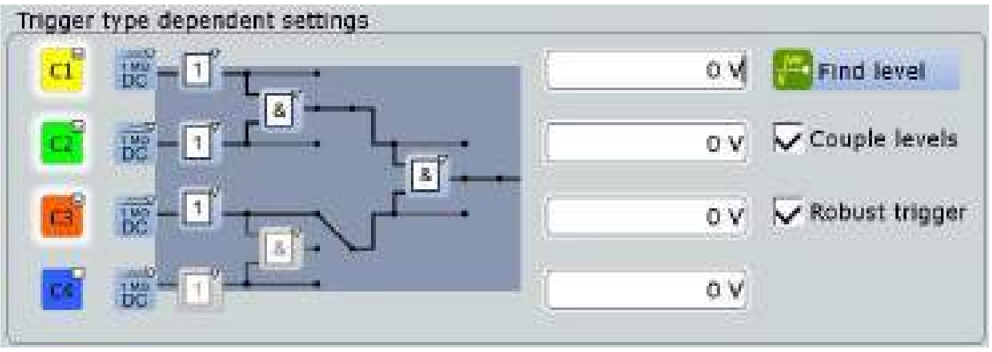
► To enable the qualification settings, select Qualify.

Example: Trigger on write access of a specific device of a bus system

In circuits using SPI, several slave devices use the same lines for reading and writing data, and each slave has its own select line. To trigger on write access of specific slave, the write line is the trigger source and the select line of the slave is set as qualifying condition.

Pattern

The pattern contains the channel selection, and the logical operations structure of hardware based boolean logic.



0 V
0 V
0 V
0 V

☑ Couple levels

☑ Robust trigger

"Channel"	Select the channels to be considered. For qualification, you can select all channel signals except for the trigger source. In Pattern trigger setup, the trigger source channel is selected by default, and you can select all other channel signals.
"Coupling"	The current coupling or ground connection is shown for each channel and can be changed directly in the pattern, if necessary.
"Boolean operator"	Defines the logical operation on the digital signal resulting from the comparison with the trigger level. ● "Direct": leaves the input value unchanged ● "NOT": inverts the input value
"Logical operator"	defines the logic combination of two sources. The sources are channel 1/2 and channel 3/4 on the first step, and in the second step the logical combination resulting from the first step. ● "AND": logical AND, conjunctive combination ● "NAND": logical NOT AND ● "OR": logical OR, disjunctive combination ● "NOR": logical NOT OR

Remote command:
`TRIGger<m>:QUALify<n>:A:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:A[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:AB:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:ABCD:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:B:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:B[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:C:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:C[:ENABle]` on page 1282
`TRIGger<m>:QUALify<n>:CD:LOGic` on page 1283
`TRIGger<m>:QUALify<n>:D:LOGic` on page 1282
`TRIGger<m>:QUALify<n>:D[:ENABle]` on page 1282

Trigger Levels

Define the trigger level for each input channel. For qualification and pattern trigger, the trigger level is a decision threshold: If the signal value is higher than the trigger level, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the trigger level.

You can set the trigger levels for all channels to the same value, see "Couple levels (Trigger level and hysteresis coupling)" on page 223.

Couple levels (Trigger level and hysteresis coupling)

Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:
`TRIGger<m>:SCOupling` on page 1270

Robust trigger qualification
Activates the robust trigger for the qualification channels. Thus you can set the robust trigger separately for the trigger source and the qualification channels.

For details, see "Robust trigger" on page 209.

Qualify
Enables the settings for trigger qualification. As soon as a qualification pattern is defined, the option is selected by default.

5.5 Holdoff

Access: "Trigger" menu > "Holdoff"

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized.

Holdoff mode
Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus. For the TV trigger, only the "Events" mode is useful.

Example:
You want to analyze the first pulse in a burst of several pulses. At first, you select a sufficiently slow time base to display the entire burst. Then, you set the holdoff time a little longer than the length of the burst. Now, each trigger corresponds to the first pulse in successive bursts, and you can change the time base to display the waveform in more detail.

The following methods are available:

"Time"	Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed.
"Events"	Defines the holdoff as a number of trigger events. The next trigger only occurs when this number of events is reached. The number of triggers to be skipped is defined in "Holdoff events".
"Random"	Defines the holdoff as a random time limited by "Random minimum time" and "Random maximum time". For each acquisition cycle, the instrument selects a new random holdoff time from the specified range. Random holdoff prevents synchronization to discover effects invisible with synchronized triggering, for example, the features of a pulse train.

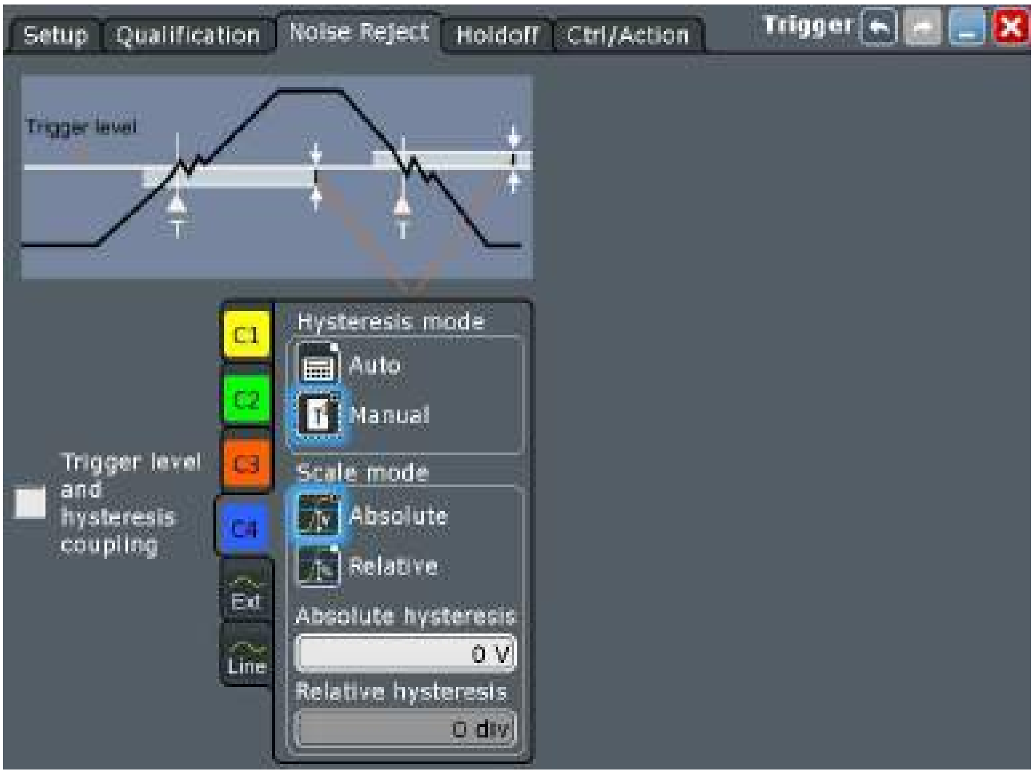
"Auto"	The holdoff time is calculated automatically based on the current horizontal scale. "Auto time scaling" defines the factor the horizontal scale is multipied with. "Auto time" shows the resulting holdoff time: *Auto time* = *Auto time scaling* * *Horizontal scale*.
"Off"	No holdoff

Remote command:
`TRIGger<m>:HOLDoff:MODE` on page 1284
`TRIGger<m>:HOLDoff:TIME` on page 1284
`TRIGger<m>:HOLDoff:EVENts` on page 1285
`TRIGger<m>:HOLDoff:MAX` on page 1286
`TRIGger<m>:HOLDoff:MIN` on page 1285
`TRIGger<m>:HOLDoff:AUTotime?` on page 1286
`TRIGger<m>:HOLDoff:SCALing` on page 1287

5.6 Noise Reject

The rejection of noise by setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

You can select the hysteresis mode and value for each channel separately, or couple the trigger levels and set the same hysteresis for channels. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.



See also: "Robust trigger" on page 209

Hysteresis mode
Selects how the hysteresis is set.

"Auto"	This is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.
"Manual"	The hysteresis is defined directly in absolute or relative values.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe[:STATe]` on page 1287

Scale mode
Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe:MODE` on page 1288

Absolute hysteresis
Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe:ABSolute` on page 1288

Relative hysteresis
Defines a range in divisions around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe:RELative` on page 1289

Noise reject (external trigger)
Enables the noise reject for the external trigger input.

Remote command:
`TRIGger<m>:ANEDge:NREJect` on page 1289

Couple levels (Trigger level and hysteresis coupling)
Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:
`TRIGger<m>:SCOupling` on page 1270

5.7 Control / Action

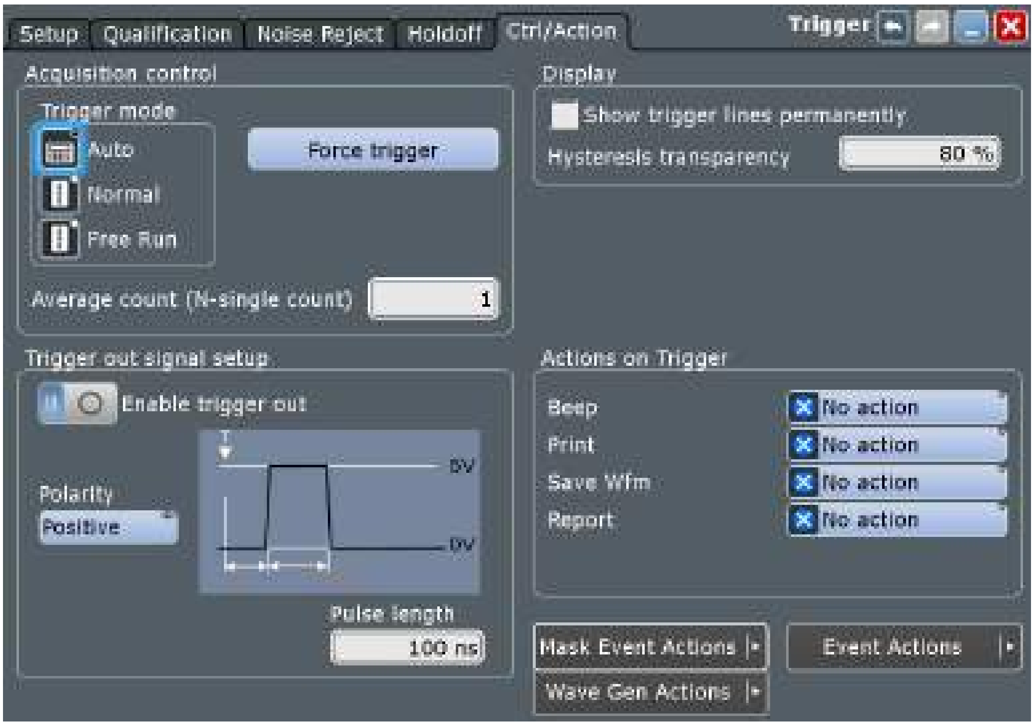
Access: TRIGGER > "Ctrl/Action" tab

The settings and functions of trigger control define when the instrument triggers. They affect all trigger types and all triggers in a trigger sequence.

In addition to the settings in the dialog box, you need the RUN STOP and SINGLE keys on the front panel to start and stop the acquisition and thus the triggering.

The action settings define what happens when a trigger occurs. All available actions can be initiated at the same time.

The R&S RTO can provide an external trigger signal to synchronize the measurements of other instruments. The trigger out signal is also adjusted and enabled in the "Control" tab.



☐ Show trigger lines permanently

Hysteresis transparency: 80 %

Average count (N-single count): 1

Polarity: Positive

Pulse length: 100 ns

Beep	☒ No action
Print	☒ No action
Save Wfm	☒ No action
Report	☒ No action

Trigger mode

Sets the trigger mode which determines the behavior of the instrument if no trigger occurs. The current setting is shown on the trigger label on top of the signal bar.

To toggle quickly between "Auto" and "Normal" mode, use the MODE key on the front panel (in "Trigger" section).

"Auto"	The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. This mode helps to see the waveform even before the trigger conditions are set correctly. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform. The time interval depends on the time base settings.

"Normal"	The instrument acquires a waveform only if a trigger occurs, that is, if all trigger conditions are fulfilled. If no trigger occurs, no waveform is acquired and the last acquired waveform is displayed. If no waveform was captured before, none is displayed. When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.
"Free Run"	The instrument starts acquisition immediately and triggers after a very short time interval independet of the time base settings and faster than in "Auto" mode. Real triggers are ignored. Use this mode if the "Auto" mode is too slow.

Remote command:
`TRIGger<m>:MODE` on page 1292

Acquisition/average count
Access:
- Trigger > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with SINGLE
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with SINGLE.
  If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 157.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 1213

Force Trigger
If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Remote command:
`TRIGger<m>:FORCe` on page 1293

RUN STOP/SINGLE
Front panel keys to start and stop a continuous acquisition or a defined number of acquisition cycles, respectively. The number of acquisitions is set with "Average count".

Remote command:
`RUN` on page 1204
`SINGle` on page 1204
`STOP` on page 1205

Trigger out signal setup

Defines the pulse that is provided to the TRIGGER OUT connector on the rear panel.

A trigger out pulse can be provided either when a trigger occurs, or when a mask test violaton occurs, or when a limit check violation in a measurement occurs.

"Enable trigger out"	Generates the trigger out signal on trigger event. The setting is not available if • A mask test is running with "Trigger Out Pulse" set to "On violation". • A measurement running with limit check enabled and "Trigger Out Pulse" set to "On violation".
"Polarity"	Sets the polarity of the trigger out pulse, that is the direction of the first pulse edge.
"Pulse length"	Sets the length of the trigger out pulse.
"Delay"	Sets the delay of the first pulse edge to the trigger point. The setting is only available if "Enable trigger out" is active.

Remote command:
`TRIGger<m>:OUT:STATe` on page 1293
`TRIGger<m>:OUT:POLarity` on page 1293
`TRIGger<m>:OUT:PLENgth` on page 1294
`TRIGger<m>:OUT:DELay` on page 1294

Show trigger lines permanently

Displays the trigger levels and the hysteresis in the diagrams until you disable this option.

Remote command:
`DISPlay:TRIGger:LINes` on page 1252

Hysteresis transparency

Defines the transparency of the hysteresis area above or below the trigger level. The hysteresis is only visible if "Show trigger lines permanently" is enabled.

Actions on trigger

The trigger can initiate several actions, each time a trigger occurs. To activate an action, set it to "On trigger". The following actions are available:

"Beep"	Generates a beep sound.
"Print"	Saves a screenshot according to settings in "File" menu > "Print Setup".
"Save Wfm"	Saves the waveform data to a file according to settings in SAVE RECALL > "Waveform / Results" > "Waveforms".
"Report"	Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:

`TRIGger<m>:EVENt:BEEP` on page 1294

`TRIGger<m>:EVENt:PRINt` on page 1295

`TRIGger<m>:EVENt:WFMSave` on page 1295

5.8 Sequence

A trigger sequence consists of at least one trigger condition and additional conditions defining when the trigger occurs.

The simple sequence "A only" only contains the A-trigger condition.

The complex trigger sequence "A → B → R" consists of two subsequent conditions - A and B - and an optional reset condition.

After the A-trigger conditions have been met, and an optional delay has passed, the B-trigger with independent conditions is enabled. A- and B-triggers are configured in the same way.

The instrument waits until one or a specified number of B-trigger conditions occur. The last B-trigger causes the trigger event, and then the sequence starts again. The B-trigger can only cause the trigger event if it occurs after the A-trigger and after the delay time.

If you expect, for example, an irregular B-trigger, you can configure a reset condition to restart the sequence. The reset condition can be a simple timeout, or a trigger condition that is defined in the same way as the A- and B-trigger conditions. Most trigger types except for Data2Clock, pattern, serial pattern, NFC, CDR, and TV can be used as reset event.

The complex trigger sequence requires that input channels CH1...4 are set as trigger sources for all conditions. All other input sources are disabled.

The "A → B → R" sequence is not available for the following trigger types.

- Data2Clock
- TV
- NFC
- CDR

The instrument checks the trigger settings for compatibility and disables settings that do not fit the previous settings in the sequence.

See also: Chapter 5.2.4, "Setting Up a Trigger Sequence", on page 205.

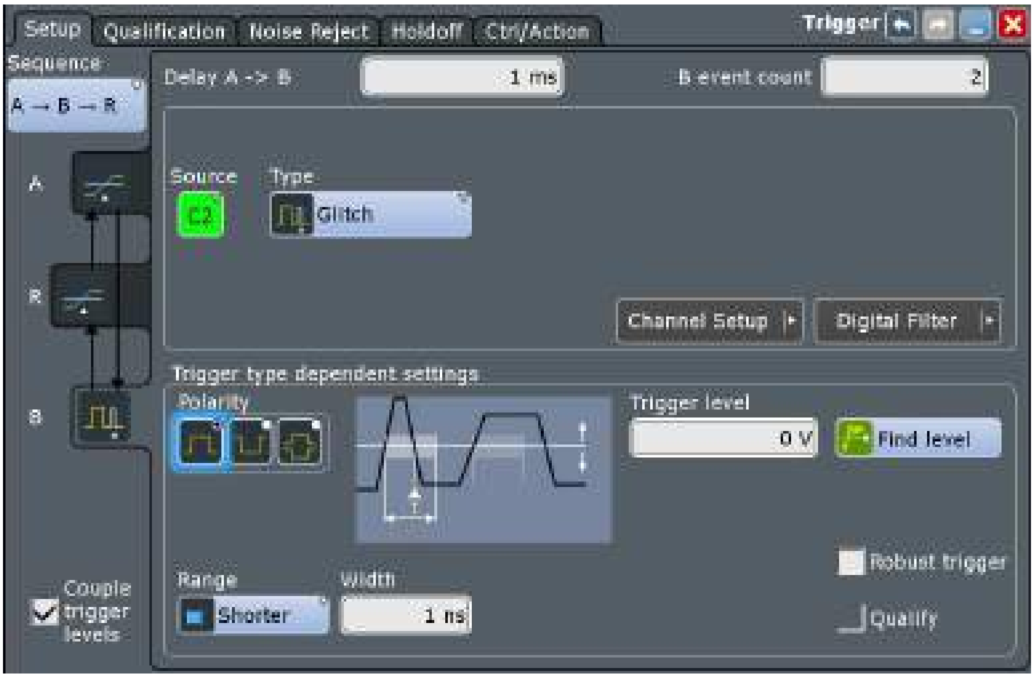
Remote command:

- `TRIGger<m>:SEQuence:MODE` on page 1290

5.8.1 B-Trigger Setup

Access: TRIGGER > "Setup" tab > "A → B → R" sequence > "B" subtab

The B-trigger is the second condition of the trigger sequence. You can configure a delay between the A- and B-trigger, and define a number of fulfilled B-trigger conditions to be ignored. The B-trigger condition is configured in the same way as the A-trigger. The instrument disables settings that do not fit the previous settings in the sequence.



Sequence: A → B → R
Delay A -> B: 1 ms
B event count: 2
Source: C2
Type: Glitch
Trigger level: 0 V
Range: Shorter
Width: 1 ns
☑ Couple trigger levels
☐ Robust trigger

Couple trigger levels
Sets the trigger levels to the values of the current trigger condition. Each channel has its own trigger level.

Example:

If the "A" tab is selected in the "Setup" tab, and the trigger level for C1 is 70 mV, the coupling sets the trigger levels for C1 in the B- and R trigger conditions also to 70 mV. If the B-trigger and/or R-trigger uses another source as the A-trigger, the level remains unchanged.

Remote command:
`TRIGger<m>:ECOupling` on page 1290

Delay
Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Remote command:
`TRIGger<m>:SEQuence:DELay` on page 1291

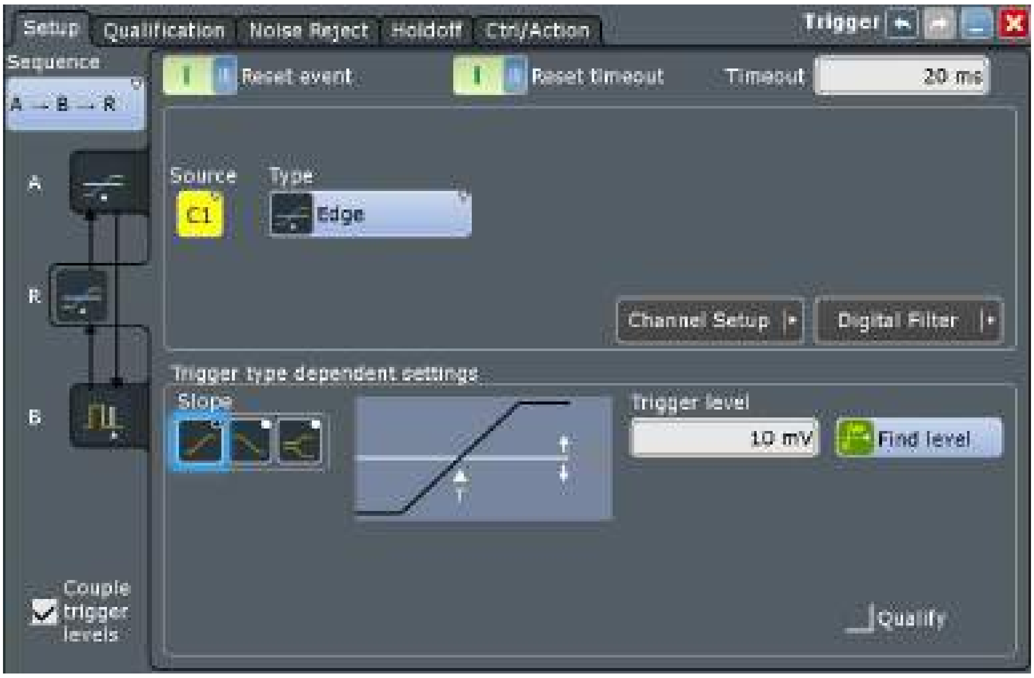
B-event count
Sets the number of B-trigger conditions to be fulfilled after an A-trigger. The last B-trigger causes the trigger event.

The waiting time for B-triggers can be restricted with a reset condition: timeout or reset event.

Remote command:
`TRIGger<m>:SEQuence:COUNt` on page 1291

5.8.2 R-Trigger Setup

The complex trigger sequence "A → B → R" consists of two trigger A and B. An optional reset condition R can be added.



Reset timeout / Timeout
If timeout is enabled, the instrument waits for the "Timeout" time for the specified number of B-triggers. If no trigger occurs during that time, the sequence is restarted with the A-trigger.

Remote command:
`TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle]` on page 1291
`TRIGger<m>:SEQuence:RESet:TIMeout:TIME` on page 1292

Reset event
If enabled, the trigger sequence is restarted by the R-trigger condition if the specified number of B-triggers does not occur before the trigger conditions are fulfilled. The R-trigger condition is configured in the same way as the A-trigger. The instrument disables settings that do not fit the previous settings in the sequence.

Remote command:
`TRIGger<m>:SEQuence:RESet:EVENt` on page 1291

5.9 Zone Trigger (Option R&S RTO-K19)

The zone trigger is a kind of trigger qualification that combines the trigger condition with the intersection or non-intersection of one or more zones or masks. The zone can be applied to any active input signal, math waveform including FFT, and XY-waveform.

You can use the zone trigger, for example, to solve the following tasks:

- To trigger if a peak in the spectrum occurs, define a zone in the FFT diagram to filter amplitude peaks. In the same way, you can filter harmonics.
- To separate rising and falling edges, define a zone around the base or top of the data signal.
- To separate read/write cycles - define a zone in the eye diagram.
- To identify a tube violation of signals with an infrequent non-monotonic edge.

To document the trigger events, use the actions on trigger. For example, create a report when the instrument triggers, or save the waveform.

Zone trigger is not available for serial protocol triggers.

5.9.1 About Trigger Zones

A zone is a mask without result box. You can adjust the shape of the zone in the same way as mask segments, graphically by dragging the corner points, or numerically in the "Masks" > "Mask Definition" dialog box. You can also use existing masks in the zone trigger. The zone trigger and usual mask tests run in parallel.

All zones and masks that are included in the zone trigger expression are indicated with yellow color.

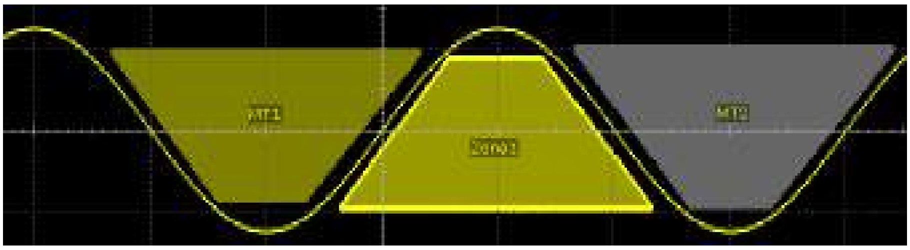


Figure 5-7: Indication of trigger zones

MT1 = Mask is included in zone trigger. Trigger if signal hits the mask (must intersect).
MT2 = Mask is not included in zone trigger.
Zone1 = Zone is included in zone trigger. Trigger if signal does not hit the zone (must not intersect).

If average or envelope acquisition is enabled, only triggered waveforms are used for envelope and average calculation on channel and math waveforms.

5.9.2 Creating Trigger Zones

You can define the trigger zones on the display, or use existing mask definitions as trigger zones.

Define trigger zones

1. Tap the "Zone trigger" icon on the toolbar.
2. In the sidebar, select if the signal must violate the zone to cause a trigger (Must Intersect), or vice versa (Must Not Intersect).
3. Tap the corner points of the zone on the screen.
4. If all points are set, tap "Use selected mask" in the sidebar.

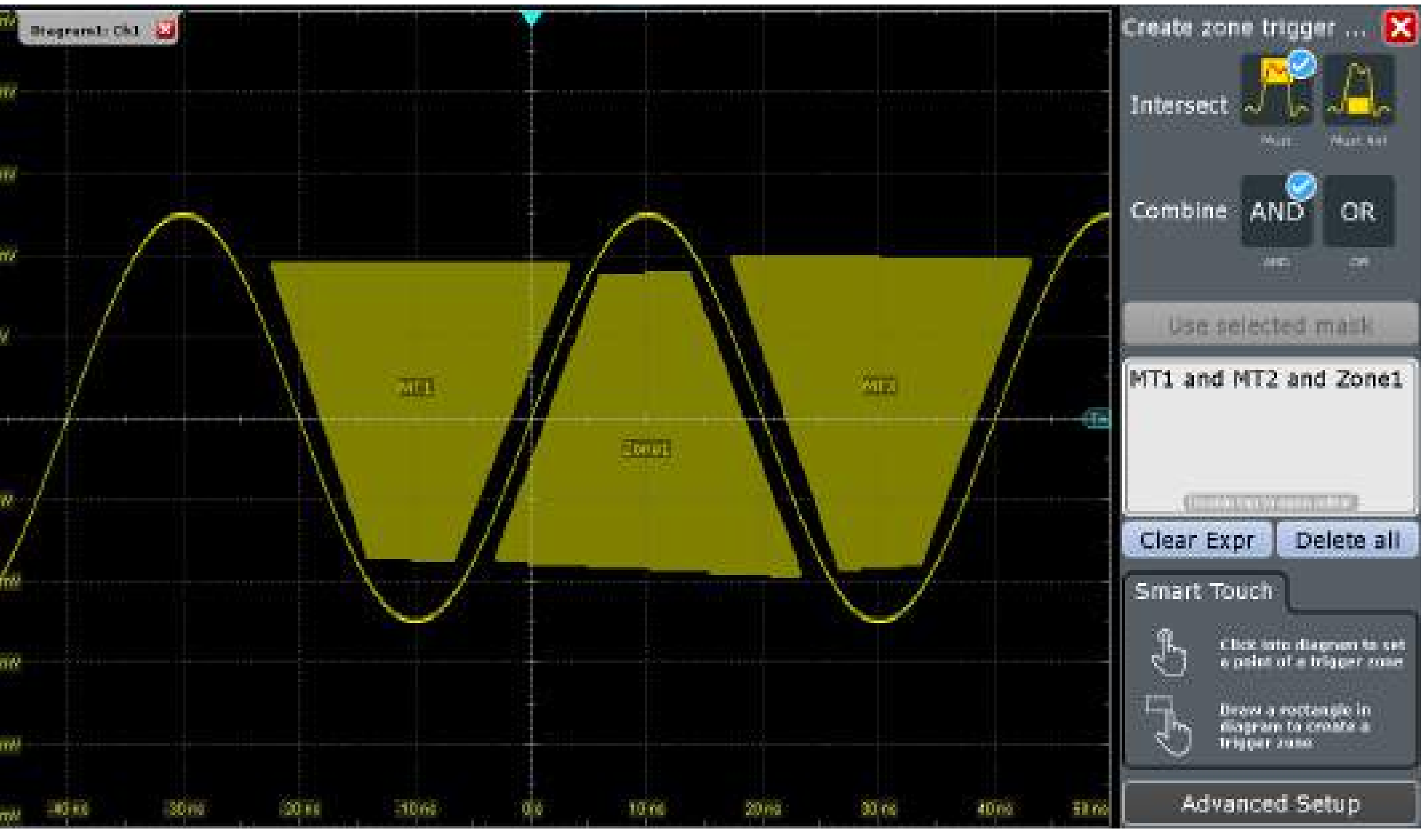
   The zone is finished, and "Zone1" is shown in the expression field.
5. If you want to define another zone, select the logic combination of the zones AND (both zones) or OR (either zone).
6. To create the second zone, repeat steps 3 and 4.
7. To define more zones, repeat steps 5 and 6.

Use existing masks for zone trigger

Prerequisites: At least one mask is created and visible on the display.

1. Tap the "Zone trigger" icon on the toolbar.
2. In the sidebar, select if the signal must violate the zone to cause a trigger (Must Intersect), or vice versa (Must Not Intersect).
3. Tap the mask on the display.
4. Tap "Use selected mask" in the sidebar.

   "MT1" is shown in the expression field.
5. If you want to add another mask test or zone, select the logic combination of the zones AND (both zones) or OR (either zone).
6. To add another mask, tap the mask on the display.
   To add a zone, tap the corner points of the zone on the screen.
7. Tap "Use selected mask" in the sidebar.



MT1 and MT2 and Zone1

Intersect
Defines if the signal must intersect the zone to allow the instrument to trigger, or if it must not intersect the zone.

Combine
Sets the logic combination of two zones.

Use selected mask
Includes the selected zone or mask in the zone expression.

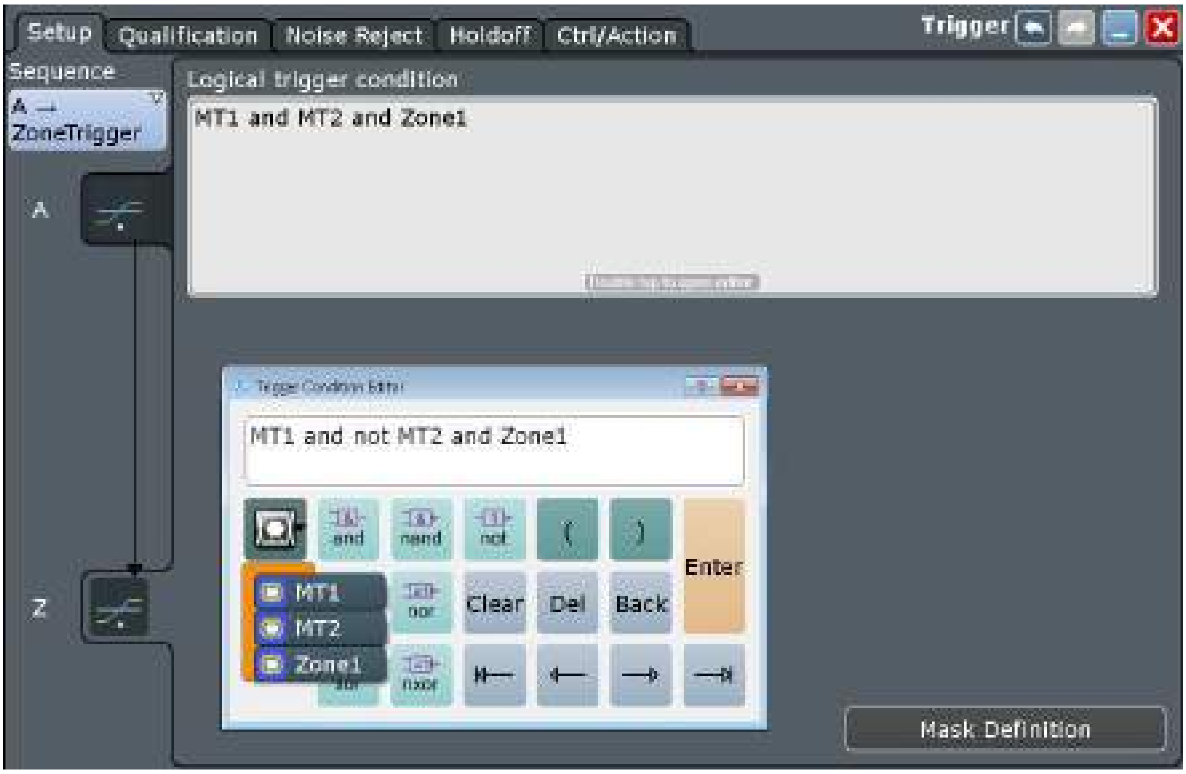
Clear Expr
Deletes the zone trigger expression. The zones are not deleted, they remain as usual masks, and the result boxes of the mask test appear.

Delete all
Deletes the zone trigger expression and the zones.

5.9.3 Trigger Zone Expressions

If all required mask tests and zones are defined, you can type the logical expression directly, or use the trigger condition editor. All logical combinations are available in the editor. To express the "Must Not Intersect" condition, use the logic NOT.

If you switch off a mask test that is used by the zone trigger, the mask is removed from the zone trigger expression automatically.



Logical trigger condition: MT1 and MT2 and Zone1

Trigger Condition Editor: MT1 and not MT2 and Zone1

Remote command:

- `TRIGger<m>:ZONE:EXPRession[:DEFine]` on page 1295

5.10 Acquisition Info

Access: "Trigger" menu > "Acquisition Info"

Shows the current number of acquisitions that have been acquired. The count is shown for a running acquisition cycle and as well for the last stopped acquisition cycle.

Remote command:

`ACQuire:CURRent?` on page 1296

6 Waveform Analysis

This chapter describes general methods to check and analyze waveforms. These are:

6.1 Zoom

The zoom functions allow you to magnify a specific section of the diagram in order to view more details. You can define several zoom areas for the same diagram and even couple them, or you use the hardware zoom.

6.1.1 Methods of Zooming

The R&S RTO provides various ways of zooming: You define the section of a diagram that you want to magnify, and the zoomed view is shown in a separate zoom diagram. Additionally, you can magnify the diagram directly: The hardware zoom changes the horizontal and vertical scales of the diagram so that you see the selected section.

There are different ways to initiate and configure the zoom function:

- **Fingertip zoom**: magnifies the waveforms around your fingertip. When you drag your finger, the magnifier moves, too. You can convert the fingertip zoom into a standard zoom diagram.
- **Graphical method**: you draw, move and adjust the zoom area on the touchscreen – a very quick and simple method for standard zoom and hardware zoom.
- **Numeric method**: you enter x- and y-values in a dialog box or adjust them using navigation controls. These are precise ways which can be used to optimize a graphically defined zoom.
  With the numeric method there are two ways of defining the zoom area:
  - Specifying **start and stop values** for the x- and y-axes; the acquired data within those values is zoomed.

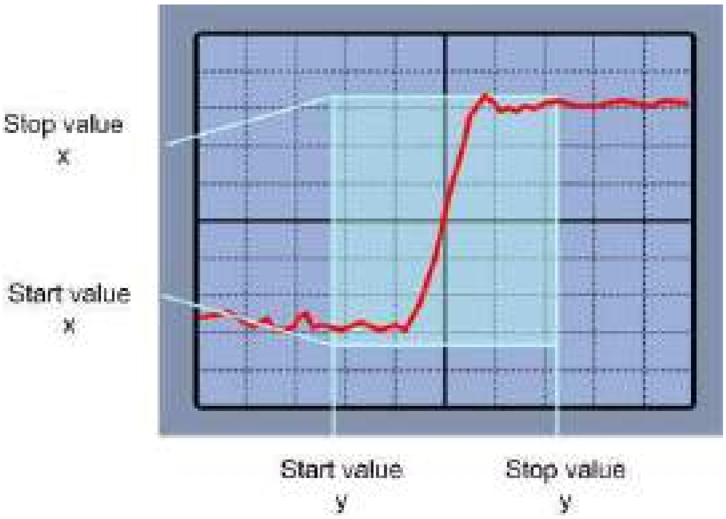


Figure 6-1: Numeric zoom using start and stop values

– Specifying the x- and y-**position** of the centerpoint of the area plus a **range** for the x- and y-axes; the area defined by that centerpoint and the ranges is zoomed.

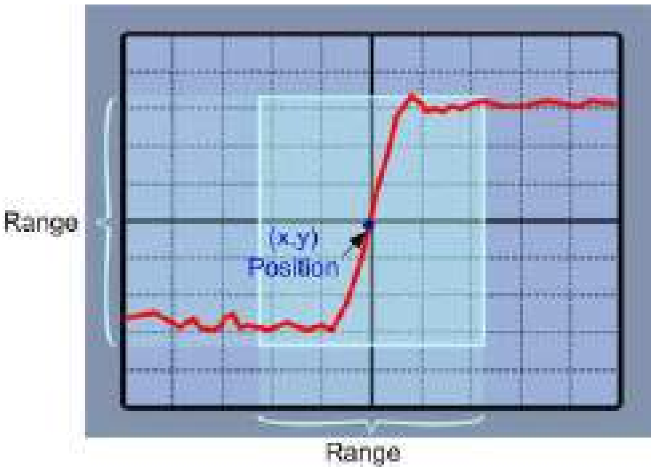


Figure 6-2: Numeric zoom using position and range

- **Coupled zoom** creates a copy of the selected zoom area. Coupled zoom areas always have the same size (size coupling). They can be positioned separately or together (position coupling).

Zoom areas can be used for gating, for example, to define a measurement gate. You can set the gate exactly to the limits of the zoom.

Evaluation gates - available histogram areas, masks, and measurement gates - can be displayed in zoom diagrams to simplify the graphical gate adjustment on the touchscreen. See: "Show evaluation gate(s) in zoom" on page 117.

6.1.2 Zoom Settings

The zoom area, i.e. the section to be enlarged, can be defined using two different methods:

- Using the zoom functions on the toolbar and draw the zoom area on the touch-screen
- Specifying numeric values:
  – start and stop values for the x- and y-axes
  – x- and y-position of one point in the diagram plus a range for the x- and y-axes

  See also: Chapter 6.1.1, "Methods of Zooming", on page 248.

6.1.2.1 Zoom Functions on the Toolbar

The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom. If you touch the icon and drag your finger down, a menu opens where you can select another zoom type.

Standard zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 1297

Hardware zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

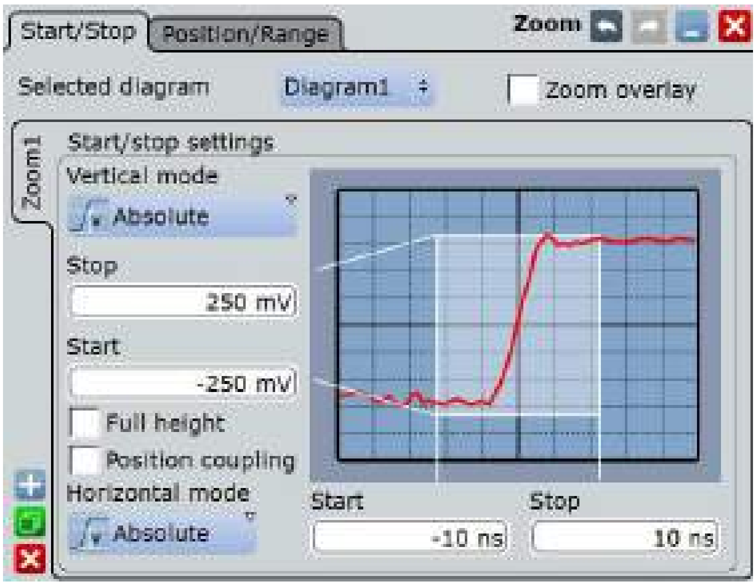
Remote command:
`LAYout:ZOOM:ADDCoupled` on page 1297

Fingertip zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

6.1.2.2 Start and Stop Settings

The "Start/Stop" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.



Selected diagram: Diagram1

☐ Zoom overlay

Vertical mode: Absolute

Stop: 250 mV

Start: -250 mV

☐ Full height

☐ Position coupling

Horizontal mode: Absolute

Start: -10 ns

Stop: 10 ns

Selected diagram
Indicates which of the waveform diagrams is selected for zooming.

Zoom overlay
Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The setting affects all zoom diagrams.

Remote command:
`LAYout:ZOOM:ONEDiagram` on page 1297

Vertical
Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:
`LAYout:ZOOM:VERTical:MODE` on page 1301
`SEARch:RESDiagram:VERT:MODE` on page 1466

Stop / Relative stop
Defines the upper limit of the zoom area on the y-axis.

Remote command:
`LAYout:ZOOM:VERTical:RELative:STOP` on page 1303
`LAYout:ZOOM:VERTical:ABSolute:STOP` on page 1302

Start / Relative start
Defines the lower limit of the zoom area on the y-axis.

Remote command:
`LAYout:ZOOM:VERTical:RELative:STARt` on page 1303
`LAYout:ZOOM:VERTical:ABSolute:STARt` on page 1302

Full height
Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling
Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
`LAYout:ZOOM:POSCoupling` on page 1298

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
`LAYout:ZOOM:HORZ:MODE` on page 1298
`SEARch:RESDiagram:HORZ:MODE` on page 1464

Start / Relative start
Defines the lower limit of the zoom area on the x-axis.

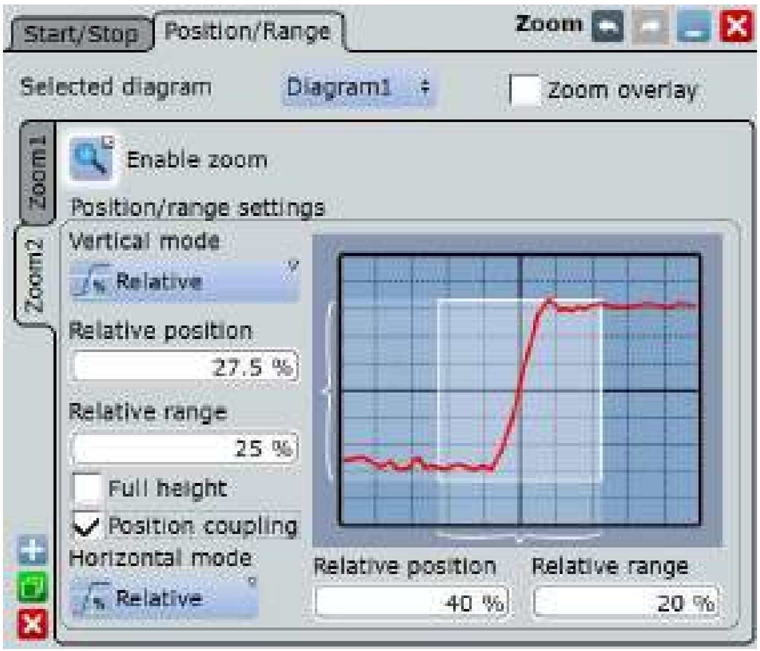
Remote command:
`LAYout:ZOOM:HORZ:ABSolute:STARt` on page 1299
`LAYout:ZOOM:HORZ:RELative:STARt` on page 1300

Stop / Relative stop
Defines the upper limit of the zoom area on the x-axis.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:STOP` on page 1299
`LAYout:ZOOM:HORZ:RELative:STOP` on page 1301

6.1.2.3 Position and Range Settings

In the "Position/Range" tab, you specify the x- and y-position of center point of the zoom area plus a range for the x- and y-axes; the area defined by that point and the ranges is zoomed.



Selected diagram: Diagram1

☐ Zoom overlay

Position/range settings

Vertical mode: Relative

Relative position: 27.5 %

Relative range: 25 %

☐ Full height

☑ Position coupling

Horizontal mode: Relative

Relative position: 40 %

Relative range: 20 %

Vertical

Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:

`LAYout:ZOOM:VERTical:MODE` on page 1301

`SEARch:RESDiagram:VERT:MODE` on page 1466

Position / Relative position (vertical)

Defines the y-value of the centerpoint of the zoom area.

Remote command:

`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 1301

`LAYout:ZOOM:VERTical:RELative:POSition` on page 1302

`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 1465

`SEARch:RESDiagram:VERT:RELative:POSition` on page 1466

Range / Relative Range (vertical)

Defines the height of the zoom area.

Remote command:

`LAYout:ZOOM:VERTical:RELative:SPAN` on page 1303

`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 1302

`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 1466

`SEARch:RESDiagram:VERT:RELative:SPAN` on page 1466

Full height

Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling
Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
`LAYout:ZOOM:POSCoupling` on page 1298

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
`LAYout:ZOOM:HORZ:MODE` on page 1298
`SEARch:RESDiagram:HORZ:MODE` on page 1464

Position / Relative position (horizontal)
Defines the x-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:POSition` on page 1298
`LAYout:ZOOM:HORZ:RELative:POSition` on page 1299
`SEARch:RESDiagram:HORZ:ABSolute:POSition` on page 1464
`SEARch:RESDiagram:HORZ:RELative:POSition` on page 1465

Range / Relative Range (horizontal)
Defines the width of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:SPAN` on page 1299
`LAYout:ZOOM:HORZ:RELative:SPAN` on page 1300
`SEARch:RESDiagram:HORZ:ABSolute:SPAN` on page 1464
`SEARch:RESDiagram:HORZ:RELative:SPAN` on page 1465

6.1.3 Zooming for Details

The usage of the various zoom methods is described in the following procedures:

- Chapter 2.3.5.2, "Using the Fingertip Zoom", on page 50
- To define the zoom area graphically on the touchscreen
- To define the zoom area numerically using start-stop values
- To define the zoom area numerically using position and range values
- To define multiple zoom areas
- To define coupled zoom areas
- To close the zoom diagram
- To use the hardware zoom

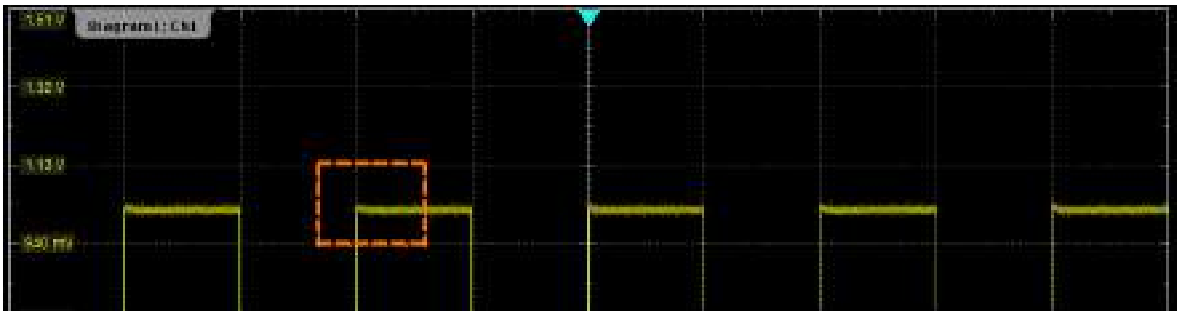
The usage of zooms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Zoom".

To define the zoom area graphically on the touchscreen

For graphical zooming, you use your finger on the screen.

1. On the toolbar, tap the "Standard Zoom" icon.

2. Touch the position that you want to define as one corner of the zoom area. Then drag your finger to the opposite corner of the zoom area.
   While you drag your finger on the touchscreen, a dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger.



   The indicated area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

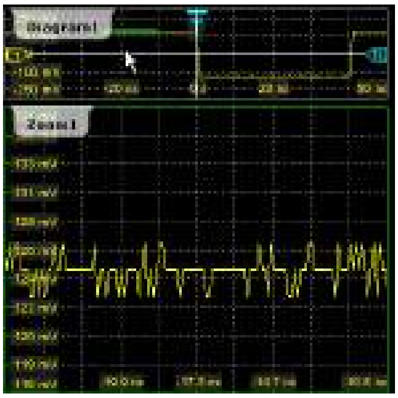


Figure 6-3: Zoom diagram and overview diagram

3. If the position of the zoom area is not correct, drag the rectangle in the overview to the correct position.

4. If the size of the zoom area is not yet ideal, tap the rectangle in the overview diagram.
   Now, 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.

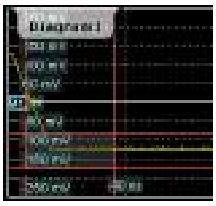


Figure 6-4: Zoom area indicated by edges

Note: Tapping the zoom area toggles between area and edge adjustment.
If the rectangle area is too small to select by tapping, press the CHECKMARK key in the navigation area to toggle between area adjustment and edge adjustment modes.

5. Touch the edge that you want to move, and drag it to the required position.

To optimize the zoom definition of an active zoom diagram, double-tap the zoom diagram. The "Zoom" dialog box for numeric definition is opened.

To adjust the zoom area using navigation controls

If you have created a zoom, and the size and position are not yet ideal, you can adjust them using the navigation knob and the navigation keys. You can adjust the size and position of the zoom area, or adjust the edges of the zoom area individually.

1. To adjust the size and position of the zoom area:
    a) Press the ☑ key until the zoom area is active (grey rectangle with white border).
    b) Turn the navigation knob to shift the zoom area. Press the knob twice to toggle between vertical and horizontal move.
    c) To adjust the size of the zoom area, press the navigation knob until "Span" is shown in the upper left corner.
    d) Turn the knob to increase or decrease the zoom area.

    Note: Pressing the navigation knob toggles between: horizontal position > horizontal span > vertical position > vertical span.

    Tip: If several zoom areas are visible, or cursors are active in addition, the ⇤ and ⇥ keys toggle between the zoom areas and the cursor sets.

2. To adjust the edges of the zoom area:
    a) Press the ☑ key until 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.
    b) Press the navigation knob until the required edge is selected (dashed red line).
    c) Turn the navigation knob to move the active edge to the required position.
    d) Press the navigation knob again. Adjust the next edge.

    Tip: Pressing the ▲ or ▼ keys moves the selected edge to the next division line left (DOWN) or right (UP). In area adjustment mode, these keys move the zoom area one division to the left (DOWN) or right (UP).

To create a new zoom using the Zoom dialog box

1. There are two ways to create a new zoom:
    - If you want to create a new, unconfigured zoom, tap the ⊞ "Add" icon.
    - If you want to create zoom based on an existing one, tap the "Copy" icon.
2. Enter a name for the zoom using the on-screen keyboard.

To define the zoom area numerically using start-stop values

1. On the "Display" menu, tap "Zoom".
2. Select the Start and Stop Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the y-axis (see Figure 6-1).
5. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
6. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the x-axis.

    When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle (see Figure 6-3).

To define the zoom area numerically using position and range values

1. On the "Display" menu, tap "Zoom".
2. Select the Position and Range Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Under "Position", define the y-value of the center point of the zoom area (see Figure 6-2).
5. Under "Range", define the height of the zoom area.
6. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
7. Under "Position", define the x-value of the center point of the zoom area.

8. Under "Range", define the width of the zoom area.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

To define multiple zoom areas

You can define more than one zoom area for the same diagram, for example to compare several peaks in a measurement. These zoom areas can be displayed in separate zoom diagrams, or together in one zoom diagram.

To define multiple zoom areas graphically, simply repeat the steps described in To define the zoom area graphically on the touchscreen - for each area. Numerically, proceed as follows:

1. On the "Display" menu, tap "Zoom".
2. Select the required tab according to the method you want to use to define the zoom area.
3. To copy the current zoom area definition, tap the "Copy" icon.
   Alternatively, tap the "Add" icon to add a new zoom area.
4. Enter a name for the new zoom diagram using the displayed on-screen keyboard.
5. Define the zoom area as described for the first zoom.

   An additional zoom diagram is displayed for the new zoom area, and another rectangle in the original diagram indicates the new zoom area. Each rectangle in the overview has the same color as the corresponding zoom diagram frame.
6. In the "Zoom" dialog box, enable "Zoom overlay".

   The zooms are shown in the same zoom diagram, as if the zoom areas are overlaid.

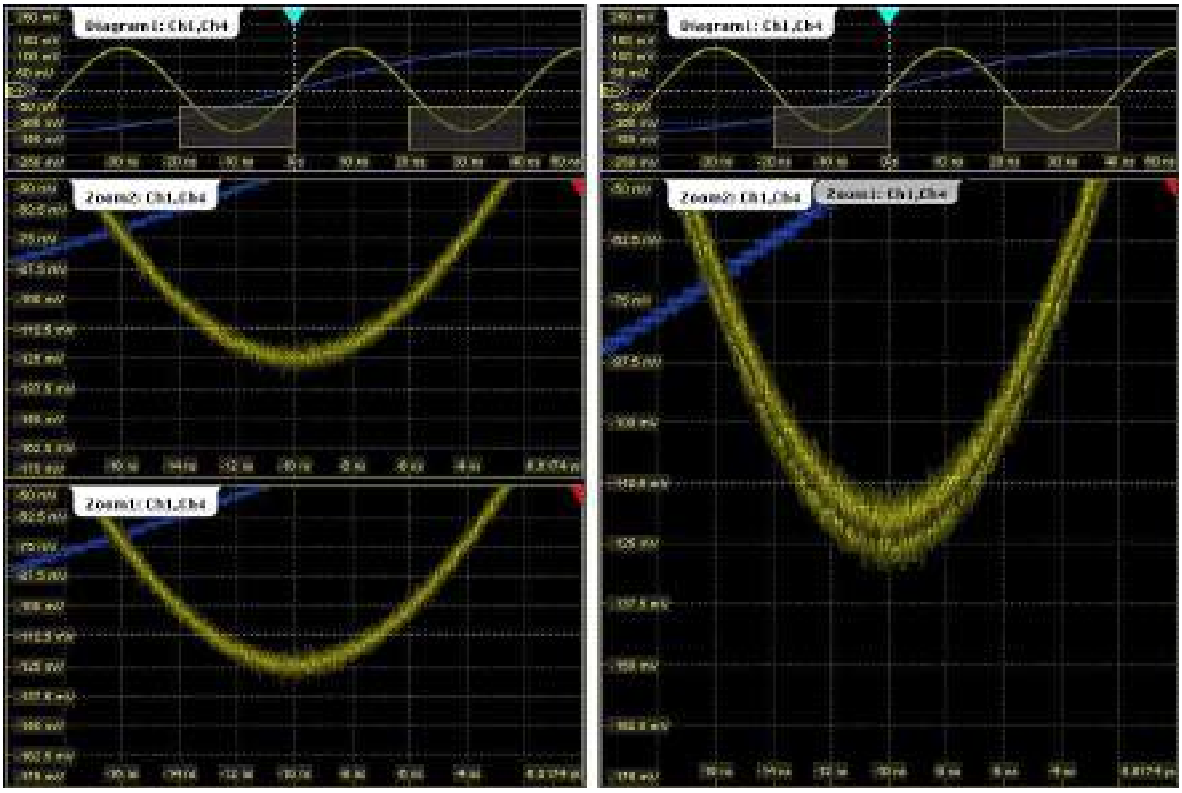


Figure 6-5: Multiple zoom diagrams. Left: separate zoom diagrams. Right: overlaid zoom

To define coupled zoom areas

You can define multiple zoom areas for one diagram that are coupled. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well. Furthermore, you can couple also the position in order to move all coupled zooms at once. Coupling is useful, for example, if you want to compare recurring peaks in a signal.

1. On the toolbar, tap the "Coupled Zoom" icon.
2. In the diagram overview, tap an existing zoom area.

   The selected zoom area is duplicated.
3. Drag the duplicate zoom area to the required position.
4. To create further coupled zooms, repeat the steps above.

   Now, if you change the zoom area size of any of the coupled zoom areas in the "Zoom" dialog box, the settings are changed for all coupled zoom areas.
5. In the "Zoom" dialog box, select the diagram that contains the coupled zooms.
6. Select a zoom tab.
7. Enable "Position coupling".

If you move one of the coupled zoom areas in the diagram, all other coupled zooms are moved as well, and their distance is kept unchanged.

To close the zoom diagram

1. Tap the "Delete" icon on the toolbar.
2. Tap the zoom diagram.

   The diagram in the overview diagram returns to the original display size.

To use the hardware zoom

In contrast to the normal zoom, the hardware zoom changes the instrument settings - horizontal and vertical scales, and also the trigger level and offset. Thus, the selected area is displayed in the diagram instead of the original waveform. No additional zoom diagram is opened.

1. On the toolbar, tap the "Hardware Zoom" icon.
2. Drag your finger on the touch screen to mark the zoom area.
   A dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger. The diagram changes and shows the magnified area.

   Tip: To return to the previous display, use the "Undo" icon.

   Note: You can combine hardware zoom and normal zoom - first use the hardware zoom, then the zoom into the display. The reverse approach is also possible: Create a zoom diagram, and then apply the hardware zoom to the waveform diagram. Both the waveform and the zoom diagrams are changed.

6.2 Reference Waveforms

You can configure up to four reference waveforms to display stored waveforms. Any active signal or mathematical waveform can be stored as a reference waveform. It can then be loaded again later to restore the waveform on the screen.

6.2.1 Working with Reference Waveforms

Reference waveforms can be displayed in addition to the signal waveforms, saved to file, and loaded back for further analysis. Reference waveforms can be loaded only from BIN files.

Note: Saving and loading reference waveforms, and preset with active reference waveform delete the undo stack. After these actions, undo is not possible.

To update a reference waveform using the toolbar icon

If you often need to update a reference waveform, you can use the "Update Ref Wfm" toolbar icon.

1. Add the "Update Ref Wfm" icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.
2. Touch the icon and open the icon menu.

3. Select the reference waveform to be used.
4. Tap the waveform to be used as reference waveform.

To display a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.
2. Select the tab for the reference waveform you want to display ("Ref1"-"Ref4").
3. Load a stored reference waveform as described in "To load a reference waveform" on page 262, or select a source to be displayed as a reference:
   a) In the "Reference" tab, tap the "Selected source" icon and select a source from the selection list. The source can be any active signal, math, or other reference waveform.
   b) Tap the "Update with" button to update the current reference waveform with the source data.
4. Tap the "Show reference waveform" icon so it is highlighted.

   The reference waveform is displayed on the screen.
5. A reference waveform can have its own scaling settings or it can be scaled according to the source settings. By default, the scaling of the reference waveform is coupled to the source settings. Additionally, it can be stretched or compressed in vertical and horizontal direction.
   If necessary, change the settings on the "Scaling" tab of the "Reference Waveform" dialog box. The original source waveform settings are displayed in the "Original Attributes" tab. To restore the original settings, tap the "Restore settings" button.
   For a description of the scaling settings, see Chapter 6.2.2.2, "Scaling", on page 264.

To save a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.

Tip: Alternatively, you can save a waveform as a reference waveform in the "File" dialog box, see Chapter 11.2.6, "Saving and Loading Waveform Data", on page 466.

2. Select the tab for the reference waveform you want to store ("Ref1"-"Ref4").
3. Display and configure the reference waveform as described in "To display a reference waveform" on page 261.
4. Select the fille format.

   Note: Reference waveforms can be loaded only from BIN files. XML and CSV formats are meant for further processing in other applications.
5. To save the waveform to the currently selected file, tap "Save". By default, the prefix for reference waveform files is "RefCurve".
   To save the waveform to another file, select "Save As".
   Enter a file name and select the directory. The file type is already defined according to the selection in the previous step. In order to load the reference waveform on the instrument again later, use the file type BIN.

   The source settings of the reference waveform and the current scaling settings are stored to the specified file.

To load a reference waveform

Note: Reference waveforms can be loaded only from BIN files.

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.
2. Select the tab for the reference waveform you want to load ("Ref1" - "Ref4").
3. To load the waveform from the specified file, tap "Load".
   To load the waveform from a different file, tap "Open". Select the file from the file selection dialog box. Only BIN files are displayed in the file list.

   The selected waveform is loaded as the specified reference waveform.
4. If the reference waveform is not visible, tap the "Show reference waveform" icon.

6.2.2 Settings for Reference Waveforms

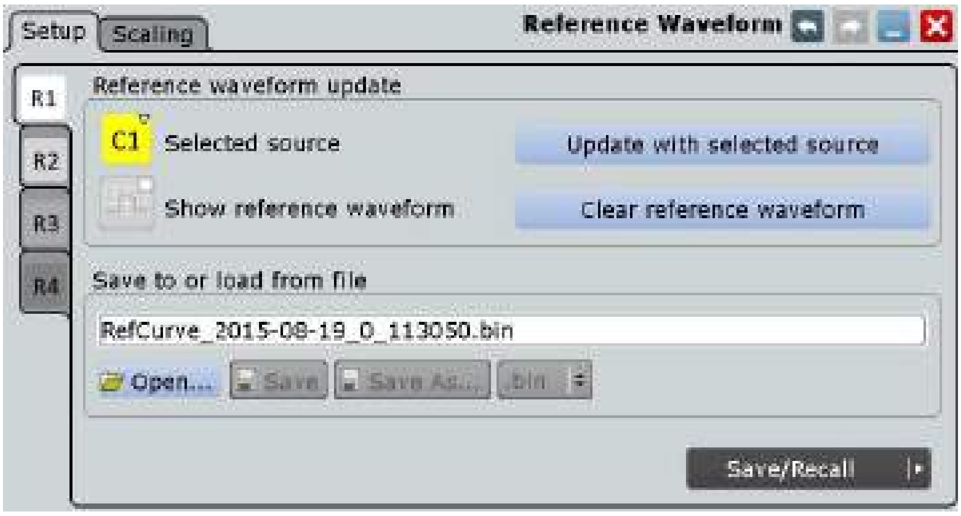
To compare waveforms and analyze differences between waveforms, you can use up to four reference waveforms R1 to R4. Each reference waveform has its own memory on the instrument. You can also save an unlimited number of reference waveforms and load them for further use.

The display of a reference waveform is independent from that of the source waveform; you can move, stretch and compress the curve vertically and horizontally.

6.2.2.1 Reference Waveform Setup

Access: REF key

In the "Setup" tab, you select the reference waveform and its source. The source can be an active waveform - trace of an input channel, math waveform or another reference waveform - or a stored waveform.



Ref 1/2/3/4

Each tab contains the settings for one of the four available reference waveforms.

Source

Selects the source waveform from the active waveforms of input channels, math signals and other reference waveforms.

Remote command:

`REFCurve<m>:SOURce` on page 1304

Update with selected source

Copies the selected source waveform with all its settings to the memory of the reference waveform. If the acquisition is running, the reference waveform is a snapshot.

Remote command:

`REFCurve<m>:UPDate` on page 1305

Show reference waveform

Displays the reference waveform in the diagram.

Remote command:

`REFCurve<m>:STATe` on page 1305

Clear reference waveform

The selected reference waveform disappears, its memory is deleted.

Remote command:
`REFCurve<m>:CLEar` on page 1306

Save to or load from file
Enter the file name of the stored reference waveform and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box, see also Chapter 11.6, "File Selection Dialog", on page 478.

By default, the file name has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

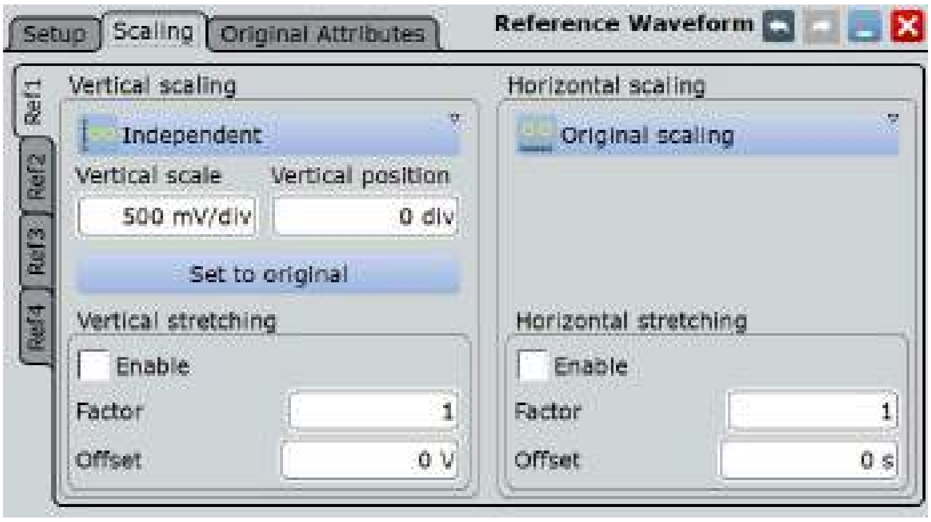
Note: Note that reference waveforms can be loaded from `.bin` files only. xml and csv formats are meant for further processing in other applications.

"Load"	Loads the specified reference waveform.
"Open"	Opens a file selection dialog box and loads the selected reference waveform file
"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file.
".bin/.xml/.csv"	Selects the file format.

Remote command:
`REFCurve<m>:OPEN` on page 1305
`REFCurve<m>:SAVE` on page 1306
`REFCurve<m>:DELete` on page 1306

6.2.2.2 Scaling

A reference waveform can have its own settings, for example, vertical position und scale. Additionally, it can be stretched or compressed in vertical and horizontal direction. The current settings and the settings of the source waveform are stored.



Vertical scaling: Independent
Vertical scale: 500 mV/div
Vertical position: 0 div
Vertical stretching: ☐ Enable
Factor: 1
Offset: 0 V
Horizontal scaling: Original scaling
Horizontal stretching: ☐ Enable
Factor: 1
Offset: 0 s

Vertical Scaling
Selects the type of vertical settings:

"Coupled to source"	Vertical position and scale of the source are used.
"Independent"	Scaling and position can be set specific to the reference waveform.

Remote command:
`REFCurve<m>:VMODe` on page 1307

Vertical scale
Sets the vertical scale for the reference waveform, if vertical scaling is set to "Independent". You can also use the vertical SCALE knob to adjust this value.

Remote command:
`REFCurve<m>:SCALe` on page 1307

Vertical position
Moves the reference waveform up or down in the diagram, if vertical scaling is set to "Independent". You can also use the vertical POSITION knob to adjust this value.

Remote command:
`REFCurve<m>:POSition` on page 1307

Set to original
Restores the settings of the source waveform, if vertical scaling is set to "Independent".

Remote command:
`REFCurve<m>:RESTore` on page 1307

Vertical Stretching
Stretching and offset change the display of the waveform independent of the vertical scale and position.

Enable ← Vertical Stretching
If enabled, the vertical offset and streching factor are applied to the reference waveform.

Remote command:
`REFCurve<m>:RESCale:VERTical:STATe` on page 1308

Factor ← Vertical Stretching
A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Remote command:
`REFCurve<m>:RESCale:VERTical:FACTor` on page 1308

Offset ← Vertical Stretching
Moves the reference waveform vertically. Enter a value with the unit of the waveform. Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Note: As for all waveforms, a vertical offset of a reference waveform can be set using the vertical POSITION knob. This offset is independent from the reference scaling offset, which is described here. If both offsets are set, their values are added up.

Remote command:
`REFCurve<m>:RESCale:VERTical:OFFSet` on page 1308

Horizontal Scaling
Selects the type of horizontal settings:

"Adjust to X-Axis"	The current horizontal settings of the diagram are used.
"Original Scaling"	Horizontal scaling and reference point of the source waveform are used.

Remote command:
`REFCurve<m>:HMODe` on page 1309

Horizontal Stretching
Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Enable ← Horizontal Stretching
If enabled, the horizontal offset and streching factor are applied to the reference waveform.

Remote command:
`REFCurve<m>:RESCale:HORizontal:STATe` on page 1309

Factor ← Horizontal Stretching
A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

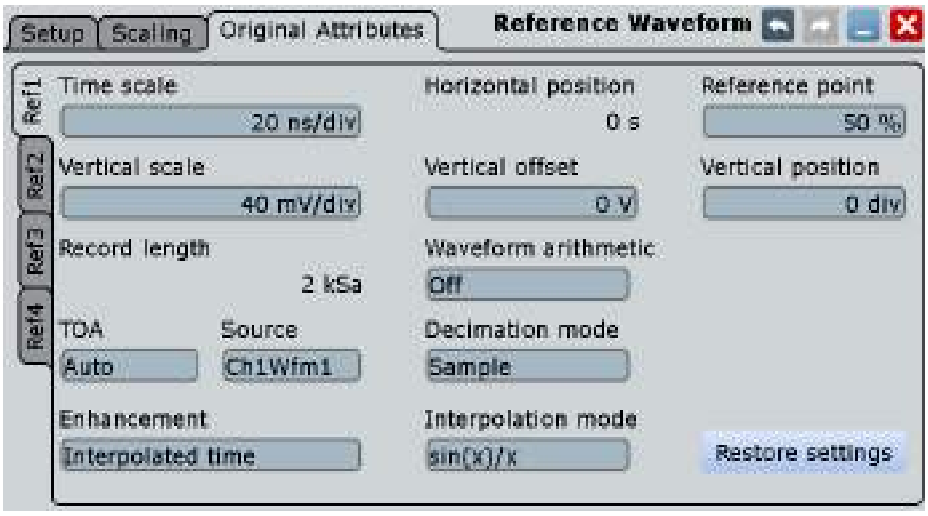
Remote command:
`REFCurve<m>:RESCale:HORizontal:FACTor` on page 1309

Offset ← Horizontal Stretching
Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram. Positive values shift the waveform to the right, negative values shift it to the left.

Remote command:
`REFCurve<m>:RESCale:HORizontal:OFFSet` on page 1309

6.2.2.3 Original Attributes

As a reference waveform can be scaled, stretched and positioned in the diagram, this tab shows the settings of the original reference waveform for information.



Time scale: 20 ns/div
Horizontal position: 0 s
Reference point: 50 %
Vertical scale: 40 mV/div
Vertical offset: 0 V
Vertical position: 0 div
Record length: 2 kSa
Waveform arithmetic: Off
TOA: Auto
Source: Ch1Wfm1
Decimation mode: Sample
Enhancement: Interpolated time
Interpolation mode: sin(x)/x

- "Time scale" on page 148
- "Vertical scale" on page 159
- "Resolution / Record length (Resolution dependency)" on page 149
- " Source " on page 263
- "Position" on page 148
- "Offset" on page 160
- "Wfm Arithmetic" on page 154
- "Mode" on page 153
- "Interpolation" on page 152
- "Reference point" on page 148
- "Position" on page 159

Restore Settings
Restores the original waveform settings from the source waveform to the reference waveform.

6.3 Mathematics

Math waveforms are calculated waveforms. You can define up to four math waveforms and display them on the screen, and use it as source for further analysis.

Math waveforms are defined by mathematical expressions (formulas). You can enter mathematical expressions using two different methods:

- "Basic": you define a simple math function in a graphical editor by selecting the source waveform(s) and the operator.
- "Advanced": you define sophisticated math functions in a formula editor, as required to your needs.

The result of an FFT analysis is a specific math waveform. For information on FFT and spectrum analysis, see Chapter 8, "Spectrum Analysis", on page 371.

The vertical scale of a math waveform is adapted automatically to the measurement results to ensure optimal display. Furthermore, you can scale each math waveform manually in vertical direction like a channel waveform.

As for channel waveforms, you can also change the arithmetic mode for the waveform to display the envelope or an average over several calculations.

You can store a math waveform as a reference waveform and restore it later, see "To save a reference waveform" on page 261.

6.3.1 Displaying Math Waveforms

Math waveforms can be displayed in addition to the channel and other waveforms. They also can be used for analysis, e.g. measurements, even if the math waveform is not active.

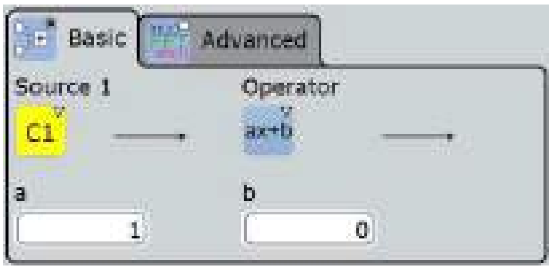
1. In the "Math" menu, select "Math Setup".
   Alternatively, press the MATH key.
2. Define the math expression for calculation in one of the following ways:
   - Chapter 6.3.2.2, "Defining a Formula in the Basic Editor", on page 271
   - Chapter 6.3.3, "Advanced Expressions", on page 271
   - Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 375
3. In the "Math Setup" dialog box, in the "Setup" tab, tap the "Enable math signal" icon.

   The math waveform is displayed on the screen.
4. To change the vertical scaling of the math waveform, tap the "Manual" icon.
5. Enter the "Vertical scale" factor (per division). If necessary, add a "Vertical offset". By default, automatic scaling is performed.

   Tip: You can also use the vertical SCALE rotary knob for scaling. In this case, the scale mode is set to "Manual" temporarily.
6. If you need the envelope or average of the math waveform over several calculations, change the arithmetic mode for the waveform as for channel waveforms.
   See also: "Wfm Arithmetic" on page 154.
7. Close the "Math Setup" dialog box.

6.3.2 Basic Editor

In the basic editor, you can define the most common mathematical formulas without knowing their correct syntax.



Remote command:

- `CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 1313

6.3.2.1 Settings in the Basic Editor

Source 1 / 2

Defines the signal source to be evaluated by the math function. Waveform 1 of channel signals can be selected.

Note: If you require other signal sources not listed here, use the formula editor provided in the "Advanced" tab. In advanced mode, any waveform of any input channel can be used as a source. See: Chapter 6.3.3, "Advanced Expressions", on page 271.

Operator

Defines the type of operation to be performed on the selected signal sources. The following functions are available:

Note: If you require other operators not listed here, use the formula editor provided in the "Advanced" tab. See: Chapter 6.3.3, "Advanced Expressions", on page 271.

"+"	Adds up the sources
"-"	Subtracts source 2 from source 1.
"x"	Multiplies source 1 by source 2.
"|x|"	Determines the absolute value of the source.
"dx/dt"	Differentiates the source value with respect to the time value. Not possible on envelope waveforms and waveforms with "Peak detect" decimation.
"log(x)"	Calculates the logarithm of the source value based on 10.
"ln(x)"	Calculates the natural logarithm of the source value (based on e).
"ld(x)"	Calculates the binary logarithm of the source value (binary logarithm, based on 2).
"Rescale"	Rescales the source values by a factor "a" and an offset "b": *ax+b*. See also: "a / b" on page 270.

"FIR filter"	Finite impulse response filter - highpass or lowpass filter for a specified cut-off frequency and characteristic. See also: "FIR: Type, Cut-Off, Characteristics" on page 270.
"Mag(FFT(x))"	Determines the magnitude of the FFT for the source values.

Noise reject

Only available for the "dx/dt" operator.

To suppress noise effects during differentiation, it can be useful not to consider two directly neighboring points to calculate *dx* (x_n-x_{n-1}). Instead, a number of samples in-between are skipped and a point a few samples further is used (e.g. x_n-x_{n-3}).

The "Basic" editor shows the default number of neighboring samples that are skipped for differentiation.

To adjust the number of samples, select the "Advanced" editor, see Table 6-4.

a / b

Defines the values for the "Rescale" function (ax+b).

"a"	Is the factor the signal source is multiplied with
"b"	Is the offset of the signal source on the y-axis

FIR: Type, Cut-Off, Characteristics

The finite impulse response filter ("Operator" = FIR) is a filter that requires three additional settings:

Source 1: C1
Operator: FIR
Type: Lowpass
Cut-Off: 10 MHz
Characteristics: Gaussian

- "Type": defines whether the FIR filter is a highpass or lowpass filter.
- "Cut-Off": sets the limit frequency for the FIR filter.
- "Charcteristics": defines whether the FIR filter has a Gaussian or a rectangular shape

The cut-off frequency depends on the horizontal resolution and the filter characteristics. The frequency for the lowpass filter can only be set in this range:

f_g_3dB = (0.001 ... 0.2)* f_a_in for Gaussian FIR filter

f_g_3dB = (0,001 ... 0.4)* f_a_in for rectangular FIR filter

Where: f_g_3dB = cut-off frequency to be set for the lowpass filter, and f_a_in = reciprocal of the resolution, or sample rate.

To check limit frequency for the highpass filter, convert it to an equivalent lowpass frequency:

f_LP = f_a_in/2 - f_HP

Where f_HP is the requested highpass limit frequency and f_LP the equivalent lowpass frequency that has to comply with the limits given above.

For advanced expression, see Table 6-10.

Envelope wfm selection
Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

Remote command:
`CALCulate:MATH<m>:ENVSelection` on page 1313

6.3.2.2 Defining a Formula in the Basic Editor

1. In the "Math" menu, select "Math Setup".
   Alternatively, press the MATH key.
2. In the "Setup" tab, select the "Basic" tab.
3. Tap the "Source 1" and "Source 2" icons and select the signal sources to which the math function is applied. For details on available signal sources, see "Source 1 / 2" on page 269.
4. Tap the "Operator" icon and select the mathematical function.
   For details on available operators, see "Operator" on page 269.
5. If the operator requires additional parameters, enter them in the input fields.

6.3.3 Advanced Expressions

In the "Advanced" tab, you can enter complex formulas to define a math waveform. The formula editor helps to enter formulas easily with correct syntax, using a large selection of operators and signal sources. Double-tap the "Advanced" tab to display the formula editor.

Derivation(Ch1Wfm1,1)

6.3.3.1 Advanced Formula Editor

Using the formula editor you can define math functions freely, using a large selection of operators and signal sources. For a procedure on using the editor, see Chapter 6.3.3.2, "Defining a Formula in the Advanced Formula Editor", on page 277.

FFTmag(Ch1Wfm1)

Remote command:

- `CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 1313

The following tables describe the buttons of the formula editor and their usage.

Table 6-1: Basics

Icon	Description	Usage/Comment, *FormulaEditor expression*
(	left bracket	enclose operands
,	comma	separates operands
)	right bracket	enclose operands
e / π	math. constants	e: Euler number: 2.7182... Pi: 3.1415...
[	left square bracket	enclose unit
V / A / Ω	units	[<unit>]
]	right square bracket	enclose unit
x^a	exponentiation with base x	x: base, a: exponent *x^a*
/	division	
*	multiplication	
-	subtraction	
+	addition	
0...9	numeric characters	
.	decimal point	

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
Exp	exponentiation with base 10	*e*
Enter	expression complete	insert expression in Setup dialog and close the formula editor
Clear	clear expression in editor	restart editing
Del	Delete	remove selected part of expression
Back	Backspace	remove last symbol, operator or operand to the left of the cursor
M / k / µ	SI-prefix for unit	<SI-prefix>[<unit>]

Table 6-2: Signal sources

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
Ch	signal waveform	*Ch<1...4>Wfm<1...3>*
Math	math waveform	*Math<1...4>*
Ref	reference waveform	*Ref<1...4>*
Meas	measurement waveform	*Meas<1...8>*

Table 6-3: Cursor keys

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
|←	move cursor to beginning	
←	move cursor 1 step to the left	
→	move cursor 1 step to the right	
→|	move cursor to end	

Table 6-4: Algebra

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
|x|	absolute x value	*abs(x)*
√x	square root of x	*sqrt(x)*
x^2	x*x	*pow(x)*
$\log_{10}$	common logarithm (base 10)	*log(x)*
$\log_e$	natural logarithm (base e)	*ln(x)*
$\log_2$	binary logarithm (base 2)	*ld(x)*
e^x	exponentiation with base e	*exp(x)*
∫xdx	integral of x	*integral(x)*

Icon	Description	Usage/Comment, *FormulaEditor expression*
d/dx	derivation of x	*derivation(x,y)* with x = waveform and y = number of skipped samples (noise reject)
ax+b	scaling of x	*rescale(x,a,b)*

Table 6-5: Bit operations

Icon	Description	Usage/Comment, *FormulaEditor expression*
digitize	convert to 0 or 1	*digitize(x)*
not	negation	*not(x)*
and		*and*
nand	negation of and	*nand*
or		*or*
nor	negation of or	*nor*
xor	exclusive or	*xor*
nxor	negation of exclusive or	*nxor*

Table 6-6: Comparison

Icon	Description	Usage/Comment, *FormulaEditor expression*
=	equal	=
≠≠	not equal	<>
<	smaller	<
>	greater	>
≤	smaller or equal	<=
≥	greater or equal	>=
More	display additional keys	

Table 6-7: FFT ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
|FFT|	magnitude of FFT value	*fftmag(x)*
FFT (φ)	FFT phase value	*fftphi(x)*
FFT -dφ*df	FFT group delay	*fftgroupdelay(x)*
FFT (re)	real part of FFT value	*fftre(x)*
FFT (im)	imag part of FFT value	*fftim(x)*

Table 6-8: Trigonometry ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
sinh	hyperbolic sine	*sinh(x)*
cosh	hyperbolic cosine	*cosh(x)*
tanh	hyperbolic tangent	*tanh(x)*

Table 6-9: Correlation ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
	Cross correlation function of two waveforms Measures the similarity of two waveforms as a function of a time-lag applied to one of them. Function limits the maximum record length to 4 MSa. Two modes of normalization are supported: biased and unbiased. The length of the correlation buffer is $N_0 + N_1 - 1$ samples. The length of the first input signal is N_0 samples and the length of the second signal is N_1 samples.	*correlation(x1, x2, biased)* *correlation(x1, x2, unbiased)* with x1 = waveform 1 and x2 = waveform 2 *correlation(x1, x2)* performs an unbiased correlation
	Auto correlation Used to find repeating patterns, for example, a periodic signal obscured by noise. The length of the auto correlation buffer is $2N - 1$ samples, if the length of the input signal is N samples. Two modes of normalization are supported: biased and unbiased.	*autocorrelation(x, biased)* *autocorrelation(x, unbiased)* with x = channel waveform *autocorrelation(x)* performs an unbiased autocorrelation
	biased / unbiased normalization for correlation and auto correlation	see above

Mathematic background for correlation:

$$Temp1\_R_{xy}(m) = \sum_{n=0}^{N1} y_n^* x_{n+m} \qquad m \in [0; N_1[$$

$$Temp0\_R_{xy}(m) = \sum_{n=1}^{N0} x_n^* y_{n+m} \qquad m \in [1; N_0[$$

The R&S RTO uses only the real part of the signal. Two modes of normalization are supported: biased and unbiased.

$$R_{xy}(m) = \begin{cases} \dfrac{1}{\min(N_0, N_1)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \dfrac{1}{\min(N_0, N_1)} Temp0\_R_{xy}^*(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-1: Biased correlation

$$R_{xy}(m) = \begin{cases} \frac{1}{a(m)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \frac{1}{a(m)} Temp0\_R^*_{xy}(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-2: Unbiased correlation

Mathematic background for auto correlation:

$$R_{xx}(m) = \begin{cases} \frac{1}{N} \sum_{n=0}^{N-m-1} x_n^* x_{n+m} & m \geq 0 \\ R^*_{xx}(-m) & m < 0 \end{cases}$$

Equation 6-3: Biased auto correlation

$$R_{xx}(m) = \begin{cases} \frac{1}{N-|m|} \sum_{n=0}^{N-m-1} x_n^* x_{n+m} & m \geq 0 \\ R^*_{xx}(-m) & m < 0 \end{cases}$$

Equation 6-4: Unbiased auto correlation

The R&S RTO uses only the real part of the signal.

Table 6-10: Filter and power ("More" keys)

Icon	Description	Usage, comment, *FormulaEditor expression*
💡	Electric power	Electric power is calculated from voltage, based on measurement impedance (see "Measurement impedance" on page 162) *elecpower(x)* = U²/R
FIR	Finite impulse response (FIR) filter	*FIR(highpass,x,y,c)* or *FIR(lowpass,x,y, c)* with: x = source (channels only), y = cut-off frequency, c = Gaussian or rectangle characteristics Example: *FIR(lowpass,Ch1Wfm1,12e+006,gaussian)* sets a Gaussian lowpass filter with 12 MHz cut-off frequency See also: "FIR: Type, Cut-Off, Characteristics" on page 270.
≈	Type of FIR filter	*highpass* / *lowpass*, see FIR filter

Icon	Description	Usage, comment, *FormulaEditor expression*
	Characteristics of FIR filter	*gaussian* / *rectangle*, see FIR filter
MA	Moving average	Calculates a mean value of several adjacent sample points. The result is a smoothed waveform. The moving average uses the full data and can be used for non-periodic signals. It works like a low-pass filter and increases the vertical resolution at the expense of bandwidth reduction. *MovingAverage(x,y)* with: x = source (channels only), y = number of samples to be averaged Example: *MovingAverage(Ch1Wfm1,1000)* Averages 1000 subsequent samples of the channel 1 waveform

Table 6-11: Clock data recovery ("More" keys, requires options R&S RTO-K12/K13)

Icon	Description	Usage/Comment, *FormulaEditor expression*
CDR	CDR: displays the generated clock signal as math waveform	Hardware: *CDR(hw)* Software 1: *CDR(sw1,x)* Software 2: *CDR(sw2,x)* where x is the signal from which the clock is recovered Example: *CDR(sw1,CH2Wfm1)* See also: Chapter 16.2.3, "Displaying the Recovered Clock Signal", on page 1053

6.3.3.2 Defining a Formula in the Advanced Formula Editor

1. In the "Math" menu, select "Math Setup".
2. In the "Setup" tab, select the "Advanced" tab.
3. Double-tap the editing area.

   The "Formula Editor" is displayed.
4. Enter the math formula including all required signal sources and operators by selecting the corresponding keys in the editor. For details on the available keys, see Chapter 6.3.3.1, "Advanced Formula Editor", on page 271.
5. To insert a physical unit in the formula, proceed as follows:
   a) If necessary, insert a decimal prefix using the "M/k/µ" key.
   b) Insert an opening square bracket using the "[" key.
   c) Insert the physical unit using the "V/A/Ω" key.

d) Insert a closing square bracket using the "]" key.

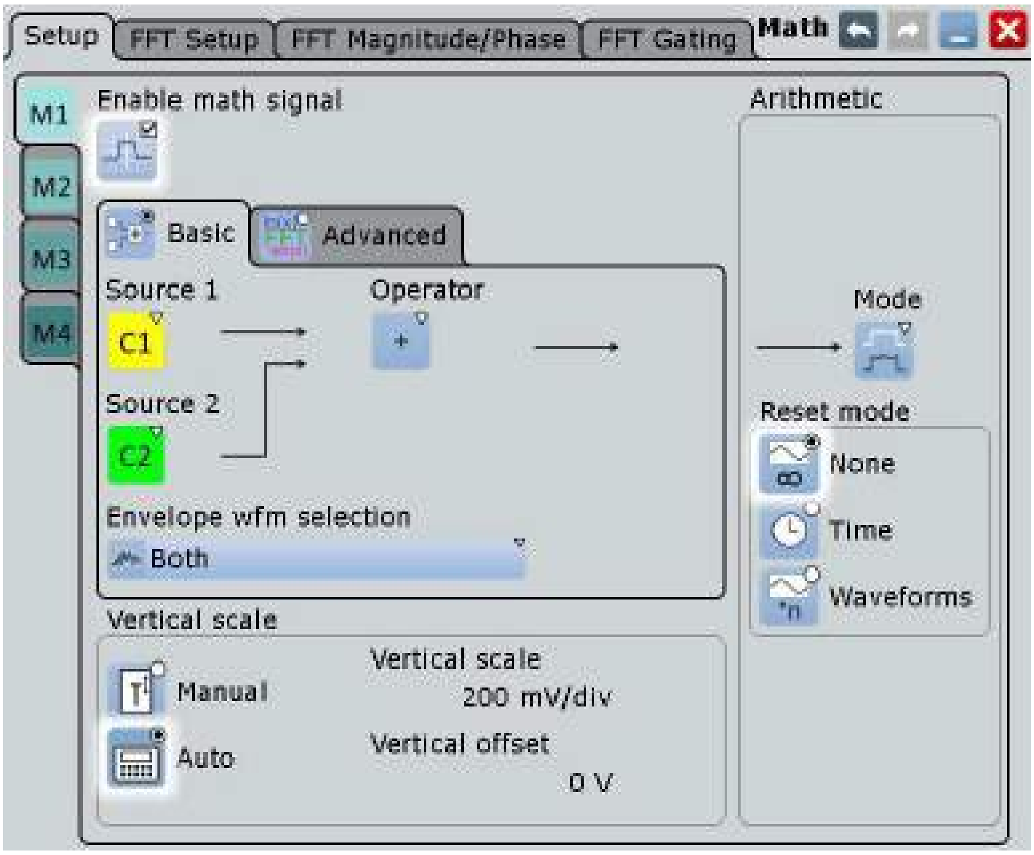
The resulting expression could be, for example: `m[V]`

6. To perform a rescaling function, proceed as follows:
   a) Select the rescaling function using the "ax+b" key.
   b) Behind the left bracket, insert the signal source using one of the following keys:
      - "Ch" for a channel
      - "Math" for a math function
      - "Ref" for a reference waveform
      - "Meas" for a measurement
   c) Insert a comma using the "," key.
   d) Insert the "a" value, i.e. the scaling factor, using the number keys.
   e) Insert a comma using the "," key.
   f) Insert the "b" value, i.e. the scaling offset, using the number keys.
   g) Insert the closing bracket using the ")" key.

   The resulting expression could be, for example: `rescale(Ch1Wfm1,3,4)`

6.3.4 Math Setup - General Settings

You can define up to 4 different math waveforms. Each waveform is defined in a separate tab in the "Math" dialog box ("Math 1"-"Math 4").



The settings for input of mathematical formulas in basic and advanced editors are described in separate chapters:

- Chapter 6.3.2.1, "Settings in the Basic Editor", on page 269
- Chapter 6.3.3, "Advanced Expressions", on page 271

The general settings for enabling, scaling and waveform arithmetic are:

Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1313

Vertical Scale

Functions to set the vertical parameters of the math waveform.

Note: If an FFT expression is defined, the vertical scaling for spectrum displays is available: "Vertical maximum" and "Vertical range" instead of "Vertical Scale" and "Vertical Offset". See Chapter 8.1.3.2, "FFT Overlap", on page 382.

Vertical scaling mode (Manual/Auto) ← Vertical Scale

By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual"	Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".
"Auto"	"Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical Scale ← Vertical Scale

Defines the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50m V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

If the "Vertical scaling mode (Manual/Auto)" on page 279 is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe` on page 1315

Vertical Offset ← Vertical Scale
Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform , positive values move it down.

If the "Vertical scaling mode (Manual/Auto)" on page 279 is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:OFFSet` on page 1314

Arithmetic
Functions to specify the waveform arithmetic for the math waveforms.

Mode ← Arithmetic
Waveform arithmetic builds the resulting waveform from several consecutive acquisitions and subsequent math calculations of the signal. For details, see "Wfm Arithmetic" on page 154.

"Original"	The original results are displayed
"Envelope"	The envelope curve of all acquired and calculated results is displayed
"Average"	The average of all acquired and calculated results is displayed
"RMS"	The root mean square of the math data is displayed. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on waveforms.
"MinHold"	Determines the minimum result for each input value from the data of the current acquisition and a number of acquisitions before.
"MaxHold"	Determines the maximum result for each input value from the data of the current acquisition and a number of acquisitions before.

Remote command:
`CALCulate:MATH<m>:ARIThmetics` on page 1314

Reset now ← Arithmetic
Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 1213

Acquisition/average count ← Arithmetic
Access:
- Trigger > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:

- It sets the number of waveforms acquired with SINGLE
- It defines the number of waveforms used to calculate the average waveform.
  Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with SINGLE.
  If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 157.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 1213

Auto reset mode / Reset mode ← Arithmetic
Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1213
`ACQuire:ARESet:TIME` on page 1214
`ACQuire:ARESet:COUNt` on page 1214

6.4 History

The history accesses the data of previous acquisitions and provides them for further analysis.

6.4.1 About History

If a continuous acquisition runs, the captured data is stored in the sample memory and the current acquisition is processed and shown on the display. After the acquisition was stopped, the history accesses the captured samples that were stored, displays these samples as history waveforms, and makes them available for further analysis. It considers all channels that were enabled during the running acquisition. When a new acquisition is started with RUN STOP or SINGLE, the memory is cleared and written anew.

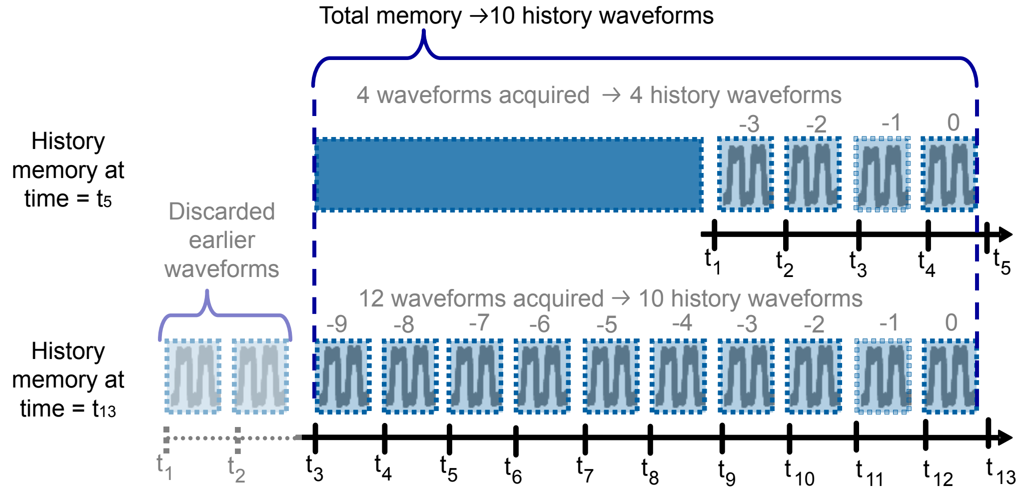


Figure 6-6: History memory. In this example, the memory can store 10 waveforms.

You can work with history waveforms in the same way as with the waveform of the latest acquisition: use zoom, cursor measurements, and automatic measurements, create math waveforms, perform mask testing and so on. Saving the history data is also possible, either completely or a part of the data.

The number of stored history waveforms depends on the memory size, the number of enabled channels, and the record length. The shorter the record length, the less the number of channels, and the larger the memory, the more history waveforms are saved.

Quick-access History dialog box

When you press the HISTORY key on the front panel or tap "Display" menu > "Show history", the history mode is enabled and the quick-access "History" dialog box is displayed. A running acquistion stops immediately.

The small quick-access "History" dialog box can remain visible on the screen during history replay, so that the history can be replayed at any time by a simple tap on the "Play" button. Closing the quick-access "History" dialog box, or starting a new acquisition disables the history mode.

Available acqs 935
Current acq -586
Time -2.905324094643 s
☐ Auto repeat

Export of history waveforms

You can export history data, see "To save the history data" on page 287.

6.4.2 History Setup

The "History" dialog box contains the complete functionality on history viewing and information. Out of these, the most important information and functions are also provided in the quick-access history dialog box.

6.4.2.1 Viewer

The settings in the "Viewer" tab control the display of history waveforms.

Date 2015:08:06
Time 9:49 14,001.992.018 s
Mode Absolute
Current acq 0
Start acq -18916
Stop acq 0
Replay time per acq 50 ms

The numbering of the waveforms refers to the current memory content. With every RUN STOP or SINGLE action, the memory content changes.

Show history / Export history
Enables the history mode and allows to save history waveforms to file.

The history display is enabled automatically when you press the HISTORY button. It is disabled when you close the quick-access "History" dialog box.

For details on data export, see "Export history" on page 458.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]` on page 1317

Current acq
Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisition have a negative index.

If a history replay is running, the field shows the number of the currently shown acquisition.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent` on page 1318

Start acq
Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative. The number of stored history acquisitions is shown in Available acquisitions on the "Information" tab.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:STARt` on page 1318

Stop acq

Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Remote command:

`CHANnel<m>[:WAVeform<n>]:HISTory:STOP` on page 1318

Select all

All acquisitions saved in the memory will be shown in the viewer.

Current

Sets the newest acquisition in the sample memory as "Stop acq" and "Current acq". This acquisition always has the index "0".

Oldest

Sets the oldest acquisition in the sample memory as "Start acq" and "Current acq".

Auto repeat

If selected, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the "Stop index".

Remote command:

`CHANnel<m>[:WAVeform<n>]:HISTory:REPLay` on page 1319

Play

Starts and stops the replay of the history waveforms from "Start acq" to "Stop acq".

Remote command:

`CHANnel<m>[:WAVeform<n>]:HISTory:PLAY` on page 1319

Replay time per acq.

Sets the display time for one acquisition. The shorter the time, the faster is the replay. The setting takes effect for history replay and the display of an Ultra Segmentation series, see Chapter 4.2.3, "Ultra Segmentation", on page 156.

Remote command:

`CHANnel<m>[:WAVeform<n>]:HISTory:TPACq` on page 1319

Time stamp

The time stamp shows the time of the currently displayed history acquisition. Thus, the time relation between acquisitions is always available.

The time stamp "Mode" can be absolute or relative:

- In "Absolute" mode, the instrument shows the date and the daytime of the current acquisition.
- In "Relative" mode, the time difference to the newest acquisition (index = 0) is shown.

The time stamp can be included in waveform data export, see "Timestamps" on page 459.

During history replay, the time value is displayed and updated if the replay speed ("Time per acquisition") is slow enough, that is 40 ms or slower.

The quick-access history dialog box always shows the relative time. In the "History Viewer" tab, you can select the time mode.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?` on page 1320
`CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?` on page 1320
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?` on page 1320
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?` on page 1321

6.4.2.2 Information

Max. acquisition count 249999
Available acqs 249999

Max. acquisition count
Displays the maximum number of acquisitions that can be saved in the sample memory and displayed with the history viewer. With Ultra Segmentation, it is also the maximum number of acquisitions in an Ultra Segmentation acquisition series.

Available acquisitions
Displays the number of acquisitions currently saved in the sample memory. This memory is also used to save an Ultra Segmentation acquisition series, so the number of acquisitions available for history viewing is the same as the number of acquisitions in an Ultra Segmentation acquisition series.

Remote command:
`ACQuire:AVAilable?` on page 1317

6.4.3 Using History

You can access the history waveforms in two ways:

- Display a particular acquisition.
- Replay all or a part of the saved waveforms to track the signal run.

Furthermore, you can export history data to a file.

- "To open the history and get information" on page 285
- "To display a particular acquisition" on page 286
- "To replay history waveforms" on page 286
- "To exit the history" on page 287
- "To save the history data" on page 287

To open the history and get information

1. Press the HISTORY key on the front panel. A running acquisition is stopped, the history mode is enabled and the quick-access "History" dialog box is displayed.

The HISTORY key is illuminated as long as the history mode is active.

2. Open the full configuration dialog box:
   - Tap the 🔧 icon.
   - Press the HISTORY key again.
   - On the "Display" menu, tap "History setup".
3. In the "History" configuration dialog box, select the "Information" tab to see how many history waveforms are saved, and how many can be saved as maximum.

To display a particular acquisition

1. In the quick-access "History" dialog box, enter the number of the required acquisition in the "Current index" field. The newest acquisition always has the index "0", older acquisitions have a negative index
2. Tap "Play" to start.

Alternatively, you can configure and start the history display from the "History" configuration dialog box:

1. Open the "History" configuration dialog box and select the "Viewer" tab.
2. If the history mode is off (the HISTORY key is not illuminated), select "Show history".

   The quick-access dialog box is displayed.
3. Drag the slider to the required acquisition. The current number is shown in the "Current index" field.
   Alternatively, enter the number of the required acquisition in the "Current index" field.
4. Tap "Play" to start.

To replay history waveforms

If you want to see the complete acquisition series without any setup, simply tap "Play" in the quick-access "History" dialog box. For specific analysis of history data, use the hestory "Viewer" setup.

1. In the "History" configuration dialog box, select the "Viewer" tab.
2. If the history mode is off (the HISTORY key is not illuminated), enable "Show history".

   The quick-access dialog box is displayed.
3. Define the part of the history you want to see by doing one of the following:
   - Tap "Select all" to see the complete history.
   - Enter the "Start Index" of the oldest acquisition to display and the "Stop Index" of the newest acquisition to display. All waveforms between the two indexes will be displayed.

To enter the oldest or newest acquisition for either index, tap the appropriate button. The newest acquisition always has the index "0". The "Start index" is always negative.

4. Tap "Play" to start.

To exit the history

► Choose one of the following ways:
   - Close the quick-access "History" dialog box.
   - On the "Display" menu, tap "Show history".
   - In the "Viewer" tab, disable "Show history".
   - Start the acquisition.

To save the history data

You can save the complete history, or some subsequent waveforms from the history, or a single history waveform. You can also decide to save the complete waveforms, or a part of each waveform.

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "Waveform" tab.
4. Tap the source icon to select the waveform you want to save.
5. If you want to save only a part of each waveform, set the "Scope".
   For settings, see "Scope" on page 457.
6. Enable "Export history".
7. If you want to write the timestamps into the data file, enable "Timestamps".
8. To save one waveform out of the history memory:
   a) Make sure that "Multiple Wfms" is disabled.
   b) Enter the number of the required acquisition in "Acq index". The newest acquisition in the memory always has the index "0". Older acquisition have a negative index.

Time stamps ☐
Scope: Full Waveform
Start -500 ns Stop 500 ns
Export history ☑
Multiple Wfms ☐
Acq index 0

   c) Tap "Save" or "Save As" to save the waveform data to the specified file.
9. To save several subsequent history waveforms:
   a) Enable "Multiple Wfms".

b) Define the range of the waveforms to be saved with "Start acq" and "Stop acq".

Time stamps ☐
Scope: Full Waveform
Start -500 ns Stop 500 ns
Export history ☑
Multiple Wfms ☑
Start acq 0
Stop acq 0

c) Tap "Start Export" to play the history and to save the history data to the specified file.

Se also Chapter 11.2.2, "Waveforms - Export Settings", on page 456.

6.5 XY-diagram

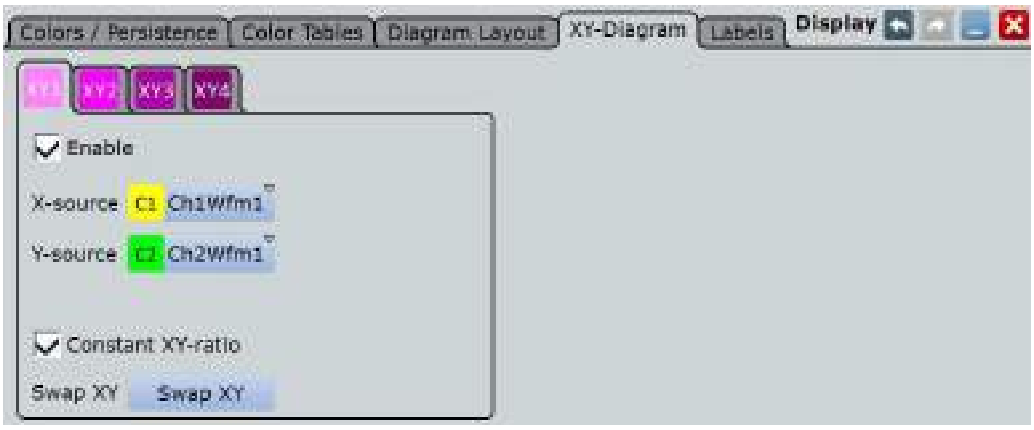
XY-diagrams combine the voltage levels of two waveforms in one diagram. They use the voltage level of a second waveform as the x-axis, rather then a time base. This allows you to perform phase shift measurements, for example. You can display up to four different XY-diagrams.

XY-diagrams can be used to display the IQ representation of a signal.

6.5.1 Settings for XY-Diagrams

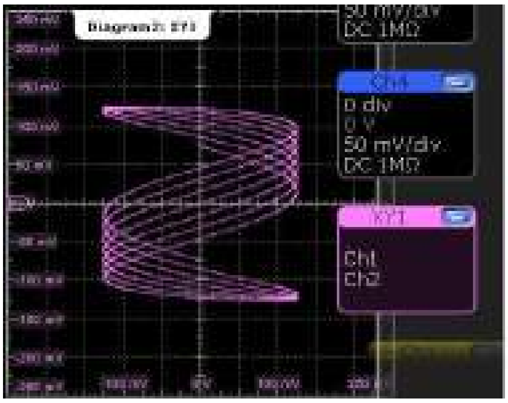
You can display up to four different XY-diagrams that use the voltage level of a waveform as the x-axis, rather then a time base.

Make sure to select the tab of the required XY-diagram.



☑ Enable
X-source C1 Ch1Wfm1
Y-source C2 Ch2Wfm1
☑ Constant XY-ratio

Enable
If activated, the XY-waveform is active and shown in a diagram, or it is minimized in a signal icon.



Remote command:
`WAVeform<m>:XYCurve:STATe` on page 1322

X-source

Defines the signal source that supplies the x-values of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:
`WAVeform<m>:XYCurve:XSOurce` on page 1322

Y-source

Defines the source to be used as the y-axis of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:
`WAVeform<m>:XYCurve:YSOurce` on page 1323

Constant XY-ratio

If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Remote command:
`WAVeform<m>:XYCurve:RATio` on page 1321

Swap XY

Replaces the source of the x-axis with the source of the y-axis and vice versa.

Remote command:
`WAVeform<m>:XYCurve:SWAP` on page 1322

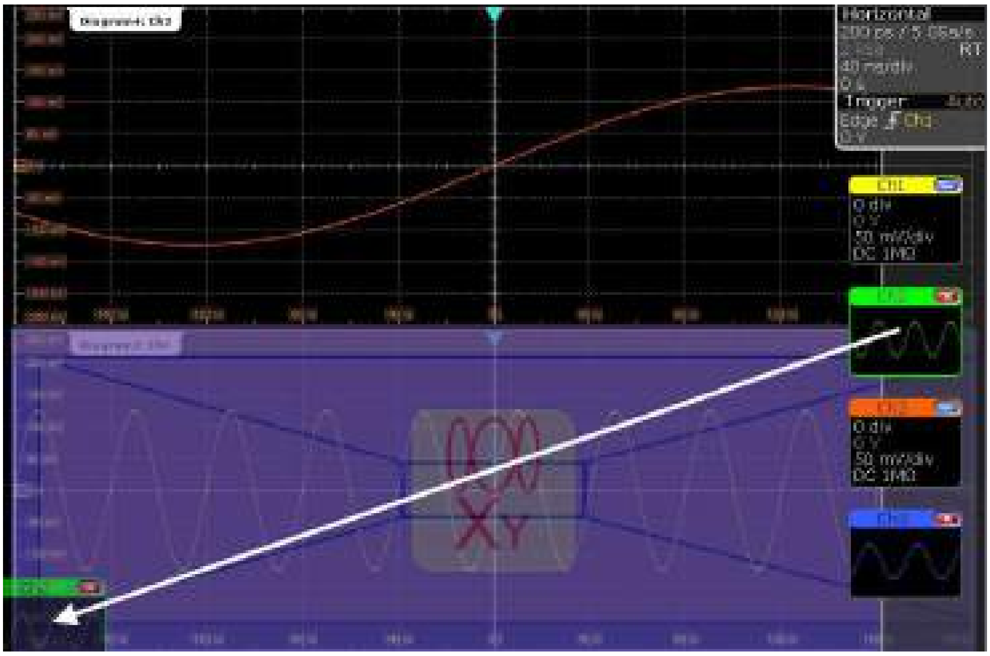
6.5.2 Displaying an XY-diagram

You can create the diagram from active waveforms with drag&drop, or use the dialog box for setup.

To display an XY-diagram with drag&drop

Prerequisites: The source waveform for the y-axis is active in a diagram, the source waveform for the x-axis is either active or minimized.

1. Drag the x-axis waveform to the lower left corner of the diagram with the y-axis waveform.
2. Drop the icon when it overlaps the left and lower diagram borders.



The diagram is converted into an XY-diagram.

To set up an XY-diagram

1. On the "Display" menu, tap "XY-diagram".
2. Activate the "State" option.
3. In the "X-source" field, define the signal source that supplies the x-values of the XY-diagram. Select one of the following:
   - One of the waveforms of any channel
   - A reference waveform
   - The results of a mathematical function
4. In the "Y-source" field, define the signal source that supplies the y values of the XY-diagram.
5. To switch the x- and y-values quickly, tap the "Swap XY" button.

6. In order to maintain a constant ratio while the x- and y-axes are adapted to the acquired data dynamically, activate the "Constant XY-ratio" option.

If the XY-diagram is active or minimized, touch and hold the signal icon to open the "XY-diagram" tab.

7 Measurements

Using the R&S RTO you can perform and display different measurements simultaneously, based on the active signal or math waveforms. The color of the results in the result table corresponds with the source waveform color.

The following measurement methods are available:

- Cursor measurements: measurements can be configured for up to 4 cursor sets to determine specific results at the manually defined cursor positions of an active waveform; the results are displayed in a result box.
- Automatic measurements: up to eight measurements can be configured and performed simultaneously on different sources; the results of each measurement are displayed in a result box.
- Quick measurements: performs a set of automatic measurements on the selected waveform at the push of a button. You can configure the set of measurement types.

7.1 Cursor measurements

7.1.1 Cursors and Results of Cursor Measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually, or can be configured to follow the waveform. You can measure on one waveform, or on two different waveforms (Sources). Up to 4 cursor sets can be configured and displayed. Each cursor set consists of a pair of horizontal or vertical cursors, or both. Cursor lines can be coupled so that the initially defined distance is always maintained.

How to set up cursor measurements is described in Chapter 7.1.2, "Performing Cursor Measurements", on page 294. The Chapter 7.1.3, "Settings for Cursor Measurements", on page 297 provides a detailed description of all settings.

Cursors can also define a gate to limit the measurement to the section of the waveform between the cursor lines. See Chapter 7.2.3.1, "Gate Settings for Measurements", on page 315.

The cursors can be displayed in the diagrams of the source waveform only, or in all diagrams. For each measurement, labels can be defined for the cursors. By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2, C3.1, C3.2, C4.1, C4.2.

7.1.1.1 Cursor Measurements on Time Based Waveforms

The results of cursor measurements are displayed in a result box. For each measurement, a separate result box is displayed. The result box is displayed automatically when a cursor measurement is enabled. Similar to waveform diagrams, you can minimize the result box to a result icon on the signal bar, and display results in a separate diagram on the screen.

For details on using the result box, see Chapter 2.4.6, "Displaying Results", on page 91.

The result box for measurement on time-based waveforms shows the following information.

Figure 7-1: Measurement results of cursor measurement on 1 source (left) and 2 sources (right)

Label	Description
t1, t2	Time at the position of the vertical cursors. You can change the values directly in the result box.
V1, V2	Vertical values of the waveform at the position of the horizontal cursors in V or A. If the cursor lines track the waveform, the measurement result is displayed. If tracking is disabled, you can change the values directly in the result box.
Δt	Difference between the vertical cursor (time) values
ΔV	Difference between the horizontal cursor values
1/Δt	Inverse time difference
ΔV/Δt	Slope of the waveform between the cursors (if measured on one source)
Type	Cursor type - horizontal, vertical, or both
Source	Source waveform or waveforms that are measured
Track waveform	If enabled, the horizontal cursors track the peaks of the waveform

7.1.1.2 Cursor Measurements on Spectrum Waveforms

If the measurement source is a spectrum waveform, the result box provides buttons for easy center definition and peak search. Measurement on 2 spectrum waveforms is not possible.

The result box for measurement on spectrum waveforms shows the following information.

f1 4.56456456 MHz V1 -8.125 dBm
f2 11.382754114 MHz V2 -93.935 dBm
BW 6.818189554 MHz ΔV -85.81 dB
☐ Track waveform

Label	Description
f1, f2	Frequency at the position of the vertical cursors
V1, V2	Vertical values of the waveform at the position of the horizontal cursors in dB. If the cursor lines track the waveform, the measurement result is displayed. If tracking is disabled, you can change the values directly in the result box.
BW	Difference between the vertical cursor (frequency) values
ΔV	Difference between the horizontal cursor values
Type	Cursor type - horizontal, vertical, or both
Source	Source waveform or waveforms that are measured
Track waveform	If enabled, the horizontal cursors track the peaks of the waveform

The peak search functions "c1, c2 absolute", "c2 next abs", "c2 next right", and "c2 next left" are also available in the "Peak Search" tab, see Chapter 7.1.3.3, "Peak Search ", on page 301.

Center definition functions are only available in the result box.

c1 to center
Sets the vertical cursor line C1 to the center frequency.

Remote command:
`CURSor<m>:FFT:TOCenter` on page 1330

Center to c1
Sets the center frequency to the frequency value that is measured at cursor line C1.

Remote command:
`CURSor<m>:FFT:SETCenter` on page 1330

7.1.2 Performing Cursor Measurements

Cursor measurements can be performed and displayed simply by using the "Cursor" icon on the toolbar. For detailed configuration, use the "Cursor" dialog box.

7.1.2.1 Performing a Simple Cursor Measurement

To display cursors using the toolbar

1. Select the waveform that you want to measure.
2. Tap the "Cursor" icon on the toolbar.
3. Tap the diagram where you want to set the cursors. Alternatively, you can draw a rectangle in the diagram to position the cursor lines.

   The cursor lines appear and the "Cursor Results" box for the selected waveform opens.
   You can drag the cursor lines on the screen, or adjust the cursor type, source and position in the result box.
   For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 292.

To display cursors using the CURSOR key

1. Select the waveform that you want to measure.
2. Press the CURSOR key.

   The cursor lines appear and the "Cursor Results" box for the selected waveform opens.
   You can drag the cursor lines on the screen, or adjust the cursor type, source and position in the result box.
   For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 292.

To disable one cursor measurement

► Close the result box.

To disable all cursor measurements

1. Press the CURSOR key.
2. Select the "Setup" tab.
3. Tap the "All Off" button.

   All cursor measurements are disabled, the cursors and cursor result boxes are removed from the display.

7.1.2.2 Configuring a Cursor Measurement

1. If a cursor measurement is already active, use one of these ways:

  - Tap the 🔧 icon in the result box.
  - Press the CURSOR key.

  Otherwise, from the "Cursor" menu select "Setup".

2. Select the "Cursor Setup" tab.
3. Select the tab for the cursor set that you want to use.
4. Tap the "Source" icon and select the measured waveform. Any active input channel, math, reference or XY-waveform can be selected.
   If you enabled the cursor measurement via the toolbar icon or CURSOR key, the source is automatically defined as the selected or active waveform.
5. If necessary, enable and select a 2nd waveform.
6. Select the cursor type - horizontal, vertical, or both.
7. Define the position of the cursors.
   a) To define exact positions of the cursors manually, enter the X-position for each vertical cursor and the Y-position for each horizontal cursor. Horizontal cursors can only be positioned manually if the "Track waveform" setting is disabled.
   b) To position the horizontal cursors automatically, select "Track waveform".
   In this case, cursor 1 indicates the current maximum, cursor 2 indicates the current minimum. If both horizontal and vertical cursors are displayed, the horizontal cursors are placed at the crossing points of the vertical cursors with the waveform. Adjust the vertical cursors manually.
   If the waveform arithmetics are set to "Envelope" and the "Track waveform" is active, select which horizontal cursor is positioned to the maximum and which to the minimum envelope values.
   c) To maintain the distance between the vertical cursors when one cursor is moved, select "Coupling".

   When you close the dialog box, you can move the cursors on the touchscreen manually; and the results are adapted accordingly.
8. To set the cursors for a spectrum measurement to peak values automatically, select the "Peak Search" tab.
   Optionally, define a peak excursion.
   Peak excursion is the minimum level value by which the waveform must rise or fall so that it is identified as a maximum or a minimum by the search functions.
   Tap one of the search function buttons to place the cursors on the selected peak value. For details, see Chapter 7.1.3.3, "Peak Search ", on page 301.
9. Optionally, select "Show in all diagrams" in the "Setup" tab. This setting enables the cursor display in all diagrams that are in the same domain as the selected source (time or spectrum).

10. Tap the "Enable" icon in the "Setup" tab to activate the cursor measurement.

    The cursors are displayed in the waveform diagrams of the measurement source and the "Cursor" result box is displayed. For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 292.

7.1.2.3 Configuring the Cursor Display

By default, the cursors are displayed as lines in the diagrams and labeled according to the syntax: C<cursor set number>.<1|2>

The cursors for the cursor set 3, for example, are labeled 3.1 and 3.2. Both the horizontal and the vertical cursors have the same labels.

You can change the default cursor display and labels.

1. Press the CURSOR key.
2. Select the tab for the cursor set you want to configure.
3. To change the display of the cursor lines:
    a) Select the "Setup" tab.
    b) Select the cursor style. See also "Cursor style" on page 299.
4. Select the "Label" tab.
5. For each vertical and horizontal cursor, enter a label.
6. Select "Show labels".

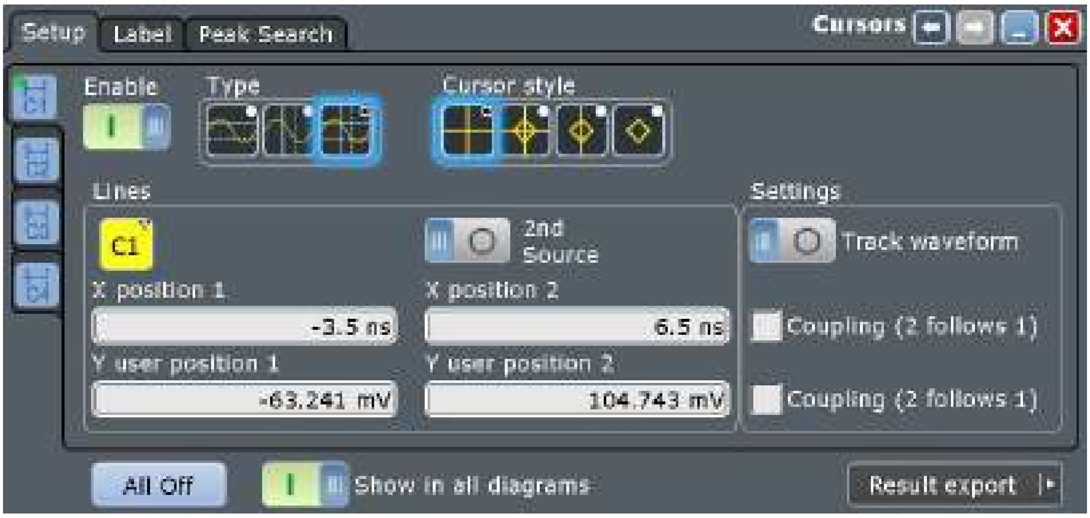
7.1.3 Settings for Cursor Measurements

Cursor measurements are configured in the "Cursors" dialog box.

7.1.3.1 Cursor Setup

Access: CURSOR key

The "Setup" tab contains general settings for cursor measurements. If you want to save the measurement results to a file, tap "Result export". See also: Chapter 11.2.4, "Numeric Results", on page 462.



X position 1: -3.5 ns

X position 2: 6.5 ns

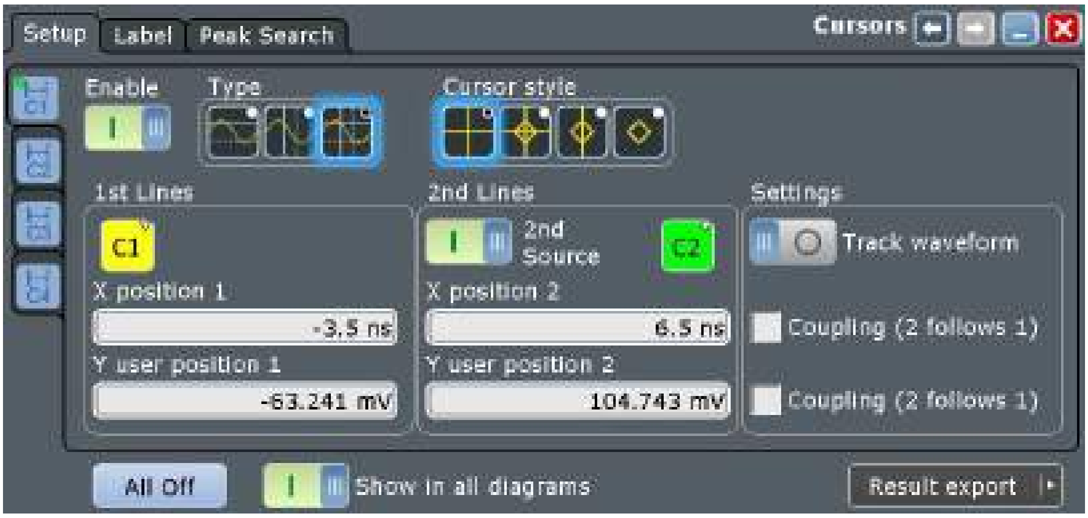
Y user position 1: -63.241 mV

Y user position 2: 104.743 mV

☐ Coupling (2 follows 1)

☐ Coupling (2 follows 1)

Figure 7-2: Setup for cursor on 1 source



X position 1: -3.5 ns

X position 2: 6.5 ns

Y user position 1: -63.241 mV

Y user position 2: 104.743 mV

☐ Coupling (2 follows 1)

☐ Coupling (2 follows 1)

Figure 7-3: Setup for cursor on 2 sources

Cursor set (vertical tab)

The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, a horizontal pair of cursors, a vertical pair of cursors, or both can be displayed.

Enable

Enables the selected cursor measurement.

Remote command:

`CURSor<m>:STATe` on page 1324

Type

Defines the cursor type to be used for the measurement.

"Horizontal cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually.
"Vertical cursors"	The vertical cursors are positioned manually.
"Both horizontal and vertical cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually. The vertical cursors are positioned manually.

Remote command:
`CURSor<m>:FUNCtion` on page 1324

Cursor style
Defines how the cursor is displayed in the diagram.

"Lines"	The cursors are displayed as lines.
"Line & Rhombus"	The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.
"Vertical line and rhombus"	The cursors are displayed as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.
"Rhombus"	The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

Remote command:
`CURSor<m>:STYLe` on page 1332

Source
Defines the source of the cursor measurement. Any of the input signal, math, reference or XY waveforms can be selected.

Remote command:
`CURSor<m>:SOURce` on page 1325

2nd source
Enables and selects a second source for the cursor measurements. If enabled, the second cursor lines Cx.2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Y user position 1|2
Defines the position of the horizontal cursor lines. The setting corresponds to the V1 and V2 values in the "Cursor Results" box.

If "Track waveform" is enabled, the user setting is disabled and the measurement results are displayed in the "Cursor Results" box.

Remote command:
`CURSor<m>:Y1Position` on page 1327
`CURSor<m>:Y2Position` on page 1327

Track waveform
The horizontal cursors track the waveform, i.e. one cursor line indicates the actual vertical maximum, and the second cursor line indicates the minimum. If the waveform changes, e.g. during a running measurement, the cursors move along with it. If both horizontal and vertical cursors are displayed, the horizontal cursors are positioned to the crossing points of the vertical cursors with the waveform. The measurement results are displayed in the "Cursor Results" box.

Tracking disables the Y-coupling (coupling horizontal cursor lines) and the Y user position settings.

Remote command:
`CURSor<m>:TRACking[:STATe]` on page 1325

X position 1|2
Defines the position of the vertical cursors.

Remote command:
`CURSor<m>:X1Position` on page 1326
`CURSor<m>:X2Position` on page 1327

Coupling (2 follows 1)
Couples the horizontal and vertical cursor pairs so that the distance between the two lines remains the same if one cursor is moved.

Remote command:
`CURSor<m>:YCOupling` on page 1328
`CURSor<m>:XCOupling` on page 1327

Envelope wfm selection 1|2
Envelope selection is effective under the following conditions:
- The waveform arithmetic of the cursor source waveform is set to envelope waveform (see "Wfm Arithmetic" on page 154)
- "Track waveform" is enabled.
- Both horizontal and vertical cursors are enabled ("Type" = *Both*).

The setting defines which horizontal cursor is positioned to the maximum and which to the minimum envelope values.

"Minimum"	The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.
"Maximum"	The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

Remote command:
`CURSor<m>:X1ENvelope` on page 1328
`CURSor<m>:X2ENvelope` on page 1329

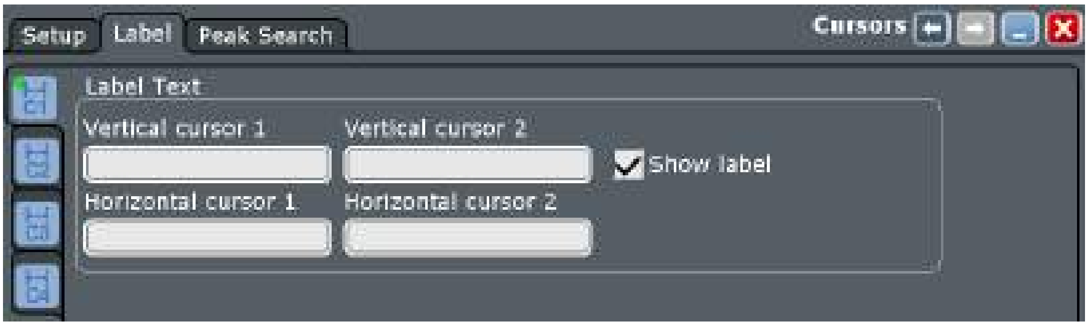
All Off
Disables all cursor measurements at once.

Remote command:
`CURSor<m>:AOFF` on page 1324

Show in all diagrams
Shows the enabled cursor measurements in all active diagrams of the same (time/spectrum) domain.

7.1.3.2 Cursor Labels

The settings in this tab configure the display of the cursors.



Cursor set (vertical tab)
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, labels can be defined for the cursors.

By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2, C3.1, C3.2, C4.1, C4.2.

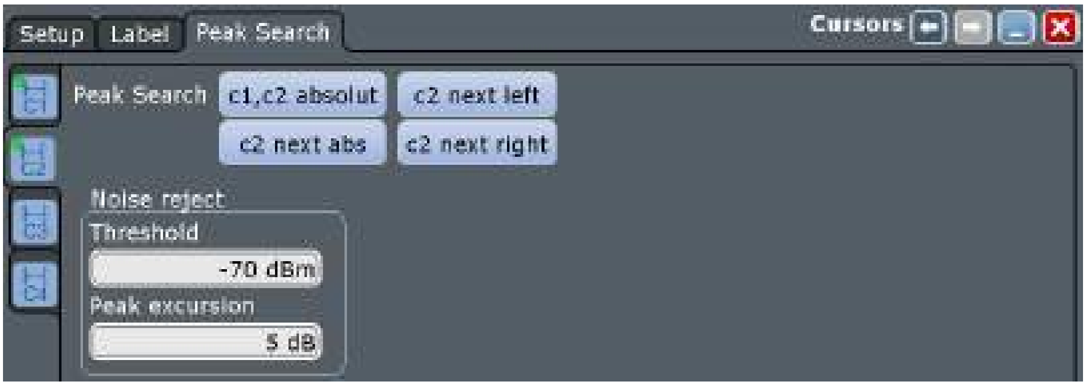
Vertical cursor 1|2
Defines a label to be displayed with the vertical cursors.

Horizontal cursor 1|2
Defines a label to be displayed with the horizontal cursors.

Show label
Shows the cursor labels in the diagram.

7.1.3.3 Peak Search

The settings on this tab are only available in spectrum mode, i.e. the source of the cursor measurement is an FFT math waveform. In this case, the cursors can indicate the results of a peak search on the waveform. You can define which peaks the instrument determines by defining the noise reject settings.



Threshold

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:

`CURSor<m>:THReshold` on page 1331

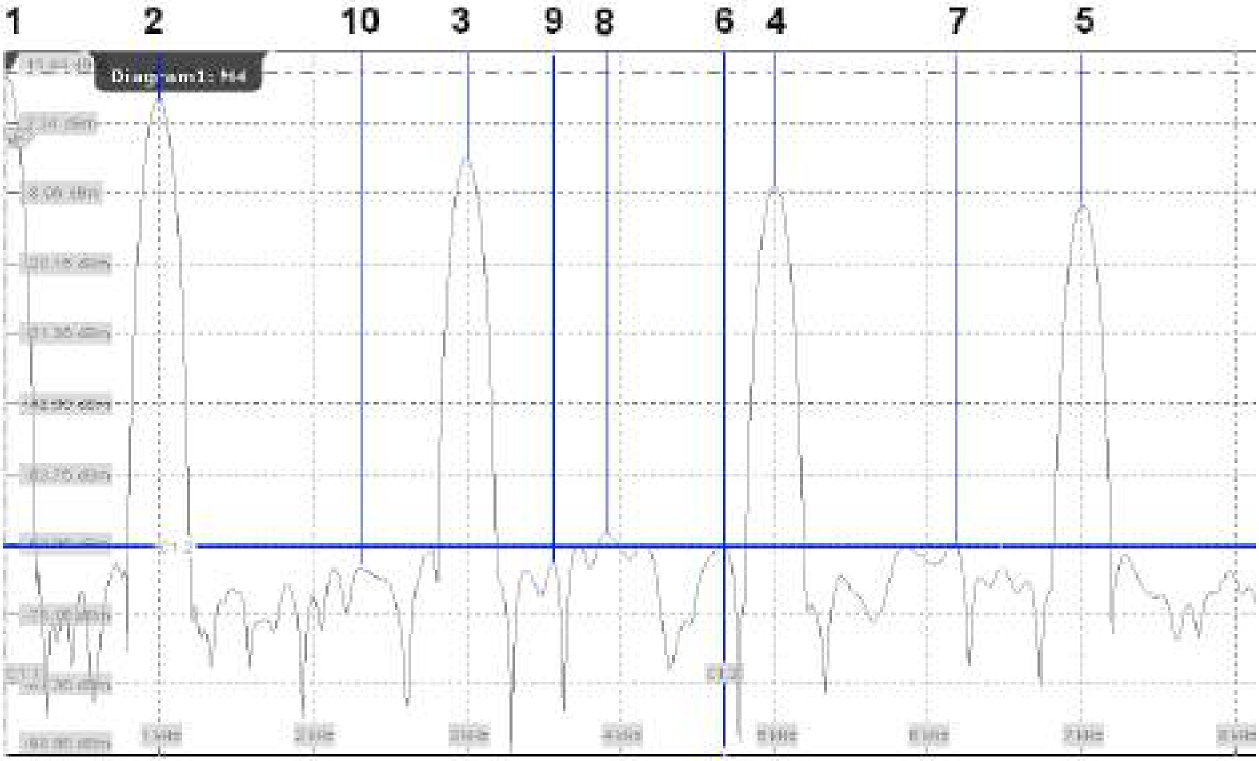
`MEASurement<m>:SPECtrum:ATHReshold` on page 1361

Peak excursion

Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:
`CURSor<m>:PEXCursion` on page 1332
`MEASurement<m>:SPECtrum:PEXCursion` on page 1360

c1, c2 absolute
Both cursors are set to the absolute peak value.

Remote command:
`CURSor<m>:MAXimum[:PEAK]` on page 1330

c2 next abs
Cursor 2 is set to the next smaller absolute peak from the current position.

Remote command:
`CURSor<m>:MAXimum:NEXT` on page 1331

c2 next right
Cursor 2 is set to the next peak to the right of the current position.

Remote command:
`CURSor<m>:MAXimum:RIGHt` on page 1331

c2 next left
Cursor 2 is set to the next peak to the left of the current position.

Remote command:
`CURSor<m>:MAXimum:LEFT` on page 1331

7.2 Automatic Measurements

The R&S RTO can perform up to 8 automatic measurements and a quick measurement simultaneously. For each measurement, various measurement types are available to measure the characteristics of a source waveform. The measurement types are grouped in categories.

The basic measurement settings are source, category, and measurement type. You can refine the setup to get more specific results:

- Multiple measurement
- Gating
- Statistics and long term measurements
- Limit checks and actions on test result

Measurement types and categories

The R&S RTO provides various measurement types in several categories, depending on the selected source.

Time domain

- Amplitude and time measurements
- Eye measurements
- Histogram measurements
- Jitter measurements (option R&S RTO-K12)
- Protocol measurements (with at least one serial protocol option)

Frequency domain

- Spectrum measurements
- Histogram measurements

Multiple measurements

For best performance, only one measurement is performed for each acquired waveform. With multiple measurement, more than one result is taken from one acquired waveform. This is useful when calculating statistics or generating tracks.

See: "Multiple measurement" on page 360.

Gating

A gate limits the measurement to a user-defined part of the waveform.

See: Chapter 7.2.3, "Measurement Gates", on page 315.

Statistics and long term measurements

To evaluate time-dependent behavior of measurement results, you can use statistics, long term measurements, and tracks.

See: Chapter 7.2.9, "Long Term Measurements and Statistics", on page 354.

7.2.1 Measurement Setup in General

7.2.1.1 General Measurement Settings

Access: "Meas" menu > "Setup"

Automatic measurements are configured in the "Measurements" dialog box.

Up to 8 measurements can be defined. Each measurement is configured in its own subtab. For each measurement, the source, category, and measurement type are defined in the "Setup" tab, and you can also enable statistic evaluation.

Envelope: Both

Main: High

Measured slope: First edge

Signal threshold: 5 %

General settings in the upper part of the dialog box relate to all measurement types. Below, the measurement types are selected and configured. Depending on the selected source, not all measurement types may be available. In the time domain, amplitude/time and eye/jitter measurements are available. In the frequency domain, spectrum measurements are available. Histogram measurements need a defined histogram as source.

This section describes the settings that relate to all measurement types. Specific settings are described in the corresponding category chapter:

- Chapter 7.2.5.2, "Amplitude/Time Measurement Settings ", on page 332
- Chapter 16.1, "Jitter Measurements", on page 1035
- Chapter 7.2.6.2, "Eye Diagram Measurement Settings", on page 341
- Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 343
- Chapter 7.2.8.3, "Histogram Measurement Settings ", on page 352

ME 1/2/3/4/5/6/7/8/Quick Meas
For each of the eight measurements, and for the quick measurement, a subtab contains the configuration settings. A green dot on the tab indicates that the measurement is active.

State
Enables the measurement.

Remote command:
`MEASurement<m>[:ENABle]` on page 1334

Source

Define the source(s) of the measurement. The source can be any input signal, math or reference waveform. Depending on the selected source, not all measurement types are available. The 2nd source is required for amplitude/time measurements that are performed on two waveforms (e.g. delay, phase).

Remote command:

`MEASurement<m>:SOURce` on page 1334

Statistics

Enables the calculation and display of statistical results.

Remote command:

`MEASurement<m>:STATistics[:ENABle]` on page 1376
`MEASurement<m>:RESult:AVG?` on page 1342
`MEASurement<m>:RESult:EVTCount?` on page 1342
`MEASurement<m>:RESult:NPEak?` on page 1342
`MEASurement<m>:RESult:PPEak?` on page 1342
`MEASurement<m>:RESult:RMS?` on page 1342
`MEASurement<m>:RESult:STDDev?` on page 1343
`MEASurement<m>:RESult:WFMCount?` on page 1343
`MEASurement<m>:RESult[:ACTual]?` on page 1342
`MEASurement<m>:ARNames` on page 1342
`MEASurement<m>:ARES?` on page 1341

Envelope

This setting is only relevant for measurements on envelope waveforms, see "Wfm Arithmetic" on page 154. If the measurement source is not an envelope, the setting is ignored.

"Maximum"	Measurements are performed on the upper envelope.
"Minimum"	Measurements are performed on the lower envelope.
"Both"	The upper and the lower envelope are used in measurements. For time measurements, the averages of min and max values are used, that is, the measurement is performed on the average waveform built from the upper and lower envelope.

Remote command:

`MEASurement<m>:ENVSelect` on page 1349

Category

Measurement category. The following categories are available:

- Amp/Time: amplitude and time measurements
- Jitter: only available if option R&S RTO-K12 is installed.
- Eye: eye diagram measurements
- Spectrum: measurements in the frequency domain, require a spectrum waveform as source
- Histogram: measurements on histograms
- Protocol: only available for audio signals (option R&S RTOK5).

7.2.1.2 Starting an Automatic Measurement

There are three methods to start an automatic measurement, each with slightly different effects:

- Using the "Measurement" icon on the toolbar:
  The icon starts the measurement with the lowest number.
  At R&S RTO2000 instruments, you can select the measurement type on the sidebar.
  See: "To start a measurement using the toolbar icon" on page 308.
- Pressing the MEAS key on the front panel.
  If no measurement is running, the measurement with the lowest number is started.
  If a measurement is already running, the key opens the "Measurement" dialog box for the currently selected measurement.
  See: "To start a measurement with the MEAS key" on page 309.
- Using the menu.
  Tap "Meas" menu > "Setup", configure the measurement and enable "State".
  See: Chapter 7.2.1.3, "Configuring Measurements", on page 309.

To start a measurement using the toolbar icon

1. Select the waveform that you want to measure.
2. Tap the "Measurement" icon on the toolbar.
3. R&S RTO2000 instruments only:
   On the sidebar, select the measurement type. If required, enable the statistics, and change the source.

4. Define the measurement range in one of these ways:
   - To measure the complete waveform, tap the diagram with the waveform.
   - To define a gate that limits the measurement, draw a rectangle on the screen.

   The "Measurements" result box is displayed.

To start a measurement with the MEAS key

1. Select the waveform on the screen.
2. Press the MEAS key.

   The measurement for the selected waveform is enabled using the next available measurement configuration. The "Measurements" result box is displayed.

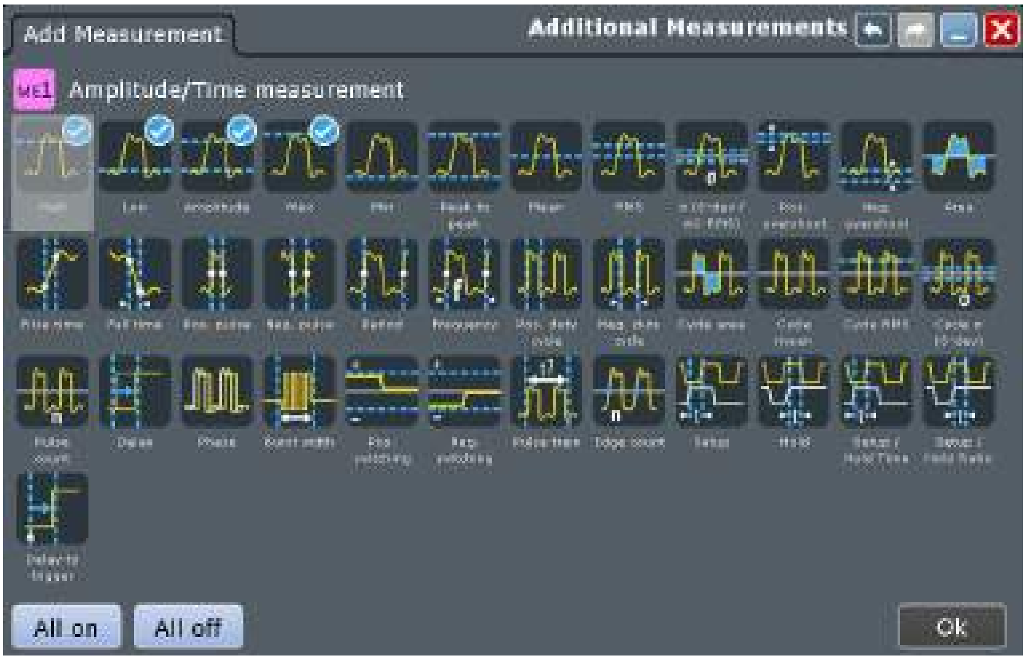
7.2.1.3 Configuring Measurements

Up to eight automatic measurements can be configured and performed simultaneously.

Spectrum measurements require an FFT math waveform as measurement source. Histogram measurements require a histogram as source.

1. If a measurement is already running, tap the 🔧 icon in the result box, or press the MEAS key to display the "Measurements" dialog box.
   Otherwise, tap the "Meas" menu and select "Setup".
2. Select the vertical tab for the measurement you want to configure.

3. Tap "Source" and select the waveform to be measured. For histogram measurements, select the histogram.
   If you enabled the measurement with the toolbar icon or MEAS key, the source is already defined. However, you can select any other input channel, math or reference waveform.
4. Select the measurement category, for example, "Amp/Time".
5. Under "Main measurement", select the main measurement type. This measurement is for long term, track and histogram measurements, and as a source for math calculations.
6. Tap "Additional Measurements" to select further measurement types.
   Select the all measurement types that you want to include in the measurement.



7. Tap "OK" to close the dialog box.
   All selected measurement types are displayed in the measurement overview. Here you can disable individual measurement types, too.
8. Depending on the selected measurement type, further settings may be required. These settings are shown in the "Parameters" area for the measurement type that is selected in the overview table.
   the settings are explained in the following chapters:
   - Chapter 7.2.5.2, "Amplitude/Time Measurement Settings ", on page 332
   - Chapter 7.2.6.2, "Eye Diagram Measurement Settings", on page 341
   - Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 343
   - Chapter 7.2.8.3, "Histogram Measurement Settings ", on page 352
9. Optionally, define a gate to restrict the measurement to a part of the waveform, as described in Chapter 7.2.3.2, "Using Measurement Gates", on page 317.

If you enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is automatically defined and enabled.

10. To compile and display statistics for the measurement, enable "Statistics". See also Chapter 7.2.9.5, "Compiling Measurement Statistics", on page 363.
11. Optionally, perform a limit check as described in Chapter 7.2.12.3, "Performing Limit Checks", on page 367.
12. Enable "State" to start the measurement.

    The results of the measurement are displayed in the result box.

7.2.2 Measurement Results

The results of automatic measurements are displayed in one or several result boxes on the screen. The result box is displayed automatically when an automatic measurement is enabled. For each measurement, a separate result box can be displayed, or the results of all measurements are listed in the same result box.

Meas 1
OccBW 1.0373 GHz
Meas 2
Low -124.51 mV
Meas 3
Amplitude 247.84 mV
Meas 4
Max 124.51 mV
Meas 5
Min -124.51 mV

If you want to save space in the display, minimize the result boxes. The most important results are also displayed and updated in the signal icon.

The function "Clear screen results" in the "Display" menu resets all results including long term measurement and statistic results and deletes the current measurement waveforms.

Which results are displayed depends on the measurement type and is described in detail in the following chapters.

The following additional results are available:

- **Statistics**
  You can enable stastical evaluation of the measurement results. Statistic information is provided in the result box for each measurement type.
  Stopping and restarting the acquisition does not reset statistics but only stops and continues them.
  See Chapter 7.2.9, "Long Term Measurements and Statistics", on page 354
- **Measurement histograms**
  Additionally, the results of measurements can be displayed in a histogram which shows the density distribution of the measurement results in a graphic and thus illustrates the statistics of the measurements.

See Chapter 7.2.8, "Histograms and Histogram Measurements", on page 347

- **Long term measurements**
  Long term measurements show the behavior of measurement results over a longer time or for a large number of samples. You can define the number of long term points and export the long term data, including statistical results. The measurement histogram is a vertical histogram shown in the long term diagram.
  Long term measuments are performed on the main measurement.
  See: Chapter 7.2.9, "Long Term Measurements and Statistics", on page 354
- **Intermediate results**
  You can display auxiliary result lines and reference levels required to perform some measurement types in the source diagram, see Chapter 7.2.2.3, "Configuring the Results Display", on page 314

From the result box, you can open the settings dialog box using the 🔧 icon.

Remote commands:

- `MEASurement<m>:ARES?` on page 1341
  `MEASurement<m>:ARNames` on page 1342
  `MEASurement<m>:RESult[:ACTual]?` on page 1342
  `MEASurement<m>:RESult:COUNt?` on page 1345

7.2.2.1 Measurement Status

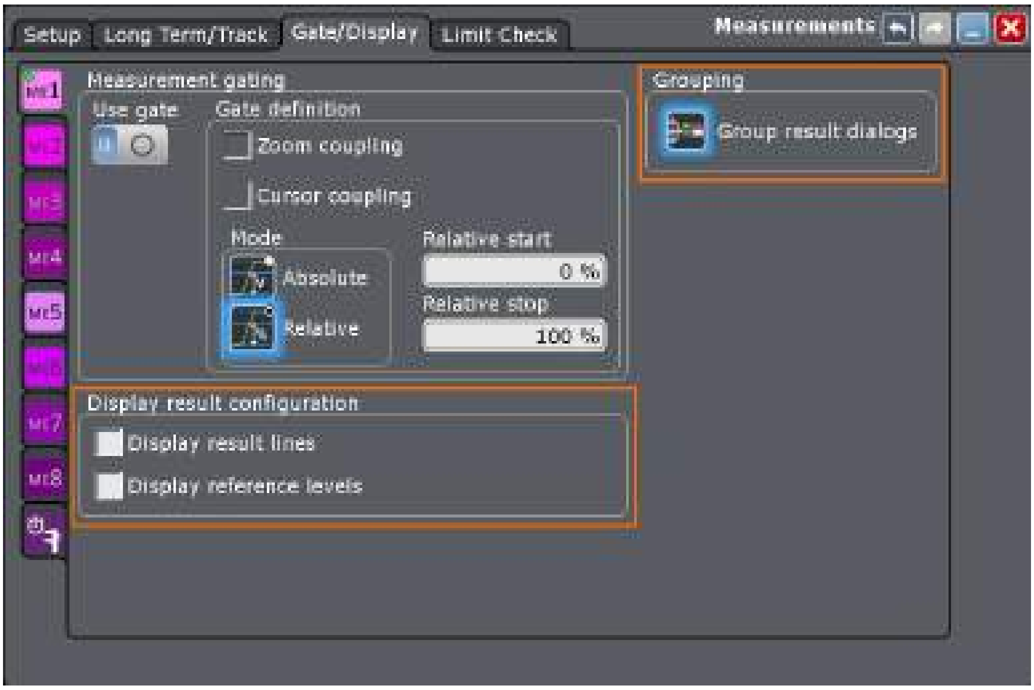
The overall status of measurement results is indicated by various icons. In general, a question mark before the result value indicates that the measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. The icon colors indicate the state of the limit and margin checks.

Icon	Description
No icon, no result value ("---")	The instrument cannot measure the required value, for example, if the acquisition does not contain at least one complete period for frequency and cycle measurements. Check and adjust the waveform settings to get results.
?	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit and marging checks are disabled.
✓	Limit and margin checks passed, measurement results are reliable.
?	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit and margin checks passed.
?	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Margin checks failed.

Icon	Description
!	Margin checks failed.
?	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit checks failed.
⚡	Limit checks failed.

7.2.2.2 Result Display Settings

The display settings for measurement results are set on the "Gate/Display" tab. Display settings are measurement-specific, each measurement can have its own settings.



Relative start 0 %
Relative stop 100 %

Gate settings are described in Chapter 7.2.3.1, "Gate Settings for Measurements", on page 315.

ME 1/2/3/4/5/6/7/8/Quick Meas
For each of the eight measurements, and for the quick measurement, a subtab contains the configuration settings. A green dot on the tab indicates that the measurement is active.

Display result lines
Displays intermediate result lines in the measurement waveform (e.g. signal thresholds) required to obtain the measurement result.

Remote command:
`MEASurement<m>:DISPlay:RESults` on page 1375

Display reference levels
Displays the reference levels used for the measurement in the diagram.

Remote command:
`MEASurement<m>:DISPlay:LEVels` on page 1374

Show result control panel
Extends the result box of the selected measurement with the source settings and the statistics enabling. Thus you can check and change the measurement sources directly in the results box, and also enable statistics there. The setting is measurement-specific and is only available if the result boxes are not grouped.

Group result dialogs
If enabled, all results are shown in one result box (default).

If disabled, the results of each measurement are shown in a separate result box.

Meas 1

High	122.53 mV
Low	-124.51 mV
Mean	-138.34 µV

Meas 2

ChPow	-12.88 dBm

High	122.53 mV
Low	-124.51 mV
Mean	-128.46 µV

ChPow	-12.893 dBm

The setting affects all measurements except for the peak list.

7.2.2.3 Configuring the Results Display

The measurement results can be displayed in a result box, in a minimized result icon on the signal bar, or as table in a separate diagram area. For details, see Chapter 2.4.6, "Displaying Results", on page 91.

You can group all measurement results together in one result box, or display a separate result box for each measurement, see "Group result dialogs" on page 314.

If you use separate (ungrouped) result boxes, you can extend the result box of a selected measurement with a small control panel which provides source settings and statistics enabling for quick access: "Measurements" dialog box > "Gate/Display" tab > "Show result control panel".

The results of an optionally connected environment sensor can also be taken into consideration in the results display of the measurement.

The display settings for measurements are provided on the "Gate/Display" tab, see Chapter 7.2.2.2, "Result Display Settings", on page 313.

To display measurement information in the diagram

You can display auxiliary lines in the diagram to determine how a measurement result was obtained. Such lines include gate areas, reference levels or intermediate result lines, such as the signal thresholds for rise and fall time measurements.

1. From the "Meas" menu, select "Gate/Display".
2. Select the tab for the measurement you want to configure.
3. To display intermediate result lines, select "Display result lines".
4. To display reference levels, select "Display reference levels".
5. To show each measurement in a separate result box, disable "Group result dialogs".

To clear the measurement results

1. On the "Display" menu, tap "Clear screen results".

   The results of all measurements are cleared.
2. To restart mesurement statistics, select "Reset" in the "Measurement Results" box, or on the "Long Term/Track" tab.

   The results in the selected measurement result box are cleared and writte anew.

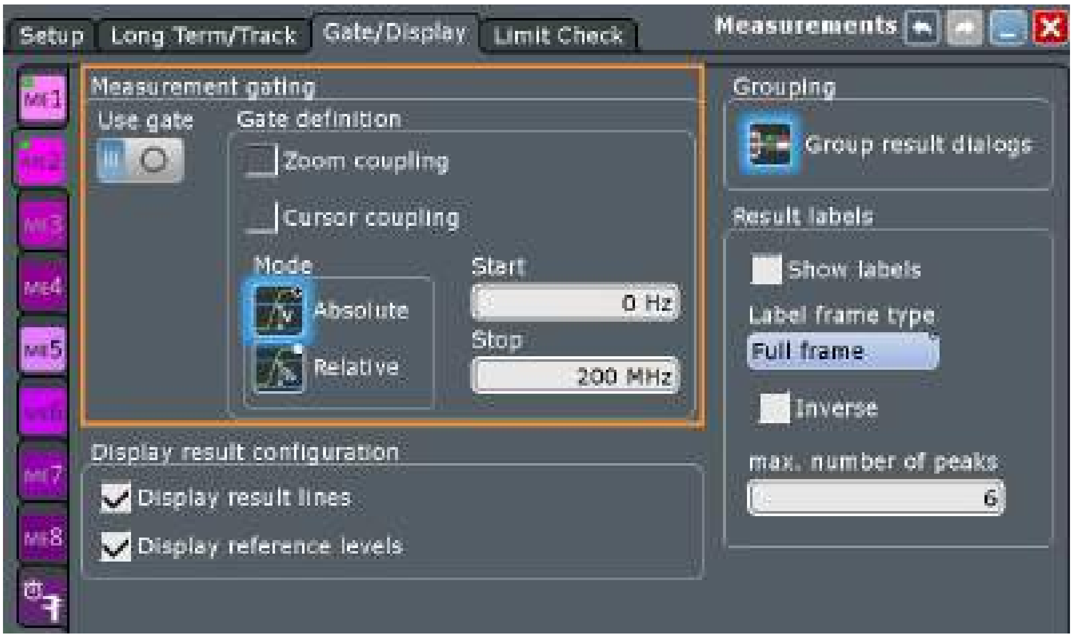
7.2.3 Measurement Gates

7.2.3.1 Gate Settings for Measurements

Gate areas limit the measurement to a user-defined range of the waveform. The gate settings are defined on the "Gate/Display" tab.

Gate settings are measurement-specific, each measurement can have its own gate. Make sure to select the correct measurement on the left.

Result display settings are described in Chapter 7.2.2.2, "Result Display Settings", on page 313.



Use gate
Considers the gating settings for the selected measurement and displays the gate.

Remote command:
`MEASurement<m>:GATE[:STATe]` on page 1383

Zoom coupling
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1410
`MEASurement<m>:GATE:ZCOupling` on page 1385
`MEASurement<m>:GATE:ZDIagram` on page 1385
`SEARch:GATE:ZCOupling` on page 1461
`SEARch:GATE:ZDIagram` on page 1461

Cursor coupling
If enabled, the gate area is defined by the cursor lines of an active cursor measurement. If several cursor measurements are enabled, select the cursor set to be used for gating. The "Start" and "Stop" values of the gate are adjusted to the values of the cursor line positions limiting the measurement to the part of the waveform between the cursor lines.

Remote command:
`MEASurement<m>:GATE:CCOupling` on page 1384
`MEASurement<m>:GATE:CURSor` on page 1384

Mode

Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1409
`MEASurement<m>:GATE:MODE` on page 1383
`SEARch:GATE:MODE` on page 1460

(Relative) Start

Defines the starting value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 1409
`MEASurement<m>:GATE:ABSolute:STARt` on page 1383
`MEASurement<m>:GATE:RELative:STARt` on page 1383
`SEARch:GATE:ABSolute:STARt` on page 1460
`SEARch:GATE:RELative:STARt` on page 1460

(Relative) Stop

Defines the end value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STOP` on page 1410
`MEASurement<m>:GATE:ABSolute:STOP` on page 1383
`MEASurement<m>:GATE:RELative:STOP` on page 1383
`SEARch:GATE:ABSolute:STOP` on page 1460
`SEARch:GATE:RELative:STOP` on page 1461

7.2.3.2 Using Measurement Gates

If you enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is automatically defined and enabled. Otherwise, or if you want to define a more precise gate area, configuration is done in the "Measurement" > "Gate/Display" dialog box.

1. On the "Meas" menu, tap "Gate/Display".
2. Select the tab for the measurement you want to configure.
3. To define the gate, use one of the following methods:
   - Define the start and stop values of the gate area by entering either absolute or relative values.
   - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option.

- If a cursor measurement has already been defined for the waveform, couple the gate area to the cursor lines by selecting the "Cursor coupling" option.

4. Tap the "Use gate" icon to enable the gate area usage.

   The measurement is performed on the selected part of the waveform. The gate is shown in the diagram.

7.2.4 Reference Levels

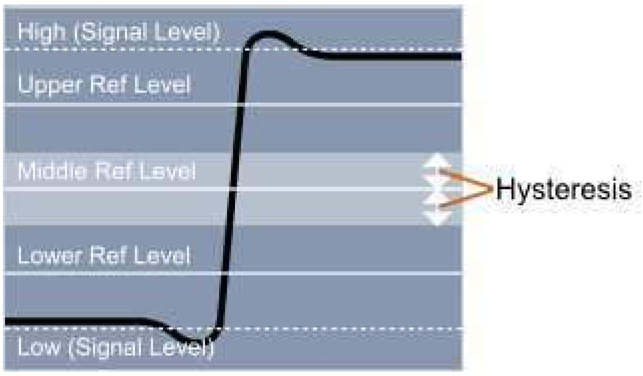
Some measurement types require reference levels to obtain the measurement points, e.g. time measurements or pulse count. Reference levels are referred to the signals, for each waveform you can define specific reference levels. Thus, for all measurements on a waveform the same reference levels are used.

Usually, reference levels are determined automatically. The instrument determines the high and low signal levels based on amplitude and histogram measurements of the acquisition. The reference levels are set relatively to the determined signal levels.

However, for irregular data and in special measurement setups it may be useful to configure the levels manually:

- Data signals can contain intervals where no data is transmitted, so that a high and low state cannot be determined for each acquisition. In this case, you can define the high and low signal levels manually to evaluate other measurement results.
- If the signal levels vary strongly or have large overshoots, the rise and fall levels may be difficult to determine.
- If fixed levels are defined for the DUT, you can configure the reference levels in the R&S RTO correspondingly and analyze the resulting measurement data.

In manual configuration, the reference levels can be set relatively to defined signal levels or as absolute values. You can also set the reference levels directly.

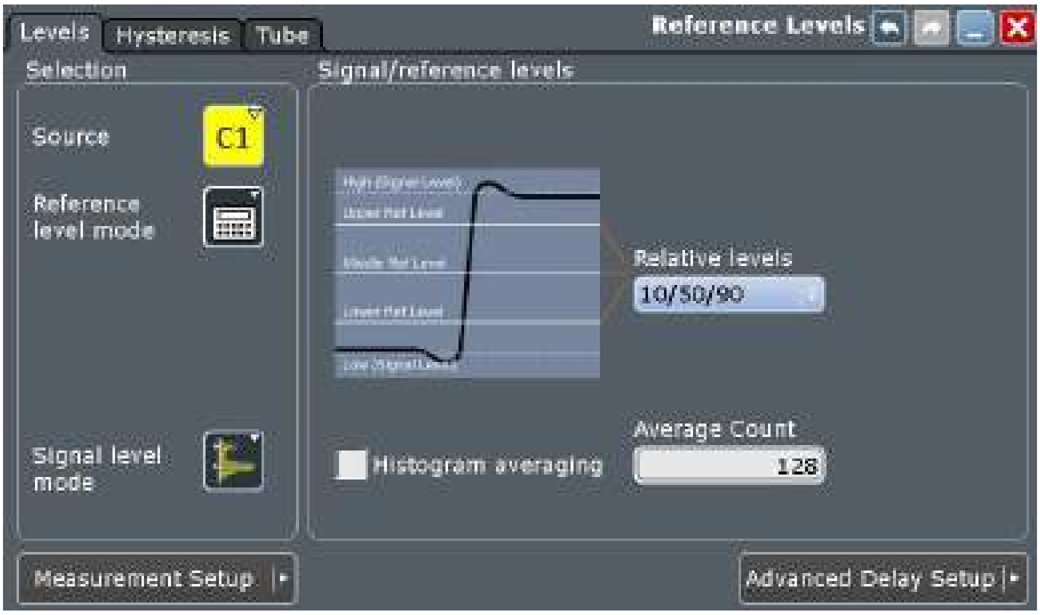


In addition to reference and signal levels, you can define a hysteresis for the middle reference level and tubes for signal levels. Hysteresis is useful for measurements that determine zero-crossings. Period, frequency, and pulse measurements are based on hysteresis - the instrument returns results if the amplitude of the signal exceeds the hysteresis. Thus, measurement during the transient oscillation is also possible. Tubes define evaluation ranges for measurements that require detection of the high level or low level. If the signal value remains within the defined tubes, it is considered to be high or low.

Reference levels and result lines can be displayed in the diagram.

7.2.4.1 Level Settings

On the "Levels" tab, you define how the reference levels are calculated, or you set them directly. In manual reference level mode, relative and absolute level definitions are possible.



Source: C1

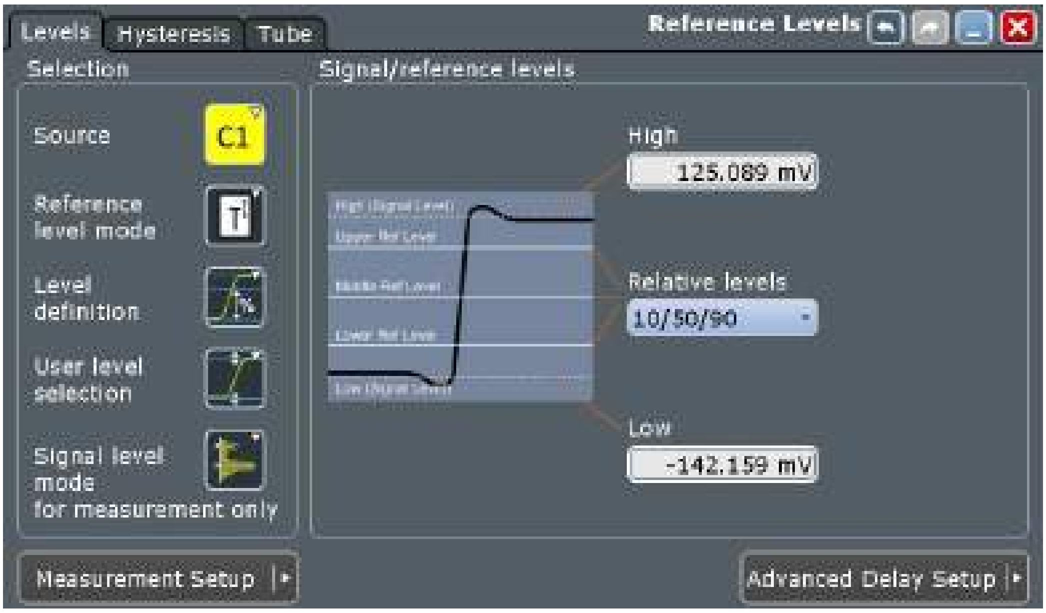
Relative levels: 10/50/90

☐ Histogram averaging

Average Count: 128

Figure 7-4: Automatic reference level definition

In automatic reference level mode, the reference levels are always relative values. You can select one of the predefined sets, or define individual percentage values.



Source: C1

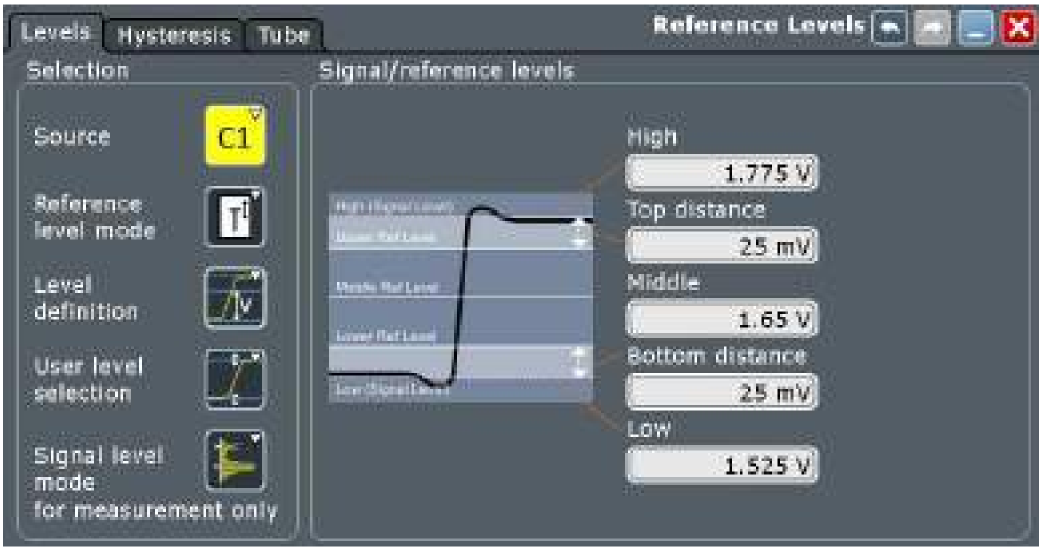
High: 125.089 mV

Relative levels: 10/50/90

Low: -142.159 mV

Figure 7-5: Manual reference level mode, relative level definition

In manual reference level mode with relative level definition, you define the absolute values of high and low signal levels or reference levels, and the reference levels as percentages of the signal amplitude.



Source: C1

High: 1.775 V

Top distance: 25 mV

Middle: 1.65 V

Bottom distance: 25 mV

Low: 1.525 V

Figure 7-6: Manual reference level mode, absolute level definition

In manual reference level mode with absolute level definition, you define the absolute values of high and low signal levels or reference levels, and the distances between reference and signal levels.

Source

Defines the source for which the reference levels are defined. The source can be any signal input, math or reference waveform.

Remote command:
Source is defined by suffix <m> in "REFLevel" subsystem, see Chapter 20.12.13, "Reference Levels", on page 1387

Reference level mode
Defines whether the reference level is configured manually or automatically.

Remote command:
`REFLevel<m>:LDETection` on page 1387

Signal level mode
Defines the computation method for high and low signal levels. The instrument analyzes the signal, performs amplitude and histogram measurements, and defines the signal levels using the selected method.

The selected method is used to compute the signal levels for determination of reference levels in automatic reference level mode. It is also used for high, low, and amplitude measurements in automatic and manual reference level modes.

See also: Chapter 7.2.8, "Histograms and Histogram Measurements", on page 347

"Auto select absolute probability"	The most suitable signal levels for the selected measurement are used.
"Peak probability"	The signal levels with the highest probability values are used. These are the upper peak value and the lower peak value of the histogram measurement.
"Mean probability"	The signal levels with mean probabilities are used.
"Absolute peak"	The absolute peak signal levels are used. These are the maximum and minimum signal values of the amplitude measurement.
"Upper absolute peak - Lower mean probability"	The high signal level is the upper absolute peak (the maximum signal level), and the low signal level is the level with the mean probability in the lower half of the histogram.
"Upper mean probability - Lower absolute peak"	The high signal level is the level with mean probability in the upper half of the histogram, and the low signal level is the lower absolute peak (the minimum signal level).
"Upper absolute peak - Lower manual"	The high signal level is the maximum result value of the amplitude measurement. The low signal level is manually set using "Low".
"Upper manual - Lower absolute peak"	The high signal level is set manually using "High". The low signal level is the minimum result value of the amplitude measurement.

Remote command:
`REFLevel<m>:AUTO:MODE` on page 1390

Level definition
In manual reference level mode, the setting defines whether the reference is configured using absolute or relative values.

Remote command:
`REFLevel<m>:LMODe` on page 1388

User level selection
In manual reference level mode, the setting defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

"User signal level"	The high and low signal levels are defined by the user.
"User reference level"	The reference levels are defined by the user.

Remote command:
`REFLevel<m>:USRLevel` on page 1389

Relative levels
Sets the lower, middle and upper reference levels, defined as percentages of the signal amplitude.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper ref level", "Middle ref level", and "Lower ref level".

For example, for "5/50/95" the levels are set to the following values:

- Lower reference level = 5% of the signal amplitude
- Middle reference level = 50% of the signal amplitude
- Upper reference level = 95% of the signal amplitude

Remote command:
`REFLevel<m>:RELative:MODE` on page 1388

Upper ref level, Middle ref level, Lower ref level
Define the reference levels in percent, if "Relative levels" is set to "User-defined".

Remote command:
`REFLevel<m>:RELative:UPPer` on page 1395
`REFLevel<m>:RELative:MIDDle` on page 1396
`REFLevel<m>:RELative:LOWer` on page 1396

High
Sets the high signal level.

The high signal level is set in manual reference level mode, for absolute level definition and user signal level selection.

Remote command:
`REFLevel<m>:ABSolute:HIGH` on page 1392

Low
Sets the low signal level.

The low signal level is set in manual reference level mode, for absolute level definition and user signal level selection.

Remote command:
`REFLevel<m>:ABSolute:LOW` on page 1393

Middle

For user signal level selection, the level is the middle level between high and low signal level. The value is adjusted automatically if you change the high or low signal levels. Vice versa, if you change the middle level, the high and low signal levels are adjusted.

For user reference level selection, the level is the middle level between upper and lower reference level. The value is adjusted automatically if you change the upper or lower reference levels. Vice versa, if you change the middle level, the upper and lower reference levels are adjusted.

Remote command:

`REFLevel<m>:ABSolute:MLEVel` on page 1394

Top distance

The distance between the high signal level and the upper reference level - for manual reference level mode and absolute level definition.

Remote command:

`REFLevel<m>:ABSolute:TDIStance` on page 1393

Bottom distance

The distance between the lower reference level and the low signal value - for manual reference level mode and absolute level definition.

Remote command:

`REFLevel<m>:ABSolute:BDIStance` on page 1394

Upper level

The upper reference level, required e.g. to determine a rise - for manual reference level mode, absolute level definition and user reference level.

Remote command:

`REFLevel<m>:ABSolute:ULEVel` on page 1395

Lower level

The lower reference level, required e.g. to determine a fall - for manual reference level mode, absolute level definition and user reference level.

Remote command:

`REFLevel<m>:ABSolute:LLEVel` on page 1395

Histogram averaging

Enables averaging over several histograms to determine the reference levels.

This function is only available in automatic reference level mode.

Remote command:

`REFLevel<m>:AUTO[:STATe]` on page 1391

Average Count

Defines the number of histograms to calculate the average from.

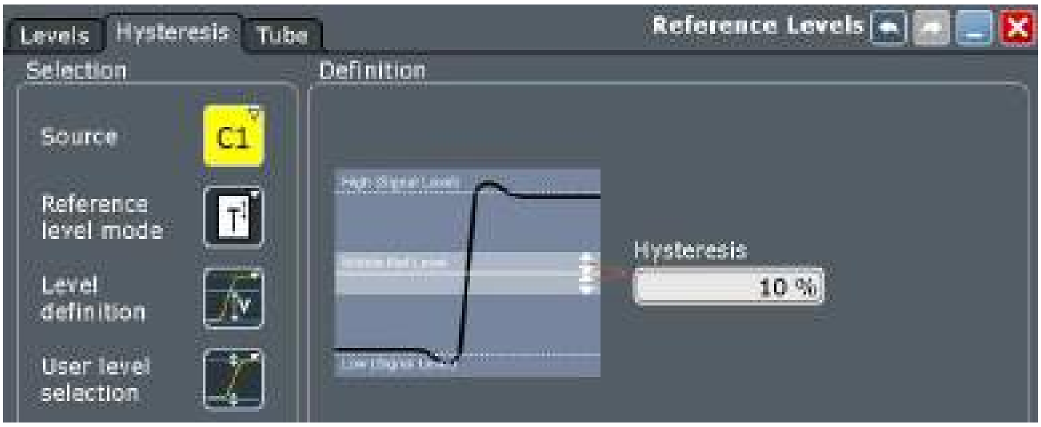
This function is only available in automatic reference level mode.

Remote command:

`REFLevel<m>:AUTO:COUNt` on page 1392

7.2.4.2 Hysteresis Tab

This tab allows you to define a hysteresis for measurements that determine zero-crossings.



Hysteresis 10 %

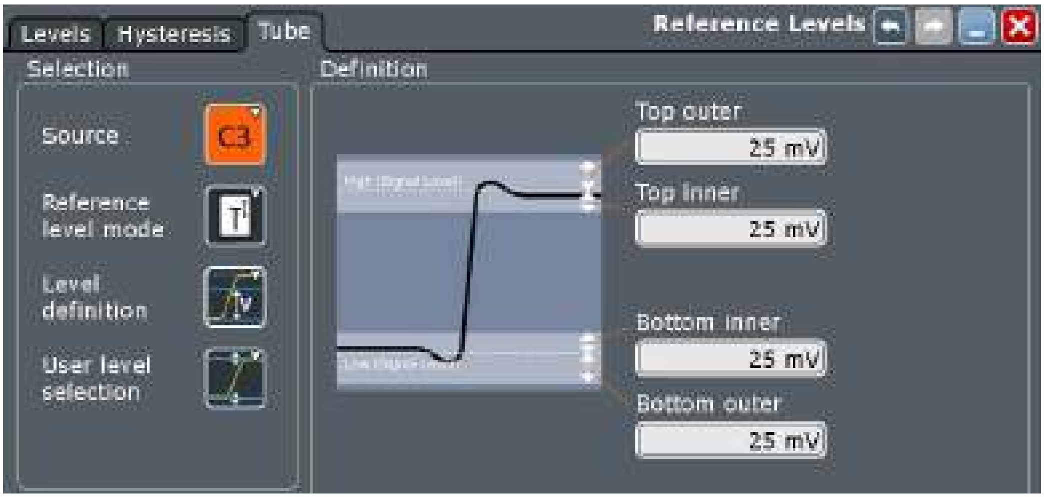
For a description of settings under "Selection", see Chapter 7.2.4.1, "Level Settings", on page 319.

Hysteresis
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Remote command:
`REFLevel<m>:RELative:HYSTeresis` on page 1397

7.2.4.3 Tube Tab

This tab allows you to define evaluation tubes for measurements that require high level or low level detection. If the signal value remains within the defined tubes, it is considered to be high or low.



Top outer 25 mV
Top inner 25 mV
Bottom inner 25 mV
Bottom outer 25 mV

For a description of settings under "Selection", see Chapter 7.2.4.1, "Level Settings", on page 319.

Top outer

Defines an area above the high signal level which is still considered to be high level.

Remote command:

`REFLevel<m>:ABSolute:TOTube` on page 1398

`MEASurement<m>:REFLevel:RESult:TOUTer?` on page 1401

Top inner

Defines an area beneath the high signal level which is still considered to be high level.

Remote command:

`REFLevel<m>:ABSolute:TITube` on page 1399

`MEASurement<m>:REFLevel:RESult:TINNer?` on page 1401

Bottom inner

Defines an area above the low signal level which is still considered to be low level.

Remote command:

`REFLevel<m>:ABSolute:BITube` on page 1399

`MEASurement<m>:REFLevel:RESult:BINNer?` on page 1400

Bottom outer

Defines an area beneath the low signal level which is still considered to be low level.

Remote command:

`REFLevel<m>:ABSolute:BOTube` on page 1399

`MEASurement<m>:REFLevel:RESult:BOUTer?` on page 1401

Relative outer

Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

Remote command:

`REFLevel<m>:RELative:OTUBe` on page 1398

Relative inner

Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

Remote command:

`REFLevel<m>:RELative:ITUBe` on page 1398

7.2.4.4 Configuring Reference Levels

To determine reference and signal levels automatically

By default, the histogram of the measurement data is evaluated to determine the required levels automatically. However, you can define several parameters to adapt the evaluation to your data.

1. On the "Meas" menu, select "Reference Levels" > "Levels".

2. Define the "Source", the waveform for which the reference is defined. The source can be any signal input, math or reference waveform.
3. Select automatic "Reference level mode".
4. Define the "Signal level mode", the method which is used to determine the signal levels. For details, see "Signal level mode" on page 321.
5. By default, the lower reference level is defined at 10% of the signal amplitude, the middle reference level at 50% and the upper reference level at 90%. You can select other "Relative levels" to be used for evaluation.
   If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
   The signal levels are determined by the instrument.
6. To determine the reference levels using average values from several histograms, enable the "Histogram averaging" option and define an "Average Count" to define how many histograms are averaged.
   Averaging is not available if "Absolute peaks" are selected as the "Signal level mode".

To determine reference levels manually

You can configure the reference levels manually as fixed absolute or relative values.

1. On the "Meas" menu, select "Reference Level" > "Levels".
2. Define the "Source", the waveform for which the reference is defined. The source can be any signal input, math or reference waveform.
3. Select manual "Reference level mode".
4. Under "Level definition", select whether you want to define the levels using absolute or relative values.
5. Under "User level selection", select whether you want to configure the high and low signal levels ("User signal level") or the lower, middle and upper reference levels ("User reference level").
6. To define high and low signal levels if "User signal level" is selected:
   a) Enter the absolute high and low signal levels.
   b) If "Level definition" is relative, select one of the predefined "Relative levels". If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
      The upper and lower reference levels are computed from the signal level values and the percentage values.
   c) If "Level definition" is absolute, set the absolute "Top distance" and "Bottom distance" values, the differences between signal and reference levels.
      The upper and lower reference levels are computed from the signal level values and the distances.

7. To define lower, middle and upper reference levels if "User reference level" is selected:
    a) Enter the absolute upper and lower reference levels.
    b) If "Level definition" is relative, select one of the predefined "Relative levels". If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
    The high and low signal levels are computed from the reference level values and the percentage values.
    c) If "Level definition" is absolute, set the absolute "Top distance" and "Bottom distance" values, the differences between signal and reference levels.
    The high and low signal levels are computed from the reference level values and the distances.

To define hysteresis and tubes

1. To define a hysteresis for the middle reference level:
    a) Select the "Hysteresis" tab.
    b) Enter a percentage of the selected signal level.

    A rise or fall from the middle reference value that does not exceed the hysteresis is rejected and not considered a zero-crossing.
2. To define a tube for the high and low signal levels:
    a) Select the "Tube" tab.
    b) In the "Relative outer" field, define a percentage of the signal level by which the absolute signal level may be larger than high signal level or lower than the low signal level.
    c) In the "Relative inner" field, define a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level.

To display reference levels and result lines

1. On the "Meas" menu, select "Gate/Display".
2. Select the tab for the measurement you want to configure.
3. Enable "Display result lines" or "Display reference levels" option, or both.

    The reference levels and intermediate results required for further measurements are displayed in the source diagram.

7.2.5 Amplitude/Time Measurements

7.2.5.1 Amplitude/Time Measurement Types

The R&S RTO provides various voltage, time, area and counting measurements in the category "Amp/Time". Some measurements require reference levels to be set according to the measurement purpose.

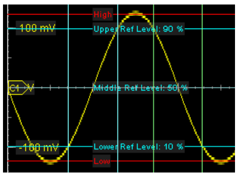
Reference levels are explained in Chapter 7.2.4, "Reference Levels", on page 318.

Amplitude Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

Table 7-1: Amplitude measurements

	Meas. type	Symbol	Description/Result
	High	X_{High}	High signal level
	Low	X_{Low}	Low signal level
	Amplitude	X_{Ampl}	Amplitude of the signal: the difference of high and low signal levels $X_{Ampl} = X_{High} - X_{Low}$
	Max	X_{Max}	Absolute maximum value of the waveform
	Min	X_{Min}	Absolute minimum value of the waveform
	Peak to peak	X_{PkPk}	Peak-to-peak value of the waveform: the difference of maximum and minimum values $X_{Ampl} = X_{Max} - X_{Min}$
	Mean	X_{Mean}	Arithmetic average of the waveform voltage values $X_{Mean} = \frac{1}{N_{Eval}} \sum_{i=1}^{N_{Eval}} x(i)$

	Meas. type	Symbol	Description/Result
	RMS	X_{RMS}	RMS (root mean square, quadratic mean) of the waveform voltage values $X_{RMS} = \sqrt{\frac{1}{N_{Eval}}\sum_{i=1}^{N_{Eval}} x^2(i)}$
	σ (S-dev)	σ_X	Standard deviation of the waveform samples $\sigma_X = \sqrt{\frac{1}{N_{Eval}-1}\sum_{i=1}^{N_{Eval}}(x(i)-X_{Mean})^2}$
	Pos. overshoot	R_{Pos}	Positive overshoot of a square wave, calculated from measurement values High, Max, and Amplitude $+Ovr = \frac{V_{top}-V_{P+}}{V_{Amp}} \cdot 100\%$
	Neg. overshoot	R_{Neg}	Negative overshoot of a square wave, calculated from measurement values Min, Low, and Amplitude $-Ovr = \frac{V_{base}-V_{P-}}{V_{Amp}} \cdot 100\%$
	Cycle mean		The mean value of one cycle
	Cycle RMS		The RMS (root mean square) value of one cycle
	Cycle σ (S-dev)		The standard deviation of one cycle
	ProbeMeter		The DC voltage from the connected probe
	Slew rate rising		Steepness of the rising edge: voltage difference between the lower and higher reference level, divided by the rise time. Result in V/s = V*Hz (blue vertical lines in the picture below).
	Slew rate falling		Steepness of the falling edge: voltage difference between the higher and lower reference level, divided by the fall time. Result in V/s = V*Hz (green vertical lines in the picture below). 

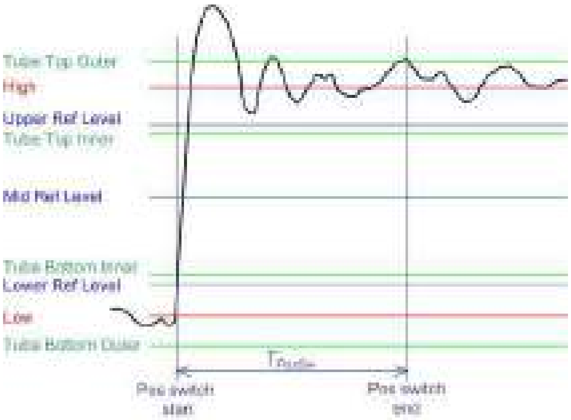
Time Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

See also: Chapter 7.2.4, "Reference Levels", on page 318.

Table 7-2: Time measurement types

	Meas. type	Symbol	Description/Result
	Rise time	T_{Rise}	Rise time of the left-most rising edge of the waveform. Rise time is the time it takes the signal to rise from the low reference level to the high reference level. Multiple measurement is possible.
	Fall time	T_{Fall}	Falling time of the left-most falling edge of the waveform. Fall time is the time it takes the signal to fall from the high reference to the low reference. Multiple measurement is possible.
	Pos. pulse	$T_{PosPulse}$	Width of a positive pulse: time between a rising edge and the following falling edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Neg. pulse	$T_{NegPulse}$	Width of a negative pulse: time between a falling edge and the following rising edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Period	T_{Period}	Time between two consecutive waveform edges of the same direction, measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Frequency	f_{Period}	Frequency of the signal, reciprocal value of the period. $f_{Period} = 1 / T_{Period}$
	Pos. duty cycle	R_{PosCyc}	Positive duty cycle: Width of a positive pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$
	Neg. duty cycle	R_{NegCyc}	Negative duty cycle: Width of a negative pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$
	Delay		Time difference between any two edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source. Set the slope and reference level for each source. See: "Delay settings (analog sources)" on page 334
	Phase		The phase difference between two waveforms (*delay / period * 360*)
	Burst width		The duration of one burst, measured from the first edge to the last

	Meas. type	**Symbol**	**Description/Result**
	Pos. switching	T_{PosSw}	Settling time at rising edges: Time between crossing the lower reference level and the last return of the signal into the top tolerance tube. 
	Neg. switching	T_{NegSw}	Settling time at falling edges: Time between crossing the upper reference level and the last return of the signal into the bottom tolerance tube. See also "Pos. switching" above.
	Pulse train		Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. Define N for the measurement.
	Setup Hold Setup/Hold time	T_{Setup} and T_{Hold}	Setup and Hold time measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 335
	Setup/Hold ratio	$T_{Setup} / (T_{Setup} + T_{Hold})$	Setup/Hold ratio measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 335
	Delay to trigger		Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data. See: ● "Delay to trigger measurement settings" on page 337 ● Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 338

Area Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

Area measurements are voltage over time measurements.

Table 7-3: Area measurement types

	Meas. type	Symbol	Description/Result
	Area	A_{Ref}	Area between the waveform and a reference level ("Area level", X_{Ref}). $A_{Ref} = \frac{T_{Eval}}{N_{Eval}} \cdot \sum_{i=1}^{N_{Eval}} (x(i) - X_{Ref})$ T_{Eval}: Evaluation time, time of a full waveform or limited by a gate
	Cycle area	A_{RefCyc}	Area between the waveform and a reference level ("Area level") measured for one period, see also "Area" measurement. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.

Counting

Access: "Meas" menu > "Setup" > "Amp/Time" category

Table 7-4: Counting measurement types

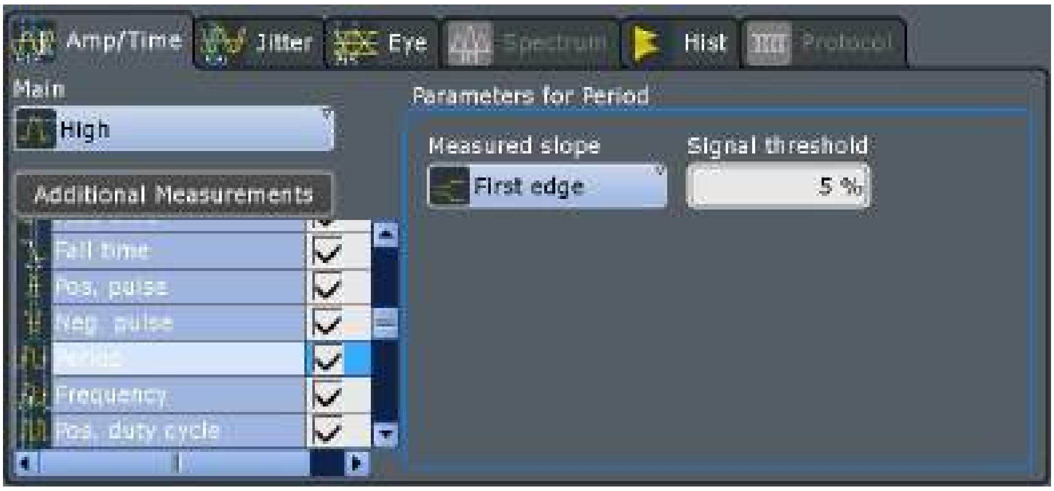
	Meas. type	Symbol	Description/Result
n	Pulse count		The number of positive or negative pulses of the waveform, or of both positive and negative pulses. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. A positive pulse is counted if a rising edge and a following falling edge are detected. A negative pulse is counted if a falling edge and a following rising edge are detected.
n	Edge count		The number of positive or negative edges, or of both positive and negative edges. The instrument determines the mean value of the signal and counts an edge every time the signal passes the mean value.

7.2.5.2 Amplitude/Time Measurement Settings

Access: "Meas" menu > "Setup" > "Amp/Time" category

Amplitude and time measurements are available for sources in the time domain. For some amplitude/time measurements, such as delay, setup/hold and delay to trigger, further setting are required to get a measurement result.

This chapter explains all available settings for amplitude/time measurements.



Main: High

Measured slope: First edge

Signal threshold: 5 %

Main measurement

Defines the main amplitude/time measurement type. This measurement is used if the measurement is used as a source for math calculations, long term measurements, and histograms. The main measurement cannot be disabled in the measurement overview.

For details on the available measurement types, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 328.

Remote command:

`MEASurement<m>:MAIN` on page 1337

Additional Measurements

Tap the "Additional Measurements" button to select measurement types that you want to perform simultaneously to the main measurement type. Tap "All on" or "All off" to enable or disable all available measurement types.

Tap "OK" to close the dialog box. All selected measurement types are displayed in an overview table in the "Measurements" > "Setup" dialog box. You can disable additional measurement types directly in the table.

If a limit check is enabled, the overview table also contains the limit and margin definitions, see Chapter 7.2.12, "Limit and Margin Checks", on page 363.

For quick measurement setup, tap "Activate" to select up to 7 additional measurement types.

For a description of available measurement types, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 328.

Remote command:

`MEASurement<m>:ADDitional` on page 1338

Signal threshold

Defines a signal value that must be exceeded for the signal value to be included in the measurement. The setting is relevant for area, time, and counting measurement types.

Remote command:

`MEASurement<m>:DETThreshold` on page 1349

Area level

The reference level used to integrate the waveform. The setting is only relevant for area measurements.

Remote command:

`MEASurement<m>:AMPTime:ALEVel` on page 1349

Pulses slope

Sets the first slope of the pulses to be counted.

The setting is available only for the "Pulse count" measurement.

"Positive"	Positive pulses are counted.
"Negative"	Negative pulses are counted.
"Either"	Both positive and negative pulses are counted.

Remote command:

`MEASurement<m>:AMPTime:PSLope` on page 1350

Measured slope

Selects the slope direction for frequency and period measurements.

"Positive / Negative"	Measures the time between rising or falling edges, respectively.
"Either"	In multiple measurements, the time is measured both between rising edges and between falling edges. In single measurements. The first edge is taken for the measurement.
"First edge"	Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either". Only available for analog measurement sources.

Remote command:

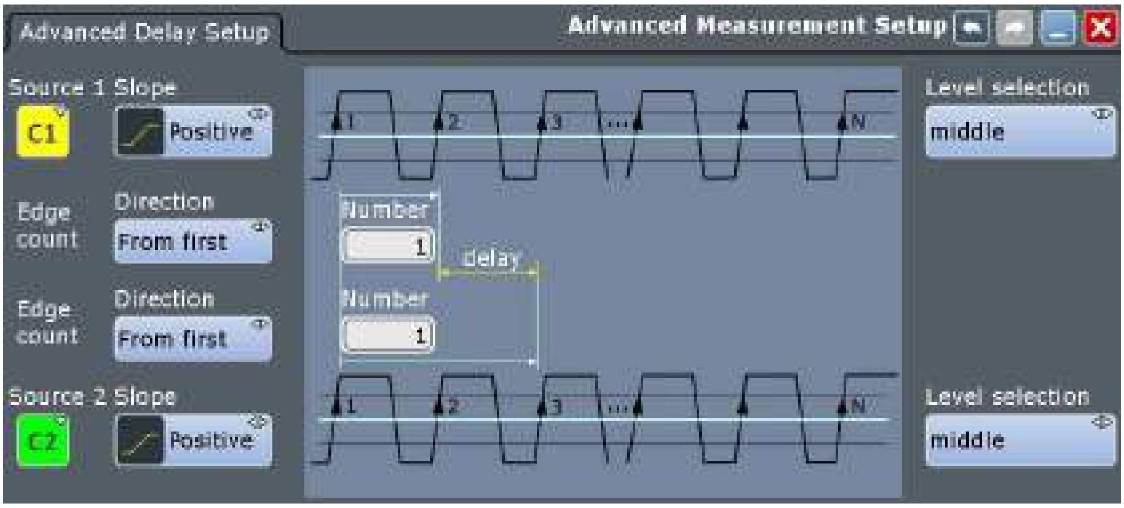
`MEASurement<m>:AMPTime:PFSLope` on page 1350

Delay settings (analog sources)

The specific settings for delay measurement allow you to measure the time between any two slopes at any reference level. Therefore, the reference levels and the slopes must be defined for each source individually. The measurement result is negative if the edge of the second source comes before the edge of the first source.

Example:

With the settings shown in the picture, the time between the second rising edge and the third from last falling edge is measured.



Source 1 Slope: C1, Positive

Edge count: Direction From first, Number 1

Edge count: Direction From first, Number 1

Source 2 Slope: C2, Positive

Level selection: middle

Level selection: middle

"Level selection"	Selects the reference level on which the time is measured.
"Slope"	Sets the edge of each source, between which the delay is measured: positive, negative, or either of them.
"Direction"	Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.
"Number"	Sets the number of the edge that is relevant for delay measurement.

Remote command:
`MEASurement<m>:AMPTime:DELay<n>:LSELect` on page 1351
`MEASurement<m>:AMPTime:DELay<n>:SLOPe` on page 1351
`MEASurement<m>:AMPTime:DELay<n>:DIRection` on page 1350
`MEASurement<m>:AMPTime:DELay<n>:ECOunt` on page 1351

Delay settings (digital sources)

Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

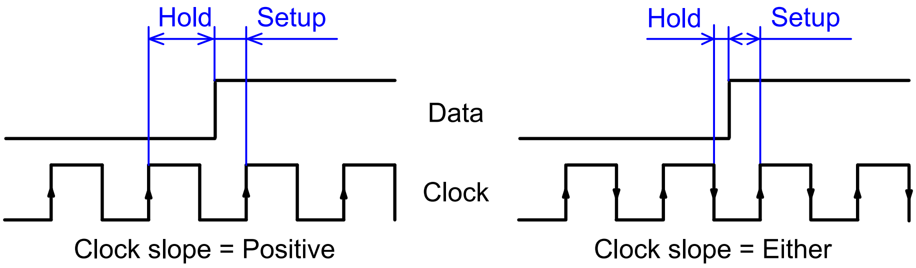
The edge direction is set with Edges slope.

Setup/Hold measurement settings

Setup/Hold measurements analyze the relative timing between two signals: a data signal and the synchronous clock signal. Setup time is the time that the data signal is steady before clock edge - the time between a data transition and the next specified clock edge. Hold time is the time that the data signal is steady after clock edge - the time between a data transition and the previous specified clock edge.

Setup/Hold Time measures and displays the setup and hold durations. Setup/Hold Ratio measurements return the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$.

The clock edge can be defined, the polarity of the data signal does not matter.



If at least one of the setup/hold measurements is selected, more settings appear to specify the measurement.


Parameters for Setup

Clock slope: Positive

Clock source: Ch2Wfm1

Data source: Ch1Wfm1

Threshold: 5 %

Clock ref level: middle

Data ref level: middle

"Clock slope"	Sets the edge of the clock from which the setup and hold times are measured: positive, negative, or either of them. If "Either" is selected, the clock edges next to the data edge are considered regardless of the clock slope.
"Clock source"	The "Clock source" is identical to the measurement "Source". It defines the waveform used as clock in the setup/hold measurement.
"Data source"	The "Data source" is identical to the "2nd Source" of the measurement. It sets the data signal.
"Clock ref level"	See "Clock ref level" on page 336
"Data ref level"	See "Data ref level" on page 336
"Threshold"	See "Signal threshold" on page 333

Remote command:
Clock slope: `MEASurement<m>:AMPTime:CSLope` on page 1352

Clock ref level

Selects the reference level of the clock on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTO-K12).

Remote command:
`MEASurement<m>:AMPTime:CLCK<n>:LSELect` on page 1353

Data ref level

Selects the reference level of the data on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTO-K12).

Remote command:
`MEASurement<m>:AMPTime:DATA<n>:LSELect` on page 1353

Pulse train count
Sets the number N of positive pulses for the "Pulse train" measurement. This measurement measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

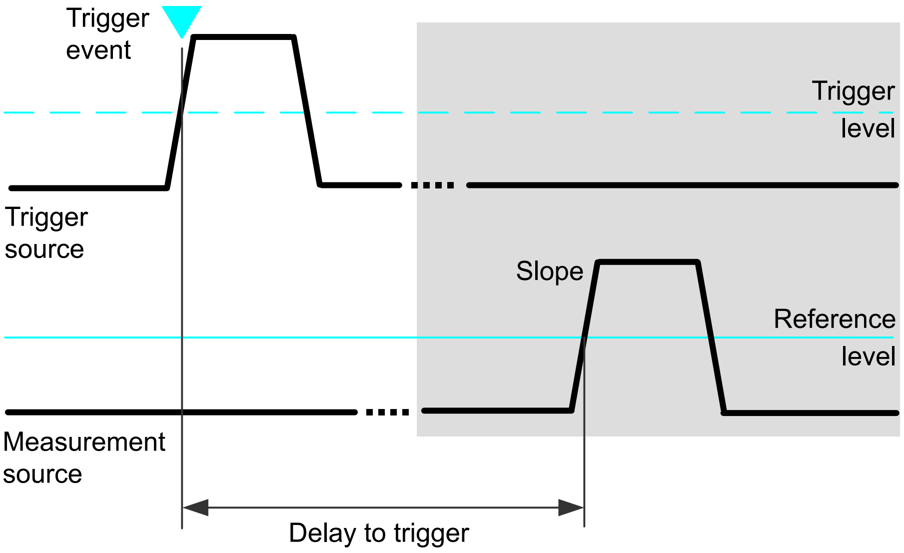
Remote command:
`MEASurement<m>:AMPTime:PTCount` on page 1352

Edges slope
Sets the edge direction to be considered. The setting is relevant for edge count measurement and delay measurement on digital channels.

"Positive"	Positive edges are considered.
"Negative"	Negative edges are considered.
"Either"	Both positive and negative edges are counted (edge count). Delay is measured either between rising edges or between falling edges. The first edge is taken for the measurement.

Remote command:
`MEASurement<m>:AMPTime:ESLope` on page 1352

Delay to trigger measurement settings
Delay to trigger measures the time between the trigger point and the following slope of a waveform. The delay between the trigger and the slope can be high compared to the accuracy of the acquisition, and the trigger point can even be outside of the current acquisition.



See also: Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 338

To configure the trigger conditions, use the trigger setup. To set up the slope, additional settings appear in the measurements "Setup" dialog box.

"Edge slope"	Sets the edge direction to be used for delay measurement: positive, negative, or either edge.
"Level selection"	Selects the reference level of the measurement source on which the delay is measured: upper, middle, or lower level.
"Signal threshold"	See "Signal threshold" on page 333

Remote command:
`MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe` on page 1353
`MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect` on page 1354

7.2.5.3 Measuring the Delay to Trigger

Delay to trigger measures the time between the trigger point and the following slope of a waveform. If the delay is completely unknown. it can be measured in two stages - first a coarse and then a precise measurement.

See also: "Delay to trigger measurement settings" on page 337

1. Set the horizontal scale and horizontal position so that the trigger point and the slope both are visible on the screen.
2. Configure the delay to trigger measurement:
   a) On the "Measurements Setup" tab, select "Delay to trigger" as main or additional measurement.
   b) Select the source, that is the waveform with the delayed slope to be measured.
   c) Select the slope, and the reference level
   d) Check the trigger settings.
   e) Enable the measurement and note the result.
3. Turn the horizontal POSITION knob and enter the measured delay as horizontal position.

   Thus, the slope is moved to the center of the screen.
4. Adjust the horizontal scale and the horizontal resolution parameters (RES REC LEN) to the required accuracy: "Sample rate", "Resolution", or "Acquisition time".

   The trigger is outside the display and is not part of the current acquisition.

5. Repeat the "Delay to trigger" measurement.

   Now the delay is measured with high accuracy. You can analyze the variance of delay values using statistical evaluation and histogram functions.

7.2.6 Eye Diagram Measurements

The eye diagram is a superposition of repetively sampled digital data. It is a tool for evaluation of signal quality and shows the combined effects of channel noise and intersymbol interference. The eye diagram is a significant means of visualizing jitter and allows you to analyze the reasons for it. By creating histograms of the eye diagram, important jitter parameters can be determined.

The waveform display style must be set to vectors: DISPLAY > "Signal Colors / Persistence" tab > "Style = Vectors"

To obtain optimized settings for an eye measurement, use the "Autoset" function that is provided on the right side of the "Eye" tab.

The following characteristic values can be determined:

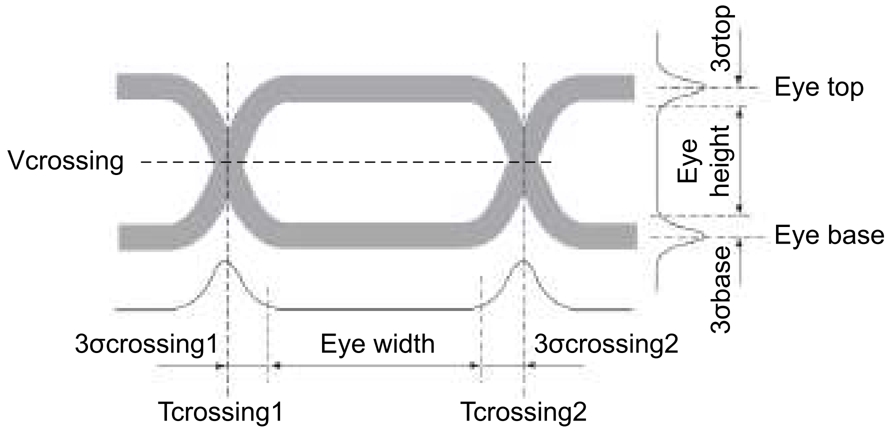


Figure 7-7: Basic eye diagram characteristics

Eye top = Mean of the upper vertical histogram
σtop = Standard deviation of the upper vertical histogram
Eye base = Mean of the lower vertical histogram
σbase = Standard deviation of the lower vertical histogram
Tcrossing = First and second mean of the horizontal histogram
σcrossing = Standard deviation of the horizontal histogram

7.2.6.1 Eye Diagram Measurement Types

Table 7-5: Eye measurement types

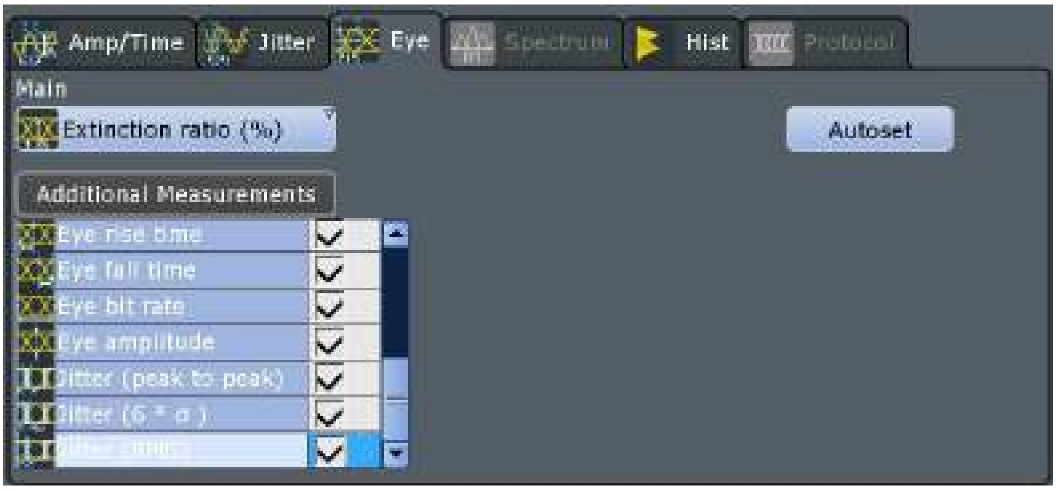
	Meas. type	**Description/Result**
%	Extinction ratio (%)	The extinction ratio is an indication of efficiency. It describes the ratio of the power used to transmit a logic level 1, to the energy used to transmit a logic level 0. The R&S RTO provides extinction ratio measurements as a percentage, and in decibels: ER (%) = Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0 because extinction ratio is defined only for positive values.
dB	Extinction ratio (dB)	ER (dB) = 10*log (Eye top / Eye base)
	Eye height	The vertical eye opening indicates the sensitivity of the transmission to noise. (Eye top – 3 * σtop) – (Eye base + 3 * σbase)
	Eye width	The horizontal eye opening indicates the time range during which the sampling of the logical state is possible. (Tcrossing2 – 3 * σcrossing2) – (Tcrossing 1 – 3 * σcrossing1)
	Eye top	Mean of the upper vertical histogram
	Eye base	Mean of the lower vertical histogram
	Q factor	Q factor = (Eye top – Eye base) / (σtop + σbase)
	Noise (RMS)	Quadratic mean of the noise of eye top and eye base
	S/N ratio	Signal-to-noise ratio SNR = 10 * log (Eye amplitude / Noise RMS)
	Duty cycle distortion	Duty cycle distortion = 20 * log (Eye amplitude / Noise RMS)
	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level
	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level

	Meas. type	Description/Result
	Eye bit rate	Frequency between two crossings
	Eye amplitude	Eye top - Eye base
	Jitter (peak to peak)	Average of the jitter for both crossing points. Jitter = (σcrossing1 + σcrossing2) / 2
	Jitter (6*σ)	Jitter (6*σ) = Jitter * 6
	Jitter (RMS)	Quadratic mean of the jitter at both crossing points

7.2.6.2 Eye Diagram Measurement Settings

Access: "Meas" menu > "Setup" > "Eye" category

Eye diagram measurements are only available for sources in the time domain.



Main: Extinction ratio (%)

- ☑ Eye rise time
- ☑ Eye fall time
- ☑ Eye bit rate
- ☑ Eye amplitude
- ☑ Jitter (peak to peak)
- ☑ Jitter (6 * σ)
- ☑ Jitter (RMS)

To obtain optimized settings for an eye measurement, use the "Autoset" function that is provided on the right side of the "Eye" tab.

The following settings are only availabe, if the category "Eye" is selected.

Main measurement

Defines the main eye measurement type. This measurement is used if the measurement is used as a source for math calculations, long term measurements, and histograms. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see Table 7-5.

Remote command:
`MEASurement<m>:MAIN` on page 1337

Additional eye measurements
Tap the "Additional Measurements" button to select measurement types that you want to perform simultaneously to the main measurement type. Tap "All on" or "All off" to enable or disable all available measurement types.

Tap "OK" to close the dialog box. All selected measurement types are displayed in an overview table in the "Measurements" > "Setup" dialog box. You can disable additional measurement types directly in the table.

If a limit check is enabled, the overview table also contains the limit and margin definitions, see Chapter 7.2.12, "Limit and Margin Checks", on page 363.

For a description of available measurement types, see Table 7-5.

Remote command:
`MEASurement<m>:ADDitional` on page 1338

Autoset
Defines optimized settings to perform an eye diagram measurement for the selected source.

7.2.7 Spectrum Measurements

Spectrum analysis determines the frequencies of a given input signal over time. Various measurements can then be performed based on the signal spectrum.

7.2.7.1 Spectrum Measurement Types

Table 7-6: Spectrum measurement types

	Meas. type	Description, result
	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in dBm
%	Occupied bandwidth	From the defined center frequency, symmetric sample value pairs to the left and right are integrated until a user-defined percentage of the total power is reached. The occupied bandwidth is the difference between the frequencies at which the requested power was reached.
N	Bandwidth	n dB down bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded. The frequencies at which the threshold is exceeded define the limits of the requested bandwidth.

	Meas. type	**Description, result**
	THD[dB], THD[%] Total harmonic distortion	Power sum of the harmonic waves divided by the power of the fundamental wave: $THD = \frac{\sum_{n=2}^{\infty} P_n}{P_1}$
	THD_a, THD_u, THD_r Total harmonic distortion	These measurements require option R&S RTO-K18 Spectrum Analysis. Root mean square of the sum of all amplitudes of the harmonic waves in relation to the amplitude of the fundamental waveform $THD_A = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_1}$ Root mean square of the power sum of harmonic waves in relation to the power of the fundamental waveform $THD_U = \frac{\sqrt{P^2 - P_1^2}}{P_1}$ Root mean square of the power sum of harmonic waves in relation to the power of all waveforms $THD_R = \frac{\sqrt{P^2 - P_1^2}}{P} = \frac{THD_U}{\sqrt{1 + THD_U^2}}$
	Peak list	This measurement requires option R&S RTO-K18 Spectrum Analysis. Table with measured peaks. For each peak, the frequency and the value is listed in a table row. The number of determined peaks can be defined.
	Harmonic search	Table with measured harmonics. For each harmonic, the frequency and the value is listed in a table row.

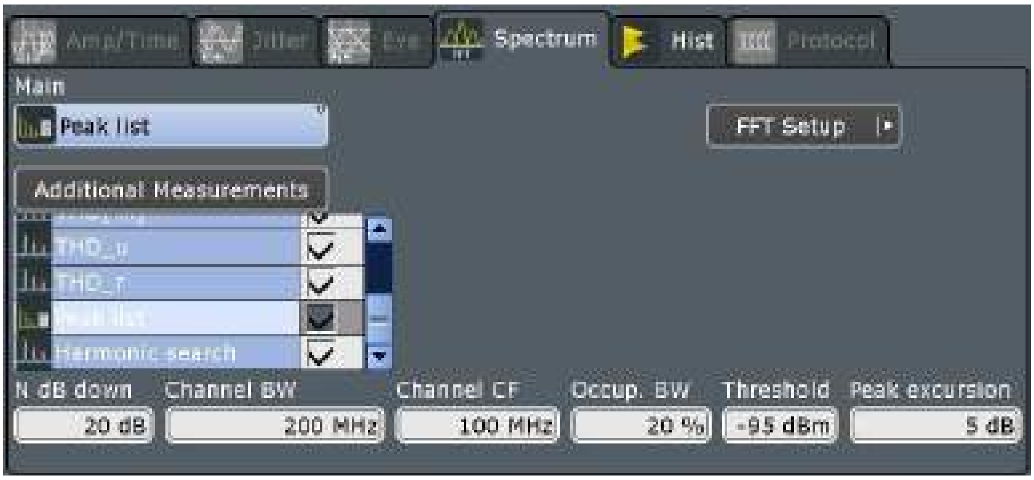
For remote command parameters and suffix types see Table 20-7.

7.2.7.2 Spectrum Measurement Settings

Access: "Meas" menu > "Setup" > "Spectrum" category

Spectrum measurements are only available if a source in the frequency domain is selected, i.e. a math waveform with an FFT operation.

For spectrum measurements, make sure that the start frequency and other FFT parameters are set correctly, and the fundamentals are not covered by the DC component of the signal. Consider also a gated measurement if the instrument cannot return any result.



Main: Peak list

N dB down: 20 dB
Channel BW: 200 MHz
Channel CF: 100 MHz
Occup. BW: 20 %
Threshold: -95 dBm
Peak excursion: 5 dB

Main measurement

Defines the main spectrum measurement type. This measurement is used if the measurement is used as a source for math calculations, long term measurements, and histograms. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see Table 7-6.

Remote command:
`MEASurement<m>:MAIN` on page 1337, Table 20-7

Additional spectrum measurements

Tap the "Additional Measurements" button to select measurement types that you want to perform simultaneously to the main measurement type. Tap "All on" or "All off" to enable or disable all available measurement types.

Tap "OK" to close the dialog box. All selected measurement types are displayed in an overview table in the "Measurements" > "Setup" dialog box. You can disable additional measurement types directly in the table.

If a limit check is enabled, the overview table also contains the limit and margin definitions, see Chapter 7.2.12, "Limit and Margin Checks", on page 363.

For a description of available measurement types, see Table 7-6.

Remote command:
`MEASurement<m>:ADDitional` on page 1338, Table 20-7

N db down

The threshold until which the samples to the left and right of the peak value are analyzed in order to determine the "Bandwidth".

Remote command:
`MEASurement<m>:SPECtrum:NDBDown` on page 1360

Channel BW

Bandwidth over which the channel power is calculated.

Remote command:
`MEASurement<m>:SPECtrum:CPOWer:BANDwidth` on page 1359

Channel CF
Center frequency from which the channel power is calculated over the specified bandwidth.

Remote command:
`MEASurement<m>:SPECtrum:CPOWer:CFRequency` on page 1360

Occup. BW
Percentage of the total power used to determine the occupied bandwidth.

Remote command:
`MEASurement<m>:SPECtrum:OBANdwidth` on page 1359

Threshold
Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

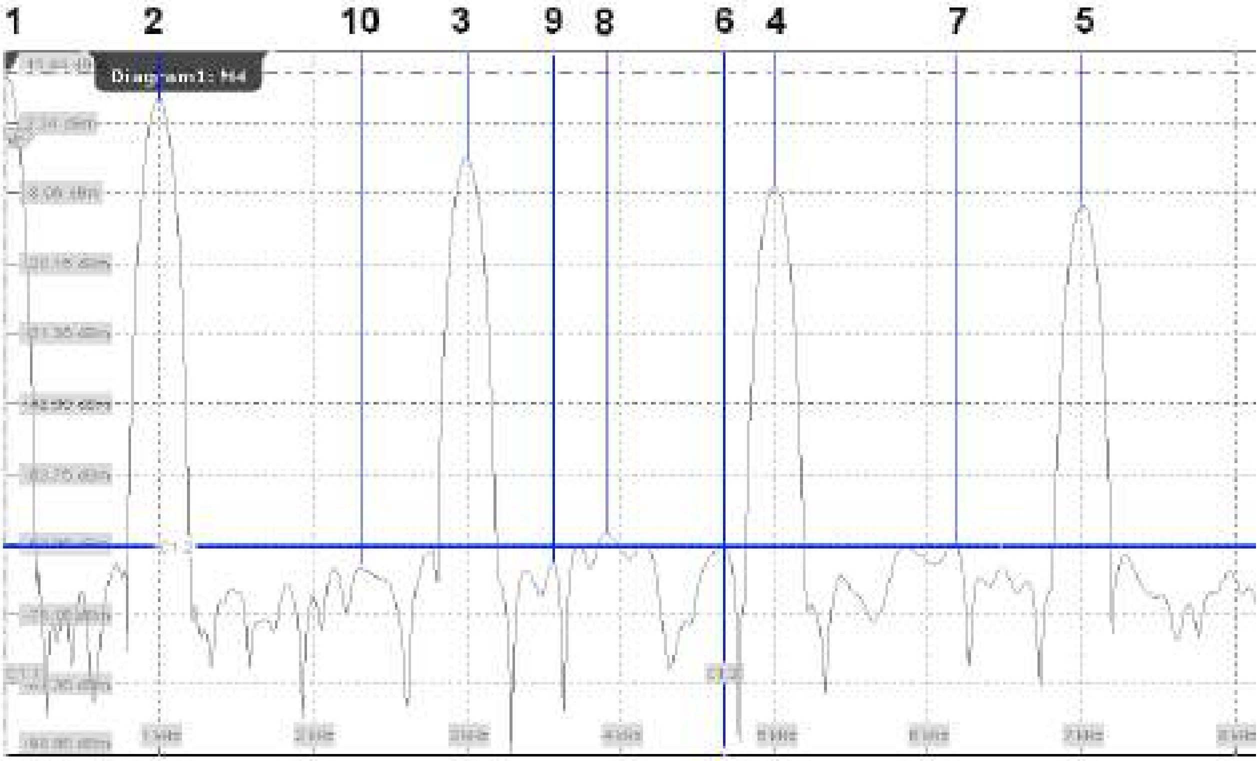
This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
`CURSor<m>:THReshold` on page 1331
`MEASurement<m>:SPECtrum:ATHReshold` on page 1361

Peak excursion
Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:
`CURSor<m>:PEXCursion` on page 1332
`MEASurement<m>:SPECtrum:PEXCursion` on page 1360

Result labels

For peak lists only: a description of each detected peak can be provided using labels in the spectrum diagram.

"Enable"	Displays a description for each detected peak in the spectrum diagram.
"Label frame type"	Defines the layout of the labels (frame, line, or none).
"Inverse"	Displays black font on white background using the "Full frame" label type.
"Max. number of peaks"	Defines the maximum number of peaks that are listed in the peak list and labeled in the diagram.
"Show Frequency"	Includes the frequency of the detected peak in the diagram labels.

Remote command:
`MEASurement<m>:RESult:SHLabels` on page 1363
`MEASurement<m>:RESult:LABorder` on page 1362
`MEASurement<m>:RESult:INVerse` on page 1362

`MEASurement<m>:RESult:MAXCount` on page 1361
`MEASurement<m>:RESult:SHFRequency` on page 1363

7.2.8 Histograms and Histogram Measurements

7.2.8.1 Histogram Characteristics and Measurement Types

Histograms are used to plot density of data, i.e. to display graphically how often which signal values occur. The histogram can be based on the input signal levels (amplitudes) or the timebase in a time domain measurement, or on frequencies or frequency levels in a spectrum measurement. They are a prerequisite for histogram measurements.

Depending on which data the histogram is based on, a vertical or horizontal histogram can be selected. A vertical, or amplitude, histogram displays horizontal bars across amplitude values. A horizontal or time/frequency histogram displays vertical bars over time/frequencies.

You can define up to 8 histograms in a diagram, one of them is displayed. They can be created quickly using toolbar icons, or in the "Meas" menu > "Histogram" dialog box. To switch the histogram display, tap the required histogram area, or select it in the "Histogram" dialog box. For histogram measurements, the measured histogram is selected independently in the measurement setup.

In a histogram, the maximum count of a waveform value is assigned to the full height (histogram peak). All other count values are displayed relative to the maximum.

The following characteristic values can be determined for histograms (illustrated for a vertical histogram):

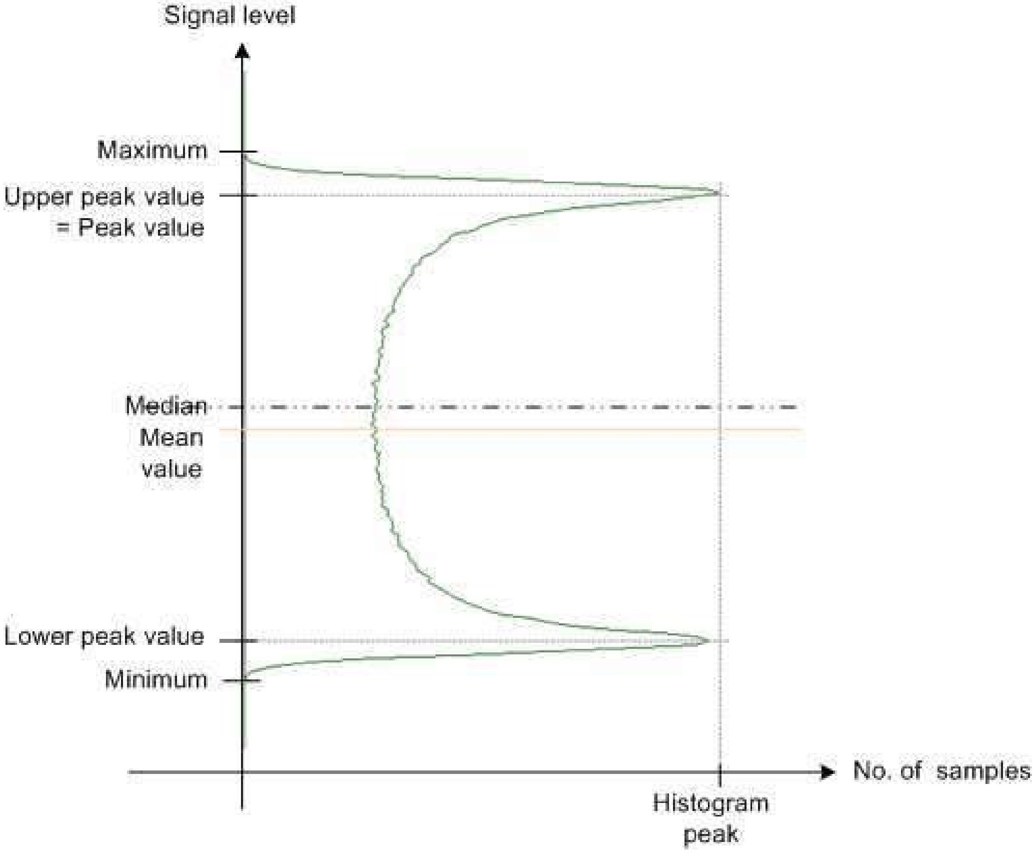


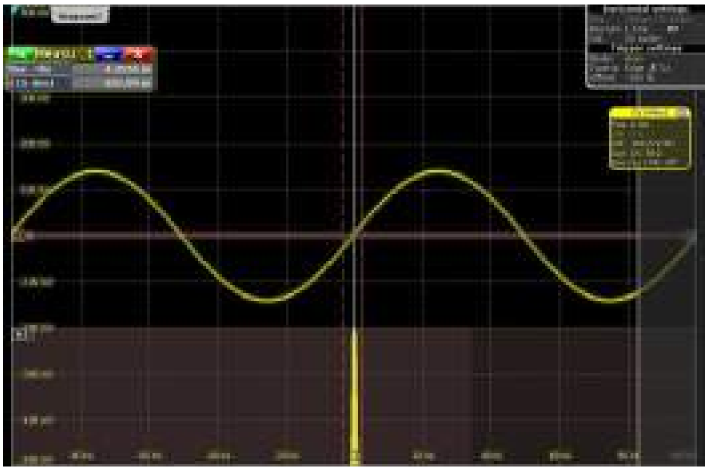
Table 7-7: Histogram measurement types

	Meas. type	Description/Result
	Waveform count	The number of acquisitions (waveforms) the histogram is based on
	Waveform samples	The number of samples from the most recent acquisition included in the current histogram
	Histogram samples	The number of samples from all acquisitions included in the current histogram
	Histogram peak	The maximum count value in the histogram
	Peak value	The signal value at the histogram peak
	Upper peak value	The signal value at the maximum count value in the upper half of the histogram

	Meas. type	Description/Result
↕	Lower peak value	The signal value at the maximum count value in the lower half of the histogram
	Maximum	The highest signal value with a probability > 0
	Minimum	The lowest signal value with a probability > 0
	Median	The signal value for which half the samples lie above, the other half below in the histogram The sample count of one signal value after the other are accumulated until half the total number of samples in the histogram is reached. The signal value for which 50% of the samples are accumulated is the median.
	Max - Min	The range of signal values with a probability > 0
	Mean	The weighted arithmetic average of the histogram
σ	σ (S-dev)	Standard deviation of the sample numbers
1 σ	Mean ±σ	The range between (mean value + standard deviation) and (mean value - standard deviation)
2 σ	Mean ±2*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
3 σ	Mean ±3*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
+	Marker + Probability %	The marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.
-	Marker - Probability %	The marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.

Rough jitter evaluation using a histogram

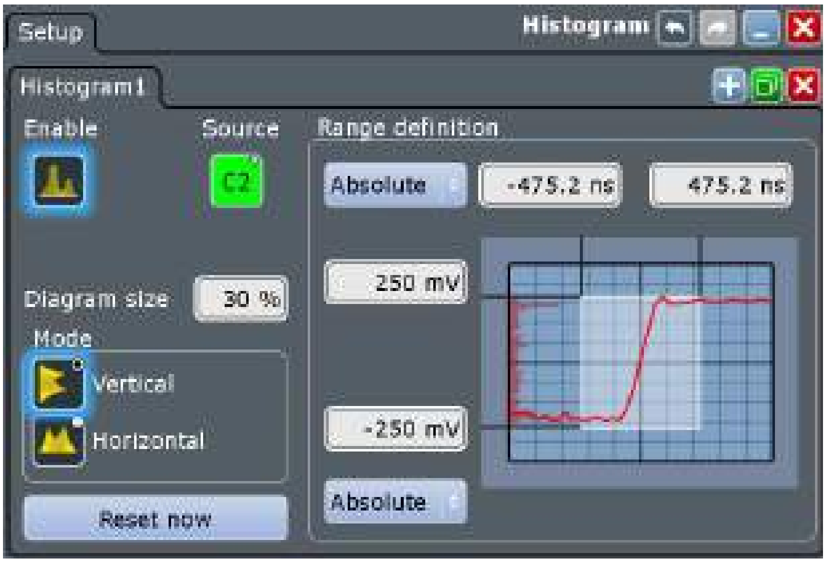
You can use a horizontal histogram to perform a rough jitter measurement. Define a histogram for a narrow amplitude range close to the trigger time. The "Max-Min" value indicates the peak jitter, while the "StdDev" value indicates the RMS jitter.



In addition to histograms on channel, math and reference waveforms, histograms can be created based on statistic measurement results. These histograms are enabled in the "Long Term/Track" tab, see Chapter 7.2.9, "Long Term Measurements and Statistics", on page 354.

7.2.8.2 Histogram Setup

In this dialog box you configure histograms on which you can perform further measurements.



Setup
Histogram
Histogram1
Enable
Source: C2
Range definition: Absolute, -475.2 ns, 475.2 ns
250 mV
-250 mV
Absolute
Diagram size: 30 %
Mode: Vertical, Horizontal

Enable

Enables or disables the histogram evaluation and display. The histogram settings are kept until the histogram is deleted.

Source

Defines the source of the histogram. Any analog channel waveform, math or reference waveform can be selected. Also measurements can serve as histogram source. In this case, the density distribution of the results of the main measurement is displayed.

Remote command:
`LAYout:HISTogram:SOURce` on page 1366

Diagram size

Defines the size of the histogram in percent of the diagram.

Mode

Defines the type of histogram.

"Vertical"	Amplitude histogram (horizontal bars across amplitude)
"Horizontal"	Time histogram (vertical bars over time). For spectrum waveforms, horizontal histograms over spectrum are not available.

Remote command:
`LAYout:HISTogram:MODE` on page 1367

Reset now

Resets the values to begin a new histogram.

Remote command:
`LAYout:HISTogram:RESet` on page 1370

Range definition mode (Absolute/Relative)

Defines whether the value range limits are entered as absolute or relative values.

Remote command:
`LAYout:HISTogram:HORZ:MODE` on page 1367
`LAYout:HISTogram:VERTical:MODE` on page 1369

Horizontal start/stop value

Defines the horizontal value range of the histogram.

Remote command:
`LAYout:HISTogram:HORZ:ABSolute:STARt` on page 1368
`LAYout:HISTogram:HORZ:ABSolute:STOP` on page 1368
`LAYout:HISTogram:HORZ:RELative:STARt` on page 1368
`LAYout:HISTogram:HORZ:RELative:STOP` on page 1368

Vertical start/stop value

Defines the vertical value range of the histogram.

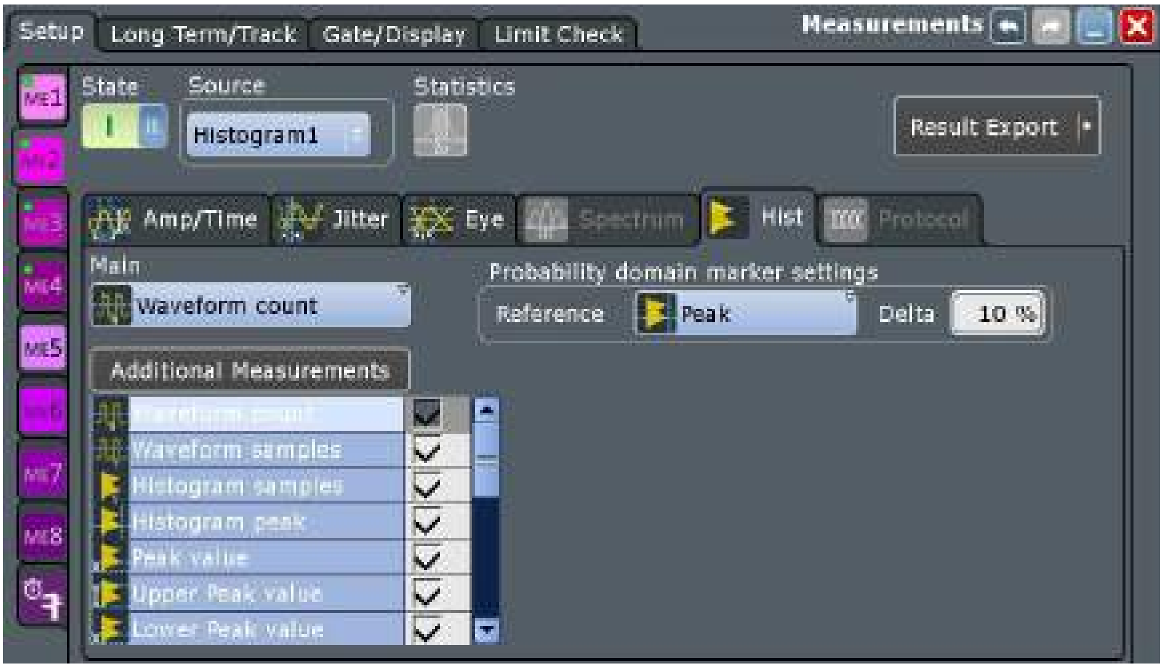
Remote command:
`LAYout:HISTogram:VERTical:ABSolute:STARt` on page 1369
`LAYout:HISTogram:VERTical:ABSolute:STOP` on page 1369

[LAYout:HISTogram:VERTical:RELative:STARt](#) on page 1369
[LAYout:HISTogram:VERTical:RELative:STOP](#) on page 1370

7.2.8.3 Histogram Measurement Settings

Access: "Meas" menu > "Setup" > "Hist" category

You can perform measurements on histograms. Before, you have to define a histogram, see Chapter 7.2.8.4, "Creating a Histogram ", on page 353.



Source: Histogram1

Main: Waveform count

Reference: Peak

Delta: 10 %

- Waveform count ☑
- Waveform samples ✓
- Histogram samples ✓
- Histogram peak ✓
- Peak value ✓
- Upper Peak value ✓
- Lower Peak value ✓

Histogram
Selects the histogram on which the measurement is based. Histograms are defined via the "MEAS > Histogram" menu item.

Remote command:
`MEASurement<m>:HISTogram:SELect` on page 1372

Main measurement
Defines the main histogram measurement type. This measurement is used if the measurement is used as a source for math calculations, and long term measurements. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see Table 7-7.

Remote command:
`MEASurement<m>:MAIN` on page 1337

Additional histogram measurements
Tap the "Additional Measurements" button to select measurement types that you want to perform simultaneously to the main measurement type. Tap "All on" or "All off" to enable or disable all available measurement types.

Tap "OK" to close the dialog box. All selected measurement types are displayed in an overview table in the "Measurements" > "Setup" dialog box. You can disable additional measurement types directly in the table.

If a limit check is enabled, the overview table also contains the limit and margin definitions, see Chapter 7.2.12, "Limit and Margin Checks", on page 363.

For a description of available measurement types, see Table 7-7.

Remote command:
`MEASurement<m>:ADDitional` on page 1338

Probability domain marker reference
Defines the marker reference in the probability domain.

"Peak"	The y-value with the maximum sample value in the histogram
"Upper Peak"	The y-value at the maximum sample value in the upper half of the histogram
"Lower Peak"	The y-value at the maximum sample value in the lower half of the histogram
"Maximum"	The highest y-value with a probability > 0
"Minimum"	The lowest y-value with a probability > 0
"Median"	The y-value for which half the samples lie above, the other half below in the histogram
"Mean"	The weighted arithmetic average of the histogram

Remote command:
`MEASurement<m>:HISTogram:PROBability:TYPE` on page 1372

Delta
Defines a range around the marker.

Remote command:
`MEASurement<m>:HISTogram:PROBability:LIMit` on page 1373

7.2.8.4 Creating a Histogram

Histograms can be used to evaluate the sample value occurrences directly. They are a prerequisite for histogram measurements.

The usage of histograms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Histogram".

To create a histogram quickly with toolbar icons

1. Select the waveform for which you need a histogram.
2. Tap the histogram icon on the toolbar.
3. Select the histogram type in the sidebar: vertical for an amplitude, horizontal for a time-based histogram.
   Check and adjust the histogram settings.

4. Tap the diagram with the waveform to be measured, or draw a rectangle on the screen to define the area on which the histogram is to be based.

   The histogram range is indicated in the diagram and a histogram with the selected waveform as a source is defined and displayed.

To create and configure a histogram in the dialog box

1. Select "Meas > Histogram", or touch and hold an existing histogram or histogram area.

   The "Histogram Setup" dialog box is displayed.
2. To create a new histogram, tap the "Add" icon in the upper right corner of the dialog box.
3. To copy an existing histogram and configure a new one based on those settings, tap the "Copy" icon.
4. To change the name of a histogram, double-tap the tab label and enter a name for the histogram using the on-screen keyboard.
5. Select a "Source" for the histogram. The source can be any input signal, math or reference waveform.
6. Define the histogram "Mode": vertical for an amplitude, horizontal for a time-based histogram.
7. Define the range of the waveform for which the histogram is to be generated. Enter the start and stop values in x and in y direction, either as absolute or relative values.
8. Enable the histogram.

7.2.9 Long Term Measurements and Statistics

The behavior of measurement results over time can be evaluated in different ways:

- Long Term Measurements
- Statistics

- Histograms on measurement results
- Track (requires option)

7.2.9.1 About Long Term Measurements and Statistics

Long term measurements

Long term measurements show the behavior of measurement results over a longer time or for many samples. Therefore the measurement results of a specified time period are summarized into one long term point. For each point, the current value measured at the end of the time period is written to the long term waveform, and statistical results for each time period are calculated, saved, and reset. This reset avoids constantly rising maximum or constantly falling minimum values until the end of the measurement.

You can define the number of long term points and export the long term data, including statistical results. The measurement histogram is a vertical histogram shown in the long term diagram.

Long term measurements are performed on the main measurement.

Statistics

If statistics are enabled for the measurement, the following information is provided in the result box for each measurement type.

Label	Description
Current	Currently measured value
+Peak	Positive peak value (maximum)
-Peak	Negative peak value (minimum)
µ (Avg)	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured events (e.g. rising edges, pulses etc.)
Wave count	Number of waveforms (acquisitions) the measurement is based on

Remote commands:

- `MEASurement<m>:RESult:AVG?` on page 1342
- `MEASurement<m>:RESult[:ACTual]?` on page 1342
- `MEASurement<m>:RESult:COUNt?` on page 1345
  `MEASurement<m>:RESult:EVTCount?` on page 1342
  `MEASurement<m>:RESult:NPEak?` on page 1342
  `MEASurement<m>:RESult:PPEak?` on page 1342
  `MEASurement<m>:RESult:RMS?` on page 1342
  `MEASurement<m>:RESult:STDDev?` on page 1343

`MEASurement<m>:RESult:STARt?` on page 1344
`MEASurement<m>:RESult:STOP?` on page 1344
`MEASurement<m>:RESult:WFMCount?` on page 1343

The peak and average values and the standard deviation of the long term points are also shown in the graph of the long term measurement.

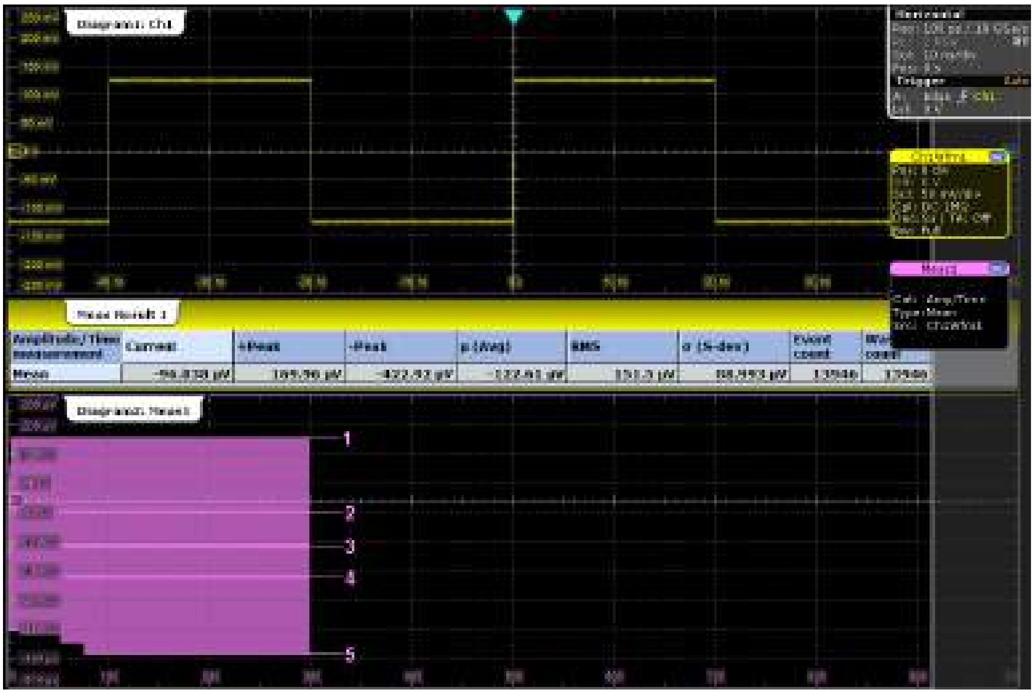


Figure 7-8: Long term measurement with statistics

1 = +Peak, maximum
2 = Average + standard deviation
3 = Average
2 = Average - standard deviation
1 = -Peak, minimum

Stopping and starting the acquisition does not reset statistics but only stops and continues them.

The instrument only resets statistical evaluation if you change measurement setup:

- Measurement types
- Gate
- Enable/disable long term measurement and histogram
- Enable continuous autoscale with enabled histogram
- Switch on/off channels
- Enable/disable cursors
- Tap "Reset" or "Clear sreen results"

After a reset, new statistics are compiled beginning with the next acquired waveform.

If limit and margin check is enabled, the icons in the result table indicate if statistical results exceed a limit or margin. These violations do not initiate an action.

Histogram on measurement results

Histograms are available not only for channel, math and reference waveforms, but also on measurement results. These histograms cannot be configured, and they are shown in a separate diagram. The source is a measurement Px. If the histogram is based on long term measurement, it is shown in the long term diagram.

The histogram is built from the results of the main measurement.

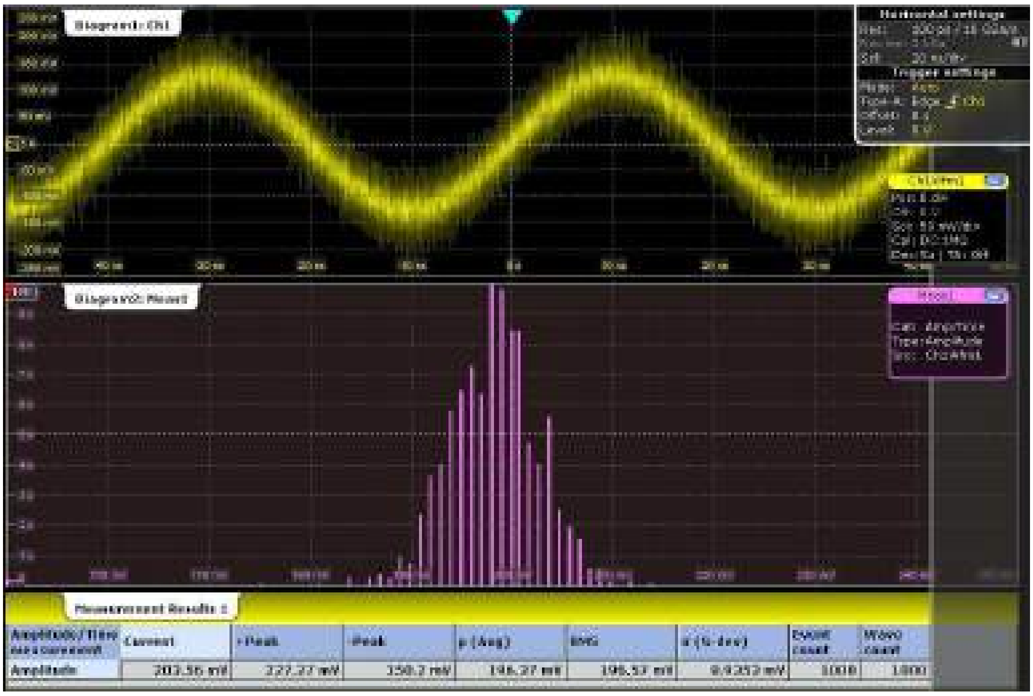


Figure 7-9: Statistical results and measurement histogram of an amplitude measurement

7.2.9.2 Long Term/Track Settings

Access: "Meas" menu > "Long Term/Track"

The settings in the "Long Term/Track" tab allow you to configure long term measurements, including statistics and measurement histogram over a longer period of time.

For scaling settings of the long term diagram, see Chapter 7.2.9.3, "Horizontal Long Term Scaling", on page 360.

The track function requires an option, see "Enable (Track)" on page 359.

Number of bins 1000

Meas scale 500 mV/div

Meas offset 0 V

Limit 1000

'Long Term', 'Track' and 'Histogram' measurements refer to 'Main Measurement'

ME 1/2/3/4/5/6/7/8/Quick Meas
For each of the eight measurements, and for the quick measurement, a subtab contains the configuration settings. A green dot on the tab indicates that the measurement is active.

Enable (Long term)
Enables long term measurement of the main measurement.

Remote command:
`MEASurement<m>:LTMeas[:STATe]` on page 1380

Statistics
Enables the calculation and display of statistical results.

Remote command:
`MEASurement<m>:STATistics[:ENABle]` on page 1376
`MEASurement<m>:RESult:AVG?` on page 1342
`MEASurement<m>:RESult:EVTCount?` on page 1342
`MEASurement<m>:RESult:NPEak?` on page 1342
`MEASurement<m>:RESult:PPEak?` on page 1342
`MEASurement<m>:RESult:RMS?` on page 1342
`MEASurement<m>:RESult:STDDev?` on page 1343
`MEASurement<m>:RESult:WFMCount?` on page 1343
`MEASurement<m>:RESult[:ACTual]?` on page 1342
`MEASurement<m>:ARNames` on page 1342
`MEASurement<m>:ARES?` on page 1341

Enable (Histogram)
Displays a histogram of measurement results - the cumulative occurrence distribution of measurement results in a graphic. Enabling the histogram enables also the statistics.

The histogram is built from the results of the main measurement.

Remote command:
`MEASurement<m>:STATistics:HISTogram` on page 1377

Number of bins
Sets the number of bins - the number of vertical bars that build the histogram.

If "Continuous auto scale" is enabled, the instrument determines the number of bins based on the timebase, the current measurements, and other settings. To set the number of bins manually, disable "Continuous auto scale".

Remote command:
`MEASurement<m>:STATistics:HBINs` on page 1377

Enable (Track)
Enables the track measurement and displays the track of the selected waveform.

The track functionality requires at least one option:
- Option R&S RTO-K31 Power Analysis
  Enables the track for amplitude and time measurements.
- Option R&S RTO-K12 Basic Jitter Analysis
  Enables the track for amplitude and time measurements. You can use tracks to display the jitter measurement results as a time-correlated waveform, see Chapter 16.1.5, "Track of Jitter Measurement Results", on page 1045.
- Option R&S RTO-K5 I²S Audio Signals
  Enables the track for protocol measurements on decoded audio buses, see Chapter 12.8.5.1, "Track", on page 609.

Remote command:
`MEASurement<m>:TRACk[:STATe]` on page 1381

Meas scaling
The measurement scale of a long term measurement diagram or measurement histogram is set automatically by the instrument, or manually.

Use automatic scaling if the measurement is running and you cannot see the expected results.

"Continuous auto scale"	Performs an automatic scaling whenever the long term waveform or the histogram does not fit in the diagram during the measurement period.
"Auto scale"	Performs an automatic scaling once so that the scaling is adapted to the current measurement results. Available only for long term measurement.
"Meas scale"	Defines the scaling per division for long term measurement period and the measurement histogram.

"Meas offset"	Defines an offset for the long term measurement and the measurement histogram.

Remote command:
`MEASurement<m>:VERTical:CONT` on page 1379
`MEASurement<m>:VERTical:AUTO` on page 1379
`MEASurement<m>:VERTical:SCALe` on page 1380
`MEASurement<m>:VERTical:OFFSet` on page 1380

Multiple measurement
Performs multiple measurements on the same source waveform and includes the results in evaluation. For example, it measures the rise time for all pulses in the waveform, not only the first.

The result box shows only the first result of the waveform, the following results are only used for evaluation.

Multiple measurement results are also considered in limit and margin checks and can initiate an action. However, the icons in the result box only indicate violations of the first result.

Multiple measurements are useful when calculating statistics or generating tracks; however, it reduces the performance of the instrument.

The number of considered measurement results can be restricted, see Limit.

Remote command:
`MEASurement<m>:MULTiple` on page 1340

Limit
Sets the maximum number of measurements per acquisition if "Multiple measurement" is enabled.

Remote command:
`MEASurement<m>:MNOMeas` on page 1340

Reset now
Resets the histogram, the long term measurement and the statistics.

Stopping and starting the acquisition does not reset these analyses but only stops and continues them.

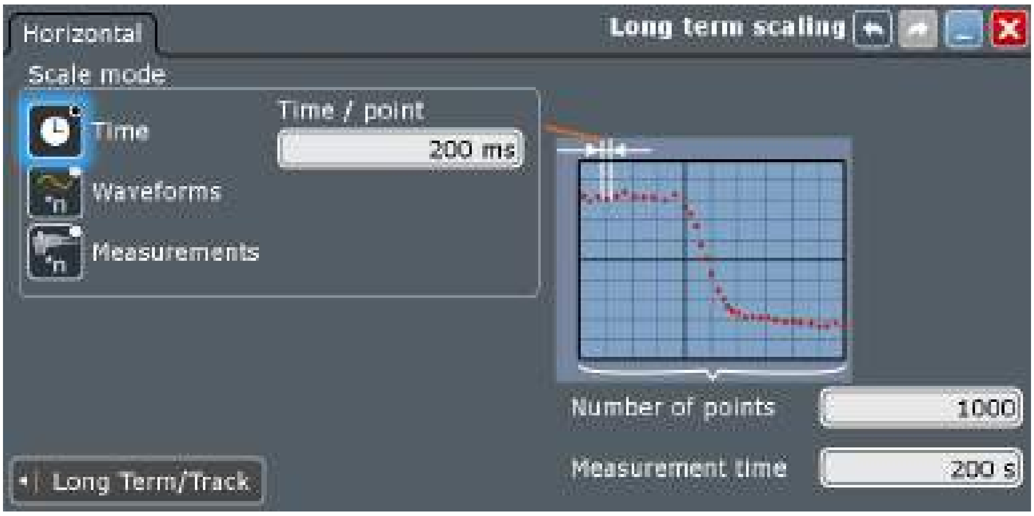
To clear only statistical results, use "Clear results" on the "Gate/Display" tab. To delete all results and waveforms, select "Display" menu > "Clear screen results".

Remote command:
`MEASurement<m>:STATistics:RESet` on page 1379

7.2.9.3 Horizontal Long Term Scaling

In this dialog box, you define the horizontal scale of long term measurement diagrams. The length of the long term measurement is defined by the number of points.

If option R&S RTO-K5 I²S Audio Signals is installed, the trend diagram is configured here.



Number of points

Defines the total number of points to be displayed in the long term measurement diagram.

Remote command:

`MEASurement<m>:LTMeas:COUNt` on page 1380

Scale mode

Defines when the points of a long term measurement are created.

If statistics are enabled, each long term measurement point shows the statistical mean and standard deviation of the results measured during the defined period.

If statistics are disabled, the first measurement result of each period is taken as long term measurement point.

"Time"	Sets one long term measurement point for the time defined in "Time/ point".
"Waveforms"	Sets one long term measurement point for a number of acquired waveforms defined in "Waveforms/point".
"Measure-ments"	Sets one long term measurement point for a number of measurement results defined in "Measurements/point".

Remote command:

`MEASurement<m>:STATistics:MODE` on page 1377

Time / point

Defines the time to create one point of the long term measurement. The "Time / point" value is a lower time limit. The real time between two points depends on the acquisition and postprocessing time.

The long term measurement is not a data logger with equidistant points as the time between two points varies.

This setting is only available if "Scale mode" is set to "Time".

Remote command:

`MEASurement<m>:STATistics:RTIMe` on page 1378

Measurement time
Defines the total duration of the long term measurement: *Time/point * Number of points*.

This setting is only available if "Scale mode" is set to "Time".

Remote command:
`MEASurement<m>:LTMeas:TIME` on page 1381

Waveforms / point
Defines the number of measured waveforms from which one point of the long term measurement is created.

This setting is only available if "Scale mode" is set to "Waveforms".

Remote command:
`MEASurement<m>:STATistics:RCOunt` on page 1378

Measurements / point
Defines the number of measurement results from which one point of the long term measurement is created.

This setting is only available if "Scale mode" is set to "Measurements".

Remote command:
`MEASurement<m>:STATistics:RMEascount` on page 1378

7.2.9.4 Performing Long-term Measurements

To evaluate time-dependant behavior of a measurement, you can perform the measurement over a long period of time or for a large number of samples.

1. From the "Meas" menu, select "Long Term/Track".
2. Select the tab for the measurement you want to configure.
3. Under "Long term", tap "Enable".
4. Since the waveform may change in the process of time, enable "Continuous auto scale" to have the scaling adapted automatically.
   Alternatively, tap the "Auto scale" to adjust the scale once and to see the long term waveform.
5. Tap "Horizontal scaling".
6. Define the "Number of points" to be shown in the long term diagram.
7. Set the "Scale mode" that defines the period of time from which one long term point is created.
   See "Scale mode" on page 361 for setting details.

   For each long term measurement point, the current measurement value is added to the long term waveform.
8. If you need the statistical data of the long term points:
   a) Tap "Long Term/Track" to return to the measurement settings.

b) Enable statistics.
c) Let the measurement run and export the data when finished, see Chapter 11.2.5, "Long Term / Meas Histograms", on page 464.

7.2.9.5 Compiling Measurement Statistics

Statistics can be compiled for all measurement types, and also for long-term measurements. If enabled, statistics for the measurement are included in the result box.

To obtain meaningful results, it may be useful to configure specific measurement settings:

- "Multiple measurement" on the "Gate/Display" tab: the measurement result is not only determined once within one acquisition, but repeatedly, if available. This provides a larger basis for statistical evaluation.
- Reference/signal levels: configuring user-defined levels may compensate for irregular data, see Chapter 7.2.4.4, "Configuring Reference Levels", on page 325.
- Gate areas: restricting the waveform range for measurement can eliminate irregular data, see Chapter 7.2.3, "Measurement Gates", on page 315.
- Defining a "Signal threshold" for amplitude vs. time measurements can eliminate noise from the evaluation, see "Signal threshold" on page 333.
- Spectrum measurements: you can eliminate noise from the evaluation, see Threshold and "Peak excursion" on page 302

To enable statistics

1. From the "Meas" menu, select "Setup".
2. Select the tab for the measurement you want to configure.
3. Tap the "Enable Statistics" icon.

7.2.10 Jitter Measurements

Jitter measurements are availabe if option R&S RTO-K12 is installed.

See Chapter 16.1, "Jitter Measurements", on page 1035.

7.2.11 Protocol Measurements

Measurements on serial buses are available for audio signals (option R&S RTO-K5). The results of these measurements are track and trend waveforms.

See: Chapter 12.8.5, "Track and Trend", on page 609.

7.2.12 Limit and Margin Checks

Limit and margin checks evaluate if the measurement result exceeds a specified value. Violations are indicated by icons in the result box. Furthermore, you can define actions that are performed on limit or margin violation, like saving the waveform or printing the measurement results.

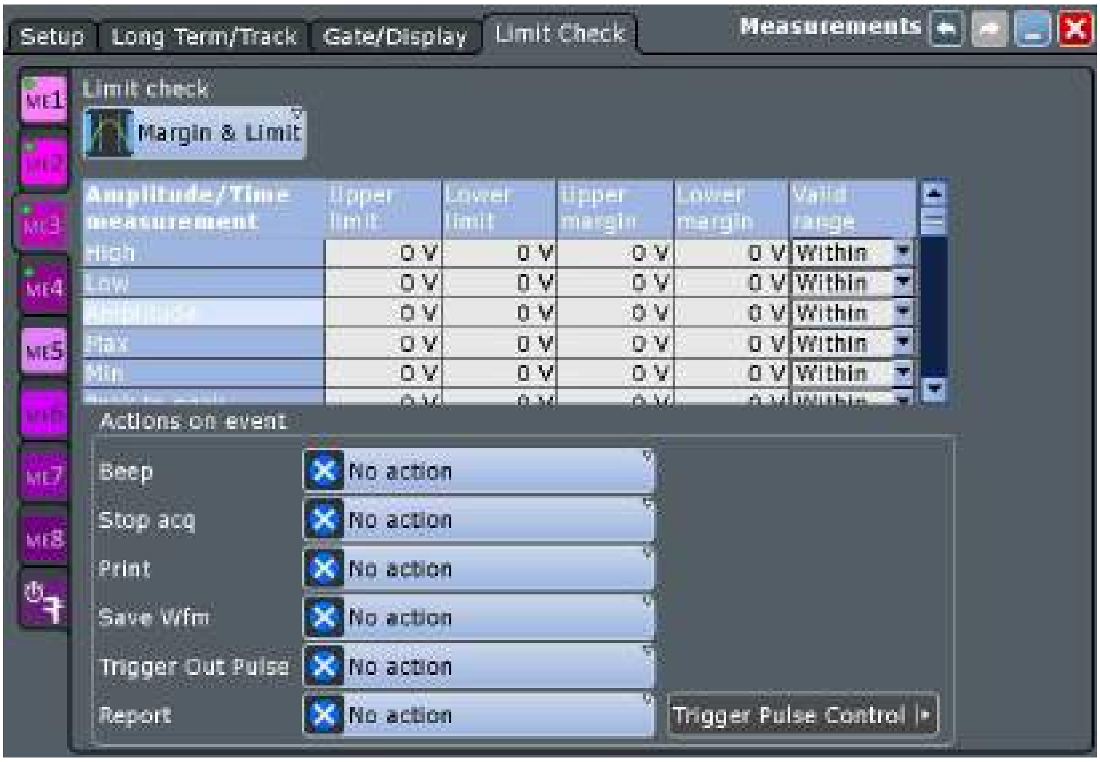
The following results are considered in limit and margin checks:

- Main and additional measurements
- Multiple measurements. All results of multiple measurements can initiate an action. However, the icons in the result box only indicate violations of the first result.
- Statistical results. Limit and margin violations of statistical results are indicated by icons in the result box. These violations do not initiate an action.

See also: Chapter 7.2.2.1, "Measurement Status", on page 312

7.2.12.1 Limit and Margin Settings

Limits and margins are configured on the "Measurements > Limit Check" tab. If the check is enabled, a table is displayed where you can set the limit and margin values and the range of valid measurement results.



Limit check: Margin & Limit

Amplitude/Time measurement	Upper limit	Lower limit	Upper margin	Lower margin	Valid range
High	0 V	0 V	0 V	0 V	Within
Low	0 V	0 V	0 V	0 V	Within
Amplitude	0 V	0 V	0 V	0 V	Within
Max	0 V	0 V	0 V	0 V	Within
Min	0 V	0 V	0 V	0 V	Within

Actions on event

Beep	No action
Stop acq	No action
Print	No action
Save Wfm	No action
Trigger Out Pulse	No action
Report	No action

Limit check

Enables the limit or margin check.

"Off"	No limit check is performed.
"Limit only"	Limits are checked for violation.
"Margin and Limit"	Margins and limits are checked for violation.

Upper limit, Lower limit, Upper margin, Lower margin, Valid range
The limits and margins are defined for each measurement type in the measurement overview table. Here you also specify the valid range.

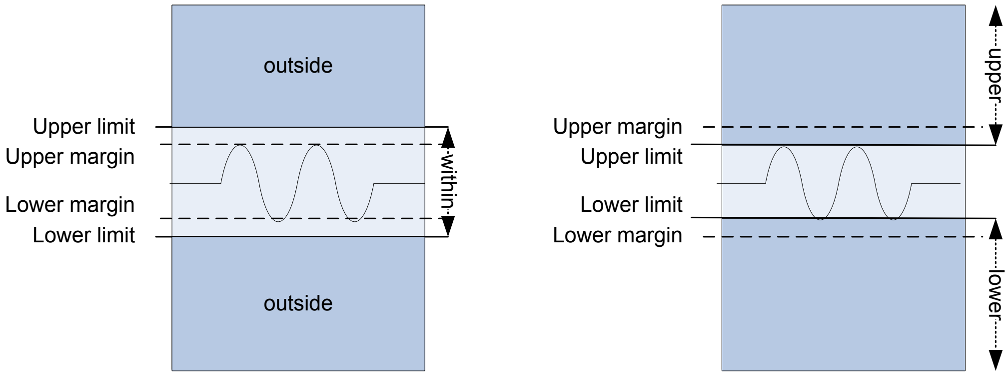


Figure 7-10: Limit and margin definition

Limits are stricter than the margins for the value check. Thus, the margins must be within the valid range. If necessary, the limit and margin values are adapted according to the selected valid range.

The settings are only visible if "Limit check" is enabled.

Remote command:
`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit` on page 1355
`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin` on page 1355
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit` on page 1355
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin` on page 1355
`MEASurement<m>:AMPTime:LCHeck<n>:VALid` on page 1354
To check limits and margins of jitter measurements, use the AMPTime remote commands.
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit` on page 1357
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin` on page 1357
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit` on page 1357
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin` on page 1357
`MEASurement<m>:EYEJitter:LCHeck<n>:VALid` on page 1356
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit` on page 1373
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin` on page 1374
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit` on page 1373
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin` on page 1374
`MEASurement<m>:HISTogram:LCHeck<n>:VALid` on page 1373
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit` on page 1364
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin` on page 1365
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit` on page 1364
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin` on page 1365
`MEASurement<m>:SPECtrum:LCHeck<n>:VALid` on page 1364

7.2.12.2 Actions on Limit Check Results

"Limit Check" tab you also define what happens when the limits and margins are exceeded. Limit checking must be enabled.

Actions are initiated by main and additional measurements, and multiple measurements.

Note that the violation actions do not distinguish between a margin violation and a limit violation. However, different icons are displayed in the result box.

For each action, you can define the event on which the action is initiated:

- On violation
  The action is initiated when the limits or margins are exceeded during the measurement.
- On successful completion
  The action is initiated when the Single acquisition has finished and the limits or margins were not exceeded.

Independent of these actions, an icon is displayed in the result box, see Chapter 7.2.2, "Measurement Results", on page 311.

Beep
Generates a beep sound.

Remote command:
`MEASurement<m>:ONViolation:BEEP` on page 1385

Stop acq
Stops data acquisition on violation.

Remote command:
`MEASurement<m>:ONViolation:ACQStop` on page 1386

Print
Prints a screenshot including the measurement results to the printer defined in the "Print" dialog box (see Chapter 11.3.2, "Printing Screenshots", on page 472).

Remote command:
`MEASurement<m>:ONViolation:PRINt` on page 1386

Save Wfm
Saves the waveform data to the file specified in SAVE RECALL > "Save/Recall" > "Waveform".

Remote command:
`MEASurement<m>:ONViolation:WFMSave` on page 1386

Trigger Out Pulse
Creates a pulse on the EXT TRIGGER OUT connector on limit violation. Also, the measurement and the limit check must be enabled to create the trigger out pulse.

If these three conditions are fulfilled, the trigger control option "Enable trigger out" is disabled. Thus, the trigger out pulse is created only on limit violation but not when a trigger occurs. The pulse is provided always with the minimum delay of 800 ns, the "Delay" cannot be set.

Remote command:
`MEASurement<m>:ONViolation:TRIGgerout` on page 1387

Report
Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:
`MEASurement<m>:ONViolation:REPort` on page 1387

7.2.12.3 Performing Limit Checks

1. On the "Meas" menu, select "Limit Check".
2. Select the tab for the measurement you want to configure.
3. Under "Limit check", select "Limit only" to distinguish only between valid and non-valid values.
   Select "Margin&Limit" to perform a two-level value check, where the margin is still valid, the limit is not.
4. Define the valid value range for each active measurement type to be checked.
   Note that the margins must always be within the valid value range. If necessary, the limit or margin values are adapted to match the selected valid range.
   See also "Upper limit, Lower limit, Upper margin, Lower margin, Valid range" on page 365
5. Define what happens when the limits and margins defined for a measurement type are exceeded.

   For each action, define when the instrument starts it:
   - If the limits or margins are exceeded
   - If the measurement is completed without limit violations
   - Not at all

   If "Print" is selected, configure the print settings as described in Chapter 11.3.2, "Printing Screenshots", on page 472.

   As a result of the limit check, the specified actions are performed and an icon indicates the status in the result box.

7.3 Quick Measurements

Quick measurement performs a set of up to eight different measurements on one source, simply by tapping the "Quick measurement" toolbar icon. The results are displayed in a results box. You can configure the measurement types to be included in quick measurement. The current configuration can be saved to repeat the measurement very quickly.

7.3.1 Starting Quick Measurement

1. Tap the waveform that you want to measure.
2. Tap the "Quick measurement" icon on the toolbar.
3. Tap the the diagram.

   The result box shows the results of the default quick measurement.

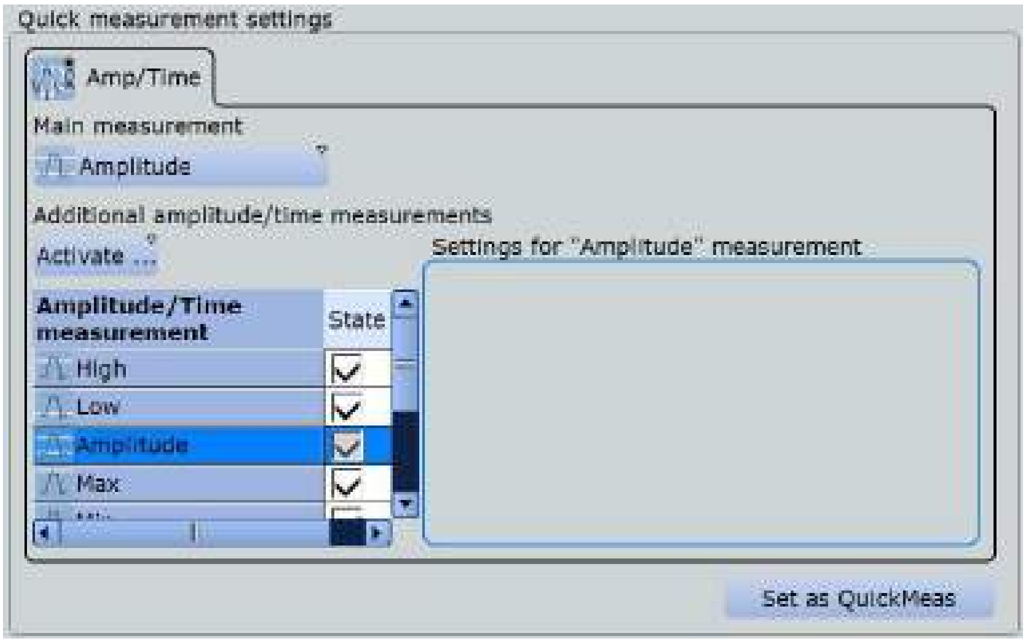
Source	
High	995.57 mV
Low	4.2688 mV
Amplitude	991.3 mV
Max	995.57 mV
Min	4.2608 mV
Peak to peak	991.3 mV
Mean	499.92 mV

7.3.2 Quick Measurement Settings

Access: "Meas" menu > "Setup" > "QuickMeas" tab

In the "QuickMeas" tab, you can change the setup of the quick measurement and apply it to the "Quick Measurement" icon in the toolbar.

The saved configuration remains until you save another QuickMeas setup, there is no reset.



Main measurement: Amplitude

Amplitude/Time measurement	State
High	☑
Low	☑
Amplitude	☑
Max	☑

Main measurement
Selects the main measurement type for quick measurement. If you enable long term measurements for a quick measurement, the long term measurement is performed only on the main measurement.

Activate
Selects a further measurement type of the selected category to the QuickMeas configuration. You can select up to 7 additional measurement types of the same category.

The selected measurement types are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

Beside the table, specific settings for the selected measurement type are shown. When you select a measurement type, check and adjust its specific setting(s).

For details on the available measurement types, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 328.

Set as QuickMeas
Saves the current QuickMeas setup. The saved QuickMeas configuration is used when you start a new quick measurement. It remains until you save another QuickMeas setup, or until you reset the instrument to "Factory defaults". The "Set as QuickMeas" is not available if the the current configuration already has been saved.

7.3.3 Configuring the Quick Measurement

See also: Chapter 7.3.2, "Quick Measurement Settings", on page 368

1. Start a quick measurement.
2. Tap the 🔧 icon in the QuickMeas results box.

3. Tap "Main measurement" and select the measurement type. Long term measurements are performed only on the main measurement.
4. In the table, disable the measurement types that you do not need.
5. Tap "Activate" and select a measurement type you want to add to the quick measurement.
6. Repeat the previous step until the setup is complete.
7. Tap "Save as QuickMeas" to save the setup. The saved QuickMeas setup is used when you start a new quick measurement.

8 Spectrum Analysis

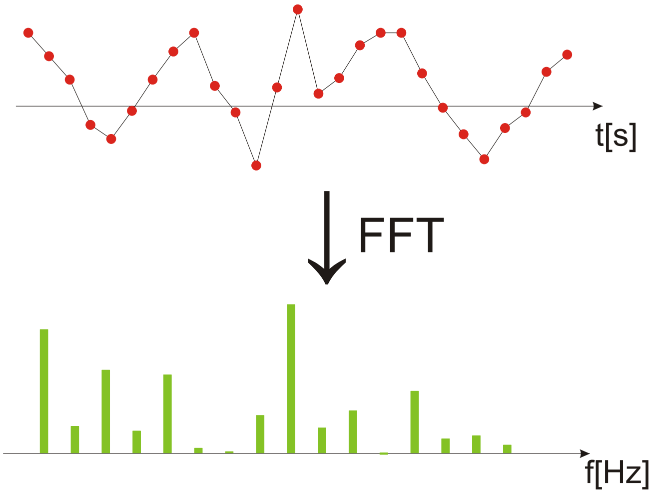
The R&S RTO provides two ways of spectrum analysis:

- Basic FFT calculation, which is included in the firmware
- Spectrum analysis option R&S RTO-K18, which is hardware-supported and provides a wide range of analysis possibilities, for example, spectrogram, cursor and automatic measurements.

8.1 FFT Analysis

8.1.1 Fundamentals of FFT Analysis

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. As a result, either the magnitude or the phase of the determined frequencies can be displayed. FFT analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

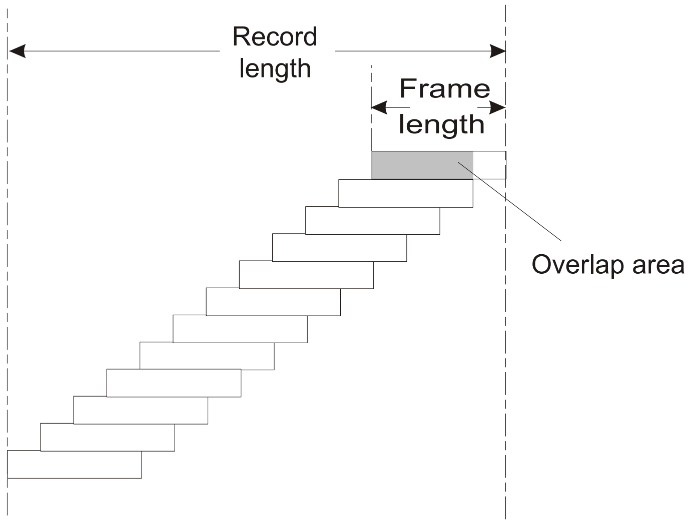


Frames/Segments

In order to convert the time domain signal to a frequency spectrum, an FFT (Fast Fourier Transformation) unit is used which converts a vector of input values into a discrete spectrum of frequencies.

Conventional oscilloscopes calculate one FFT per capture. The R&S RTO can calculate multiple FFTs per capture by dividing one capture into several *segments*, or *frames*. Thus, the R&S RTO can visualize how the frequency content of a signal changes over time which helps to detect intermittent or sporadic signal details. Furthermore, the R&S RTO allows consecutive frames to overlap. This is especially useful in conjunction with window functions since it enables a gap-free frequency analysis of the signal.

The overlapping factor can be set freely. The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation. The size of the frame depends on the number of input signal values (record length), the overlap factor, and the FFT size (number of samples used for FFT calculation).



Window functions

Each frame is multiplied with a specific window function after sampling in the time domain. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

There are a number of window functions that can be used in FFT analysis. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

For details, see "Window type" on page 381.

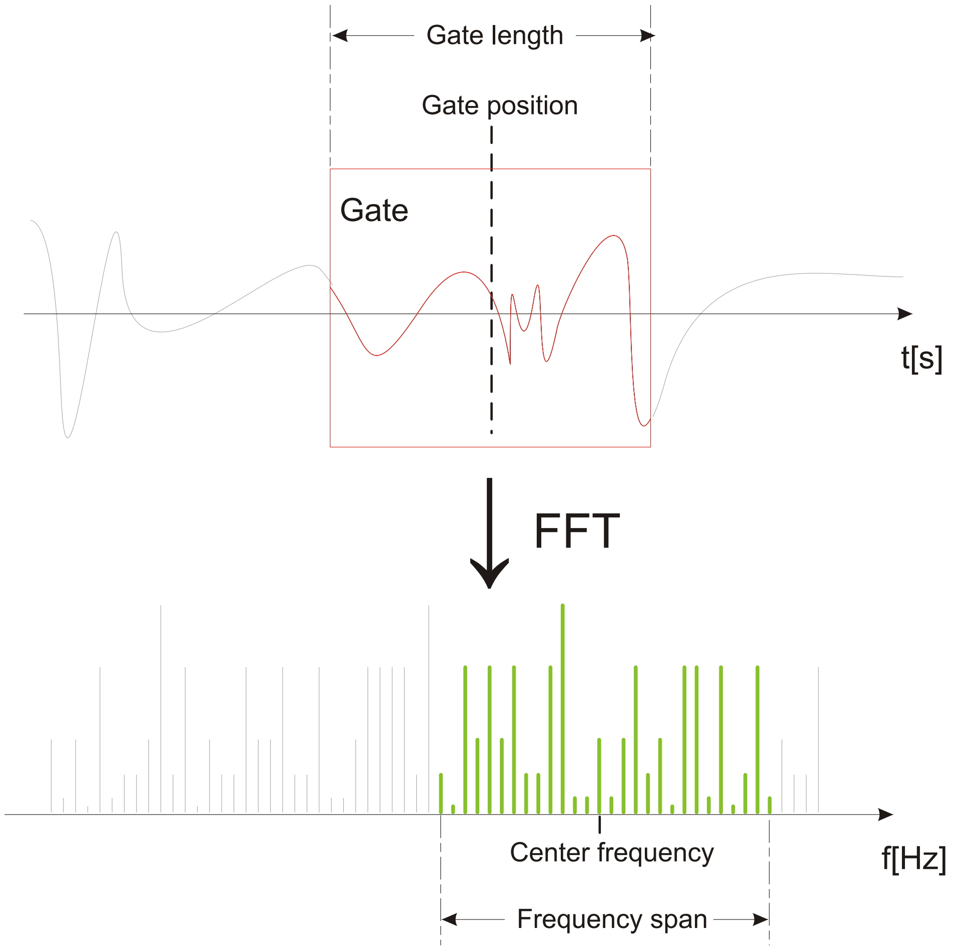
Combining FFT results

After the window function has been applied to the FFT results for each segment, the results for all segments of the data acquisition must be combined to obtain the final waveform. Various arithmetic functions are available for FFT segments, such as averaging, enveloping, or minimum and maximum calculation.

Gating functions

You can restrict the time base of the input signal for which FFT analysis is to be performed. There are various methods to do so:

- Define absolute start and stop times for the time base extract
- Define relative start and stop values that define a percentage of the original time base
- Couple the time base extract for FFT to an active zoom area.



Restricting the result range

You can restrict the results of the FFT analysis to a specified frequency range. The frequency range can be defined in two ways:

- Define a center frequency and frequency span
- Define start and stop frequencies

Using the new cursor functions for spectrum waveforms you can easily determine the results for the current center frequency by moving the cursor to that frequency ("C1 to Center"). On the other hand, if you detect a point of interest in the spectrum diagram, you can place the cursor on it and then move the center frequency to the position of the cursor automatically ("Center to c1").

See Chapter 7.1, "Cursor measurements", on page 292.

Magnitude vs. phase display

The result of an FFT analysis is a spectrum of frequencies. Either the magnitudes or the phases of those frequencies are displayed, depending on the used FFT function. In "Basic" mode, and for the "Advanced" mode FFT functions |FFT|, FFT (re) and FFT (im), the magnitude is displayed. For the "Advanced" mode FFT (φ) function, the phase is displayed.

For magnitude display, you can select the scale and range of magnitudes to be displayed. For linear scaling, the vertical value range of the input signal is used. For logarithmic scaling, the logarithmic power of the frequency is displayed. In this case, the input signal must be given in either Volt or Watt. The resulting value range is defined by a maximum value and a range size. Logarithmic scaling can also be set in relation to a given reference value.

For phase display, you can select the unit and suppress phases beneath a threshold value which are most likely caused by noise. The value range [-π, + π] or [-180°, +180°] is used. Phase shifts due to a limitation of the value range can be eliminated using the "Unwrap" function.

Dependencies between FFT parameters

FFT analysis in the R&S RTO is highly configurable. Several parameters, including the resolution bandwidth, frequency span and center frequency, can be defined according to the user's requirements. Note, however, that several parameters are correlated and not all can be configured independently of the others.

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The minimum achievable RBW is dependent on the integration time which is equivalent to the number of samples available for FFT calculation. If a higher spectral resolution is required the number of samples must be increased by using a higher sample rate or longer record length. To simplify operation some parameters are coupled and automatically calculated, such as record length and RBW.

The **frequency span** and **center frequency** define the start and stop frequency of the spectral diagram. By default, a suitable frequency range according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled, so that the parameters can be adjusted automatically as necessary.

With a **Span/RBW ratio** of 100 and a screen resolution of 1000 pixels, each frequency in the spectrum is displayed by 10 pixels. A span/RBW ratio of 1000 provides the highest resolution. For full flexibility the span/RBW coupling can also be disabled. Note, however, that a higher span/RBW ratio (i.e. low RBW values and large frequency spans) result in large amounts of data and extend the duration of the calculation.

Advanced FFT functions

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

- **FFT (φ)**: phase display
- **FFT (im)**: imaginary part of FFT value (magnitude)
- **FFT (re)**: real part of FFT value (magnitude)

- **FFT -dφ*df** (group delay): the negative derivative of the phase with respect to frequency; useful to measure phase distortion

8.1.2 Configuring Spectrum Waveforms

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed very quickly. By defining additional FFT parameters, the waveform can be configured in more detail.

As a result, either the magnitude or the phase of the determined frequencies can be displayed, or more complex FFT functions. Analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

The usage of FFT is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > FFT".

To display a basic spectrum waveform

1. Tap the "FFT" icon on the toolbar, then tap the waveform for which the FFT is to be performed.

   The first available math waveform is configured to use the selected waveform as a source and the "Mag(FFT(x))" operator, and is enabled. The spectrum waveform is displayed in a new diagram.

2. Alternatively:
   a) Press the MATH key to open the "Math" dialog box.
   b) In the "Setup" tab, in the "Basic" editor, select the input signal as "Source 1".
   c) Select "Mag(FFT(x))" as the "Operator".
   d) Select the "Enable math signal" icon.

3. If required, edit the spectrum waveform parameters as described in the following procedures.

To display advanced spectrum waveforms

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

1. In the "Setup" tab of the "Math" dialog box, select the "Advanced" expression editor.

2. Double-tap the edit area.

   The "FormulaEditor" is displayed.

3. Tap the "More" key to display further functions in the editor.

4. Tap the required function key.

5. Select the source channel.

6. Close the parenthesis and tap "Enter".

To configure the spectrum of FFT analysis

By default, a suitable frequency range for the expected horizontal values according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled. If a more precise evaluation is required, for example for postprocessing in a different application, disable the coupling and change the frequency ranges and resolution bandwidth values as required.

1. Select the "FFT Setup" tab of the "Math" dialog box.
2. Tap the "Frequency axis" button to select the type of scaling you want to use: linear or logarithmic.
3. Disable the "Span/RBW coupling".
4. Specify the frequency range to be displayed using one of the following methods:
   - Enter a "Center frequency" and a "Frequency span" that define the spectrum.
   - Enter a "Start frequency" and "Stop frequency" that define the spectrum.
   - Tap the "Full Span" button to display the complete spectrum resulting from the FFT analysis.
5. Define the resolution bandwidth for the FFT result.
   The resolution bandwidth defines how precise the results are, i.e. how close together the individual frequencies can be. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

   You can define the RBW manually, or couple it to other FFT settings. Do one of the following:
   - To couple the RBW to the span, enable the "Span/RBW coupling" option and define the "Span/RBW ratio". The smaller the ratio, the higher the RBW becomes to display the same frequency span.
   - Enter the "Resolution BW" manually. The "Span/RBW coupling" option is automatically disabled.
   - To couple the RBW to the specified record length, in the "FFT Gating" tab of the "Math" dialog box, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
6. Select the most suitable "Window type" for your source data. Window functions are multiplied with the input values and thus can improve the FFT display. For details, see "Window type" on page 381.
7. Optionally, select an arithmetic mode for the FFT segments. This mode defines how the individual segment results are combined to a final spectrum waveform. In the "FFT Overlap" tab of the "Math" dialog box, tap "FFT Segment Arithmetic" and select the required mode from the list.
8. If you use an arithmetic mode, increase the "Overlap factor" for neighboring segments to increase the accuracy of the results.

To restrict the input values (gating)

By default, the FFT is calculated for the entire record length as defined for the data acquisition. However, you can restrict the time range for which the FFT is calculated, resulting in a restricted spectrum. Alternatively, the record length can be determined automatically according to the selected RBW.

1. Select the "FFT Gating" tab of the "Math" dialog box.
2. Determine how the input length is configured by selecting one of the following options:
   - To ensure that the FFT is calculated for the full defined record length, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled). The RBW is adapted so that the record length can be acquired in the specified acquisition time. However, the RBW is restricted, so that data acquisition may fail if the record length is too long for the specified acquisition time.
   - To couple the used record length to the required RBW, select the "RBW controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
     The required acquisition time for the defined RBW value is indicated.
   - To restrict the basis of the FFT calculation to a certain time base, configure a time gate, that is: an extract of the time base in the original diagram. To do so, enable the "Use Gate" option, then do one of the following:
     - Select the "Absolute" mode and enter the "Start" and "Stop" times that define the gate area.
     - Select the "Relative" mode and enter the percentages of the total time base that define the "Relative Start" and "Relative Stop" times.
     - If a zoom area has already been defined in the original diagram and you want to use the same time base for FFT analysis, select "Zoom coupling".

   The spectrum waveform displays the spectrum for the specified time span.

To configure magnitude results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit. Use logarithmic scaling only for input values in Volt or Watt.
3. Decide whether you want to configure the value range manually or use the automatic settings by tapping the corresponding icon.
4. In manual mode, define the size of the "Vertical range" and the "Vertical maximum" to be displayed.
   In automatic mode, define the size of the "Range" to be displayed.
   For logarithmic scaling in dB, also define the "Reference level" to be used.

To configure phase results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit.

3. To eliminate phase shifts due to a limitation of the value range, enable the "Unwrap" function.
4. To suppress small phase values due to noise, enable the "Suppression" function and enter a "Threshold" value.

To couple spectrum displays

The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

1. Open the "FFT Coupling" tab of the "Math" dialog box.
2. Select the spectrums to be coupled. The spectrum for the currently selected math waveform cannot be selected. Its settings are applied to the selected spectrums.
3. If necessary, define an FFT function to be used for the coupled math waveforms so that a spectrum is displayed. See Chapter 6.3.1, "Displaying Math Waveforms", on page 268.

8.1.3 FFT Configuration Settings

8.1.3.1 FFT Setup

Access: MATH > "FFT Setup"

In this tab you define the settings for the FFT window. The display can be restricted to the results for a certain time base extract and to a specified frequency range.

Additional settings are available on this tab if the Spectrum Analysis option (R&S RTO-K18) is installed.

See Chapter 8.2.4, "Spectrogram Configuration Settings", on page 393.

Enable math signal: I

Center frequency: 505 MHz

Frequency span: 990 MHz

Start frequency: 10 MHz

Stop frequency: 1 GHz

☑ Span/RBW coupling

Span/RBW ratio: 100

Resolution BW: 9.9 MHz

Window type: Blackman Harris

☑ Use color table

Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1313

Frequency axis (R&S RTO-K18 only)

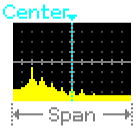
Defines the scaling method for the frequency (x-)axis of the spectrogram.

"Logarithmic"	Logarithmic scaling
"Linear Unit"	Linear scaling

Remote command:

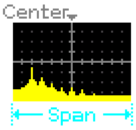
`CALCulate:MATH<m>:FFT:LOGScale` on page 1402

Center frequency
Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the "Frequency span" setting.



Remote command:
`CALCulate:MATH<m>:FFT:CFRequency` on page 1403

Frequency span
The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center frequency" setting.



Remote command:
`CALCulate:MATH<m>:FFT:SPAN` on page 1404

Full span
Displays the full frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:FULLspan` on page 1404

Start frequency
Defines the start frequency of the displayed frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:STARt` on page 1403

Stop frequency
Defines the stop frequency of the displayed frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:STOP` on page 1403

Span/RBW Coupling
Couples the frequency span to the "Resolution BW" setting.

Remote command:
`CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO` on page 1405

Span/RBW Ratio
Defines the coupling ratio for Span/RBW. This setting is only available if `CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO` is ON.

Remote command:
`CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio` on page 1405

Resolution BW
Defines the resolution bandwidth. Note that the resolution bandwidth is correlated with the span, record length and acquisition time. If a constant record length is to be used, the RBW may be adapted if the required number of samples cannot be acquired. If span and RBW values are coupled, changing the span will also change the RBW.

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 371.

Remote command:
`CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue]` on page 1405
`CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted?` on page 1404

Window type
Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTO to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Window type	Frequency resolution	Magnitude resolution	Measurement recommendation
Rectangular	Best	Worst	Separation of two tones with almost equal amplitudes and a small frequency distance
Hamming Hann	Good	Poor	Frequency response measurements, sine waves, periodic signals and narrow-band noise
Blackman Harris (default)	Worst	Best	Mainly for signals with single frequencies to detect harmonics Accurate single-tone measurements
Gaussian	Good	Good	Weak signals and short duration
Flattop2	Poor	Best	Accurate single-tone measurements
Kaiser Bessel	Poor	Good	Separation of two tones with differing amplitudes and a small frequency distance

Remote command:
`CALCulate:MATH<m>:FFT:WINDow:TYPE` on page 1405

Use color table
If enabled, the spectrum waveform (and a spectrogram, if available) is displayed according to the assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 113.

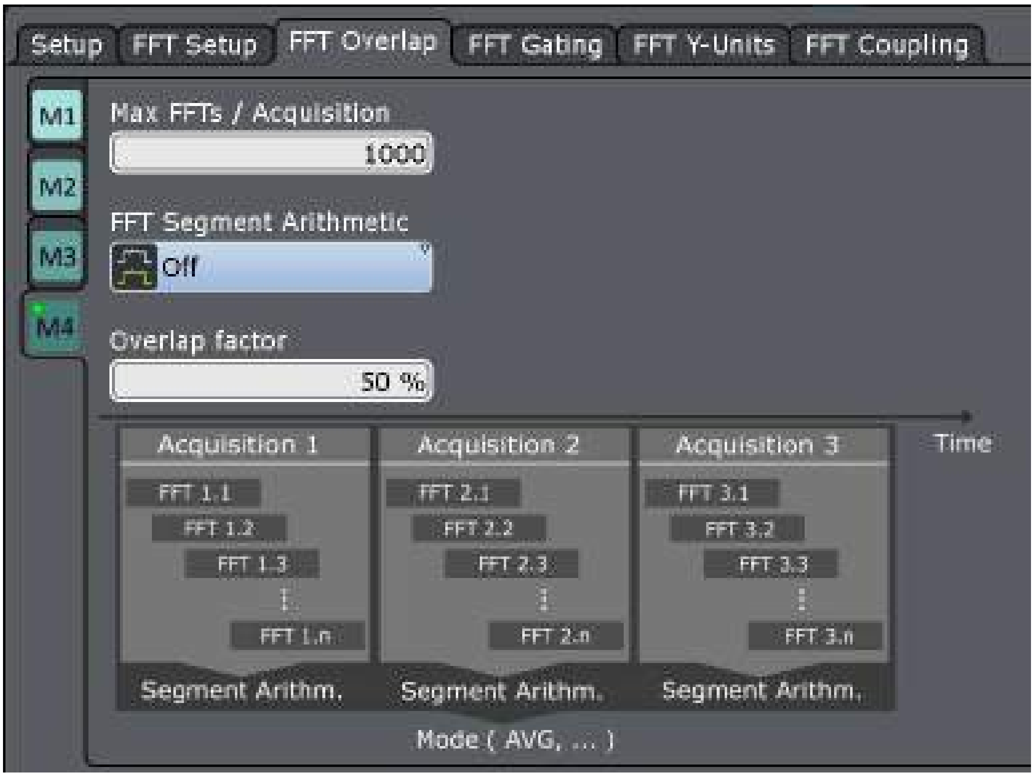
If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values. For spectrum diagrams, this setting corresponds to the common waveform display. The spectrogram, on the other hand, is then displayed in gray tones, which is not very useful.

Remote command:
`CALCulate:MATH<m>:FFT:USEColtab` on page 1415

8.1.3.2 FFT Overlap

Access: MATH > "FFT Overlap"

In this tab you define the settings for the magnitude and phase of the frequencies.



Max FFTs / Acquisition: 1000

FFT Segment Arithmetic: Off

Overlap factor: 50 %

Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
`CALCulate:MATH<m>:STATe` on page 1313

Max FFTs / Acquisition

Restricts the maximum number of FFTs to be calculated for each data acquisition. Due to the other parameter settings, the required number of FFTs may become very high, thus slowing performance. By restricting the number of FFTs, you can avoid performance loss without changing the other parameters.

However, if the maximum number of FFTs is lower than the required number to cover the entire waveform, the waveform may only be analyzed partially. In this case, the "Frame coverage" indicates the percentage of the waveform that was analyzed, i.e. which part of the data was included in the FFT calculation.

Remote command:

`CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1407

`CALCulate:MATH<m>:FFT:FRAMe:COVerage?` on page 1407

FFT Segment Arithmetics

FFT analysis can only be performed on a maximum number of values at once. If more values must be calculated, the input signal is divided into segments, each of which is calculated separately. The segments need not be disjunct, that is: they may overlap, so that some values have several FFT results. In this case, the arithmetic mode defines how the final result is calculated from the individual results.

The following methods are available:

"Off"	The data of only one segment is taken into consideration. In effect, no arithmetics are processed.
"Envelope"	Detects the minimum and maximum values for FFT calculation over all segments. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof). These envelopes indicate the range of all FFT values that occurred.
"Average"	The average is calculated over all segments.
"RMS"	The root mean square is calculated over all segments. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on segments.
"MinHold"	Determines the minimum result for each input value from the data of the current acquisition and the acquisitions before.
"MaxHold"	Determines the maximum result for each input value from the data of the current acquisition and the acquisitions before.

Remote command:

`CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics` on page 1406

Overlap Factor

Defines the minimum factor by which two neighboring segments overlap. If the required number of segments to cover the input values allows for more overlap, the factor is increased.

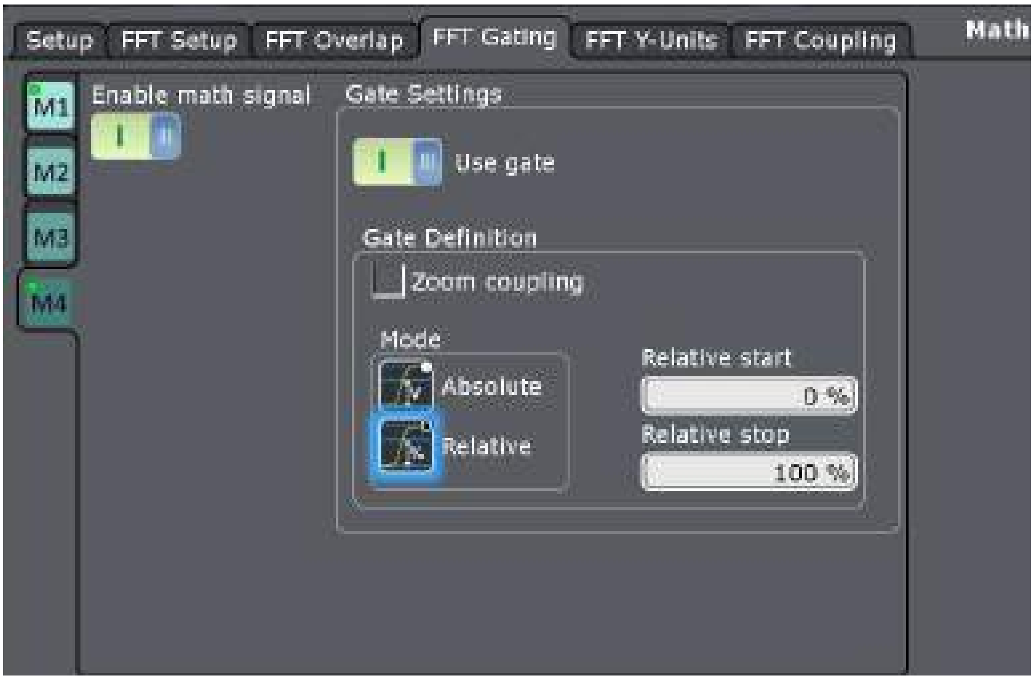
The higher the overlap factor, the more segments are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:OFACtor` on page 1407

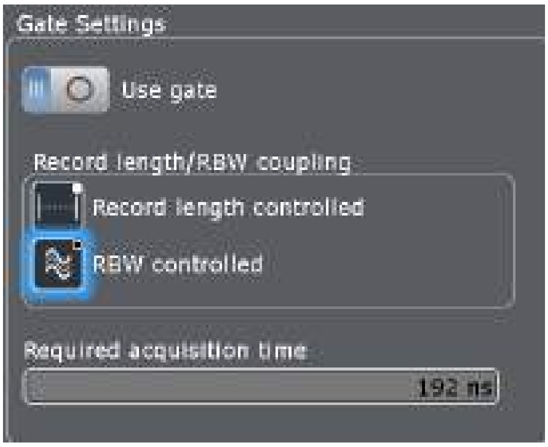
8.1.3.3 FFT Gating

Access: MATH > "FFT Gating"

FFT gating allows you to restrict FFT analysis to a certain time base of the input signal.



If no gate is used, you can define the record length as dependent on the RBW, or the RBW as dependent on the record length (which is defined by the acquisition time).



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1313

Use Gate

Enables FFT gating and shows the gate.

If enabled, the "Gate Definition" settings are displayed.

If disabled, the relation between the record length and the RBW can be defined manually instead.

When a gate is used, the RBW is adapted, if necessary. The smaller the gate, the higher the RBW.

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 371.

Gate Definition

Defines the gate settings for FFT gating.

Zoom coupling ← Gate Definition

Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:

`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1410
`MEASurement<m>:GATE:ZCOupling` on page 1385
`MEASurement<m>:GATE:ZDIagram` on page 1385
`SEARch:GATE:ZCOupling` on page 1461
`SEARch:GATE:ZDIagram` on page 1461

Mode ← Gate Definition

Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:

`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1409
`MEASurement<m>:GATE:MODE` on page 1383
`SEARch:GATE:MODE` on page 1460

(Relative) Start ← Gate Definition
Defines the starting value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 1409
`MEASurement<m>:GATE:ABSolute:STARt` on page 1383
`MEASurement<m>:GATE:RELative:STARt` on page 1383
`SEARch:GATE:ABSolute:STARt` on page 1460
`SEARch:GATE:RELative:STARt` on page 1460

(Relative) Stop ← Gate Definition
Defines the end value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STOP` on page 1410
`MEASurement<m>:GATE:ABSolute:STOP` on page 1383
`MEASurement<m>:GATE:RELative:STOP` on page 1383
`SEARch:GATE:ABSolute:STOP` on page 1460
`SEARch:GATE:RELative:STOP` on page 1461

Record Length/RBW Coupling
The record length and resolution bandwidth are coupled during FFT analysis. If you change one value, the other must be adapted accordingly. You can keep either value constant, thus preventing automatic adaptation when the other parameter is changed. However, this may cause the FFT analysis to fail.

This setting is only available if gating is not enabled (otherwise the gate determines the RBW automatically).

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 371.

"Record length controlled"	The record length remains constant. If not enough samples are available for the selected RBW, the RBW will be decreased.
"RBW controlled"	The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

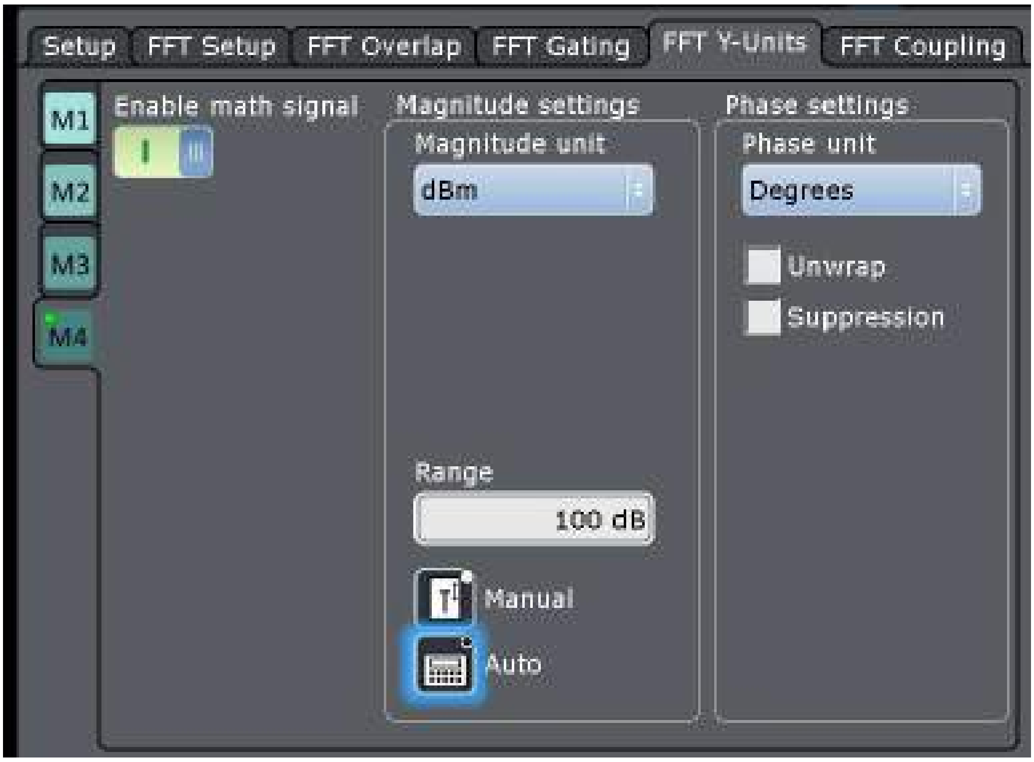
Remote command:
`CALCulate:MATH<m>:FFT:GATE:COUPling` on page 1408

Required acquisition time
The required acquisition time is calculated for the defined RBW value if "RBW constant" is selected, and is displayed for information only. If the required acquisition time is not available (e.g. because acquisition has already been stopped), an error message is displayed in the FFT Setup tab indicating that not enough samples are available for the defined RBW.

Remote command:
`TIMebase:RACTime?` on page 1408

8.1.3.4 FFT Y-Units

Access: MATH > "FFT Y-Units"



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1313

Magnitude unit

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impedance.

"Linear"	Linear scaling; displays the RMS value of the voltage
"dBm"	Logarithmic scaling; related to 1 mW

"dB"	Logarithmic scaling; related to reference level
"dBµV, dBmV, dBV"	Logarithmic scaling; related to voltage 1 µV, 1 mV, 1 V, respectively
"dBps, dBns, dBµs, dBms, dBs"	Logarithmic scaling; related to time 1 ps, 1 ns, 1 µs, 1 ms, 1 s, respectively
"dBHz, dBkHz, dBMHz, dBGz"	Logarithmic scaling; related to frequency
"dBA, dBmA, µdBA"	Logarithmic scaling; related to current

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:SCALe` on page 1411

Reference level
Defines the reference level for dB scaling.

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:LEVel` on page 1410

Vertical scaling mode (Manual/Auto)
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual"	Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".
"Auto"	"Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical maximum
Defines the maximum value on y-axis for spectrum displays. Only available for "Manual" scale mode.

Vertical range
Defines the range of FFT values to be displayed.

Remote command:
`CALCulate:MATH<m>:VERTical:RANGe` on page 1315

Range
Defines the vertical value range in spectrum mode.

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:RANGe` on page 1411

Phase unit
Defines the scaling unit for phase display.

- Radians
- Degrees

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:SCALe` on page 1412

Unwrap
If enabled, phase shifts due to a limitation of the value range are eliminated.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:UNWRap` on page 1413

Suppression
Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:SUPPression` on page 1412

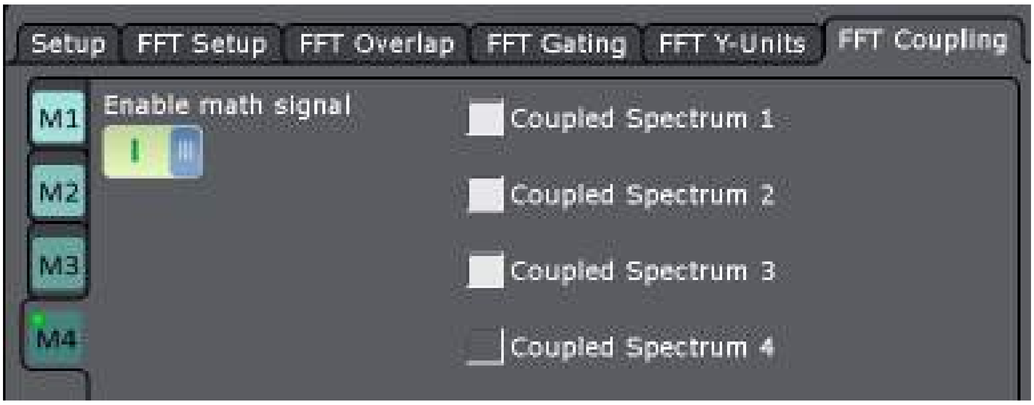
Threshold
Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if "Suppression" is enabled.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 1412

8.1.3.5 FFT Coupling

Access: MATH > "FFT Coupling"

Up to four spectrum displays can be shown simultaneously, one for each math waveform. The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.



Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
`CALCulate:MATH<m>:STATe` on page 1313

Coupled Spectrum 1/2/3/4
Copies the current FFT settings of the selected math waveform (M1/M2/M3/M4) to the other selected math waveforms, and couples those waveforms. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

Two different sets of spectrums can be coupled at the same time, for instance Spectrum 1 can be coupled to Spectrum 2, while Spectrum 3 is coupled to Spectrum 4.

Note that the formula of the coupled math waveforms is not changed. If necessary, you must select an FFT function for the math waveform manually before the FFT settings of the coupled waveform are applied. See Chapter 6.3.1, "Displaying Math Waveforms", on page 268.

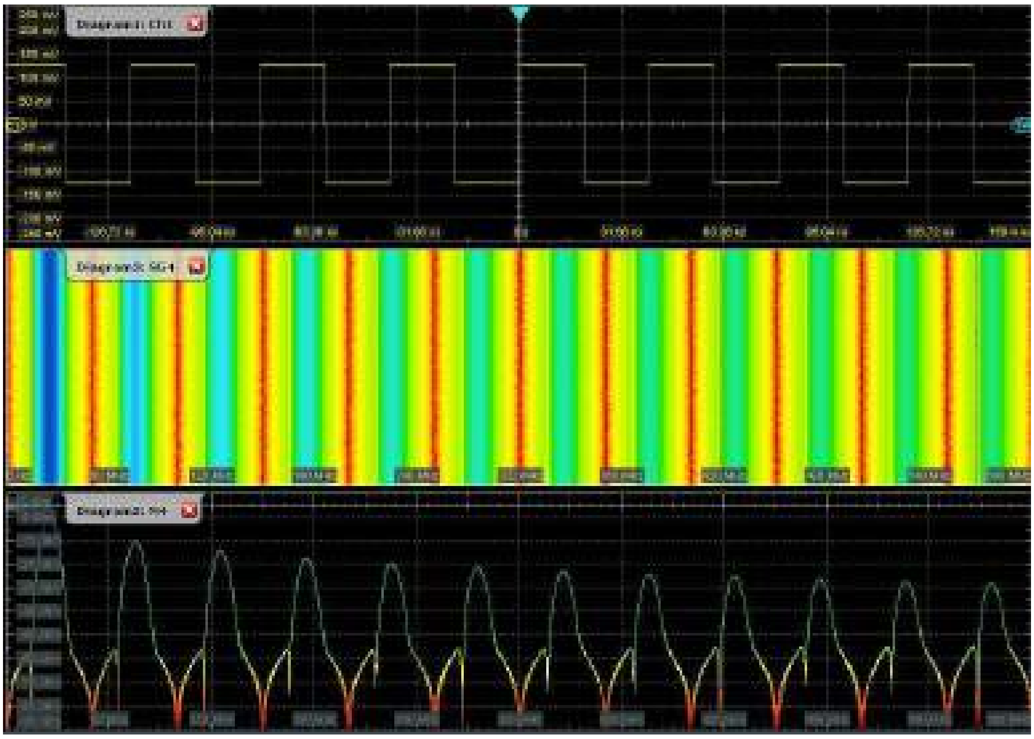
Remote command:
`CALCulate:MATH<m>:FFT:COUPled:WITH<m2>` on page 1413

8.2 Spectrum Analysis (Option R&S RTO-K18)

Spectrum Analysis is only available if the Spectrum Analysis (R&S RTO-K18) option is installed.

8.2.1 Spectrogram Display

The Spectrum Analysis option provides a new diagram for spectrum waveforms: a spectrogram. When you enable a spectrogram, three windows are displayed: the power vs. time diagram at the top, the spectrogram in the middle (labeled "SG") and the power vs. frequency (=spectrum) diagram at the bottom.



A spectrogram shows how the spectral density of a signal varies over time. The x-axis shows the frequency, the y-axis shows the time. A third dimension, the power level, is indicated by different colors. Thus you can see how the strength of the signal varies over time for different frequencies.

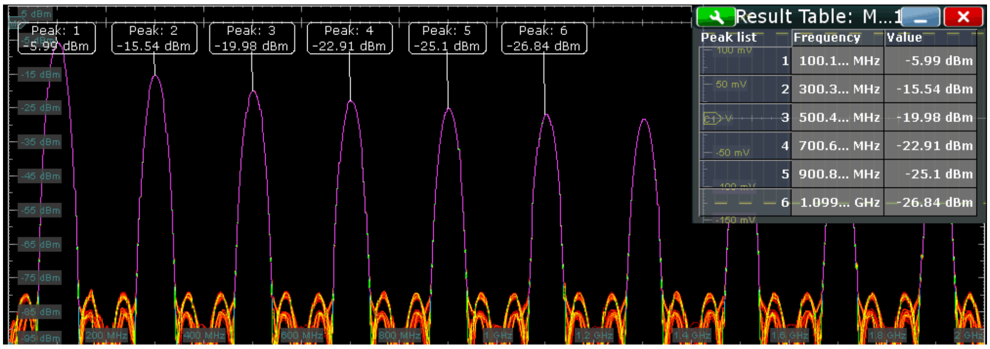
The spectrogram is updated with each data acquisition, from top to bottom, so that the most recent trace is at the bottom. Up to two time lines can be shown at a specified position so that you can analyze the spectrum at a specific point in time.

The spectrum diagram indicates the power vs. frequency values for a single data acquisition. If a time line is enabled, the spectrum shows the results at the selected time. Otherwise, the spectrum shows the results of the most recent data acquisition.

8.2.2 Spectrum Analysis Functions

In addition to spectrograms, the Spectrum Analysis option also provides some new automatic measurements based on spectrum waveforms.

- A peak list measurement detects all peaks above a user-definable threshold and optionally indicates the peaks in the spectrum diagram.



Result Table: M...1

Peak list	Frequency	Value
1	100.1... MHz	-5.99 dBm
2	300.3... MHz	-15.54 dBm
3	500.4... MHz	-19.98 dBm
4	700.6... MHz	-22.91 dBm
5	900.8... MHz	-25.1 dBm
6	1.099... GHz	-26.84 dBm

Figure 8-1: Peak list with labels for spectrum waveform

For a description of the measurement settings see Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 343.

- The new THD measurements are an extension to the basic THD measurement that was already available. See Chapter 7.2.7, "Spectrum Measurements", on page 342 for details.
- Cursor measurements on spectrum waveforms provide easy center definition and peak search functions, see Chapter 7.1.1.2, "Cursor Measurements on Spectrum Waveforms", on page 293.

8.2.3 Configuring Spectrograms

Spectrograms are only available if the Spectrum Analysis (R&S RTO-K18) option is installed.

1. Tap the "FFT" icon on the toolbar, then tap the waveform for which the FFT is to be performed.

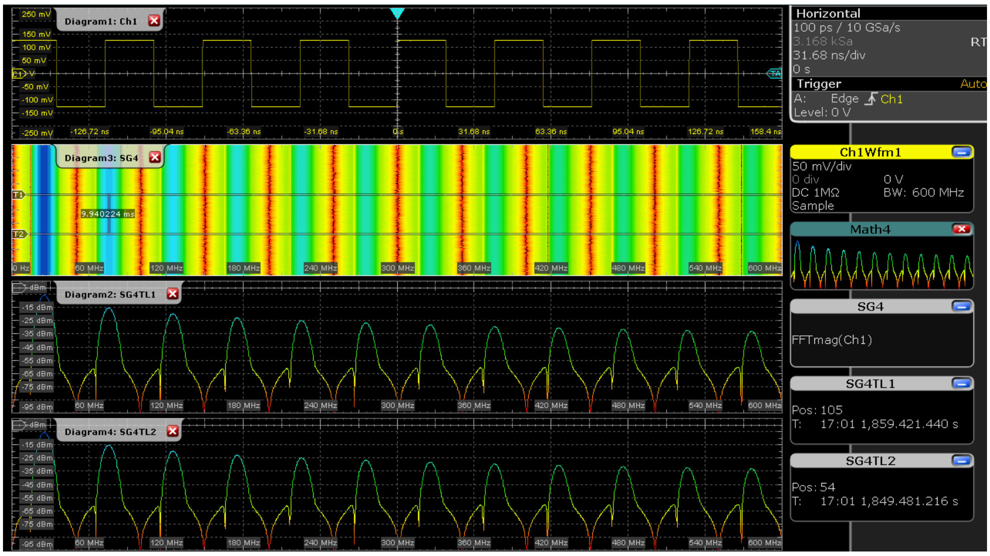
   The first available math waveform is configured to use the selected waveform as a source and the "Mag(FFT(x))" operator, and is enabled. The spectrum waveform is displayed in a new diagram.

2. Select the "FFT Setup" tab of the "Math" dialog box.
3. In the "Spectrogram" area, select "Enable".

   A spectrogram diagram is displayed. A new signal icon for the spectrogram is displayed in the signal bar ("SGx").
   Additional settings for time lines become available in the dialog box.

4. Optionally, to display a time line and thus mark a specific waveform in the spectrogram, select "Enable" for one of the two time lines.

   A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram.
   The spectrum diagram displays the results for the selected waveform(s). A new signal icon is displayed in the signal bar for each time line ("SGxTL1|2").



Horizontal
100 ps / 10 GSa/s
3.168 kSa
31.68 ns/div
0 s
Trigger Auto
A: Edge Ch1
Level: 0 V

Ch1Wfm1
50 mV/div
0 div 0 V
DC 1MΩ BW: 600 MHz
Sample

SG4
FFTmag(Ch1)

SG4TL1
Pos: 105
T: 17:01 1,859.421.440 s

SG4TL2
Pos: 54
T: 17:01 1,849.481.216 s

Figure 8-2: Signal icons for the spectrogram time lines (example from the R&S RTO2000)

5. To view the spectrum for each time line in a separate diagram, drag the signal icon for one time line to the diagram area and drop it.

   A new window is displayed for the selected time line, and the original diagram displays the other time line.

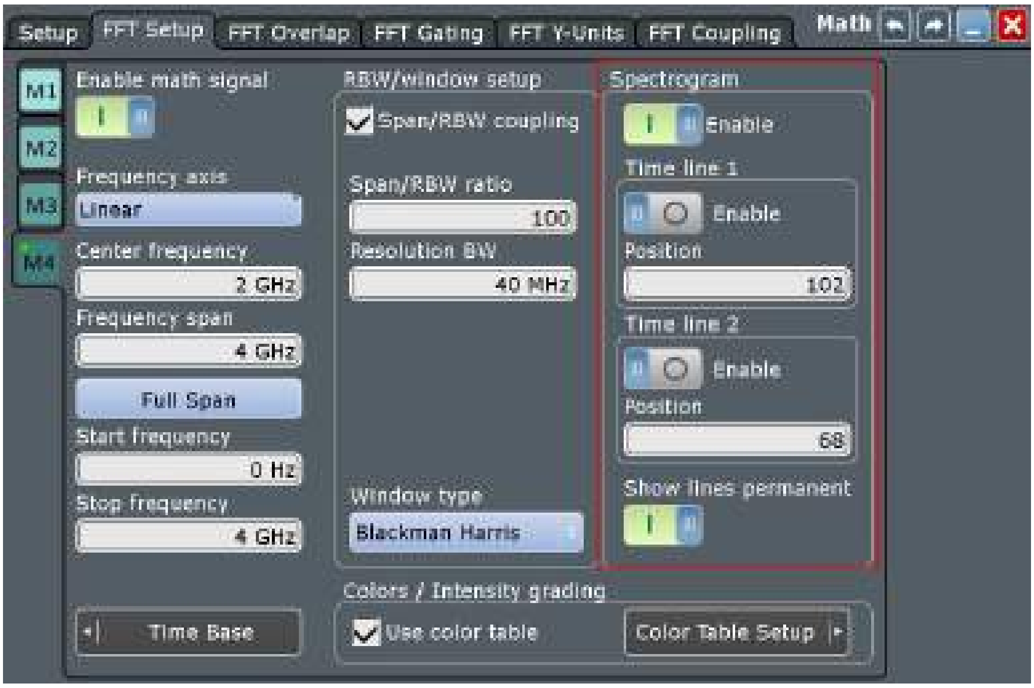
6. To view a different waveform from the spectrogram, move the time lines in the spectrogram.

8.2.4 Spectrogram Configuration Settings

Access: MATH > "FFT Setup"

Spectrograms are only available if the Spectrum Analysis (R&S RTO-K18) option is installed. Furthermore, a math (FFT) waveform must be configured and enabled.

See Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 375.



Frequency axis: Linear

Center frequency: 2 GHz

Frequency span: 4 GHz

Start frequency: 0 Hz

Stop frequency: 4 GHz

Span/RBW ratio: 100

Resolution BW: 40 MHz

Window type: Blackman Harris

Time line 1 Position: 102

Time line 2 Position: 68

Enable

Enables the spectrogram display.

If enabled, a new signal icon for the spectrogram is displayed in the signal bar ("SGx").

Remote command:

`CALCulate:MATH<m>:FFT:SPECtrogram:STATe` on page 1416

Time line 1/2

A time line marks a single spectrum in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram. A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram. A new signal icon is displayed in the signal bar for each time line ("SGxTL1|2").

You can enable and display two time lines at the same time. This allows you to compare the results at different times.

The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings.

See "Max. acquisition count" on page 285 and Chapter 6.4.2.1, "Viewer", on page 283.

Remote command:

`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` on page 1416
`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` on page 1416

Show lines permanently

Displays the spectrogram time lines in the diagrams until you disable this option.

If disabled, only the small arrow icons are permanently visible. The line is only displayed temporarily when you touch the arrow.

9 Mask Testing

9.1 About Mask Testing

Masks are used to determine whether the signal remains within specified limits, e.g. to uncover signal anomalies or test compliance and stability of digital signals. The limits are specified as "mask", which is laid over the input signal in the display. Thus you can easily detect where the signal violates the mask.

Mask testing with R&S RTO has only a minor impact on the acquisition rate, thus mask violations are detected very fast and reliably.

With R&S RTO, you can define own masks easily. Specific actions can be executed when mask violations occur. For error analysis, you can stop the acquisition on a failed test and use the history view to look at the previous waveforms.

Mask test

A mask test consists of:

- Mask definition
- Waveform to be tested
- Fail criteria for test
- Actions to be taken on violation or successful completion

Mask Definition

A mask can be created in several ways:

- The individual mask points are defined, either on the touch screen or as numerical values. This mask type is called *user mask*.
  For details, see Chapter 9.2.2.1, "Mask Definition: User Mask", on page 400.
- The mask is derived from an existing waveform. This mask type is called *waveform mask*.
  For details, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 403.

Fail Criteria for Testing

The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance". Fail condition defines if sample hits or the number of acquisitions with sample hits are considered. Violation tolerance sets the number of tolerable sample hits or acquisition hits. A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

See also: "Fail condition, Violation tolerance" on page 399.

9.1.1 Results of a Mask Test

The result box of a mask test shows the following test results:

Acq. Completed		429
Acq. Remaining		71
State	Running	
Sample hits		75
Acquisition hits		6
Fail rate		---
Test result	Fail	

Acq. completed
Number of tested acquisitions.

Remote command:
`MTESt:RESult:COUNt:WAVeforms?` on page 1431

Acq. remaining
Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation, or if the acquisition has been stopped manually before the required number of acquisitions has been acquired.

See also: Chapter 9.3.4, "Running a Mask Test", on page 416.

Remote command:
`MTESt:RESult:COUNt:REMaining?` on page 1431

State
Shows if the test has been completed. The state is set to "Finished" when "Nx Single count" acquisitions are tested and the number of "Acq. remaining" is 0. as long as the number of tested acquisitions is less the "Nx Single count" number, the state is "Running".

If you run the acquisition with RUN STOP, or the number of played history acquisitions exceeds "Nx Single count", the mask testing is perfomed according to fail criteria settings independently of the test state. The testing is not stopped when the state is set to "Finished".

Remote command:
`MTESt:RESult:STATe?` on page 1430

Sample hits
Number of samples that hit the mask.

Remote command:
`MTESt:RESult:COUNt:FAILures?` on page 1432

Acquisition hits
Number of acquisitions that contained at least one sample hit.

Remote command:
`MTESt:RESult:COUNt:FWAVeforms?` on page 1432

Fail rate
Ratio of acquisition hits to the number of tested acquisitions.

Remote command:
`MTESt:RESult:FRATe?` on page 1432

Test result
A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits.

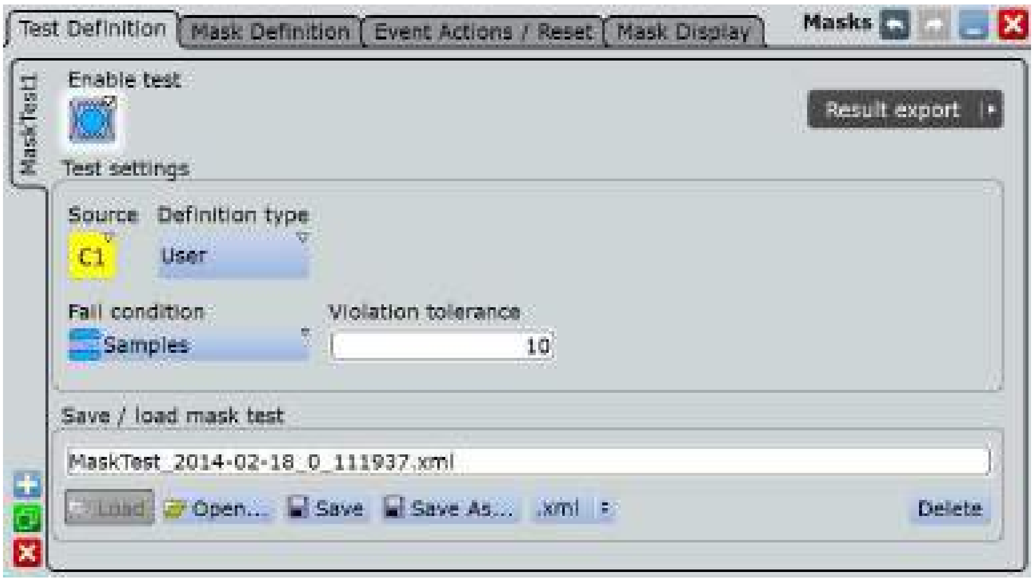
Remote command:
`MTESt:RESult[:RESult]?` on page 1431

9.2 Mask Test Settings

9.2.1 Test Definition

Access: MASKS > "Test Definition"

The "Test Definition" tab provides all settings for the mask test itself: the waveform to be tested, pass/fail conditions, and saving/loading the mask definition.



Enable test ☑

Source: C1
Definition type: User
Fail condition: Samples
Violation tolerance: 10

MaskTest_2014-02-18_0_111937.xml

The content of the "Test Definition" tab depends on the selected definition type: "User" or "Waveform". If "Waveform" is selected, the main mask settings can be set directly on the "Test Definition" tab. For a description of these settings, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 403.

Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Remote commands:

`MTESt:ADD` on page 1417

`MTESt:REMove` on page 1417

Enable test
Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, or if a stop action is configured with Stop acq..

Closing the result box also disables the mask test.

Remote command:
`MTESt[:STATe]` on page 1417

Source
Selects the waveform to be tested against the mask. All channel waveforms can be tested.

Remote command:
`MTESt:SOURce` on page 1418

Definition type
Sets the method of mask definition.

"User"	The mask is created manually by tapping the mask points on the touch screen and/or by entering the numerical x- and y-values of the mask points.
"Waveform"	The mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.
"Eye"	Requires jitter option R&S RTO-K12. To create a mask, you select the shape and set the mask dimensions according to the test standard. See: Chapter 16.3, "Mask Testing on Eye Diagrams", on page 1054.

Remote command:
`MTESt:CTYPe` on page 1419

Fail condition, Violation tolerance
The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance".

"Fail condition" defines the kind of hits to be considered for test evaluation:
- "Samples": Considers the number of samples that hit the mask.
- "Acquisitions": Considers the number of acquisitions that contain at least one sample hit. How many samples hit the mask in that acquisition is not relevant.

"Violation tolerance" sets the number of tolerable sample hits or acquisition hits.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

Example:

Fail condition: Acquisitions

Violation tolerance: 5

MaskTest2

Acq. Completed		429
Acq. Remaining		71
State	Running	
Sample Hits		76
Acquisition hits		6
Fail rate		---
Test result	Fail	

The example test has failed when the sixth acquisition violated the mask.

Remote command:
`MTESt:CONDition` on page 1418
`MTESt:TOLerance` on page 1419

Save / load mask test
Provides all functions to store and recall a mask test. The mask definition, defined actions and fail conditions are stored in an R&S RTO-specific xml file.

"Load, Save"	Recalls or stores the specified file.
"Open, Save As"	Opens a dialog box where you can select the directory the file name. See also: Chapter 11.6, "File Selection Dialog", on page 478.
"Delete"	Opens a dialog box where you can select the file to be deleted.

Remote command:
`MTESt:FILE:NAME` on page 1420
`MTESt:FILE:SAVE` on page 1420
`MTESt:FILE:OPEN` on page 1420
`MTESt:FILE:DELete` on page 1420

9.2.2 Mask Definition

Access: MASKS > "Mask Definition"

With mask definition, you define the shape of the mask - the form and position of its limit lines. The content of the "Mask Definition" tab depends on the selected "Definition type": "User" or "Waveform".

The "Definition type" is a common setting on the top of the tab, see "Definition type" on page 399.

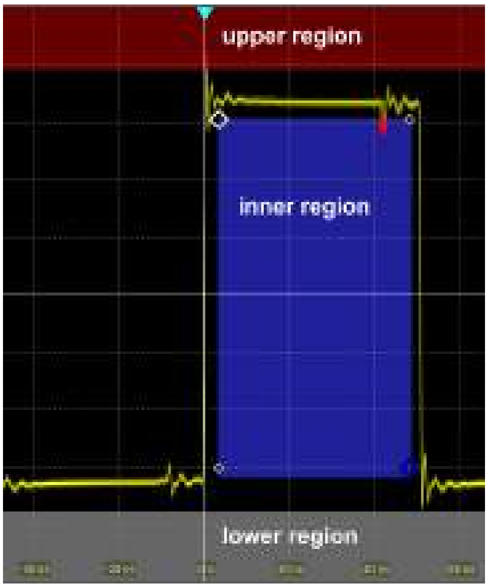
Below, you find the specific settings:

9.2.2.1 Mask Definition: User Mask

Access: MASKS > "Mask Definition" > "Definition type" = "User"

A user mask is defined by entering the time and voltage values for all corner points of the mask segments. A user mask has at least one segment. Complex masks can have up to 16 segments.

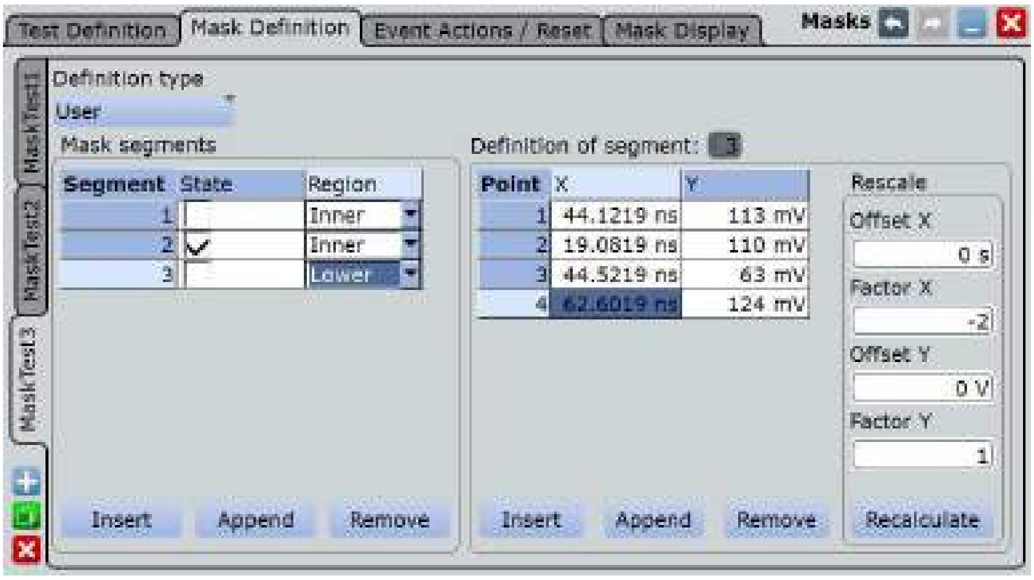
An inner segment is an area defined by three or more points. Upper and lower segments limit the signal on top and bottom of the screen. They are defined by a line, the region above or below the line is set automatically as mask segment.



Alternatively, you can set the corner points on the touch screen and adjust the values in the "Mask Definition" tab.

To save the mask, select the "Test Definition" tab and save the mask test.

Settings overview:



Definition type: User

Mask segments

Segment	State	Region
1	☐	Inner
2	☑	Inner
3	☐	Lower

Definition of segment: 3

Point	X	Y
1	44.1219 ns	113 mV
2	19.0819 ns	110 mV
3	44.5219 ns	63 mV
4	62.6019 ns	124 mV

Rescale

Offset X: 0 s

Factor X: -2

Offset Y: 0 V

Factor Y: 1

Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Mask segments

Defines the number and state of mask segments for the selected mask test. Here you can:

- Insert a new segment before the selected segment.
- Append a new segment at the end of the list.
- Remove the selected mask segment from the list.
- Select the region that builds the mask.
  - Inner region: the segment points form a closed geometrical shape, which is the mask segment.
  - Upper region: the segment points are connected to a line, the display area above this line is the mask segment.
  - Lower region: the segment points are connected to a line, the display area below this line is the mask segment.
- Enable and disable the mask segments individually. Disabled segments are not considered by running tests.

Remote command:
`MTESt:SEGMent:STATe` on page 1421
`MTESt:SEGMent:ADD` on page 1421
`MTESt:SEGMent:REMove` on page 1422
`MTESt:SEGMent:INSert` on page 1422
`MTESt:SEGMent:REGion` on page 1422
`MTESt:SEGMent:COUNt?` on page 1421

Definition of segment

The number of the selected segment is shown above the table. In the definition table, the individual points of the selected mask segment are listed with exact horizontal and vertical numerical coordinates. Here you can:

- Insert a new point before the selected point.
- Append a new point at the end of the list.
- Remove the selected point from the list.
- Change the x- and y-values of each point. To scale or move the complete segment, use offset and factor values, see Rescale.

Remote command:
`MTESt:SEGMent:POINt:ADD` on page 1423
`MTESt:SEGMent:POINt:REMove` on page 1423
`MTESt:SEGMent:POINt:INSert` on page 1423
`MTESt:SEGMent:POINt:X` on page 1424
`MTESt:SEGMent:POINt:Y` on page 1424
`MTESt:SEGMent:POINt:COUNt?` on page 1423

Rescale

You can rescale and move mask segments by numerical input of factors and offsets. The values change the selected mask segment and take effect on "Recalculate".

Offset X ← Rescale

Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XOFFset` on page 1425

Factor X ← Rescale
Stretches or compresses the selected mask segment in horizontal direction. The x-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XFACtor` on page 1425

Offset Y ← Rescale
Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YOFFset` on page 1425

Factor Y ← Rescale
Stretches or compresses the selected mask segment in vertical direction. The y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YFACtor` on page 1425

Recalculate ← Rescale
Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Remote command:
`MTESt:SEGMent:RESCale:RECalculate` on page 1424

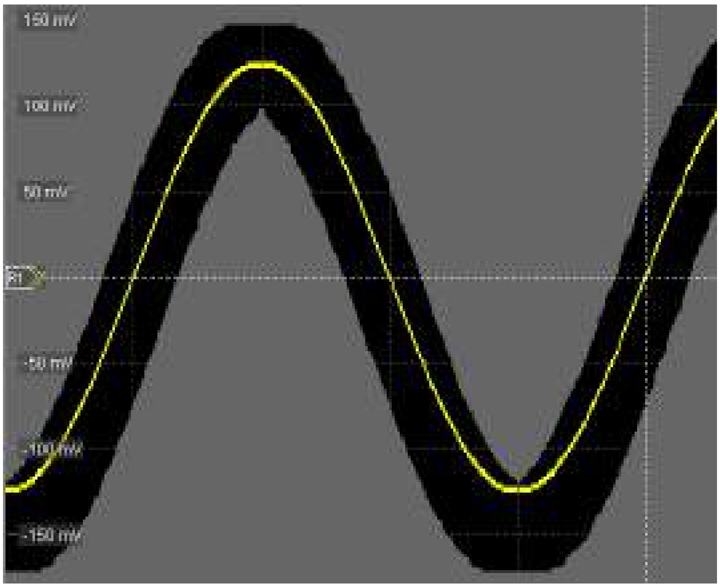
9.2.2.2 Mask Definition: Waveform Mask

Access: MASKS > "Mask Definition" > "Definition type" = "Waveform"

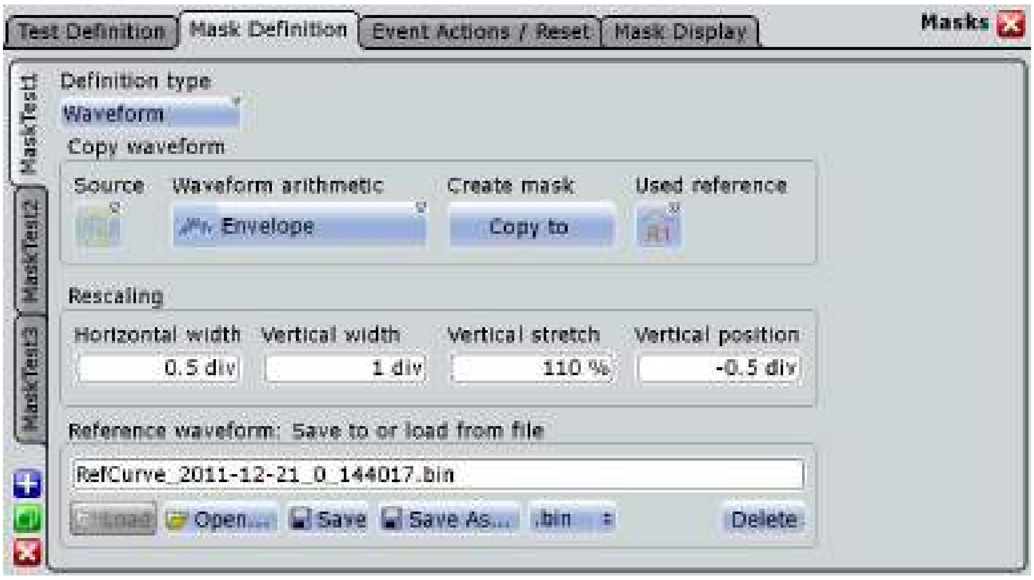
A waveform mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.

During mask testing using a waveform mask, the record length is limited to 1 MSample.

The source for a waveform mask is a reference waveform. The reference waveform can be defined before mask definition, or loaded from a file, or it is created from the waveform to be tested.



Settings overview:



Definition type: Waveform

Waveform arithmetic: Envelope

Horizontal width: 0.5 div

Vertical width: 1 div

Vertical stretch: 110 %

Vertical position: -0.5 div

Reference waveform: Save to or load from file

RefCurve_2011-12-21_0_144017.bin

Common settings:

- "Definition type" on page 399
- "Source" on page 399
- "Wfm Arithmetic" on page 154

Create mask

Creates the upper and lower mask limit from the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test "Source" waveform which is selected in the "Test Defintion" tab.

Remote command:

`MTESt:WFMLupdate` on page 1426

Used reference

Sets the reference waveform from which the mask is created.

The reference waveform can be created before with "Reference Waveform Setup", or loaded from a file in the lower part of the dialog box. If the reference waveform was not defined before mask definition, it is created automatically from the mask test "Source" waveform.

Remote command:
`MTESt:REFWfm` on page 1426

Horizontal width

Sets the width of the mask in horizontal direction. The specified number of divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask. The overall mask width is twice the specified horizontal width.

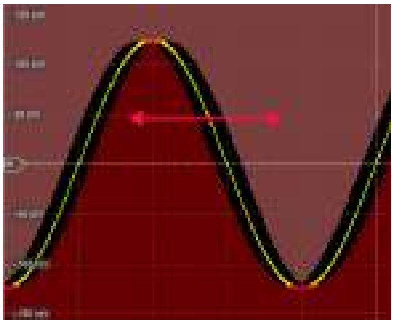


Figure 9-1: Waveform mask with horizontal width = 0.2 div

Remote command:
`MTESt:WFMRescale:XWIDth` on page 1427

Vertical width

Sets the width of the waveform mask in vertical direction. The specified number of divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down, and the overall height of the mask is twice the vertical width.

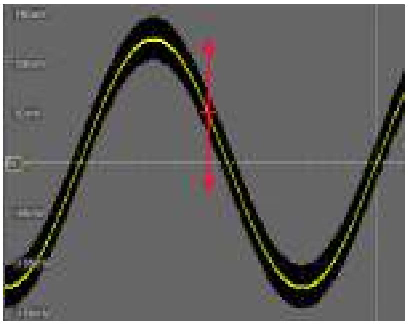


Figure 9-2: Waveform mask with vertical width = 0.5 div

Remote command:
`MTESt:WFMRescale:YWIDth` on page 1427

Vertical stretch

Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit. Values > 100% stretch the mask, and values < 100% compress it.

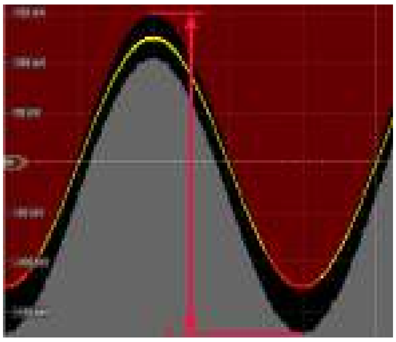


Figure 9-3: Waveform mask with vertical width = 0.5 div, vertical position = -0.5 div, vertical stretch = 110%

Remote command:

`MTESt:WFMRescale:YSTRetch` on page 1428

Vertical position

Moves the mask vertically within the display.

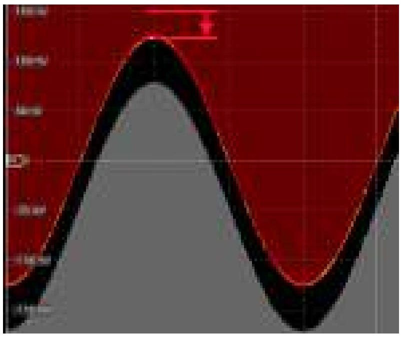


Figure 9-4: Waveform mask with vertical width = 0.5 div and vertical position = -0.5 div

Remote command:

`MTESt:WFMRescale:YPOSition` on page 1427

Reference waveform: save to or load from file

Loads the waveform from the selected file to the "Reference" and creates the mask immediately.

See also: "Save to or load from file" on page 264.

9.2.3 Event Actions /Reset

Access: MASKS > "Event Actions /Reset "

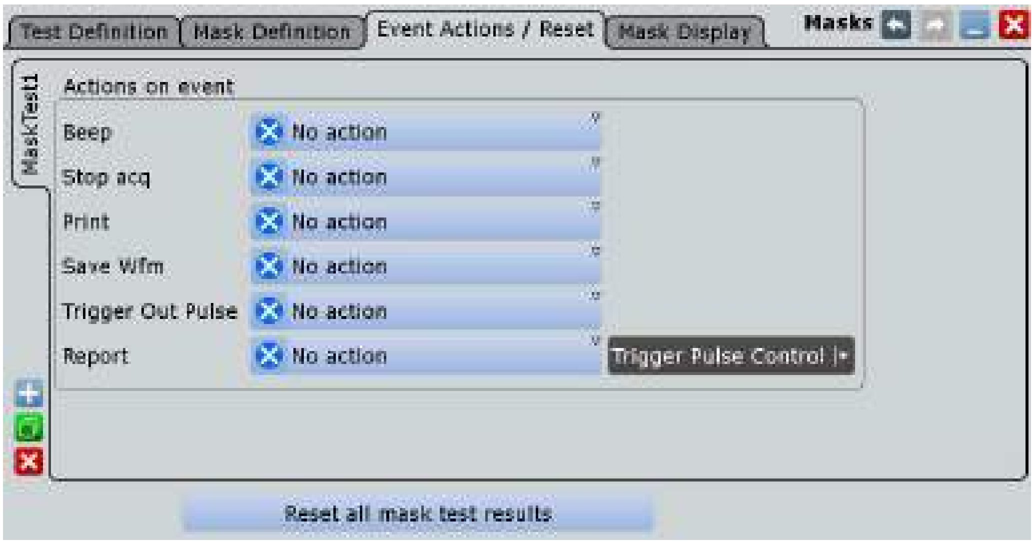
The settings in this tab define what happens when the mask test has failed or when it has passed successfully. Furthermore, you can reset all totals and results in the "Mask Test" result boxes.

Most actions can be initiated either on failure or on success:

- On violation
  The action is initiated as soon as the fail criteria is fulfilled.
- On successful completion
  The action is initated when the SINGLE acquisition has finished and the fail citeria is not fulfilled - the fail condition and violation tolerance limit have not been reached.

There are two usual test practices:

- Testing a defined number of waveforms against the mask and initiate an action when the acquisition cycle has been completed without failure:
  - Set the number of acquistions to be tested: "Average count (N-single count)"
  - Start SINGLE
- Testing a continuous acquisition or a defined number of waveforms against the mask and initiate an action as soon as the fail criteria is fulfilled



Actions on event

Beep	No action
Stop acq	No action
Print	No action
Save Wfm	No action
Trigger Out Pulse	No action
Report	No action

Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Beep
Generates a beep sound.

Remote command:
`MTESt:ONViolation:BEEP` on page 1428

Stop acq.
Stops the waveform acquisition on mask violation.

Remote command:
`MTESt:ONViolation:STOP` on page 1428

Print
Prints a screenshot including the mask test results to the printer defined in the "Print" dialog box (see Printer).

Remote command:
`MTESt:ONViolation:PRINt` on page 1429

Report
Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:
`MTESt:ONViolation:REPort` on page 1429

Save Wfm
Saves the failed waveform as a reference waveform to the file specified in SAVE RECALL > "Save/Recall" > "Waveform".

Remote command:
`MTESt:ONViolation:SAVewaveform` on page 1429

Trigger Out Pulse
Creates a pulse on the EXT TRIGGER OUT connector on mask violation or successful completion of the test cycle. The minimum time difference between two trigger out pulses is 30 ms because the instrument detects mask violation at display update. Events with a higher frequency are not captured completely.

If this event is enabled and the mask test is running, the trigger control option "Enable trigger out" is disabled. Thus, the trigger out pulse is provided only on mask test result but not when a trigger occurs. The pulse is provided always with the minimum delay of 800 ns, the "Delay" cannot be set.

Remote command:
`MTESt:ONViolation:TRIGgerout` on page 1430

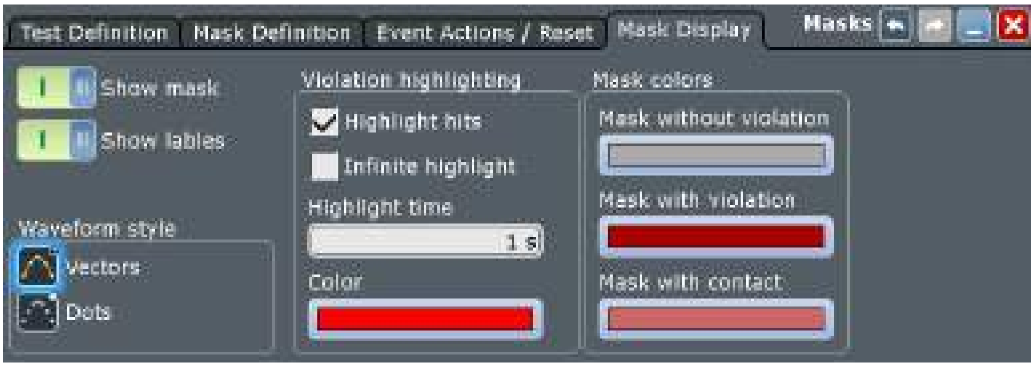
Reset
Clears all totals and results in all "Mask Test" result boxes.

Remote command:
`MTESt:RST` on page 1418

9.2.4 Mask Display

Access: MASKS > "Mask Display"

The "Mask Display" tab contains all settings for mask and hit display.



Show mask
Switches the display of all mask segments on or off.

Show labels
Switches the display of the mask test name on or off.

To change the name of the mask test, open the "Test Definition" tab, double-tap the mask test subtab and enter the new mask test name.

Remote command:
`MTESt:LABel` on page 1430
`MTESt:REName` on page 1430

Waveform style
See: "Style" on page 112.

Highlight hits
If selected, the mask hits are highlighted on the screen. You can define the color and the time of the hit display.

Highlight settings are not applied to trigger zones, which are based on masks.

Infinite highlight
If selected, the mask hits are highlighted for an unlimited period of time.

Highlight time
Sets the time how long the mask hits are highlighted.

Color
Sets the color of samples that violated the mask.

Mask without violation
Sets the color of masks segments that were not hit.

Mask with violation
Sets the color of mask segments the signal has entered into.

Mask with contact
Sets the color of masks segments that were touched at the border. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the actual result.

9.3 Working with Masks

This chapter explains step-by-step how mask tests are setup and preformed. For the explanation of the individual settings, see Chapter 9.2, "Mask Test Settings", on page 398.

The usage of masks tests is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Mask Test".

9.3.1 Setting Up User Masks

9.3.1.1 Creating User Masks

There are two ways to create a new mask:

- Graphical way by tapping the mask points on the touchscreen,
- Numerical entry of the x- and y-values of the mask points.

You can combine both methods. For example, at first you enter the mask quickly on the touchscreen, and then modify the point coordinates with precise values.

To create a mask graphically on the touch screen

1. Tap the "Masks" icon on the toolbar.
2. Tap the corner points of the mask segment on the touch screen.

   Tip: To create an exact rectangle, draw the diagonal of the rectangle on the screen.
3. Tap "Finish segment" in the sidebar.

   Now you can enter another segment to the current mask test or add an new mask test
4. To finish the mask definition, close the sidebar.

You can also enter only two points to create a line. When you finish the mask segment by double-tapping the second point, the display region above or below the line is defined as mask. If the line is in the upper half of the display, the region above the line becomes the mask (upper region). If the line is in the lower half, the region below the line is taken (lower region).

To create a mask numerically in the dialog box

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 400.

1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. Create a new mask test:
    a) Tap the "+"-icon in the lower left corner.
    b) Enter a name for the new mask test.

    A new, empty tab for the mask test appears.
4. Check the horizontal and vertical units and adjust them, if necessary.
5. In the "Mask segments" area, tap "Insert" to create a new mask segment.
6. Set the corner points of the mask segment:
    a) In the "Definition of segment" area, tap "Insert".
    Point 1 appears.
    b) Tap the X-cell and enter the X-value of the point.
    c) Tap the Y-cell and enter the Y-value of the point.
    d) To insert the next point:
        - Tap "Insert" to add a point before the selected point.
        - Tap "Append" to add a point at the end of the list.
    e) Set the X- and Y-values for this point.
    f) Repeat the last two steps until all points are defined.

9.3.1.2 Modifying User Masks

To change an existing mask definition, you can also use the graphical method on the touch screen, or the numerical way, or combine both.

With the graphical method, you can:

- Move, add, and delete segments
- Move and delete points

Adding points to an existing segment graphically is not possible.

With the numerical method, in the "Mask Definition" tab, you have all modification possibilities. You can delete and add points and segments, change the coordinates, and also stretch a segment, or move it by adding an offset.

To add a mask segment on the touch screen

1. Tap a mask segment of the mask test that you want to complement.
2. Tap the "Masks" icon on the toolbar.
3. Tap the corner points of the new mask segment on the touch screen.
4. To finish the segment and mask definition, double-tap the last point, or tap the "Select" icon on the toolbar.

To delete a mask segment on the touch screen

1. On the toolbar, tap the "Delete" icon.
2. Tap the mask segment to be deleted.

To delete a point on the touch screen

1. Tap the mask segment from which you want to delete a point.

   The selected segment is now in definition mode, shown with blue color.
2. On the toolbar, tap the "Delete" icon.
3. Tap the point to be deleted.

To move a segment on the touch screen

1. Drag&drop the segment to the new position.
2. Tap outside the mask to deselect the mask segment.

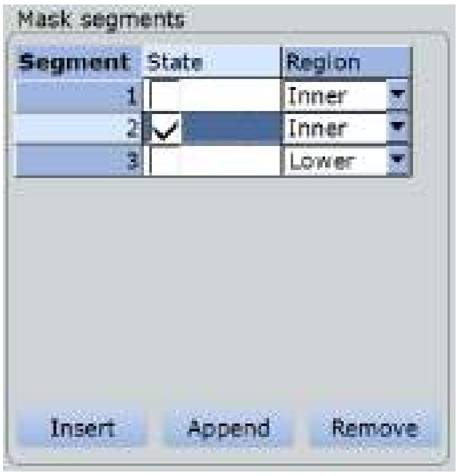
To move a point on the touch screen

1. Tap the mask segment to be changed.
2. Drag&drop the point to the new position.
3. Tap outside the mask to deselect the mask segment.

To change the mask definition numerically

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 400.

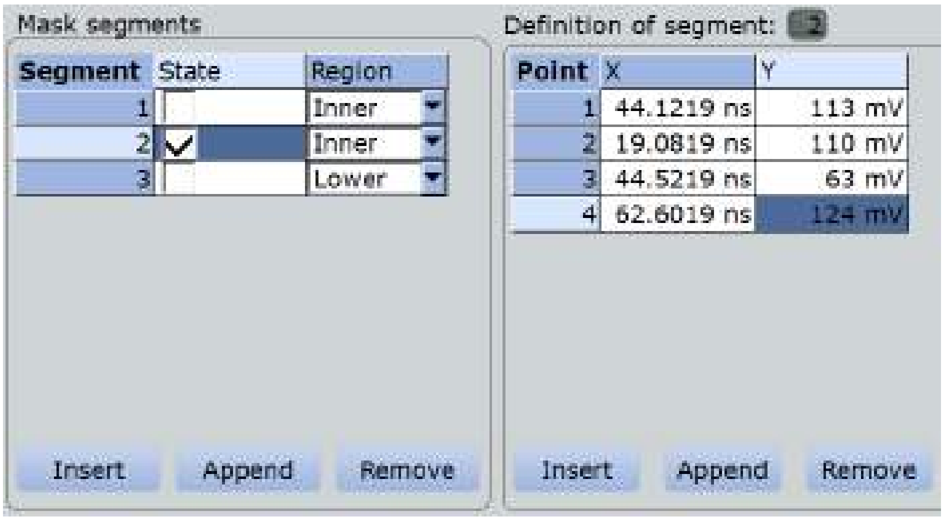
1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.
4. To add or delete a mask segment, tap the segment's row in the "Mask segments" table and tap the required button below:
    - "Insert": to add a new segment before the selected segment.
    - "Append": to add a new segment at the end of the list.
    - "Remove": to delete the selected mask segment from the list.



Segment	State	Region
1	☐	Inner
2	☑	Inner
3	☐	Lower

5. To add, delete, or move a point of a segment:
    a) Select the segment in the "Mask segments" table.
    b) Select the point in the "Definition of segment" table.
    c) To add or delete the selected point, use the buttons below the table.
        - "Insert": to add a new point before the selected point.
        - "Append": to add a new point at the end of the list.
        - "Remove": to delete the selected point from the list.

d) To move the selected point, change the X- and Y-values.



Mask segments

Segment	State	Region
1	☐	Inner
2	☑	Inner
3	☐	Lower

Definition of segment: 2

Point	X	Y
1	44.1219 ns	113 mV
2	19.0819 ns	110 mV
3	44.5219 ns	63 mV
4	62.6019 ns	124 mV

To rescale and move a mask segment

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 400.

1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.
4. Select the required segment in the "Mask segments" table.
5. To stretch or compress the selected mask segment, enter the "X-Factor" for horizontal scaling and the "Y-Factor" for vertical scaling. The x-values and y-values of all points are multiplied with the corresponding factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.
6. To move the selected mask segment, enter the "X-Offset" for horizontal direction and the "Y-Offset" for vertical direction. The specified offset is added to the corresponding values of all points.
7. Tap "Recalculate" to perform the scaling and/or move.

9.3.2 Setting Up a Mask Test

In addition to the mask definition, the mask test contains further settings:

- the waveform to be tested
- the criteria for a failed test
- the actions to be taken if a test has failed or has been completed successfully

1. Press the MASKS key on the front panel.

2. Select the "Test Definition" tab.
3. Select the "Source" to be tested.
4. Set the conditions for a failed test:
   a) Fail condition: select if sample hits or the number of acquisitions with sample hits are considered.
   b) Violation tolerance: number of tolerable sample hits or acquisition hits.

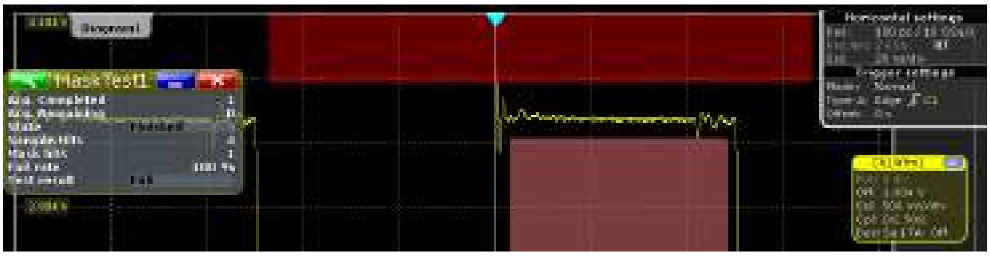
   A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.
5. Select the "Event Actions / Reset" tab.
6. For each action, select when the action will be executed:
   - "On violation" if the mask test has failed
   - "On successful completion"

9.3.3 Configuring the Mask and Hit Display

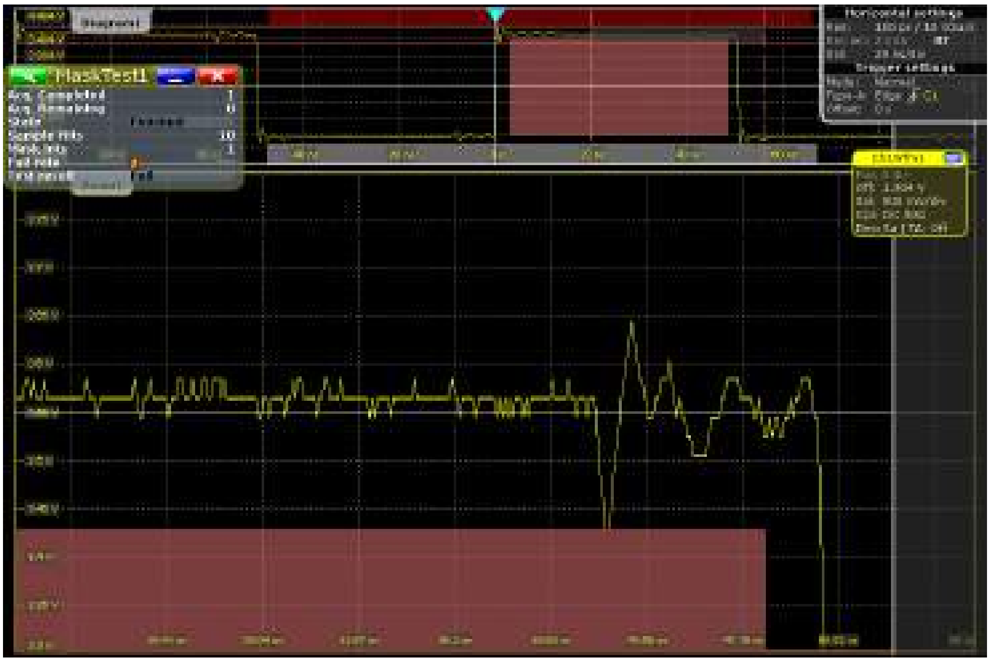
The display of masks and mask violation is the same for all mask tests.

The settings mentioned here are described in detail in Chapter 9.2.4, "Mask Display", on page 408.

1. Press the MASKS key on the front panel.
2. Select the "Mask Display" tab.
3. Select "Show mask" to display the masks of all enabled mask tests on the screen.
4. Define how the sample hits are displayed:
   a) Select "Highlight hits" to display the sample hits.
   b) Set the "Highlight time" or "Infinite highlight".
      Set the "Color" of the sample hits.
5. Define the color of the masks segments depending on the violation state:
   - Mask without violation
   - Mask with violation
   - Mask with contact: This color shows that the edge of the mask segment was touched. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the correct result.



Acq. Completed 1
Acq. Remaining 0
State Finished
Sample hits [illegible]
Mask hits 1
Fail rate 100 %
Test overall Fail



9.3.4 Running a Mask Test

Before you can start a mask test, make sure that the mask setup is complete:

- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 410 and Chapter 9.3.1.2, "Modifying User Masks", on page 411.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 414
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 415.

You can perform continuous testing or test a specified number of acquisitions.

1. Press the MASKS key on the front panel.
2. Select the "Test Definition" tab.
3. Select "Enable test".

   If the acquisition is running, the test starts immediately.
4. If the acquisition is not running, press RUN STOP.

   The tests starts and runs until you stop the acquisition or the stop action is executed if defined.
5. To test a specified number of acquisitions:
   a) Press the ACQUISITION key.
   b) Set the "Average count" to the number of acquisitions.
      See also:"Acquisition/average count" on page 154
   c) Press SINGLE.

Note: If you run the acquisition with RUN STOP, the state of the mask test is set to "Finished" when this number of acquisitions has been captured but the mask testing continues until the acquisition will be stopped.

9.3.5 Saving and Loading Masks

Mask test definitions remain on the instrument until they are changed or deleted, or PRESET is performed. If you want to keep a mask test, you can save and reload them.

To save a mask

1. Press the MASKS key on the front panel.
2. Select the "Test Definition" tab.
3. To save the mask file in the current directory, change the file name if needed, and tap "Save".
   You can use the automatic file name generation, see Chapter 11.5, "Autonaming", on page 476.
4. To select the directory and enter the file name, tap "Save As".

To load a mask

1. To load the specified mask file, tap "Load."
2. To load the mask from a different file, tap "Open". Select the file from the file selection dialog box.

9.3.6 Mask Testing on History Acquisitions

In the same way as for running acquisitions, you can set up and perform the mask testing also on history waveforms.

The requirements for mask testing on history waveforms are also the same:

- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 410 and Chapter 9.3.1.2, "Modifying User Masks", on page 411.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 414
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 415.

1. Perform and finish the acquisition.
2. Press HISTORY.
3. In the quick-access "History" dialog box, tap "Play".

   The mask testing is performed on the complete history memory, starting with the oldest acquisition. The state of the mask test is set to "Finished" when "Nx Single count" acquisitions are tested.

For details on history, see Chapter 6.4, "History", on page 281.

10 Search Functions

Search functions allow you to detect and analyze specific events in the acquired data quickly and simply. You can search in various waveforms for several events at once. The search area can be limited by a gate.

The events that can be searched for are basically the same events you can trigger on. Thus, the search parameters are defined in the same way as the trigger conditions. The results are displayed in a result box and optionally shown in a zoom window.

10.1 Overview: Search Definition and Results

10.1.1 Search Definition

You can define up to 8 different searches and let them run simultaneously. For each search, you define the criteria, the parameters of each criterion, the gate, and the result display.

The instrument keeps the settings until the next preset. If you save a user-defined preset, the search settings are included in the preset.

Each search is configured in a separate tab and contains:

- *Search control*
  If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.
  If acquisition is stopped and you enable a search, the data of the last acquisition is searched.
  Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.
- *Source*
  Waveform that is searched for one or more events. You can search in analog and digital signals, math or reference waveforms, and tracks. Furthermore, search in decoded data of serial buses is possible.
- *Search criteria and parameters*
  Various search criteria are available, depending on the source. Most parameters known from trigger event definition can also be configured as search conditions. Unlike triggering, you can configure several event types to be searched for simultaneously.
  If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search ", on page 301.
- *Search gate*
  Searches can be performed on the entire waveform, or only a on defined area (gate). The gate can be coupled to an existing zoom.
  Gating is not available for searches on digital signals and serial buses.

- *Result presentation*
  For each search, you define how the search results are displayed: in a result table and/or in a search zoom window.
- *Noise rejection*
  Hysteresis for the selected source is defined for each search separately, in absolute or relative values.
  Noise rejection is not available for searches on serial buses.

Remote commands:

- `SEARch:ADD` on page 1433
- `SEARch:REMove` on page 1433

10.1.2 Search Results

The results are displayed in a "Search Results" box and optionally in a zoom window.

Search Results box

The results of each search are tabulated in a "Search Results" box.

If you search for several event types in parallel, the results are presented in several tabs - one for each search event and one for the combined results. Each tab contains a table with the position and, if available, further parameters for each result. The tables row can be sorted, and you can define a maximum number of table entries in the "Result Presentation" dialog box. As with all result boxes, you can minimize it, display it like a diagram, and define the default position.

Search result	Physical X position	Polarity	Filter type
1	123.7 ns	Positive	High
4	800 ps	Positive	High
7	-124.3 ns	Positive	High

If "Auto clear" is enabled in the "Result Presentation" dialog box, the instrument displays the search results of the last acquisition. If "Auto clear" is disabled, the first result of each acquisition is listed until the maximum number of entries in the table is reached.

Remote commands for result query:

- `SEARch:RESult[:ALL]?` on page 1468

Search zoom windows

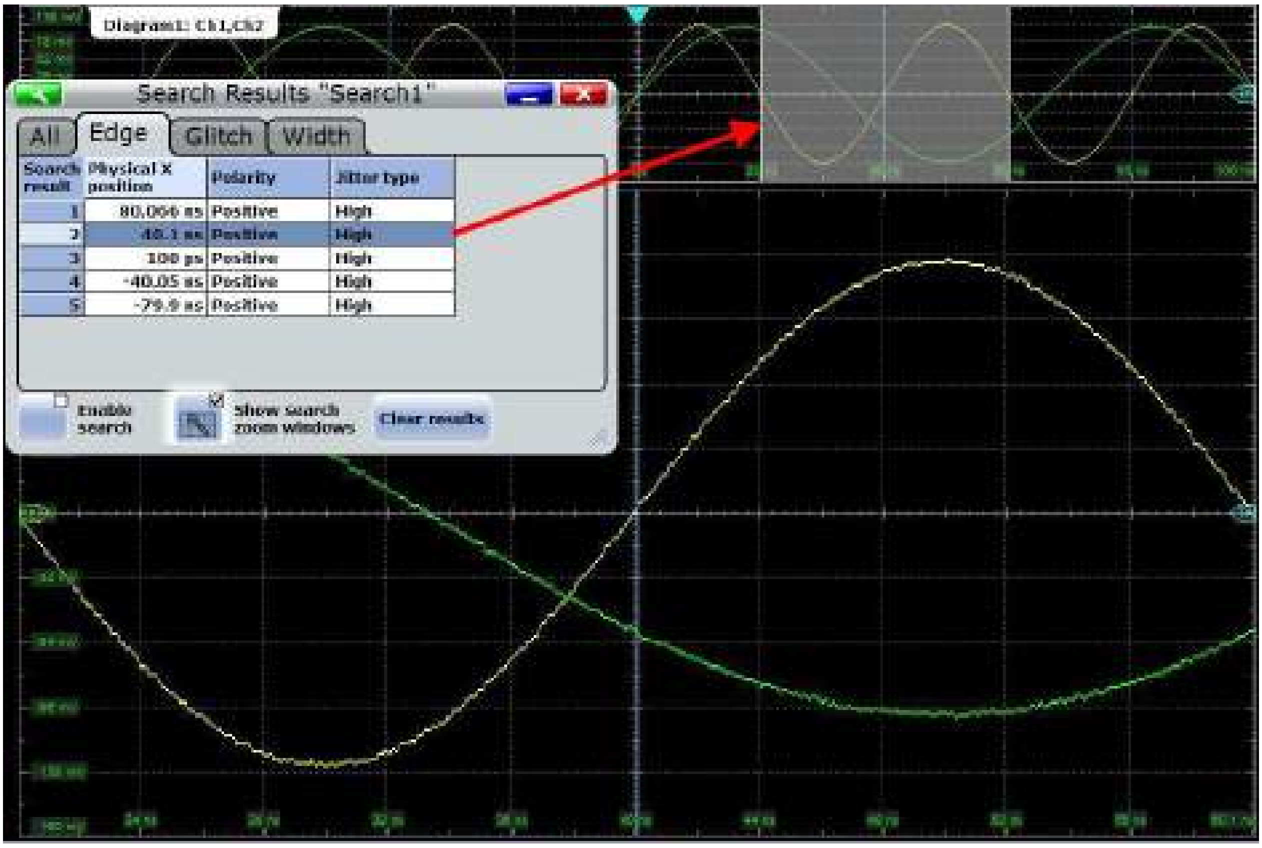
Search zoom windows allow you to analyze the search results in more detail. By default, the zoom is displayed for the selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.

Navigating search results

If a search zoom window has been opened, it shows the first result that was found.

► To display the zoom of a specific search result, tap the result line in the result table to set the zoom to this event.



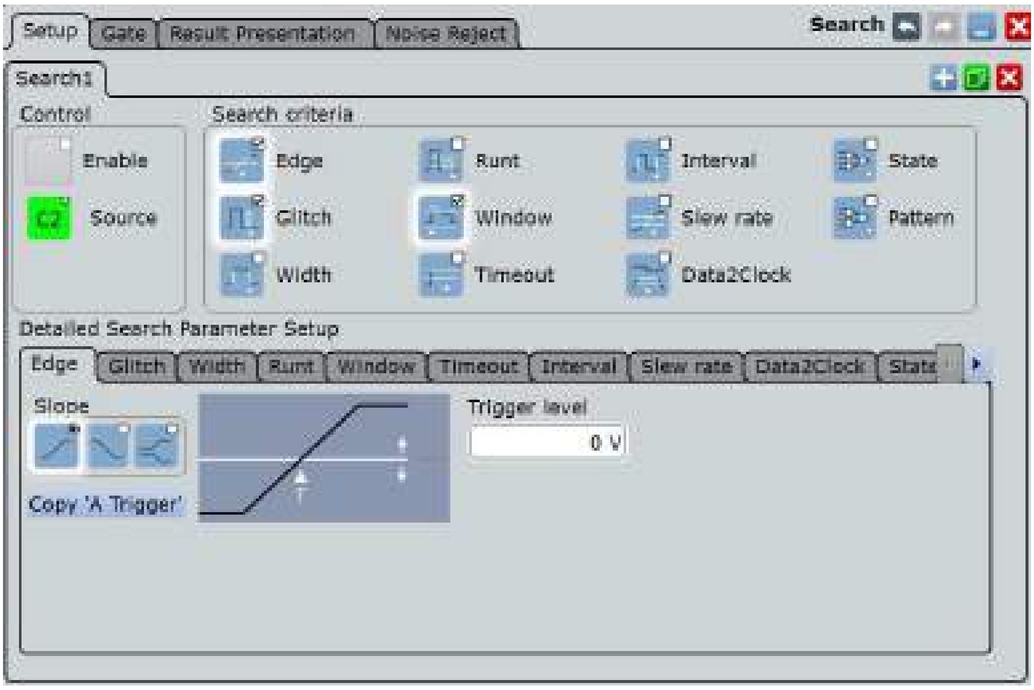
Search result	Physical X position	Polarity	Jitter type
1	80.066 ns	Positive	High
2	40.1 ns	Positive	High
3	100 ps	Positive	High
4	-40.05 ns	Positive	High
5	-79.9 ns	Positive	High

The zoom area in the source diagram moves to the selected result and the zoom is displayed.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 248.

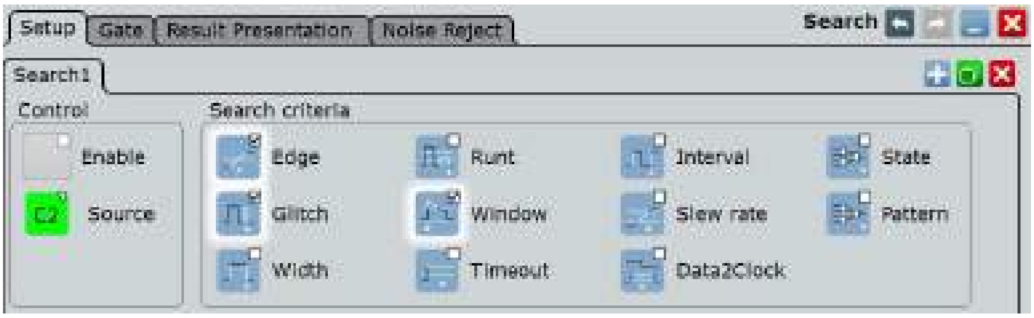
10.2 Search Setup

The search setup includes the source selection, the selection of search events (criteria), event-specific search conditions, and search control.



10.2.1 Search Criteria

Access: SEARCH > "Setup" tab



Enable

If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.

If acquisition is stopped and you enable a search, the data of the last acquisition is searched.

Remote command:
`SEARch:ONLine` on page 1434
`SEARch:ALL` on page 1434

Source

Defines the waveform to be searched. The source can be any analog and digital input signal, math or reference waveform, or track. While the instrument triggers only on real input signals, it can search also calculated and restored waveforms.

If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search ", on page 301.

For some serial protocol options, search on a serial bus is available. For details, see the relevant chapters of the "Protocol Analysis" chapter.

Depending on the selected source, different search criteria are available.

Remote command:
`SEARch:SOURce` on page 1434

Edge, Glitch, Width, Runt, Window, Timeout, Interval, Slew rate, Data2Clock, State, Pattern
Search criterias for analog and digital input signals, math andreference waveforms, and tracks. For search on digital channels, only edge, width, timeout and Data2Clock searches are available.

Tap the icon to include or exclude the search criteria in the next search. You can enable several event types for simultaneous search.

Remote command:
`SEARch:TRIGger:EDGE[:STATe]` on page 1435
`SEARch:TRIGger:GLITch[:STATe]` on page 1435
`SEARch:TRIGger:WIDTh[:STATe]` on page 1436
`SEARch:TRIGger:RUNT[:STATe]` on page 1435
`SEARch:TRIGger:WINDow[:STATe]` on page 1436
`SEARch:TRIGger:TIMeout[:STATe]` on page 1435
`SEARch:TRIGger:INTerval[:STATe]` on page 1435
`SEARch:TRIGger:SLEWrate[:STATe]` on page 1435
`SEARch:TRIGger:DATatoclock[:STATe]` on page 1435
`SEARch:TRIGger:STATe[:STATe]` on page 1435
`SEARch:TRIGger:PATTern[:STATe]` on page 1435

10.2.2 Search Parameters

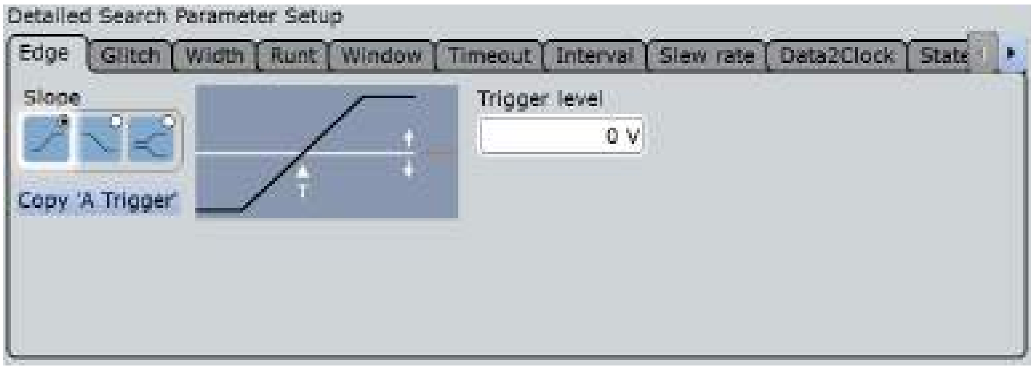
Most parameters available for trigger event definition can also be configured as search conditions. Each event type is defined in a separate subtab.

If the source is a spectrum, the instrument performs a frequency marker search.

For serial protocol options, search on a serial bus is available. These searches have protocol-specific search criteria. For details, see the relevant chapters of the "Protocol Analysis" chapter.

10.2.2.1 Edge

The edge search works the same way as the edge trigger.



Trigger level
0 V

Slope
Sets the edge typ: rising edge ("Positive"), falling edge ("Negative"), or both.

Remote command:
`SEARch:TRIGger:EDGE:SLOPe` on page 1437

Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1436

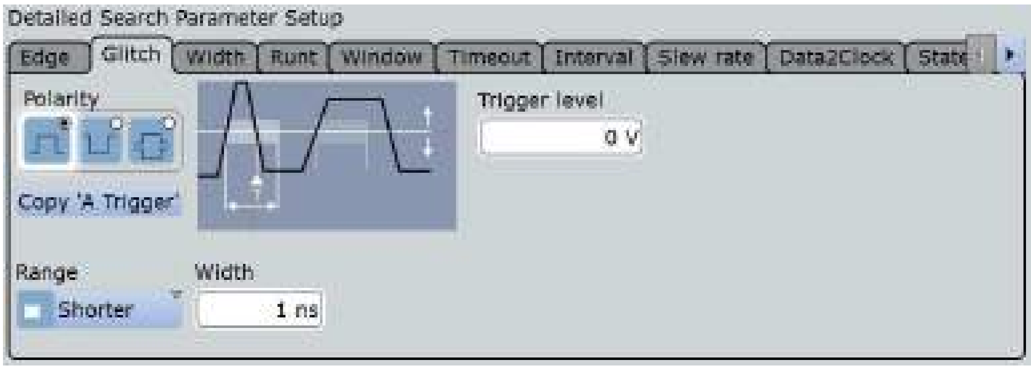
Copy 'A Trigger'
Copies the trigger type-specific settings from the A-trigger configuration to the search settings. The source itself is not copied.

Remote command:
`SEARch:TRIGger:EDGE:ACOPy` on page 1436
`SEARch:TRIGger:GLITch:ACOPy` on page 1436
`SEARch:TRIGger:WINDow:ACOPy` on page 1436
`SEARch:TRIGger:WIDTh:ACOPy` on page 1436
`SEARch:TRIGger:RUNT:ACOPy` on page 1436
`SEARch:TRIGger:WINDow:ACOPy` on page 1436
`SEARch:TRIGger:TIMeout:ACOPy` on page 1436
`SEARch:TRIGger:INTerval:ACOPy` on page 1436
`SEARch:TRIGger:SLEWrate:ACOPy` on page 1436
`SEARch:TRIGger:DATatoclock:ACOPy` on page 1436
`SEARch:TRIGger:STATe:ACOPy` on page 1436
`SEARch:TRIGger:PATTern:ACOPy` on page 1436

10.2.2.2 Glitch

The glitch search works the same way as the glitch trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.

The glitch search is not available if the search source is a digital channel.



Trigger level 0 V

Range Shorter

Width 1 ns

Polarity, Range, Width
See trigger settings:

- "Range" on page 213
- "Width" on page 213
- "Polarity" on page 213

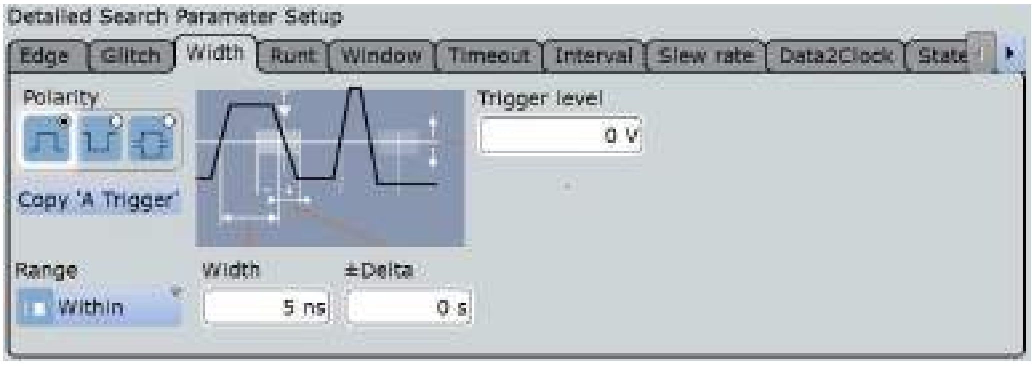
Remote command:
`SEARch:TRIGger:GLITch:POLarity` on page 1437
`SEARch:TRIGger:GLITch:RANGe` on page 1438
`SEARch:TRIGger:GLITch:WIDTh` on page 1438

Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1436

10.2.2.3 Width

The width search works the same way as the width trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.



Polarity, Range, Width, ±Delta

See trigger settings:

- "Polarity" on page 214
  While the width trigger can only analyze positive *or* negative polarity, searching for a width is also possible for both polarities at the same time ("Either").
- "Range" on page 215
- "Width" on page 215
- "±Delta" on page 215

Remote command:

`SEARch:TRIGger:WIDTh:POLarity` on page 1446
`SEARch:TRIGger:WIDTh:RANGe` on page 1446
`SEARch:TRIGger:WIDTh:WIDTh` on page 1447
`SEARch:TRIGger:WIDTh:DELTa` on page 1445

Trigger level

Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

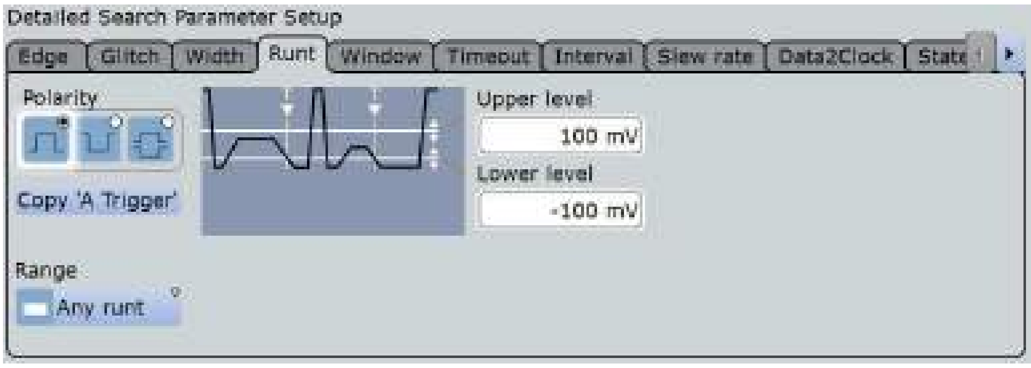
Remote command:

`SEARch:TRIGger:LEVel[:VALue]` on page 1436

10.2.2.4 Runt

The runt search settings are the same as the runt trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The runt search is not available if the search source is a digital channel.



Upper level 100 mV

Lower level -100 mV

Range: Any runt

Polarity, Range, Runt width, ±Delta

Time limit for the runt, see trigger settings:

- "Polarity" on page 213
- "Range" on page 216
- "Runt width" on page 217
- "±Delta" on page 217

Remote command:

`SEARch:TRIGger:RUNT:POLarity` on page 1441
`SEARch:TRIGger:RUNT:RANGe` on page 1441
`SEARch:TRIGger:RUNT:WIDTh` on page 1442
`SEARch:TRIGger:RUNT:DELTa` on page 1440

Upper level, Lower level

Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

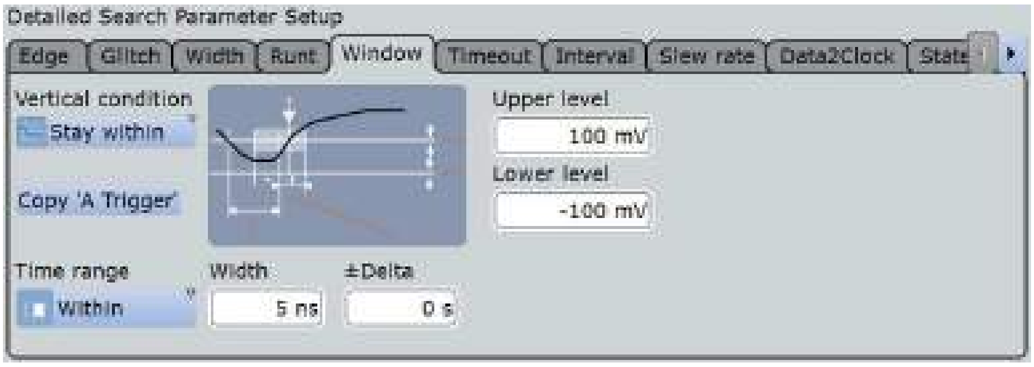
Remote command:

`SEARch:TRIGger:LEVel:RUNT:UPPer` on page 1442
`SEARch:TRIGger:LEVel:RUNT:LOWer` on page 1442

10.2.2.5 Window

The window search settings are the same as the window trigger settings. This search type is not available if the search source is a digital channel.To apply the trigger settings to search, tap Copy 'A Trigger'.

The window search is not available if the search source is a digital channel.



Vertical condition: Stay within

Upper level 100 mV

Lower level -100 mV

Time range: Within

Width 5 ns

±Delta 0 s

Vertical condition
Defines the run of the signal relative to the window, see "Vertical condition" on page 217.

Remote command:
`SEARch:TRIGger:WINDow:RANGe` on page 1447

Time condition, Width, ±Delta
Set the time limit for the vertical condition, see
- "Time condition" on page 218
- "Width" on page 218
- "±Delta" on page 218

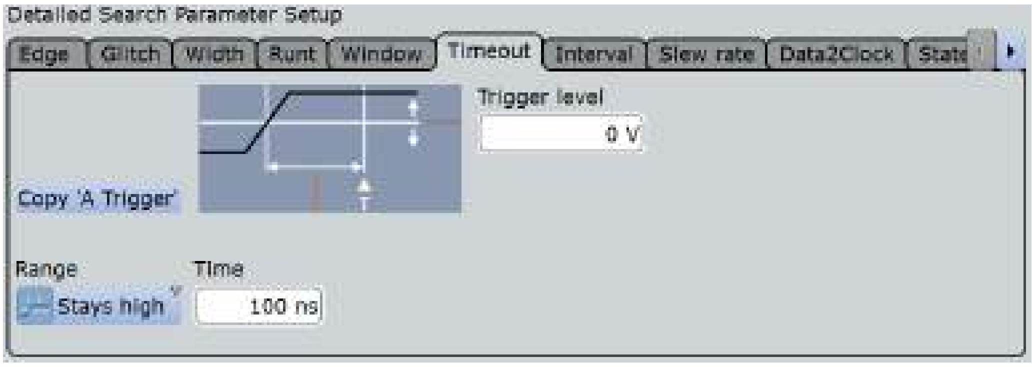
Remote command:
`SEARch:TRIGger:WINDow:TIMerange` on page 1448
`SEARch:TRIGger:WINDow:WIDTh` on page 1449
`SEARch:TRIGger:WINDow:DELTa` on page 1447

Upper level, Lower level
Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

Remote command:
`SEARch:TRIGger:LEVel:WINDow:UPPer` on page 1449
`SEARch:TRIGger:LEVel:WINDow:LOWer` on page 1449

10.2.2.6 Timeout

The timeout search settings are the same as the timeout trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Trigger level: 0 V
Range: Stays high
Time: 100 ns

Range, Time
Set the timeout condition, see
- "Range" on page 219
- "Time" on page 219

Remote command:
`SEARch:TRIGger:TIMeout:RANGe` on page 1445
`SEARch:TRIGger:TIMeout:TIME` on page 1445

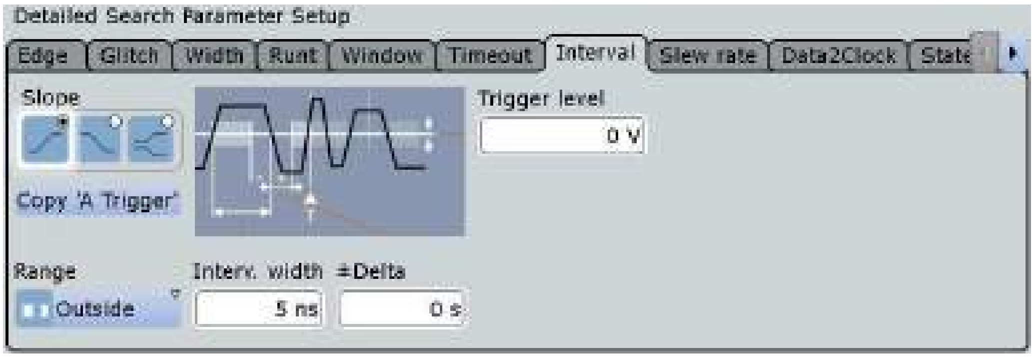
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1436

10.2.2.7 Interval

The interval search settings are the same as the interval trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The interval search is not available if the search source is a digital channel.



Trigger level: 0 V
Range: Outside
Interv. width: 5 ns
±Delta: 0 s

Slope, Range, Interv. width, ±Delta
Set the interval condition, see

- "Slope" on page 220
  While the interval trigger can only analyze rising or falling edges, searching for a width is possible for both edges at the same time ("Either").
- "Range" on page 220
- "Interv. width" on page 220
- "±Delta" on page 221

Remote command:
`SEARch:TRIGger:INTerval:SLOPe` on page 1439
`SEARch:TRIGger:INTerval:RANGe` on page 1439
`SEARch:TRIGger:INTerval:WIDTh` on page 1440
`SEARch:TRIGger:INTerval:DELTa` on page 1439

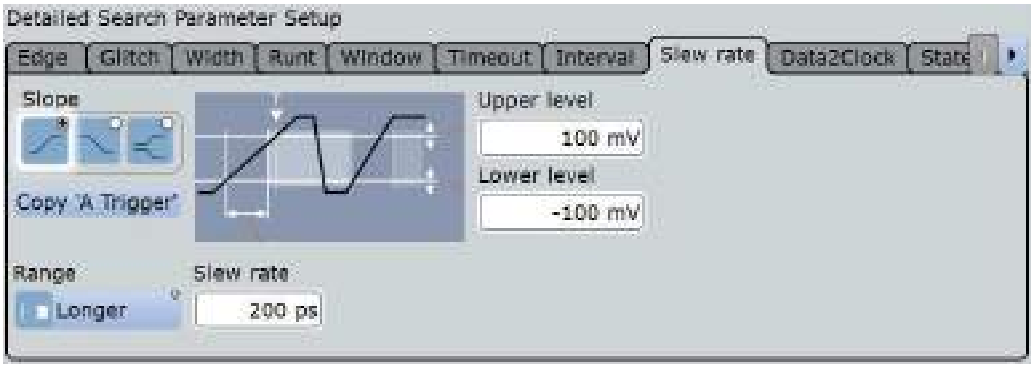
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1436

10.2.2.8 Slew Rate

The slew rate search settings are the same as the slew rate trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The slew rate search is not available if the search source is a digital channel.



Upper level: 100 mV

Lower level: -100 mV

Range: Longer

Slew rate: 200 ps

Polarity, Range, Slew rate, ±Delta

- "Slope" on page 211
- "Range" on page 222
- "Slew rate" on page 222
- "±Delta" on page 222

Remote command:

`SEARch:TRIGger:SLEWrate:SLOPe` on page 1443
`SEARch:TRIGger:SLEWrate:RANGe` on page 1443
`SEARch:TRIGger:SLEWrate:TIME` on page 1444
`SEARch:TRIGger:SLEWrate:DELTa` on page 1443

Upper level, Lower level

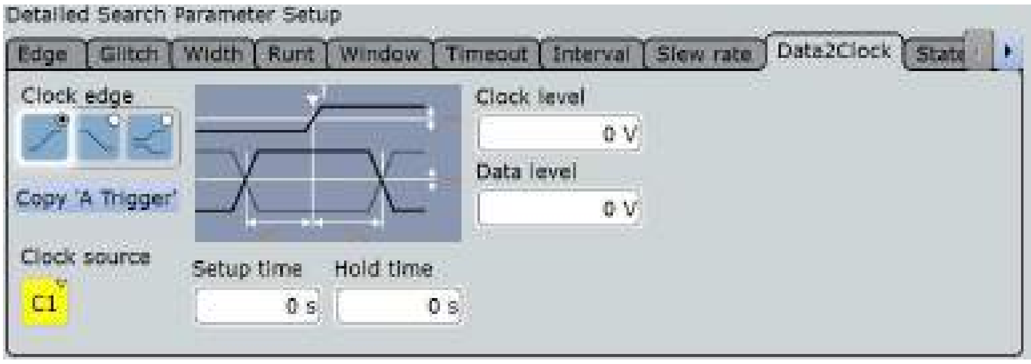
Set the upper and lower voltage thresholds. When the signal crosses a level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:

`SEARch:TRIGger:LEVel:TRANsition:UPPer` on page 1444
`SEARch:TRIGger:LEVel:TRANsition:LOWer` on page 1444

10.2.2.9 Data2Clock

The Data2Clock search settings are the same as the Data2Clock trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Clock source: C1
Clock level: 0 V
Data level: 0 V
Setup time: 0 s
Hold time: 0 s

Clock source, Clock edge, Clock level
Set the clock settings. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:
`SEARch:TRIGger:DATatoclock:CSOurce` on page 1450
`SEARch:TRIGger:DATatoclock:CEDGe` on page 1450
`SEARch:TRIGger:DATatoclock:CLEVel` on page 1450

Data level
Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1436

Setup time, Hold time
Sets the minimum time **before** (Setup) and **after** (Hold) the clock edge while the data signal must stay steady above or below the data level.

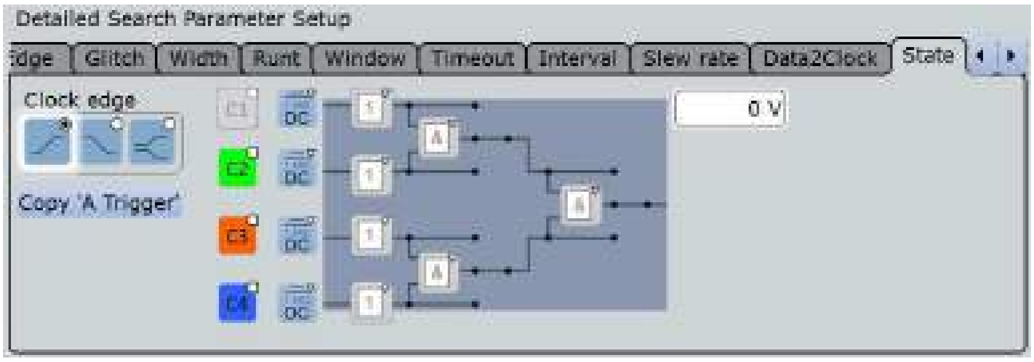
See also: "Setup time" on page 224 and "Hold time" on page 224.

Remote command:
`SEARch:TRIGger:DATatoclock:STIMe` on page 1451
`SEARch:TRIGger:DATatoclock:HTIMe` on page 1451

10.2.2.10 State

The state search is a qualified edge search. The state search is only available for analog channel sources (Ch1 to Ch4).

Note: The logic combination of CH1 and CH3 is different from the trigger settings. Thus, "Copy 'A' Trigger" does not work.



Clock source, Clock edge
Define the clock settings. The clock signal is the waveform to be searched.

Remote command:
`SEARch:TRIGger:STATe:CSOurce` on page 1456
`SEARch:TRIGger:STATe:CEDGe` on page 1456
`SEARch:TRIGger:STATe:CLEVel` on page 1457

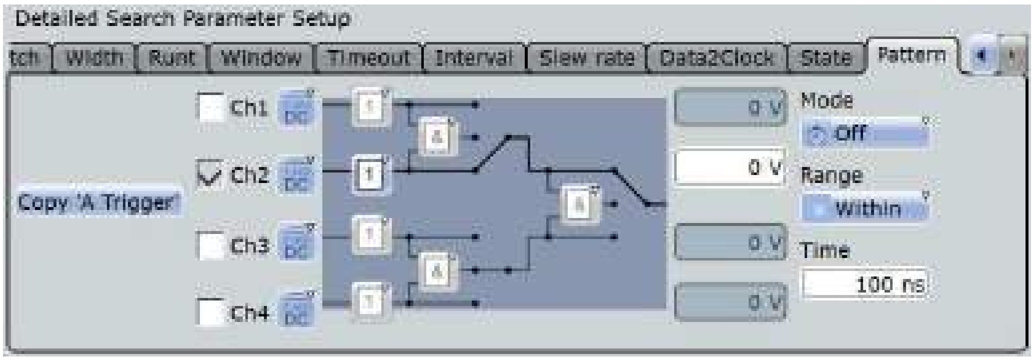
State pattern
State settings are similar to the state trigger, but the logic combination of CH1 and CH3 is different. See also "Pattern" on page 225.

Remote command:
`SEARch:TRIGger:STATe:A[:ENABle]` on page 1457
`SEARch:TRIGger:STATe:A:LOGic` on page 1457
`SEARch:TRIGger:STATe:AB:LOGic` on page 1458
`SEARch:TRIGger:STATe:ABCD:LOGic` on page 1458

10.2.2.11 Pattern

The pattern search combines a logical combination of the input channels with a timing condition. The pattern search is only available for analog channel sources (Ch1 to Ch4).

Note: The logic combination of CH1 and CH3 is different from the trigger settings. Thus, "Copy 'A' Trigger" does not work.



Pattern
Pattern search settings are similar to the pattern trigger, but the logic combination of CH1 and CH3 is different. See also "Pattern" on page 225. .

Remote command:
`SEARch:TRIGger:PATTern:A[:ENABle]` on page 1452
`SEARch:TRIGger:PATTern:A:LOGic` on page 1452
`SEARch:TRIGger:PATTern:AB:LOGic` on page 1453
`SEARch:TRIGger:PATTern:ABCD:LOGic` on page 1453

Timing condition: Mode, Range, Time, Width, ±Delta
Additional time limitation to the pattern, see "Additional settings: Timing" on page 226

Remote command:
`SEARch:TRIGger:PATTern:MODE` on page 1453
`SEARch:TRIGger:PATTern:TIMeout:MODE` on page 1454
`SEARch:TRIGger:PATTern:TIMeout[:TIME]` on page 1454
`SEARch:TRIGger:PATTern:WIDTh:RANGe` on page 1455
`SEARch:TRIGger:PATTern:WIDTh[:WIDTh]` on page 1455
`SEARch:TRIGger:PATTern:WIDTh:DELTa` on page 1455

10.2.3 Frequency Marker Search

When you start a search on a spectrum, a frequency marker search is performed to detect peaks in a spectrum. You can define which peaks the instrument will find by defining the noise reject settings.

Threshold
See "Threshold" on page 302.

Peak excursion
See "Peak excursion" on page 302.

10.2.4 Configuring the Search Setup

There are two ways to create a search:

- Creating a simple default search using the toolbar icon. This method is not available for search on serial buses.
- Setting up a search using the dialog box.

To perform a simple search

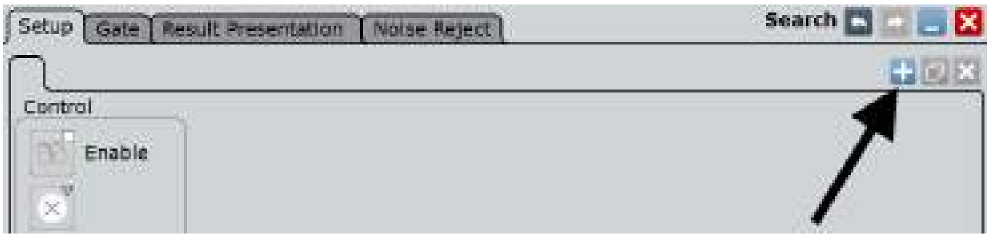
1. If more than one waveform is in the diagram, select the waveform to be searched by tapping it in the diagram.
2. Select the "Search" icon on the toolbar.

3. Tap the diagram with the waveform to be searched, or drag a rectangle on the diagram to define the search area.

   The default edge search is configured as "Search<x>" and performed. The "Search Results" box is displayed.

To create a user-defined search

1. Press the SEARCH key.
2. There are two ways to create a search:
   - If you want to create a new, unconfigured search, tap the ⊞ "Add" icon.

   - If you want to create a new search based on an existing one, tap the "Copy" icon.
3. Enter a name for the search using the on-screen keyboard.

To configure a user-defined search

1. Select the "Setup" tab and the search you want to configure.
2. Select the "Source" on which you want to perform the search.
3. Select the events to be included in the search.
4. Define the settings of the first search event.
   To use the same conditions as defined in the trigger configuration of the A-event, tap "Copy 'A-Trigger". The selected trigger settings are applied to the search settings.
5. Repeat the previous steps to define further events for the same search.
6. To perform the search only on a part of the waveform, configure the gate in the "Gate" tab as described in Chapter 10.3.2, "Defining the Search Gate", on page 436.
7. To filter out noise from the search results, configure noise rejection as described in Chapter 10.5.2, "Defining Noise Rejection for Searches", on page 441.

   Note: A-event copy, gating and noise reject are not available for search on serial buses.

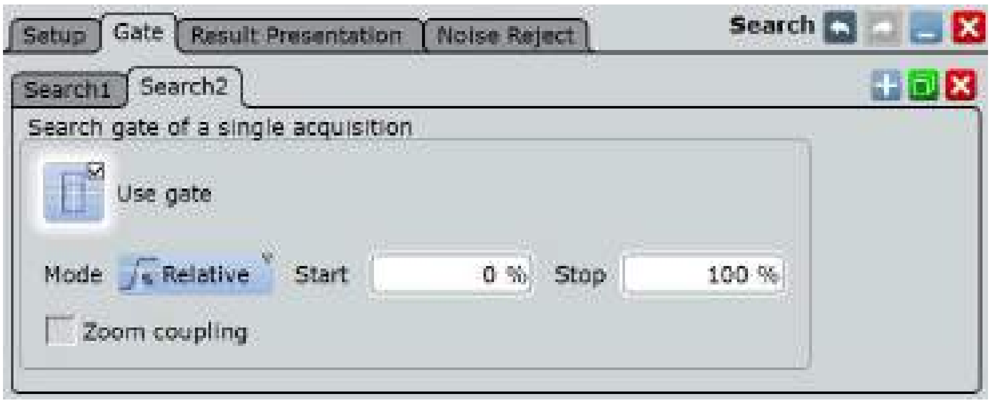
10.3 Search Gate

The gate defines the search area within the source waveform. You can use absolute or relative values to define the gate, or couple it to a previously defined zoom area.

10.3.1 Gate Settings

The search gate settings are identical to those for gate areas for measurements or FFT analysis.

Gating is not available if the search source is a digital channel or a serial bus.



Use Gate
Enables the gate settings and shows the gate. Search is only performed on the defined gate area of the source waveform.

Remote command:
`SEARch:GATE[:STATe]` on page 1459

Mode
Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1409
`MEASurement<m>:GATE:MODE` on page 1383
`SEARch:GATE:MODE` on page 1460

(Relative) Start
Defines the starting value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 1409
`MEASurement<m>:GATE:ABSolute:STARt` on page 1383

`MEASurement<m>:GATE:RELative:STARt` on page 1383
`SEARch:GATE:ABSolute:STARt` on page 1460
`SEARch:GATE:RELative:STARt` on page 1460

(Relative) Stop
Defines the end value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP` on page 1409
`CALCulate:MATH<m>:FFT:GATE:RELative:STOP` on page 1410
`MEASurement<m>:GATE:ABSolute:STOP` on page 1383
`MEASurement<m>:GATE:RELative:STOP` on page 1383
`SEARch:GATE:ABSolute:STOP` on page 1460
`SEARch:GATE:RELative:STOP` on page 1461

Zoom coupling
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1410
`MEASurement<m>:GATE:ZCOupling` on page 1385
`MEASurement<m>:GATE:ZDIagram` on page 1385
`SEARch:GATE:ZCOupling` on page 1461
`SEARch:GATE:ZDIagram` on page 1461

10.3.2 Defining the Search Gate

If you create a search using the "Search" toolbar icon, you can directly define the gate by dragging a rectangle on the diagram. Otherwise, you define the gate in the "Gate" tab of the "Search" dialog box.

1. Press the SEARCH key and select the "Gate" tab.
2. Select the search for which you want to define the gate.
3. Use one of the following methods:
    - Set the absolute or relative "Mode" and enter the start and stop values of the gate area.
    - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option. If several zoom diagrams are defined, select the zoom diagram to be used for gating.
4. Tap "Use gate" to enable the gate.

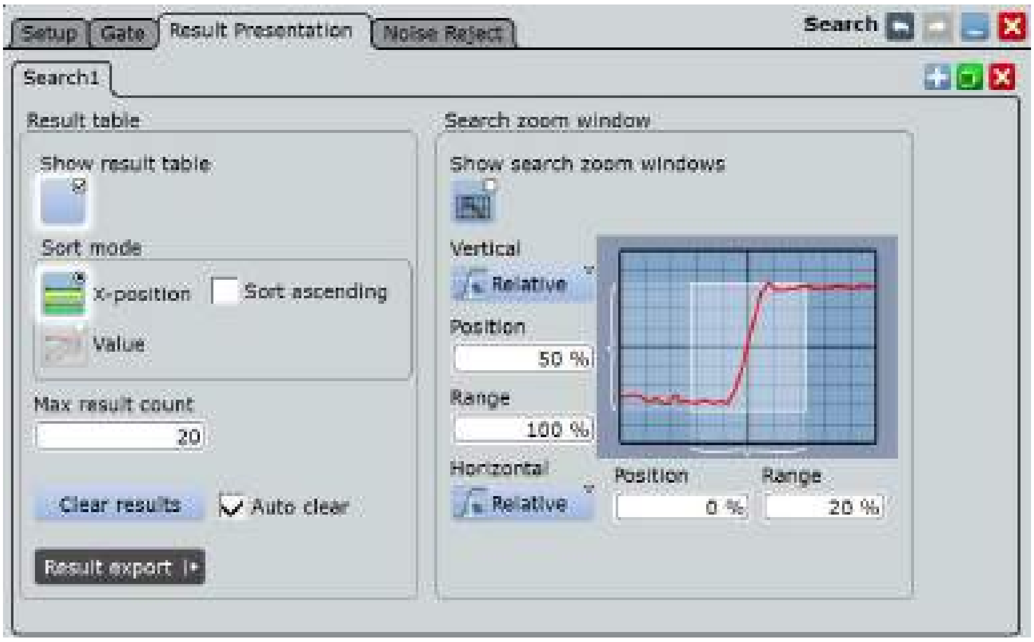
5. Optionally, tap "Show gate" to display the gate area in the diagram.

10.4 Result Presentation

Search results are displayed in a table in the "Search Results" box. In addition, a zoom window for a selected search result can be displayed so that you can analyze the result in more detail.

10.4.1 Result Presentation Settings

The following settings configure the layout of the result table in the "Search Results" box and the size and position of the search zoom window. The result tables can be sorted by x-position or value. You can define a maximum number of table entries.



Max result count 20

Vertical Relative

Position 50 %

Range 100 %

Horizontal Relative

Position 0 %

Range 20 %

Result table
These settings refer to the search result table.

Show result table ← Result table
Displays or hides the search result table.

Remote command:
`SEARch:RESult:SHOW` on page 1467

Sort mode ← Result table
Sorts the search results by x-value position or value of the result.

Remote command:
`SEARch:RESult:SORT[:MODE]` on page 1468

Sort ascending ← Result table

By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".

Remote command:

`SEARch:RESult:SORT:ASCending` on page 1467

Max result count

Defines the maximum number of entries in the search result table.

Remote command:

`SEARch:RESult:LIMit` on page 1467

Auto clear

If "Auto clear" is enabled, the instrument displays the search results of the last acquisition.

If "Auto clear" is disabled, the first result of each acquisition is listed until the maximum number of entries in the table is reached.

Clear results

Clears the search results once and starts a new search.

Remote command:

`SEARch:CLEar` on page 1433

Search zoom window

The search zoom window allows you to analyze the search results in more detail.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 248

The search zoom area is marked in the waveform diagram. You can change the color of the area with: "Display" menu > "Diagram layout" > "Search result gate symbol color" on page 117.

Show search zoom windows ← Search zoom window

If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Remote command:

`SEARch:RESDiagram:SHOW` on page 1465

Vertical ← Search zoom window

Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:

`LAYout:ZOOM:VERTical:MODE` on page 1301

`SEARch:RESDiagram:VERT:MODE` on page 1466

Position / Relative position (vertical) ← Search zoom window

Defines the y-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 1301
`LAYout:ZOOM:VERTical:RELative:POSition` on page 1302
`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 1465
`SEARch:RESDiagram:VERT:RELative:POSition` on page 1466

Range / Relative Range (vertical) ← Search zoom window
Defines the height of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:RELative:SPAN` on page 1303
`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 1302
`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 1466
`SEARch:RESDiagram:VERT:RELative:SPAN` on page 1466

Horizontal ← Search zoom window
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
`LAYout:ZOOM:HORZ:MODE` on page 1298
`SEARch:RESDiagram:HORZ:MODE` on page 1464

Position / Relative position (horizontal) ← Search zoom window
Defines the x-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:POSition` on page 1298
`LAYout:ZOOM:HORZ:RELative:POSition` on page 1299
`SEARch:RESDiagram:HORZ:ABSolute:POSition` on page 1464
`SEARch:RESDiagram:HORZ:RELative:POSition` on page 1465

Range / Relative Range (horizontal) ← Search zoom window
Defines the width of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:SPAN` on page 1299
`LAYout:ZOOM:HORZ:RELative:SPAN` on page 1300
`SEARch:RESDiagram:HORZ:ABSolute:SPAN` on page 1464
`SEARch:RESDiagram:HORZ:RELative:SPAN` on page 1465

10.4.2 Configuring the Search Results Presentation

Initially, the "Search Results" box is displayed in front of the other diagrams or as result icon on the signal bar, depending on the default setting in the "Diagram Layout" tab. Alternatively, you can display it in its own area on the screen, like any other diagram.

For details, see "Displaying Results" in the "Getting Started" manual.

To configure the result tables

1. Press the SEARCH key to open the "Search" dialog box.

2. Select the tab for the search you want to configure.
3. Select the "Result Presentation" tab.
4. Select "Show result table" to display the "Search Results" box.
5. Select the sort mode of the result table.
6. By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".
7. Define a maximum number of results to be displayed in the result table in the "Max result count" field.

To display search zoom windows

1. In the "Search Results" box, select "Show search zoom windows".

   This stops a running search and a running acquisition.
   The zoom area is indicated in the diagram that displays the source waveform of the search. The zoom window is displayed for the first result that was found.
2. If you need to adjust the search zoom area, you can drag the area or their edges on the screen. You can also enter the limits of the search zoom window in the "Search > Results Presentation" tab.
   Be aware, that the zoom window size is valid for all results of a search definition, so if you change the settings drastically for one result, they may not be correct for the next search result you switch to.

   See also:
   - Chapter 6.1.3, "Zooming for Details", on page 254
   - "Navigating search results" on page 421

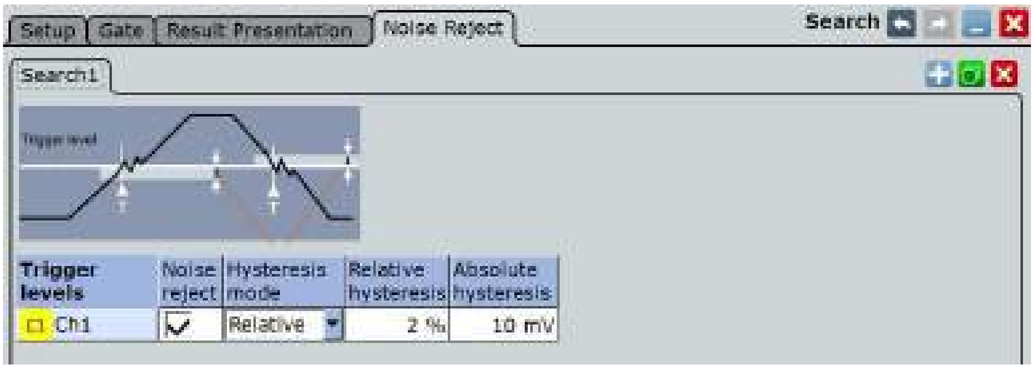
10.5 Noise Reject

Noise rejection for searches is very similar to noise rejection for triggers. You can reject noise by setting a hysteresis in order to avoid finding events caused by noise oscillation around the trigger level.

10.5.1 Noise Reject Settings

You can select the hysteresis mode and value for each analog and digital input channel, math and reference waveform.

The noise reject settings are similar to those for triggers, see also Chapter 5.6, "Noise Reject", on page 236.



Trigger levels	Noise reject	Hysteresis mode	Relative hysteresis	Absolute hysteresis
Ch1	☑	Relative	2 %	10 mV

Noise reject

If enabled, the hysteresis is considered for the search.

Remote command:

`SEARch:TRIGger:LEVel:NOISe[:STATe]` on page 1463

Hysteresis mode

Defines whether values absolute or relative to the vertical scaling are used.

Remote command:

`SEARch:TRIGger:LEVel:NOISe:MODE` on page 1462

Relative / Absolute hysteresis

Defines a range in absolute or relative values around the search level. If the signal jitters inside this range and crosses the level, no search event is detected.

Absolute hysteresis values are adapted when the relative hysteresis is changed , and vice versa.

If you change the vertical scaling, either the relative or the absolute value is adjusted automatically.

Remote command:

`SEARch:TRIGger:LEVel:NOISe:ABSolute` on page 1462
`SEARch:TRIGger:LEVel:NOISe:RELative` on page 1463

10.5.2 Defining Noise Rejection for Searches

1. Press the SEARCH key to open the "Search" dialog box.
2. Select the "Noise reject" tab.
3. Select the tab for the search you want to configure.
4. Define the absolute or relative hysteresis. If you change one value, the other is automatically calculated.

11 Data and File Management

This chapter describes how to manage instrument settings, and measurement results like waveform data, numeric results and screenshots.

The SAVE RECALL key provides functions for saving and restoring data on the instrument. A naming pattern is available and can be adjusted to simplify a clear data storage.

The effect of the CAMERA key can be configured to save or print screenshots or reports.

11.1 Instrument Settings

In order to repeat measurements at different times or perform similar measurements with different test data, it is useful to save the used instrument settings and load them again later. Furthermore, it can be helpful to refer to the instrument settings of a particular measurement when analyzing the results. Therefore, you can easily save the instrument settings of a measurement. In addition to the measurement-related settings, user-specific display settings can also be saved and loaded.

The R&S RTO provides three types of saving and restoring settings.

- **Savesets** contain the complete instrument and measurement configuration except for user-specific display settings.
- **User preferences** contain user-specific display settings like diagram layout, toolbar, intensity and transparency settings.
- **User-defined presets** contain the complete instrument setup including display settings, except for transparency and intensity. These settings can be restored by pressing the PRESET key.

Access: SAVE RECALL key > "Save/Recall" tab

11.1.1 Savesets

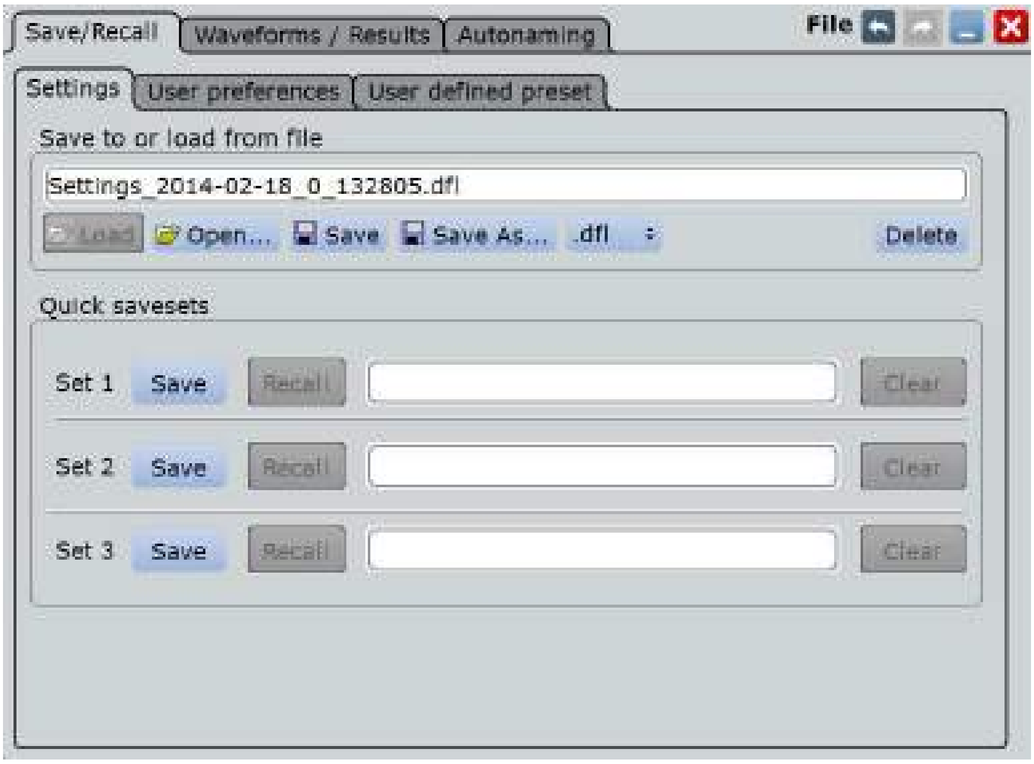
Savesets contain the complete instrument and measurement configuration icluding a screenshot of the current display, but except for user-specific display settings stored as user preferences. You can save an unlimited number of setting files.

To load a saveset quickly, you can use the "Load saveset" function on the toolbar. A graphical preview helps you to find the required settings file.

If you often need to store the instrument settings, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file.

For the most frequently used measurements, store the settings in "Quick savesets" and recall them very quickly. Up to 3 quick savesets can be used. They are stored automatically, the name and storage place are fixed.

11.1.1.1 Settings



Settings_2014-02-18_0_132805.dfl

Save to or load from file
Enter the file name to load or to save the setting data to, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box. See also: Chapter 11.6, "File Selection Dialog", on page 478.

By default, saveset file names have the prefix "Settings_".

"Load"	Loads the specified file.
"Open"	Opens a file selection dialog box and loads the selected file.
"Save"	Saves the data to the selected file.

"Save As..."	Opens the file selection dialog box and saves the data to the selected file.
".dfl/.xml"	Selects the file format.
"Delete"	Deletes the selected file.

Remote command:
`MMEMory:SAV` on page 1475
`MMEMory:RCL` on page 1475

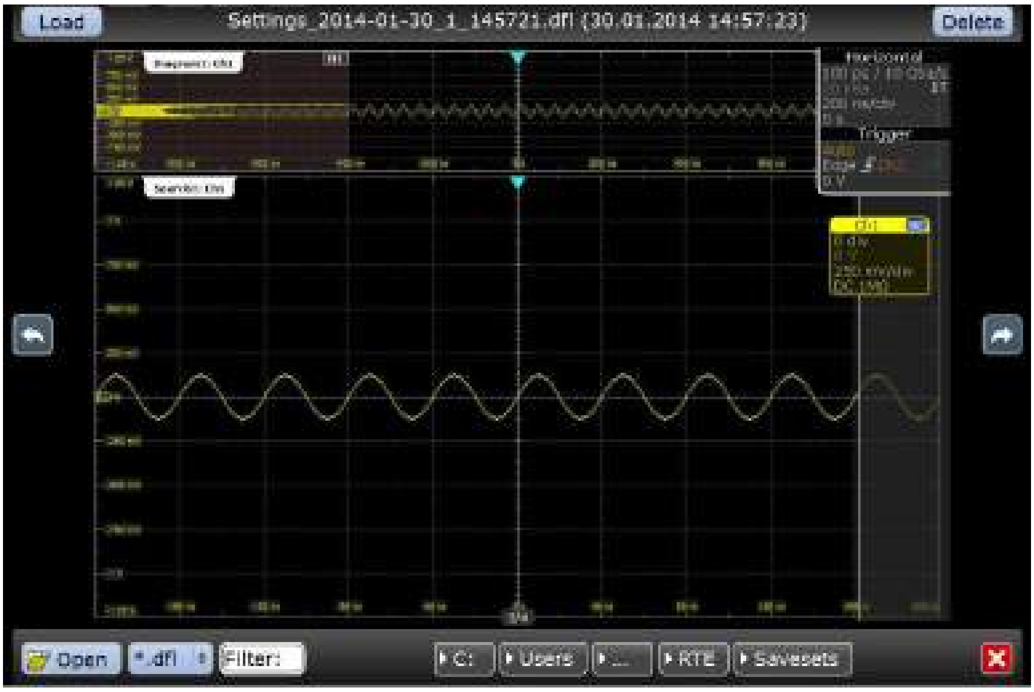
Quick savesets
A saveset stores the current measurement and instrument settings at the touch of a button, and reloads them in the same way. Three savesets are available for the most frequently used measurements.

Savesets are stored automatically with standard names, so it is useful to describe the settings in a comment.

"Save"	Saves the current measurement and instrument settings to one of the three savesets.
"Recall"	Loads the instrument settings from one of the three savesets.
"Comment"	Double-tap the edit field to describe the settings saved in the selected saveset.
"Clear"	Deletes the selected saveset.

11.1.1.2 Load Saveset Function

The "Load saveset" function is available on the toolbar. Here, a graphical preview helps you to find the required settings file.



1. On the toolbar, tap the "Load saveset" icon.

   A window opens and shows the screenshot of the first measurement configuration that is stored in the default `Saveset` directory.

2. Find the required saveset file:
   - Tap the "Next" icon on the rigth or the "Previous" icon on the left to scroll the savesets of the directory.

     The file name is shown on the top, and the screenshot helps to identify the settings.
   - Select the file format: `*.dfl` or `*.xml`.
   - If the saveset was stored in another directory, use the path buttons at the bottom or tap "Open" to open the required directory.

3. Tap "Load" in the upper left corner to recall the settings of the selected file.

11.1.1.3 Saving and Loading Settings

Settings can be stored in a file with user-defined name and location, or in a quick saveset. The settings in a saveset can be saved and retrieved very quickly at the touch of a button, so savesets are ideal for frequently used measurements.

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 443.

To save instrument settings in a quick saveset

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. For one of the three available quick savesets, enter a comment in the "Quick savesets" area to identify the configuration.
5. Tap the corresponding "Save" button

   The current instrument settings are saved in the selected quick saveset.

To load instrument settings from a quick saveset

1. Press the SAVE RECALL key.

2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap the required "Recall" button in the "Quick savesets" area.

   The saved settings are loaded to the R&S RTO.

To save settings to a saveset file

Alternatively, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file to the folder and file specified in the "Settings" tab. See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Save" to save the settings to the specified file.
   Tap "Save As" to save the settings to a different file. Select the file and directory from the file selection dialog box.

   The current settings are saved to the selected file.

To load settings from a saveset file

Alternatively, you can use the "Load saveset" function on the toolbar, see Chapter 11.1.1.2, "Load Saveset Function", on page 444.

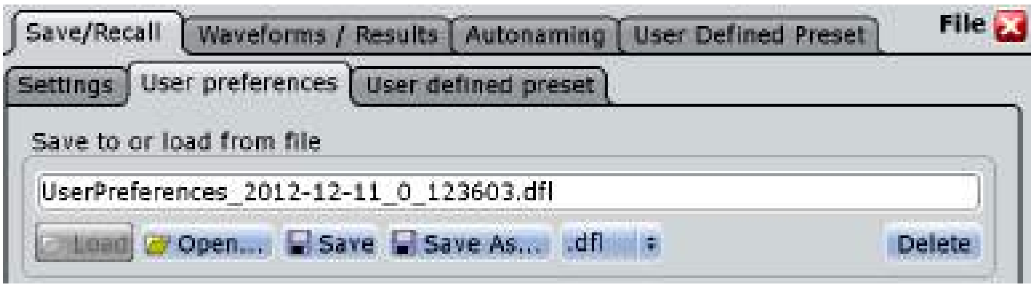
1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Load" to load the settings from the specified file.
   Tap "Open" to navigate to a different file. Select the file from the file selection dialog box and tap "Select".

   The saved settings are loaded to the R&S RTO.

11.1.2 User Preferences

User preferences contain user-specific display settings like diagram layout, toolbar, intensity and transparency settings. By default, these file names have the prefix "User-Preferences_".

User preferences are saved and loaded in the same way as saveset files but on the User preferences tab. See also: "To save settings to a saveset file" on page 446 and "To load settings from a saveset file" on page 446.



Save to or load from file
The file name to load or to save the data to.

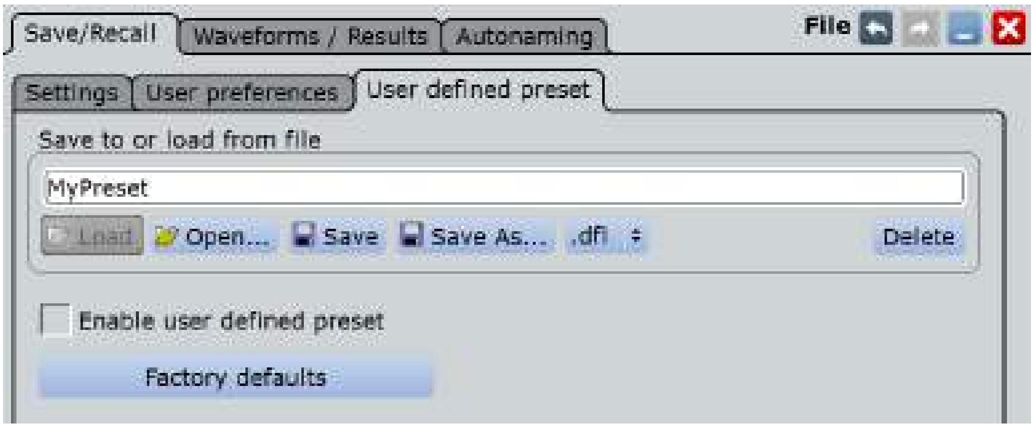
By default, user preference file names have the prefix "UserPreferences_".

For details, see the Save to or load from file function in the "Settings" tab.

11.1.3 User-defined Preset

A user-defined preset contains the complete instrument setup including display settings, except for transparency and intensity. You can save the current configuration to a preset file, and load a previously saved preset file. You can then specify that these settings are to be applied with the PRESET key.

11.1.4 User-defined Preset - Settings



Save to or load from file
The file name with extension `.dfl` to load or to save the settings to.

For details, see the Save to or load from file function in the "Settings" tab.

Enable user-defined preset
If enabled, the settings from the selected preset file are restored when the PRESET key is pressed.

If disabled, PRESET sets the instrument to the factory defaults.

Factory defaults

Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After laoading factory defaults, perform a self-aligment to synchronize the signal data ("File" menu > "Selfalignment").

Remote command:
`SYSTem:PRESet` on page 1185

11.1.5 Restoring Settings

When you have changed many different settings on the instrument and are no longer sure which settings are causing which effect in the measurement, you may want to restore the default settings and start anew. The following methods are available:

- Saving instrument settings to a user-defined preset and restoring the instrument settings to user-defined default values
- Restoring all settings on the R&S RTO to the factory-defined values
- Restoring settings from a file (see "To load settings from a saveset file" on page 446)

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 443.

To save a user-defined preset

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Enter a name for the preset file and select the file format.
5. Tap Save.

   Note: If you want to store the file in another directory than the default one, select "Save As". See also: Chapter 11.6, "File Selection Dialog", on page 478

To restore the instrument settings to user-defined default values

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Tap "Open" and select the preset file that contains the required settings.

   The instrument settings are restored to values that are stored in the file.
5. To use these settings as presest values, select "Enable user-defined preset".
6. Press the PRESET key.

To restore all settings to the factory defaults

1. Press the SAVE RECALL key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Tap the "Factory defaults" button.

   All settings on the R&S RTO are reset to their factory-defined values. As long as no user-defined preset file is loaded and Enable user defined preset is disabled, the PRESET key also resets the instrument settings to factory defaults.

11.2 Waveforms and Results

You can export various data to file: waveform data, histograms, and measurement results.

For information on data export in I/Q mode (option R&S RTO-K11), see Chapter 15.3, "I/Q Data Output", on page 1031.

11.2.1 Waveform Export Files

Waveforms can be stored in XML, CSV, or BIN format.

Reloading waveforms: Restrictions

In order to reload waveform data as a reference waveform, it must be stored in BIN format.

If multiple acquisitions of one waveform are exported (Data logging or Multiple waveforms), only the first acquisition can be reloaded.

If the signal is a spectrum, reloading is only possible for waveforms with "Magnitude unit" = Linear. Waveforms with logarithmic unit cannot be reloaded.

Data of all waveforms is saved in two files. One file contains the waveform data values and is indicated by `*Wfm.*` in the file name. The second file contains the header data, for example, time scale, vertical scale, vertical and horizontal positions, interpolation mode and much more. Header data is required to restore the waveform from data, or to analyze the data values of the data file.

11.2.1.1 Header Files

The header files of XML and BIN waveform files are written in XML format. The header files of CSV waveform files are written in CSV format. You can open the header files and use their information for data analysis.

CSV header files only contain the property names and values, one property per row.

```
Resolution:1e-010:
RecordLength:1000:
```

XML header files contain more information than CSV header files. The additional information is required to reload the stored waveforms with their correct settings.

```
<Prop Avail="0" ValueKey="" Name="Resolution" Value="1e-010" UserValue="0"
Step="1e-011" Default="0" Min="0" Max="1e+026" StepDefault="1e-011"
StepFactor="10" Resolution="0" UnitId="55" UnitName="s" UnitPowerProduct=""
BitGroupSize="0" Format="0"></Prop>

<Prop Avail="0" ValueKey="" Name="RecordLength" Value="1000" UserValue="1000"
Step="1" Default="1000" Min="0" Max="4294967295" StepDefault="1" StepFactor="10"
Resolution="1" UnitId="93" UnitName="Sa" UnitPowerProduct="" BitGroupSize="0"
Format="0"></Prop>
```

Header files contain the following properties:

Table 11-1: Header file properties

Value	Description
General	
FirmwareVersion	Firmware version that is installed on the R&S RTO (last entry in the header file)
Source	Name of the exported waveform
Resolution	Time between two samples *Resolution = 1 / Sample Rate*
SignalResolution	Time between two samples in this waveform. The value can differ from Resolution if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the frequency range of FFT bins.
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate
DecimationFactor	Factor to the number of data samples to achieve the required sample rate *Decimation factor = ADC sample rate / Sample rate*
TraceArithmetics	Off, Envelope, or Average

Value	Description
InterleavedTraceCount	Number of y-values saved at each sampling time. The value is usually 1. The value is 2, if min and max values are saved for each sample, for example, for envelope waveforms.
SignalFormat	Format of the data values: ● FLOAT: floating point numbers, general export format ● INT (8 Bit): Integer 8 bit, used for "Raw (ADC sample)" data export. ● INT (16 Bit): Integer 16 bit, used for "Raw (ADC sample)" data export in high definition mode (option R&S RTO-K17).
Timestamp	Absolute time of the waveform recording
ByteOrder	Endianess, only relevant for raw data export in high definition mode (SignalFormat = INT (16 Bit)). ● LSB first: little endian, least significant byte first ● MSB first: big endian, most significant byte first
NumericFormat	Number format of bus values and digital channel data (bit pattern format)
Record length	
RecordLength	Number of samples in a waveform record of one acquisition
HWRecordLength	Equivalent to the RecordLength
SignalRecordLength	Number of required samples in the waveform. The value can differ from RecordLength and HWRecordLength if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the number of FFT bins.
SignalHardwareRecordLength	Number of samples actually available in this waveform, including the number of required samples in the waveform and the additional samples needed for further computation
LeadingSettlingSamples	Number of additional samples before the beginning of waveform samples. These additional samples are needed for further computation, for example, for filters.
Horizontal system	
TimeScale	Horizontal scale in seconds per division
HorizontalDivisionCount	Number of horizontal divisions
RescaleCenterTime	Horizontal position, the time distance between the reference point and the zero point of the diagram
RescaleCenterPoint	Position of the reference point in % of the screen
ReferencePoint	Position of the zero point in % of the screen
TriggerOffset	Time distance from the trigger point to the zero point of the diagram
XStart	Horizontal start value of the waveform (time or frequency) *)
XStop	Horizontal stop value of the waveform (time or frequency)
HardwareXStart	Actual horizontal start value of data, including the settling time for further computation *)
HardwareXStop	Actual horizontal stop value of data, including the settling time for further computation

Value	Description
	*) If the waveform is a spectrum, the XStart and HardwareXStart values may be slightly smaller than the specified start frequency, or even get negative. The spectrum is centered on the center frequency, and the frequency range covered by one spectral bin is given by the SignalResolution. Hence, the spectral bin in the center of the spectrum always covers the range [CenterFrequency; CenterFrequency + SignalResolution[. As a result, the range covered by the first spectral bin in the spectrum may reach further than the start frequency specified by the user. It is ensured that the specified start frequency is included in the frequency range.
Vertical system In case of multi channel export, the values of channel1 are delivered, no matter if channel 1 is exported or not.	
VerticalScale	Vertical scale of the waveform in Volts per division, or other unit / division
VerticalDivisionCount	Number of vertical divisions
VerticalPosition	Vertical position of the waveform in divisions
VerticalOffset	Vertical offset of the waveform in Volts, or other unit
NofQuantisationLevels	Theoretical number of quantization levels in the signal. This value depends on the waveform format (8 bit, 16 bit, …). In case of a math waveform, it depends on the quantization levels of the operands and on the operator type.
BaseYStart	Vertical start value of the waveform
BaseYStop	Vertical stop value of the waveform
Multi channel export The header files contain strings like this: `MultiChannelVerticalOffset: 4:1.63:1.96:0:0:1e-005:0:-1e+026:1e+026:1e-005:10:0:V:`. Only the first 5 values and the unit at the end of the string are relevant for data analysis. All other values are for internal use and not explained here. Examples are in csv format.	
MultiChannelExport	Indication whether multiple channels are exported simultaneously: On | Off
MultiChannelExportState	Number of channels and export status of the individual channels, for example, 4:On:Off:On:On...: channels 1, 3 and 4 are exported.
MultiChannelVerticalOffset	Number of channels and vertical offset of the individual channels, for example, 4:0:0:0.02:0...: channel 3 has an offset of 20 mV.
MultiChannelVerticalPosition	Number of channels and vertical position of the individual channels, for example, 4:0:0:0:2...: the position of channel 4 is 2 divisions.
MultiChannelVerticalScale	Number of channels and vertical scale of the individual channels, for example, 4:0.05:0:0.03:0.04...: scale of channel is 50 mV/div, channel 3 has 30 mV/div and channel 4 has 40 mV/div.
MultiChannelBaseYStart	Number of channels and minimum value of the vertical range for each individual channel, for example, 4:-0.25:0:-0.13:-0.28...
MultiChannelBaseYStop	Number of channels and maximum value of the vertical range for each individual channel, for example, 4:0.25:0:0.17:0.12...: The range of channel 1 is -250 mV to 250 mV. The range of channel 3 is -130 mV to 170 mV. The range of channel 4 is -280 mV to 120 mV.

Value	Description
History	
TimestampState	State of the timestamps export. If on, the timestamps of each history waveform is written to the waveform data file.
Math waveform	
BaseUnit	Base unit of a mathematic waveform, for example, linear unit
ViewUnit	User-selected unit of a mathematic waveform, for example, logarithmic unit for a spectrum. The value is only valid if the exported waveform is a math waveform.
ViewUnitRelative	Indication of a relative unit. It is true if the math waveform has the ViewUnit "dB", for example. The value is only valid if the exported waveform is a math waveform.
ViewReferenceLevel	Reference level for a relative unit. The value is only valid if the exported waveform is a math waveform, and the unit is relative.
FFT	
CenterFreq	Center frequency of the spectrum
FreqSpan	Frequency span of the spectrum
FrequencyStart	Start frequency of the spectrum
FrequencyStop	Stop frequency of the spectrum
WindowType	Window used for the spectrum computation
ResolutionBW	Resolution bandwidth of the spectrum
AdjustedResolutionBW	Actual resolution bandwidth of a spectrum waveform. The value is only valid if the exported waveform is a spectrum.
GateRBWCoupling	Indication whether the record length or the resolution bandwidth is a constant for the spectrum computation
Parameters for power calculation	
Impedance	Impedance used for power calculation
NoiseBandwidth	Noise bandwidth of a spectrum waveform, required for power calculation. The value is only valid if the exported waveform is a spectrum.
Parameters for internal use	
SourceType	Source qualifier
TraceType	Waveform qualifier
ValueType	
TOADone	
BaseUnitRelative	Base unit indication

Value	Description
UseInterSampleTriggerOffset	
ISO_TRG SC_POST SC_TRG	

11.2.1.2 Waveform Data Files

The waveform data files - indicated by `*Wfm.*` in the file name - contain the actual waveform data. Usually only Y-values - mostly voltage values - are written subsequently. If the signal is a spectrum, the data of the last frame is written.

If the waveform consists of minimum and maximum values, two Y-values per sample are written, and the property `InterleavedTraceCount` in the header file is >1. This applies to envelope waveforms, for example.

The option "Interleaved X/Y" allows you to include horizontal values into the file.

if multi-channel export is enabled, the Y-values of the selected channels are written in interleaved order.

- One channel, single acquisition export
  - Normal waveform:
    Y_0; Y_1; Y_2; Y_3; ...
  - Envelope waveform:
    $Ymin_0$; $Ymax_0$; $Ymin_1$; $Ymax_1$; $Ymin_2$; $Ymax_2$; $Ymin_3$; $Ymax_3$; ...
  - Normal waveform, interleaved x/y data:
    X_0; Y_0; X_1; Y_1; X_2; Y_2; X_3; Y_3; ...
  - Envelope waveform, interleaved x/y data:
    X_0;$Ymin_0$; $Ymax_0$; X_1; $Ymin_1$; $Ymax_1$; X_2; $Ymin_2$; $Ymax_2$; X_3; $Ymin_3$; $Ymax_3$; ...
- Multi-channel, single acquisition export
  In the example, two channels are exported.
  - Normal waveforms:
    $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$; $YCh1_2$; $YCh2_2$; $YCh1_3$; $YCh2_3$; ...
  - Envelope waveforms, channel 1 and channel 2 are envelopes:
    $YCh1min_0$; $YCh1max_0$; $YCh2min_0$; $YCh2max_0$; $Ymin_1$; $Ymax_1$; $YCh2min_1$; $YCh2max_1$; $Ymin_2$; $Ymax_2$; $YCh2min_2$; $YCh2max_2$; $Ymin_3$; $Ymax_3$; $YCh2min_3$; $YCh2max_3$; ...
  - Normal waveforms, interleaved x/y data:
    X_0; $YCh1_0$; $YCh2_0$; X_1; $YCh1_1$; $YCh2_1$; X_2; $YCh1_2$; $YCh2_2$; X_3; $YCh1_3$; $YCh2_3$; ...
  - Envelope waveform and normal waveform, interleaved x/y data:
    X_0;$YCh1min_0$; $YCh1max_0$; $YCh2_0$; X_1; $YCh1min_1$; $YCh1max_1$; $YCh2_1$; X_2; $YCh1min_2$; $YCh1max_2$; $YCh2_2$; X_3; $YCh1min_3$; $YCh1max_3$; $YCh2_3$; ...

In XML and CSV waveform value files, the data of each sample is grouped. The example shows the values of two samples for two waveforms and interleaved x/y data. The first waveform is an envelope, the second one is a normal waveform.

In CSV files, the data values for a given sampling time is written in one row.

```
-1.96e-008    -0.0079051387     -0.0059288535     -0.1027668
-1.95e-008    -0.0098814229     -0.0079051387     -0.10474309
```

In XML format, an empty line marks the beginning of the next sample.

```
<Data>-1.96e-008</Data>
<Data>-0.0079051387 </Data>
<Data>-0.0059288535 </Data>
<Data>-0.1027668 </Data>

<Data>-1.95e-008</Data>
<Data>-0.0098814229 </Data>
<Data>-0.0079051387 </Data>
<Data>-0.1027668 </Data>
```

If multiple acquisitions (Data logging / Multiple waveforms) are exported, the first acquisition is written in the same way as with single acquisition export. The following acquisitions are appended in the same way. If the signal is a spectrum, the last frame of each acquisition is saved.

Before and after the waveform data, the instrument writes some leading and trailing settling samples. They ensure that all measurements can be performed on the reloaded waveform that could be performed on the original waveform. The number of leading settling samples is provided in the header file.

11.2.1.3 Number of Samples in the Export File

In this section, a sample is defined as one or more values acquired at a given sampling time. The number of samples for one channel and acquisition is given in the header file by the property `SignalHardwareRecordLength`. This number includes the number of required samples in the waveform and additional samples at the beginning (leading samples) and the end of the file (trailing samples).

The number of additional samples is:

No of additional samples = SignalHardwareRecordLength - SignalRecordLength

The number of leading additional samples is given in the header file: `LeadingSettlingSamples`.

The number of trailing additional samples is:

No of trailing additional samples = No of additional samples - LeadingSettlingSamples
= SignalHardwareRecordLength - SignalRecordLength - LeadingSettlingSamples

If the waveform has more than one Y-value per sample (e.g. envelope), the property `InterleavedTraceCount` is > 1, and the number of values in the file for this waveform is:

*No of values per waveform = InterleavedTraceCount * SignalHardwareRecordLength*

If multiple acquisitions are exported, the total number of values in the file is:

*No of values = InterleavedTraceCount * SignalHardwareRecordLength * No of exported acquisitions*

If "Interleaved x/y"is enabled, one horizontal value is added per sample. The total number of values in the file is:

*No of values = (1+ InterleavedTraceCount) * SignalHardwareRecordLength * No of exported acquisitions*

MSO option R&S RTO-B1:

If the data of digital channels is stored in BIN format, one bit is written for each sample. 8 data samples are written in one byte (data word). For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

11.2.2 Waveforms - Export Settings

In this tab, the storage settings for waveform data are defined.

☐ Multi channel   Source C1

Scope Full Waveform   Start -100 ns   Stop 100 ns

Data logging ☐   Export history ☐

RefCurve_2016-06-10_0_141404.bin   .bin

☐ Raw (ADC direct)   ☐ Interleaved x/y

See also: Chapter 11.2.6, "Saving and Loading Waveform Data", on page 466.

For details of data export in I/Q mode (option R&S RTO-K11), see Chapter 15.3, "I/Q Data Output", on page 1031.

Source
Selects the waveform to be exported if "Multichannel export" is disabled. Active waveforms of input channels, math signals and reference waveforms are available for export.

If the MSO option R&S RTO-B1 is installed, you can save also digital channels and parallel buses.

Remote command:
`EXPort:WAVeform:SOURce` on page 1478

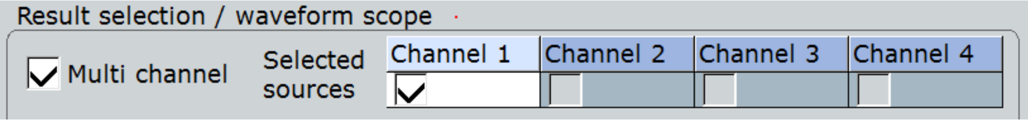
Multi-channel export
Enables or disables the export of multiple input channels. If enabled, you can export the data of selected input channels (Selected sources) into one file.

If disabled, you can export one Source waveform.

You can reload exported multiple channels if they are stored in BIN format. The import asks you to assign each stored waveform to a reference waveform.

Remote command:
`EXPort:WAVeform:MULTichannel` on page 1479

Selected sources
Select the channels to be included in data export if "Multichannel export" is enabled. Waveform1 of up to four input channels can be saved into one file.



Result selection / waveform scope

☑ Multi channel

Selected sources	Channel 1	Channel 2	Channel 3	Channel 4
	☑	☐	☐	☐

Remote command:
`CHANnel<m>:EXPortstate` on page 1479

Scope
Defines the part of the waveform record that has to be stored.

"Full waveform"	Saves the complete waveform record.
"Zoom"	Saves the data included in the zoom area if at least one zoom is defined for the source waveform. The start and stop values of the area are shown. If several zooms are defined, select the "Zoom" to be used for export.
"Cursor"	Saves the data between the cursor lines if at least one cursor measurement is defined for the source waveform. The start and stop values of the area between the cursor lines are shown. If several cursor sets are defined, select the "Cursor set" to be used for export.
"Gate"	Saves the data included in the measurement gate if a gated measurement is defined for the source waveform. Select the "Measurement" for which the required gate is defined. The start and stop values of the gate are shown.
"Manual"	Saves the data between user-defined "Start" and "Stop" values.

Remote command:
`EXPort:WAVeform:SCOPe` on page 1480
`EXPort:WAVeform:STARt` on page 1480
`EXPort:WAVeform:STOP` on page 1481
`EXPort:WAVeform:ZOOM` on page 1481

EXPort:WAVeform:CURSorset on page 1481
EXPort:WAVeform:MEAS on page 1482

Data logging / Multiple Wfms
The "Data logging / Multiple Wfms" setting enables the export of subsequent acquisitions of the selected waveforms. If "Export history" is disabled, the setting is named "Data logging", and it exports the data of a running Nx Single acquisition. If "Export history" is enabled, the setting is named "Multiple Wfms", and it exports the history waveform data to file.

If multiple acquisitions of one waveform are exported into a BIN file, the first acquisition can be reloaded as reference waveform.

"Data logging" enables the export of all waveforms of an Nx Single acquisition into one file. The waveform records are written in historical order one after the other, either the complete records or the sections as defined in "Scope". Set the number of acquisitions to be acquired and stored with "Acq. count". The maximum amount of data that can be written is shown in "Max. file size".

Enabling "Data logging" stops a running acquisition. To start the logging, tap Start Export or press SINGLE.

Pressing "Run cont" disables data logging.

Data logging ☑
Export history ☐
Acq count 1

If "Export history" is enabled, the option "Multiple Wfms" allows you to save several or all history waveforms. Define the part of the history to be exported using "Start acq" and "Stop acq".

Remote command:
EXPort:WAVeform:DLOGging on page 1482

Start Export
Starts an Nx Single acquisition series and simultaneously saves the waveform data to a file if data logging is enabled.

If "Export history" is enabled, the button starts the history replay and simultaneously saves the history waveforms.

Remote command:
RUNSingle on page 1204 (Nx Single acquisition)
CHANnel<m>[:WAVeform<n>]:HISTory:PLAY on page 1319 (history export)

Export history
Enables the history mode and the export of history waveforms to file. The setting is also available in the "History" dialog box under the designation"Show history".

To save one waveform from the history, enter the number of the required acquisition in "Acq index", and tap "Save".

To save several subsequent history waveforms, enable "Multiple Wfms" and define the range of the waveforms to be saved using "Start acq" and "Stop acq". These range settings are also available in the "History" dialog box. Start the history replay and simultaneous saving with "Start Export".

Remote command:

`CHANnel<m>[:WAVeform<n>]:HIStory[:STATe]` on page 1317

`CHANnel<m>[:WAVeform<n>]:HIStory:STARt` on page 1318

`CHANnel<m>[:WAVeform<n>]:HIStory:STOP` on page 1318

Timestamps

If enabled, the relative timestamps of all history waveforms are written into the waveform data file at the beginning of each waveform record.

Remote command:

`EXPort:WAVeform:TIMestamps` on page 1483

Save to file

Enter the filename to save the waveform to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file. See also Chapter 11.6, "File Selection Dialog", on page 478
".bin/.xml/.csv"	Selects the file format. Note that reference waveforms can be loaded from `.bin` files only. See also: Chapter 11.2.1, "Waveform Export Files", on page 449.

Remote command:

`EXPort:WAVeform:NAME` on page 1479

`EXPort:WAVeform:SAVE` on page 1480

Interleaved x/y
Includes horizontal values in the export data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written.

Interleaved x/y data cannot be exported as raw values, the "Raw (ADC direct)" option is not available.

The setting is not available for the export of digital channel data.

Remote command:
`EXPort:WAVeform:INCXvalues` on page 1483

Raw (ADC direct)
Enables the export of data in the raw sample format of the ADC. The data format is integer 8 bit (signed 8-bit binary format). This format reduces the file size (1 Byte/sample instead of 4 Bytes/sample in binary files) but decreases the precision of the values.

If the high definition mode is active (option R&S RTO-K17), the data format is integer 16 bit, except for peak detect decimation (8 bit). See "Export" on page 165.

Only y-values are exported, the "Interleaved x/y" option is not available.

Currently, the setting is not available for the export of digital channel data.

Data conversion:

To convert INT8 or INT16 data to physical quantities, e.g. voltages, use the following formulas:

ConversionFactor = *VerticalScale* * *VerticalDivisionCount* / *NofQuantisationLevels*

PhysicalQuantity = (*Value_ADC* * *ConversionFactor*) + *VerticalOffset*

The raw values are written in the `*.Wfm.*` file, all other values can be found in the corresponding header file.

	INT8	INT16, HD mode
VerticalScale	0.05	0.05
NofQuantisationLevels	253	253 * 256
VerticalDivisionCount	10	10
Value_ADC	-61	-61
ConversionFactor	0.05 * 10 / 253 = 0.00197628	0.05 * 10 / (253 * 256) = 0.0000771986
Voltage	(-61 * 0.00197628) + 0 = -120.5 mV	(-61 * 0.0000771986) + 0 = -4.7091146 mV

Remote command:
`EXPort:WAVeform:RAW` on page 1483

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 1182

11.2.3 Waveform Histograms

Access: SAVE RECALL > "Waveforms/Results > Wfm Histograms"

The waveform histogram export saves data in two files. The `*.Wfm.*` file contains 256 or 512 absolute or relative histogram values. The other file is the header file.

Contents of the header file:

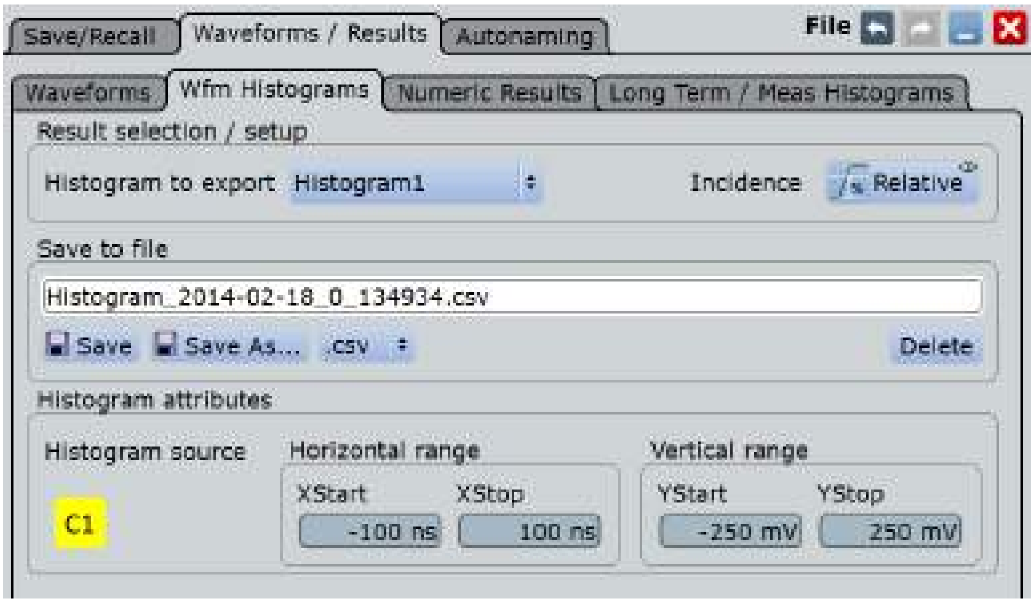
- Source waveform of the histogram
- Histogram mode: vertical or horizontal
- Incidence of exported values: absolute or relative
- Histogram range: XStart, XStop, YStart, YStop
- Name of the exported histogram

Data conversion:

Using the header data, you can calculate the waveform value to which a histogram value belongs:

*YValue = (YStop - YStart) / HistogramValuesCount * HistogramValueNumber + YStart*

YStart	-0.25 V
YStop	0.25 V
HistogramValuesCount	256 (total number of written rows in a CSV file)
HistogramValueNumber	68 (number of the row in a CSV file)
Y-Value	(0.25 - (-0.25)) / 256 * 68 - 0.25 = -0.11719 V



Histogram to export: Histogram1

Incidence: Relative

Histogram_2014-02-18_0_134934.csv

.csv

Histogram source: C1

Horizontal range: XStart -100 ns, XStop 100 ns

Vertical range: YStart -250 mV, YStop 250 mV

Histogram to export
Selects the histogram to be exported. All active waveform histograms are shown in the list.

Measurement histograms can also be exported, see Chapter 11.2.5, "Long Term / Meas Histograms", on page 464.

Remote command:
`EXPort:HISTogram:SELect` on page 1484

Incidence
Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1484

Save to file
Enter the filename to save the waveform histogram to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "Histogram_". You can define a pattern for automatic naming in the "Autonaming" tab. The default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTO\Histograms`

"Save"	Saves the histogram data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the histogram data to the selected file. See also Chapter 11.6, "File Selection Dialog", on page 478
".bin/.xml/.csv"	Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1485
`EXPort:HISTogram:SAVE` on page 1485
`EXPort:HISTogram:DATA?` on page 1485

Histogram source, Horizontal range, Vertical range
Show the source and the limits of the histogram area for information. The ranges are set in the "Histogram" dialog box ("Meas" menu > "Histogram"). See also: Chapter 7.2.8.2, "Histogram Setup", on page 350.

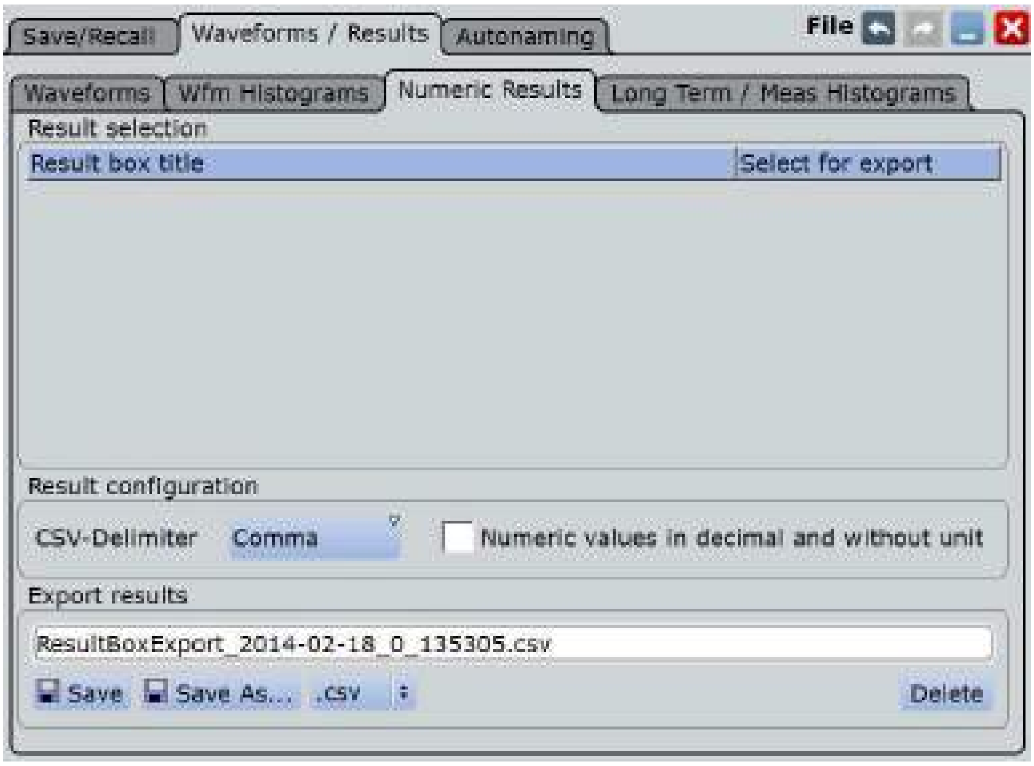
11.2.4 Numeric Results

In this tab, you can select the result boxes to be saved, and define the storage settings.

Access: SAVE RECALL > "Waveforms/Results > Numeric Results"

Access to the tab is available in all tabs where measurement and analysis settings are defined, for example, in the "Measurements Setup", "Cursors Setup", and "Masks Test Definition" tabs: Simply tap the "Result Export" button.

Furthermore, you can export the decode result tables of serial protocol analysis.



CSV-Delimiter: Comma

☐ Numeric values in decimal and without unit

ResultBoxExport_2014-02-18_0_135305.csv

Result selection
The table lists all result boxes and decode tables that are currently open, including minimized boxes and docked boxes. Select the results that you want to save to file. All results are written into one file.

Note: If the result box is minimized, only the columns shown on the result icon are saved (2 columns). Statistical results are not shown on the minimized results icon, and they are not saved.

CSV-Delimiter
Selects the value delimiter that is used to convert the values in columns. For MS Excel, the semicolon is recommended to be used.

Numeric values without unit
By default, numeric result values are written with their unit to the file. If the option is enabled, the values are saved with more decimal places.

Export results
Enter the filename to save the results to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "ResultBoxExport_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save" Saves the selected results to the indicated file.

"Save As..."	Opens the file selection dialog box and saves the selected results to the selected file. See also Chapter 11.6, "File Selection Dialog", on page 478
".csv/.html"	Selects the file format. ● CSV: comma-separated values. You can select the value delimiter with "CSV-Delimiter" to ensure that the file can be read by the analyzing software. The decimal separator is the point. Tip for using MS Excel: It is recommended that you use the semicolon as csv delimiter. When you open the file with MS Excel, use "File > Open" and follow the wizard to set the separators correctly, or set the separator settings with "Tools > Options > International". ● HTML: Results are saved as web page for display in a browser.

11.2.5 Long Term / Meas Histograms

Access: SAVE RECALL > "Waveforms / Results" > "Long Term / Meas Histograms"

You can export the data of long-term measurements and the measurement histogram data to file .

The measurement export saves results in two files. The `*.Wfm.*` file contains data values, and the other file is the header file.

The header file contains:

- Source waveform of the measurement
- Measurement scale
- Export type = Histogram or Long term
- Exported measurement
- Histogram range: XStart, XStop, YStart, YStop
  The range is only relevant for export type = histogram. The measurement axis is the X-axis, which can be a horizontal or vertical axis depending on the histogram mode.

Long-term measurements: The `*.Wfm.*` file contains one value or value set for each long-term measurement point. The maximum number of points is defined in the "Horizontal scaling" dialog box.

- If statistics are disabled, the current result of the main measurement is written - one double value per long-term point.
- If statistics are enabled, seven values for each long-term point are saved:
  - Current value of the long-term point
  - Upper peak
  - Lower peak
  - Average
  - Standard deviation

  - Event count per point: number of measurement results that creates one long-term point
  - Waveform count per point: number of waveforms included in one long-term point.

Measurement histogram: The `*.Wfm.*` file contains 1000 absolute or relative histogram values.

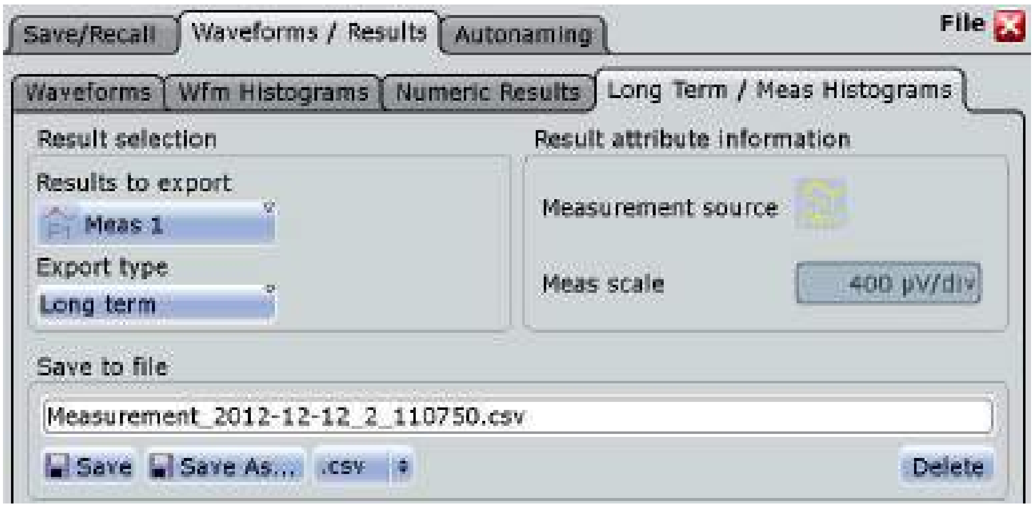
Data conversion of measurement histogram data:

Using the header data, you can calculate the measurement value to which a histogram value belongs:

*MeasValue = (XStop - XStart) / 1000 * HistogramValueNumber + XStart*

Example: The 273rd histogram value is 0.491749. That means, the relative frequency of the measurement value 0.1246 V is 0.491749.

XStart	0.07 V
XStop	0.27 V
HistogramValueNumber	273 (number of the row in a CSV file)
MeasValue	(0.27 - 0.07) / 1000 * 273 + 0.07 = 0.1246 V



Results to export: Meas 1

Export type: Long term

Measurement source

Meas scale: 400 µV/div

Measurement_2012-12-12_2_110750.csv

Results to export
Selects the measurement to be exported.

Remote command:
`EXPort:MEASurement:SELect` on page 1485

Export type
You can export the result data of the long-term measurement, or the measurement histogram. To export the data, the required type must be enabled in "Measurements > Long Term/Track": "Long term Enable" or "Histogram Enable".

Remote command:
`EXPort:MEASurement:TYPE` on page 1486

Incidence
Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1484

Measurement source, Meas scale
Show the measurement settings source and scale for information.

Save to file
Enter the filename to save the measurement data to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "Measurement_". You can define a pattern for automatic naming in the "Autonaming" tab. The default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTO\Measurements`

"Save"	Saves the measurement data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the measurement data to the selected file. See also Chapter 11.6, "File Selection Dialog", on page 478
".bin/.xml/.csv"	Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1485
`EXPort:MEASurement:SAVE` on page 1486
`EXPort:MEASurement:DATA?` on page 1487

11.2.6 Saving and Loading Waveform Data

You can save the data of a channel, math or reference waveform to an `.xml`, `.csv`, or `.bin` file. The data export of several channels into one file is also possible. Files in `.bin` format can be reloaded to the R&S RTO as reference waveforms.

Instead of a complete waveform, you can also save a part of it, limited by a previously defined zoom, cursor lines, measurement gate or user-defined time values.

To save waveform data quickly, you can add the "Save Waveform" icon to the toolbar and use it for saving. The icon does not work for saving actions that are started with "Start export" (data logging and multiple history waveforms).

It is also possible to save history data to file. Furthermore, you can save a "live record" of a running RUN Nx SINGLE acquisition to one data file.

For details on waveform save/recall settings, see Chapter 11.2.2, "Waveforms - Export Settings", on page 456.

The following procedures are described:

- "To save a waveform or a part of a waveform to a file" on page 467
- "To save a waveform using the toolbar icon" on page 467

- "To export waveform data of a running acquisition" on page 467
- "To save the history data" on page 287
- "To load a reference waveform" on page 262
  "To save a reference waveform" on page 261

To save a waveform or a part of a waveform to a file

1. Press the SAVE RECALL key.
2. Tap the "Waveforms/Results" tab.
3. Tap the "Waveforms" subtab.
4. Select the waveforms to be saved:
   - To save one waveform, tap the "Source" icon and select the waveform.
   - To save data of several channels, enable "Multi channel" and select the channels.
5. In the "Scope" list, select the part of the waveform record to be saved. Zoom, cursor and gate segments require the same setup for the selected waveform before saving. For "Manual", enter the "Start" and "Stop" time of the section.
6. Check the filename under "Save to file" and change it if needed. Usually, autonaming is used.
7. Check the file format and the "Export format" settings and change them if needed.
8. Tap "Save" to save the waveform data to the specified file.
   Tap "Save As" to save the waveform data to a different file or file type. Select the file from the file selection dialog box.

To save a waveform using the toolbar icon

1. Add the "Save Waveform" icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.
2. Set the scope, export format, and other parameters in SAVE RECALL > "Waveforms / Results" > "Waveforms".
3. If necessary, adjust the autonaming pattern and the storage path in SAVE RECALL > "Autonaming".
4. To save the waveform data:
   a) Tap the "Save Waveform" icon on the toolbar.
   b) Tap the waveform to be saved.
      If you tap the diagram background, the data of the focused waveform is saved.

To export waveform data of a running acquisition

1. Select the waveforms to be saved and the scope as described in "To save a waveform or a part of a waveform to a file" on page 467, step 1 to 5.

2. If you want to save only a section of each waveform, set the "Scope".
3. Enable "Data logging".
4. Enter the number of acquisitions to be acquired and saved in "Acq count".
5. Check the filename under "Save to file" and change it, if needed. Usually, autonaming is used.
6. Tap "Start Export" to start the acquisition and to save the acquired waveform data to the specified file.

To load waveform data as a reference waveform

To reload waveform data from a previous measurement, the waveform must have been stored as a reference waveform in a BIN file before.

The procedure is described in "To load a reference waveform" on page 262

11.3 Screenshots

To store the graphical results of the measurement, you can either print the current display on a printer or save an image to a file. The instrument saves or prints a screenshot of the graphic area. To document current settings, the open dialog box can be included in the screenshot.

The "Save Screenshot" toolbar icon saves the current display to a file according to the settings in "File" menu > "Print setup". See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.

You can configure the CAMERA key to save or print screenshots by a single keypress. See also Chapter 3.3.2, "Hardkeys: Function Assignment", on page 106.

If you want to save all user data (for example screenshots, waveform data, settings...) to a USB flash drive, change the default path of the user data directory: SAVE RECALL > "Autonaming" tab > "Default path for all file operations" > tap the USB flash drive symbol in the file explorer.

Screenshots on a computer using the Web interface

If the R&S RTO is connected to a LAN, you can create and save screenshots of the instrument's display on a computer. See Chapter 19.3.2, "LXI Web Browser", on page 1140.

Meta information in screenshots

The meta data of the screenshot also contains instrument information. In PNG and JPEG files, meta information is saved as EXIF information and can be read, for example, using the ExifTool.

Example:

Reading meta information using the ExifTool

Command: `# exif C:\Screenshot_2016-07-14_0_110551.png`

Result:

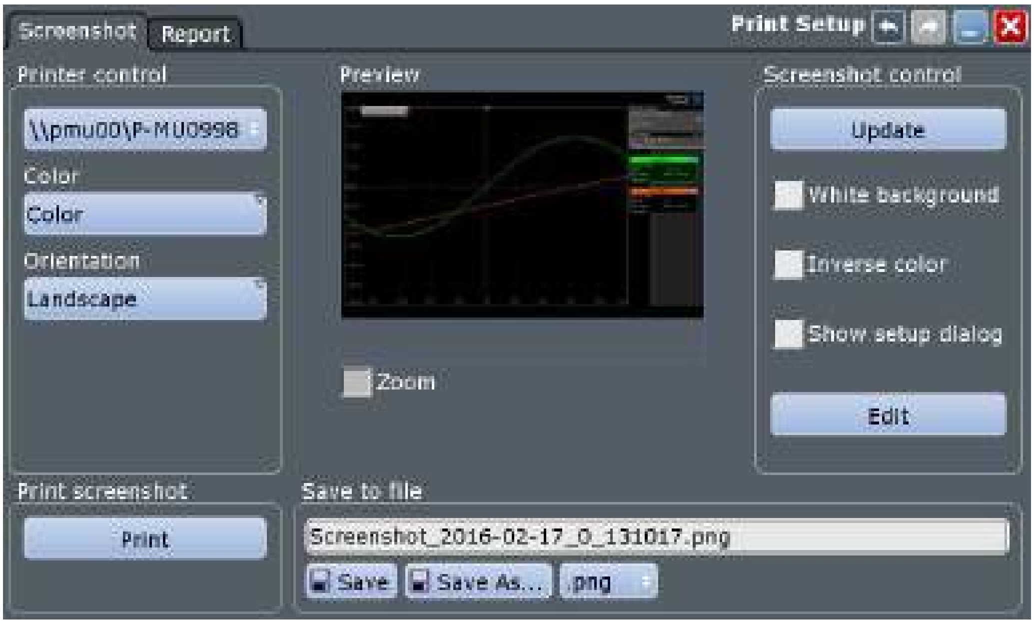
```
ExifTool Version Number          : 10.20
File Name                        : Screenshot_2016-07-14_0_110551.png
Directory                        : C:/
File Size                        : 37 kB
File Modification Date/Time      : 2016:07:14 11:05:51+02:00
File Access Date/Time            : 2016:07:14 11:05:51+02:00
File Creation Date/Time          : 2016:07:14 11:05:51+02:00
...
Instrument Firmware Version      : 3.30.0.46
Instrument Material Number       : 1329.7002k44
Instrument Serial Number         : 123456
Image Size                       : 1280x800
Megapixels                       : 1.0
```

11.3.1 Screenshot Settings

Access: "File" menu > "Print setup"

In the "Screenshot" dialog box, you configure the image to be printed, saved, or included in a report. You select the printer and the storage location for screenshot files. In addition, you can edit the image before saving or printing, and include an open dialog box in the image. The image is created when you open the dialog box, and can be updated at any time.

You can print and save the image in the "Screenshot" dialog box. To save screenshots quickly, use the "Save Screenshot" toolbar icon, or configure and use the CAMERA key.



Printer: \\pmu00\P-MU0998

Color: Color

Orientation: Landscape

Save to file: Screenshot_2016-02-17_0_131017.png, png

Printer

Selects a configured printer to print screenshots and reports. You can use a local printer or a network printer. The instrument firmware uses the Windows printer configuration, no additional printer setup is required. To make a printer available for R&S RTO, add and configure it in the Windows operating system: "Devices and Printers"

Depending on the printer driver, printing to a file is also possible. By default, the "RS Printer" drivers for JPG, PDF, PNG, and TIFF files are installed. To configure the name and storage location of the printed files, open the Windows printer configuration window (see above) and select "File > Printing Preferences > Save" for the required driver.

Remote command:
`SYSTem:COMMunicate:PRINter:SELect<1..2>` on page 1492

Color

Defines the color mode for printing. The setting affects the output on a printer and also the printing to a file using the "RS Printer" drivers for JPG, PDF, PNG, and TIFF files.

"Black and white"	Black and white output
"Color"	Color output

Remote command:
`HCOPy:DEVice<m>:COLor` on page 1489

Orientation
Toggles the page orientation between "Landscape" and "Portrait."

Remote command:
`HCOPy:PAGE:ORIentation<1..2>` on page 1489

Print
Prints the current image together with saved editing changes on the selected Printer.

If the printer is configured to print to a file, "Print" is an alternative of "Save image to file".

Remote command:
`HCOPy:DESTination<1..2>` on page 1488
`HCOPy:IMMediate<m>[:DUM]` on page 1490
`HCOPy:IMMediate<m>:NEXT` on page 1491

Preview
Shows a preview of the screenshot. The image is created when the dialog box opens.

Zoom ← Preview
Enlarges the preview display and adds scrollbars to zoom into specific areas of the print image. Zooming does not affect the original display.

Update
Updates the preview of the screenshot with the current display view, e.g. after changes to the settings have been made, or an additional channel has been activated.

White background
Inverts the background color. So you can print waveforms with normal waveform colors on white background.

Remote command:
`HCOPy:WBKG` on page 1490

Inverse color
Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

Remote command:
`HCOPy:DEVice<m>:INVerse` on page 1489

Show setup dialog
If you want to save dialog boxes in screenshots, enable "Show setup dialog". The currently open dialog box is included in the screenshot. Use the CAMERA key to print or save the display.

Remote command:
`HCOPy:SSD` on page 1490

Edit

Opens the screenshot in the Paint application. Edit the image as necessary. You can store the file using "Save as" or print the file from Paint. Alternatively, save the file and close the Paint application to return to the "Print Setup" dialog, then print or save the edited image. The changes are not shown in the preview.

Save to file

Defines the filename to which screenshot is saved. By default, the filename has the prefix "Screenshot_". Double-tap the filename to open the file selection dialog box.

If you want to save all user data (for example screenshots, waveform data, settings...) to a USB flash drive, change the default path of the user data directory: SAVE RECALL > "Autonaming" tab > "Default path for all file operations" > tap the USB flash drive symbol in the file explorer.

"Save"	Saves the current screenshot to the specified file.
"Save As..."	Opens the file selection dialog box. Here you can adjust the target directory and the file name and save the current screenshot to the file. The symbols of important target folders are listed on the left of the file explorer.
"Delete"	Opens the file selection dialog box and deletes the selected file.

Remote command:
`HCOPy:DEVice<m>:LANGuage` on page 1488
`HCOPy:DESTination<1..2>` on page 1488
`MMEMory:NAME` on page 1488
`HCOPy:IMMediate<m>[:DUM]` on page 1490
`HCOPy:IMMediate<m>:NEXT` on page 1491
`MMEMory:DELete` on page 1473

11.3.2 Printing Screenshots

You can configure the format and colors used for printing, and edit the image.

1. Open the "File" menu and select "Print setup". You can use a local printer or a network printer. Depending on the printer driver, printing to a file is also possible. See also "Printer" on page 470.
2. Tap the printer selection box and select the printer.
3. Tap the "Color" selection box to configure black and white or color images.
4. Tap the "Orientation" selection box and select the paper format.
5. To enhance the images for print on white paper, enable "White background" or "Inverse color".

6. If the current display is likely to have changed since you have opened the "Print Setup" dialog box (e.g. due to a running measurement), tap "Update image".

   The screenshot is updated.
7. To zoom into the screenshot, enable the "Zoom" option beneath the preview area.

   The image is enlarged and scrollbars are displayed to scroll through the image.
8. To edit the image in an external application and process it further from there, tap "Edit image".
9. To print the image to the selected printer, tap "Print".

11.3.3 Configuring and Saving Screenshots

You can edit the image, invert all colors, and set the background color. A preview of the current image is shown for reference.

1. Open the "File" menu and select "Print setup".
2. To enhance the images for later print on white paper, enable "White background" or "Inverse color". If you print this image later on a monochrome printer, you get a grayscaled picture. The contrast of the resulting gray lines depends on waveform colors and the used printer.
3. Select the file format: png, jpg, or another one.
4. By default, screenshots are saved in the `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ScreenShots` directory. To change the directory, tap "Save As" and configure the path. The symbols of important target folders are listed on the left of the file explorer.
5. Tap "Save".

   The file is saved and the dialog box closes.
6. Check if the screenshot was saved to the desired directory.
7. To save further screenshots, use one of the following ways:
   - Configure the CAMERA key. Press the key to save a screenshot. See also Chapter 3.3, "Frontpanel Setup", on page 106.
   - Add the "Save Screenshot" icon to the toolbar. Tap the icon to save an image. See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.
   - In the "Print setup" dialog box, tap "Save" to save the image to the specified file.
   - To save the image with a dedicated filename or to another directory, open the "Print setup" dialog box and tap "Save As". Select the path, enter a filename, and tap "Save".

Printing on a black-and-white printer

- If you use the "White background" or "Inverse color" settings and save the image to a file, you get a grayscaled picture. The contrast of the resulting gray lines on the printout depends on waveform colors and the used printer.
- To get a monochrome image, set the "Color = Black and white" and tap "Print" to start the direct printout or the print to file. See also "Printer" on page 470.

11.4 Reports

Reports document the current measurement and test results. The report contains general information, current vertical and horizontal settings, trigger settings, active channels and all current results except for zoom and search results. A screenshot is also included.

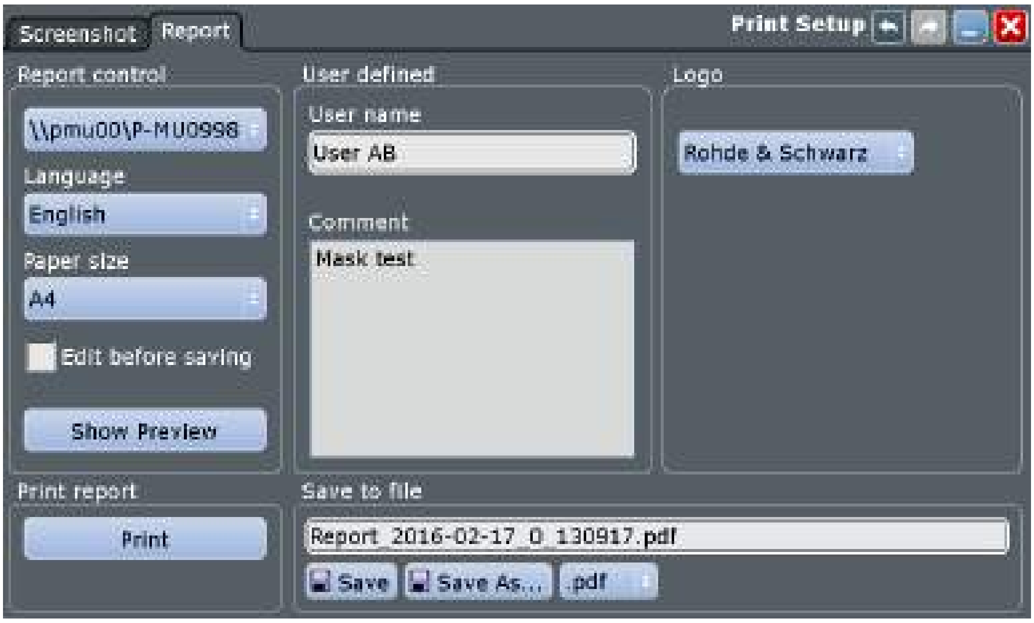
The report is configured in the "Report" tab, the screenshot is configured in the "Screenshot" tab.

You can create the report manually, or automatically on defined events:

- Press the CAMERA key. Before, configure the key to create or print reports, see Chapter 3.3, "Frontpanel Setup", on page 106
- Tap the "Create report" toolbar icon.
  Before, add the icon to the toolbar, see also Chapter 2.4.5.2, "Configuring the Toolbar", on page 85.
- Action on micro button, available on active Rohde & Schwarz probes
- Action on trigger
- Event action at mask testing
- Event action at limit checks

11.4.1 Report Settings

Access: "File" menu > "Report Setup"



\\pmu00\P-MU0998

Language: English

Paper size: A4

☐ Edit before saving

User name: User AB

Comment: Mask test

Logo: Rohde & Schwarz

Report_2016-02-17_0_130917.pdf

.pdf

Printer
See "Printer" on page 470.

Language
Selects the language to be used in the report. Available languages are listed in the data sheet.

Remote command:
`REPort:LANGuage` on page 1492

Paper size
Selects the paper size: A4 or US Letter.

Remote command:
`REPort:PAPersize` on page 1492

Edit before saving
Enable to edit the report info when you save reports using the CAMERA key. When you press the key, a dialog box opens where you can change the user name and the comment.

Show Preview
Opens the current report in PDF format.

User name / Comment
Enter information that appears in the general information section at the beginning of the report.

Remote command:
`REPort:USER` on page 1493
`REPort:COMMent` on page 1493

Logo
By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown. A preview of the selected log file is shown.

Remote command:
`REPort:LOGType` on page 1492
`REPort:LOGO` on page 1493

Print
Starts the printout to the configured printer.

Save to file
Select the file format and define the filename of the report file. By default, the filename has the prefix "Report_".

Double-tap the filename to open the file selection dialog box.

"pdf/doc/html"	Selects the report format.
"Save"	Saves the current report to the specified file.
"Save As..."	Opens the file selection dialog box and saves the report to the selected file.

Remote command:
`REPort:FILE:NAME` on page 1493
`REPort:FILE:SAVE` on page 1493

11.5 Autonaming

In this tab you can define the pattern for automatic file name generation. This name is used as the default file name. The default path is the storage location for all saved files and their subdirectories.

eg: Prefix_<UserText>_<Date>_<Index>_<Time>.xml

☑ Prefix ☐ User text ☑ Date ☑ Index ☑ Time

C:\Users\Public\Documents\Rohde-Schwarz\RTx

11.5.1 Autonaming Settings

Prefix
If enabled, inserts the default prefix in the file name. The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

Remote command:
`MMEMory:AUTonaming:PREFix` on page 1476

Text input
User-defined text to be inserted after the prefix.

Remote command:
`MMEMory:AUTonaming:TEXT` on page 1477

User text (enable)
If enabled, inserts the specified user text after the prefix.

Remote command:
`MMEMory:AUTonaming:USERtext` on page 1476

Date
If enabled, inserts the current date.

Remote command:
`MMEMory:AUTonaming:DATE` on page 1476

Index
If enabled, inserts an index.

Remote command:
`MMEMory:AUTonaming:INDex` on page 1477

Time
If enabled, inserts the current time.

Remote command:
`MMEMory:AUTonaming:TIME` on page 1477

Default path for all file operations
Defines the default path displayed in the file selection dialog box for loading and storing operations.

Remote command:
`MMEMory:AUTonaming:DEFaultpath` on page 1477

Reset
Resets the default file path.

Remote command:
`MMEMory:AUTonaming:RESPath` on page 1477
`MMEMory:AUTonaming:RESall` on page 1477

11.5.2 Defining Default File Paths and Names

When a save or load operation is performed, a default file name and path is provided. You can configure which path is used and how the file name is generated. In the file selection dialog box you can change the folder and name as desired.

To define the default file path

1. Press the SAVE RECALL key.
2. Select the "Autonaming" tab.
3. Double-tap the "Default path for all file operations" field.

   The directory selection dialog box is opened.
4. Select the folder in which the data is to be stored by default.
5. To restore the factory-set default path, tap "Reset" next to the path field.

To define the automatic file name pattern

The automatic file name pattern can consist of the following elements:

<Prefix>_<UserText>_<Date>_<Index>_<Time>

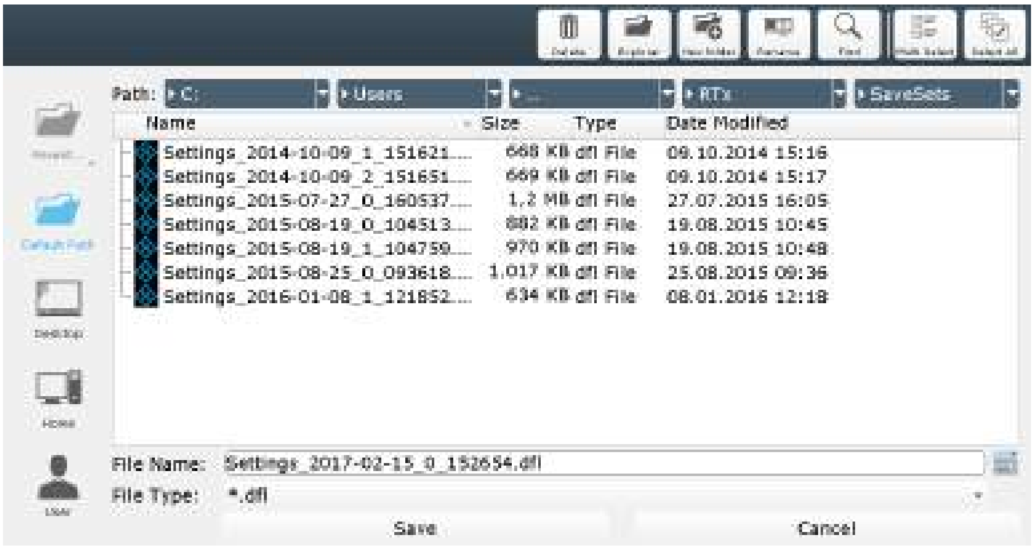
The prefix depends on the data type to be stored and cannot be changed by the user. The other elements can be enabled or disabled as required.

1. Press the SAVE RECALL key.
2. Select the "Autonaming" tab.
3. To insert a user-defined text after the prefix, enter the text in the edit field. and enable "User text".
4. If you want to exclude the prefix, current date, time or an index (serial number), disable the corresponding option.

   The specified elements are used to generate the default file name for the next storage operation.

11.6 File Selection Dialog

The file selection dialog provides a file explorer from which you can select a file to load or to save data to. You can also manage your files in this dialog.



Path: C: | Users | ... | RTx | SaveSets

Name	Size	Type	Date Modified
Settings_2014-10-09_1_151621....	668 KB	dfl File	09.10.2014 15:16
Settings_2014-10-09_2_151651....	669 KB	dfl File	09.10.2014 15:17
Settings_2015-07-27_0_160537....	1,2 MB	dfl File	27.07.2015 16:05
Settings_2015-08-19_0_104513....	882 KB	dfl File	19.08.2015 10:45
Settings_2015-08-19_1_104759....	970 KB	dfl File	19.08.2015 10:48
Settings_2015-08-25_0_093618....	1,017 KB	dfl File	25.08.2015 09:36
Settings_2016-01-08_1_121852....	634 KB	dfl File	08.01.2016 12:18

File Name: Settings_2017-02-15_0_152654.dfl

File Type: *.dfl

Save

Cancel

Path

Tap the path elements to change the current folder. The default folder is defined in Default path for all file operations.

You can save the data in a local folder on the instrument, to an external storage device (usually a USB flash drive), or to an folder on a connected network drive. The path list provides all available drives and folders.

On the left, shortcut icons provide access to often used folders.

Toolbar

The toolbar on the top provides various functions for file management.

File Name

The file name to be loaded or stored to. Double-tap the file name, or tap the keyboard icon to enter the file name using the online keyboard.

The default file name for new files is defined in the "Autonaming" tab, see Chapter 11.5, "Autonaming", on page 476.

File Type

The file extension of the file to be loaded or stored to.

Save, Select

Selects the specified file for the open or save operation and closes the dialog box.

Cancel

Closes the dialog box without selecting a file.

12 Protocol Analysis

Using the serial protocol options for the R&S RTO, you can analyze various serial protocols.

12.1 Basics of Protocol Analysis

Before you can analyze a serial signal, the bus has to be configured according to the protocol and specifics of the signal. The configuration contains:

- Assignment of the data and clock lines to the input channels
- Logical thresholds
- Protocol-specific settings

Serial data can be analyzed in several ways:

- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, or on specified data patterns in the message.
  Triggering on a trigger event sequence is not supported, and holdoff settings are not available.
  For all serial protocols except for SPI, I²C and UART, triggering requires an option.

- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decode results are listed in a table.
  For all serial protocols, decoding requires an option.
- Search on decoded signal data: For most serial protocols, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, because several event types can be combined. Thus, you get the results for the complete acquisition cycle.

12.1.1 Configuration - General Settings

For all protocols, configuration starts with the selection of the serial bus and the protocol. The "Trigger Setup" button leads directly to the trigger configuration.

Table 12-1: Configuration settings are protocol-specific. They are described in the related chapters:

ARINC 429	Chapter 12.10.2, "ARINC 429 Configuration", on page 639
Audio	Chapter 12.8.2, "Audio Signal Configuration", on page 598
CAN, CAN FD	Chapter 12.5.1, "CAN and CAN-FD Configuration", on page 527
Custom: Manchester / NRZ	Chapter 12.16.2, "Custom: Manchester / NRZ Configuration", on page 780
CXPI	Chapter 12.24.2, "CXPI Configuration", on page 951
Ethernet 10BASE-T and 100BASE-TX	Chapter 12.11.2, "Ethernet Configuration", on page 652
FlexRay	Chapter 12.7.1, "FlexRay Configuration", on page 579
I²C	Chapter 12.2.2, "I²C Configuration", on page 491
LIN	Chapter 12.6.2, "LIN Configuration", on page 566
MDIO	Chapter 12.18.2, "MDIO Configuration", on page 821
MIL-1553	Chapter 12.9.2, "MIL-STD-1553 Configuration", on page 620
MIPI D-PHY	Chapter 12.14.2, "D-PHY Configuration", on page 726
MIPI M-PHY	Chapter 12.15, "M-PHY (Option R&S RTO-K44)", on page 745
MIPI RFFE	Chapter 12.13.2, "RFFE Configuration", on page 703
SENT	Chapter 12.12.2, "SENT Configuration", on page 671
SpaceWire	Chapter 12.22.2, "SpaceWire Configuration", on page 907
SPI	Chapter 12.3.2, "SPI Configuration", on page 507
UART	Chapter 12.4.2, "UART Configuration", on page 520
USB	Chapter 12.19.2, "USB Configuration", on page 842
8b/10b	Chapter 12.17.2, "8b/10b Configuration", on page 808

Protocol: I2C

Make sure that the tab of the correct serial bus is selected on the left side.

Protocol
Defines protocol type of the bus for bus configuration and trigger settings.

Remote command:
`BUS<m>:TYPE` on page 1494

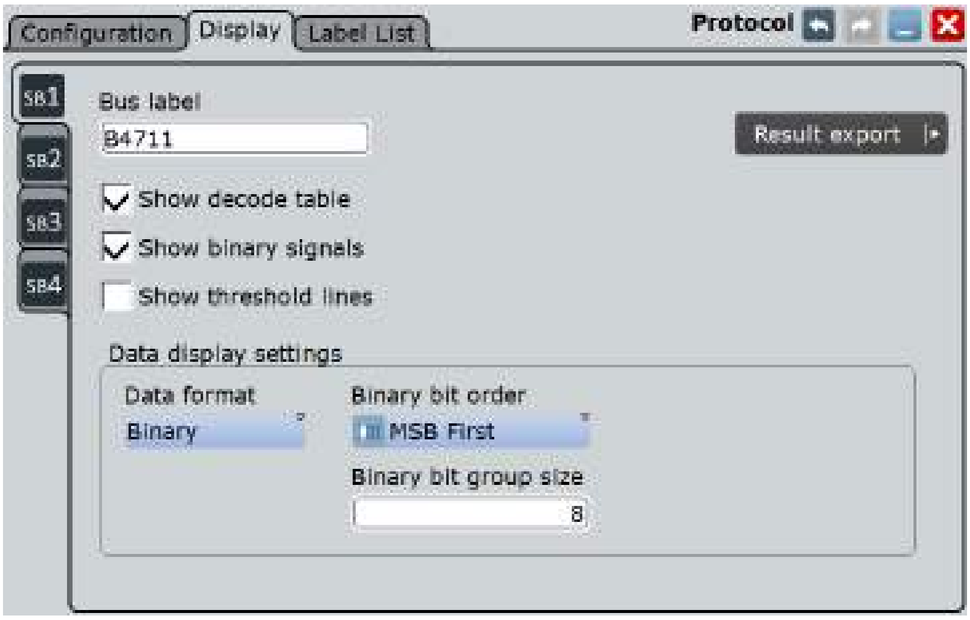
Decode
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Note: Exception for I²C, SPI, and UART signals:. The decode function is only available if the appropriate protocol option is installed. The bus can be used as trigger source without any option, provided that the bus is configured correctly.

Remote command:
`BUS<m>[:STATe]` on page 1495

12.1.2 Display

For all protocols, you can select to display the decoded signal as a table and to show the binary signal on the screen. Optionally, you can assign a label to the bus.



Bus label: B4711

☑ Show decode table

☑ Show binary signals

☐ Show threshold lines

Data format: Binary

Binary bit order: MSB First

Binary bit group size: 8

For some protocols, the result table provides a button to show the details of the selected frame.

Bus label

Defines a label to be displayed with the bus.

Remote command:
`BUS<m>:LABel` on page 1496

Show decode table

Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Table 12-2: Decode results are protocol-specific. They are described in the related chapters:

ARINC 429	Chapter 12.10.5, "ARINC 429 Decode Results", on page 645
Audio	Chapter 12.8.4, "Audio Decode Results", on page 607
CAN, CAN FD	Chapter 12.5.4, "CAN and CAN FD Decode Results", on page 546
Custom: Manchester / NRZ	Chapter 12.11.4, "Ethernet Decode Results", on page 658
CXPI	Chapter 12.24.5, "CXPI Decode Results", on page 968
Ethernet 10BASE-T and 100BASE-TX	Chapter 12.11.4, "Ethernet Decode Results", on page 658
FlexRay	Chapter 12.7.4, "FlexRay Decode Results", on page 588
I²C	Chapter 12.2.5, "I²C Decode Results (Option R&S RTO-K1)", on page 499
LIN	Chapter 12.6.5, "LIN Decode Results", on page 573
MDIO	Chapter 12.18.5, "MDIO Decode Results", on page 829
MIL-1553	Chapter 12.9.5, "MIL-STD-1553 Decode Results", on page 630
MIPI D-PHY	Chapter 12.14.4, "D-PHY Decode Results", on page 736
MIPI M-PHY	Chapter 12.15.4, "M-PHY Decode Results", on page 762
MIPI RFFE	Chapter 12.13.5, "RFFE Decode Results", on page 717
SENT	Chapter 12.12.5, "SENT Decode Results", on page 691
SpaceWire	Chapter 12.22.4, "SpaceWire Decode Results", on page 914
SPI	Chapter 12.3.4, "SPI Decode Results (Option R&S RTO-K1)", on page 514
UART	Chapter 12.4.4, "UART Decode Results (Option R&S RTO-K2)", on page 525
USB	Chapter 12.19.4, "USB Decode Results", on page 856
8b/10b	Chapter 12.17.4, "8b/10b Decode Results", on page 815

Remote command:
`BUS<m>:RESult` on page 1496

Show binary signals
For each configured line, the binary signal is displayed additionally to the decoded signal.

Show threshold lines
If selected, the threshold levels are displayed in the diagram.

Remote command:
`BUS<m>:THReshold` on page 1496

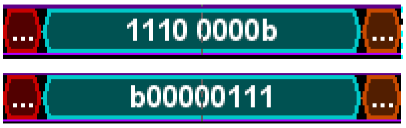
Data format
Sets the data format for decoded data values of the selected bus in the "Decode results" box and in the combs of the decoded signal.

Remote command:
`BUS<m>:FORMat` on page 1497

Binary bit order
Select MSB or LSB to define the data bit order in the combs of the decoded signal. The setting is only available for the binary data format, and only for protocols sending data LSB first (UART, SPI, LIN, Audio, ARINC429).

If the "Binary bit order" is LSB, you can read the bits of an LSB first signal in LSB first order in the combs, while the results table displays the correct values MSB first.

Binary bit group size
Sets the number of bits that forms a bit group in the comb display of the selected bus. The setting is only available for the binary data format, and only for protocols sending data LSB first (UART, SPI, LIN, Audio, ARINC429).



MSB first, bit group size = 4

LSB first, bit group size = 8

Result export
Opens the "File" dialog box. Select the "Waveforms/Results" tab > "Numeric" subtab to save the decode results to file.

Show details
Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Remote command:
`BUS<m>:RESDetail` on page 1496

12.1.3 Label Lists

For all protocols using ID or address identification, it is possible to create label lists containing addresses or IDs, a symbolic name for each node (symbolic label), and some protocol-specific information.

You can load label lists, and activate its usage for decoding. As a result, an additional "Label" column appears in the "Decode results" table, containing the symbolic label. The frame captions of the decoded signal show the symbolic label instead of the ID or address values so it is easy to identify the messages of the different bus nodes.

You can also also use the label list to trigger on an identifier or address. Instead of entering the value, you select the name, which is defined in the label list.

Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:

- Chapter 12.2.4, "I²C Label List", on page 498
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 544
- Chapter 12.6.4, "LIN Label List", on page 571
- Chapter 12.7.3, "FlexRay Label List", on page 587
- Chapter 12.10.4, "ARINC 429 Label List", on page 645
- Chapter 12.9.4, "MIL-STD-1553 Label List", on page 629

12.1.3.1 Content and Format of the PTT File

Label lists are stored as PTT (protocol translation table) files. The PTT file format is an extension of the CSV format (comma-separated values). You can edit it with standard editors, for example, with MS Excel or a text editor.

The PTT file has three types of lines:

- Comment lines begin with a hash character #. A hash character at any other position in the line is treated like a standard character.
- Command lines begin with a commercial at character @. An @ character at any other position in the line is treated like a standard character.
- Standard lines are the lines that not qualify as comment or command lines. They build the core of the label list.

Command lines

Command lines define the version of the PTT file and the protocol name:

- @FILE_VERSION: must appear exactly once in the file
- @PROTOCOL_NAME: must appear at least once in the file. Thus, one file can contain several label lists for different protocols.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
@PROTOCOL_NAME = i2c
[... Label list for I2C]
@PROTOCOL_NAME = can
[... Label list for CAN]
# --- End of PTT file
```

Standard lines

Standard lines define the contents of the label list. The rules for standard lines follow the csv convention, they are:

- Values are separated by commas
- Space characters following a delimiter are ignored
- Values with a special character (comma, newline, or double quote) must be enclosed in double quotes
- Text in double quotes must be escaped by double quote characters

The format of the numeric value is indicated by a suffix. The following formats are supported:

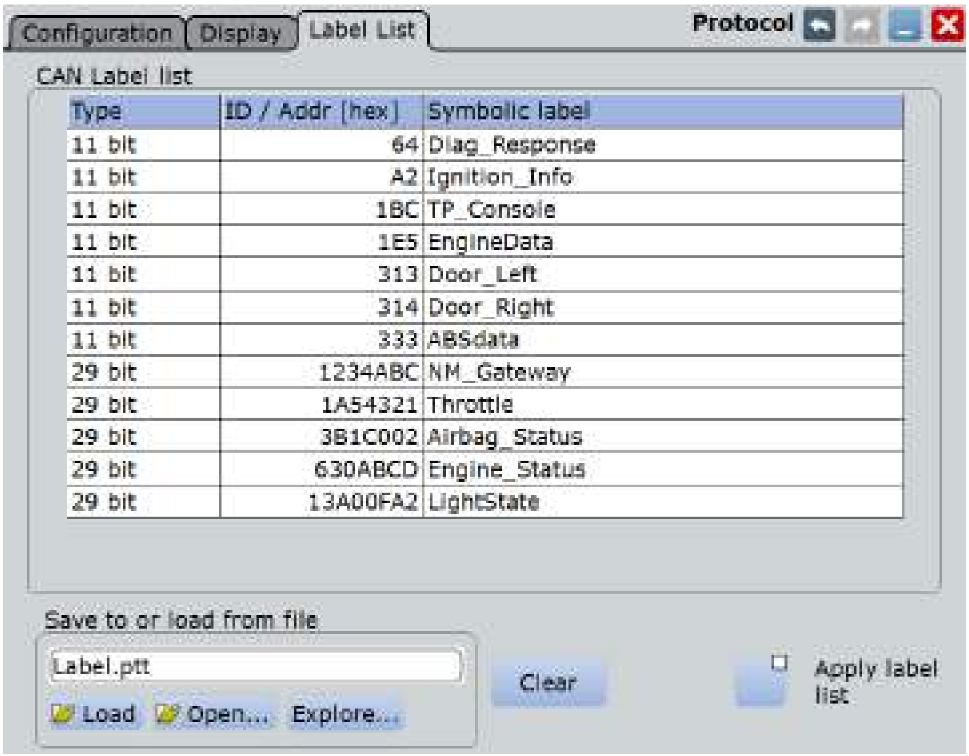
Format	Suffix	Example
Decimal	<empty> d	`106, DeviceName` `106d, DeviceName`
Hexadecimal	h	`6Ah, DeviceName` or prefix: `0x6A, DeviceName`
Octal	o	`152o, DeviceName`
Binary	b	`01101010b, DeviceName`

The maximum supported word size for (unsigned) integers is 64 bits.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
@PROTOCOL_NAME = i2c
#    Following two lines are equal:
7,01h,Temperature
7,01h, Temperature
#    A comma must be enclosed in double quotes:
7,01h,"Temperature, Pressure, and Volume"
#    A double quote must also be enclosed in double quotes:
7,7Fh,"Highspeed ""Master"" 01"
#    Following lines yield the same result:
7d,0x11,Pressure
7h,11h,Pressure
0x7,17d,Pressure
7,17,Pressure
```

12.1.3.2 Label List - General Settings

In the "Label List" tab, you can load, read and activate label list files.



CAN Label list

Type	ID / Addr [hex]	Symbolic label
11 bit	64	Diag_Response
11 bit	A2	Ignition_Info
11 bit	1BC	TP_Console
11 bit	1E5	EngineData
11 bit	313	Door_Left
11 bit	314	Door_Right
11 bit	333	ABSdata
29 bit	1234ABC	NM_Gateway
29 bit	1A54321	Throttle
29 bit	3B1C002	Airbag_Status
29 bit	630ABCD	Engine_Status
29 bit	13A00FA2	LightState

Save to or load from file

Label.ptt

The common settings for all protocols are:

Save to or load from file
Selects and loads a label list file. Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:

- Chapter 12.2.4, "I^{2}C Label List", on page 498
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 544
- Chapter 12.6.4, "LIN Label List", on page 571
- Chapter 12.7.3, "FlexRay Label List", on page 587
- Chapter 12.10.4, "ARINC 429 Label List", on page 645
- Chapter 12.9.4, "MIL-STD-1553 Label List", on page 629

Remote command:
`BUS<m>:NEWList` on page 1497

Clear
Deletes the label list from the instrument.

Apply label list
Activates the label list to be used for decoding. The "Label" appear in the "Decode results" table and in the frame captions of the decoded signal.

Remote command:
`BUS<m>:SYMBols` on page 1498

12.1.4 Bit Pattern Editor

If you want to enter a specified address or data pattern, the bit pattern editor helps you to enter the pattern in various formats - decimal, hexadecimal, octal, binary and ASCII.

Binary: 01100101 00111111 01110010

Hexadecimal: 65 3F 72

☑ Overwrite mode

Representation format (right column): Hex

The editor displays the pattern in two columns. The left column always shows binary data. For the right column, you can select the format, the default depends on the data specifics. You can edit data in the left or right column. The keypad adapts itself to the column format, only keys appropriate to the format are enabled.

The data is grouped and converted in bit groups. The size of a bit group depends on the address or data specifics and is set by the instrument. Groups are automatically separated by blanks. The maximum size of a bit group is 64 bit, the most common group size is 1 byte.

"Overwrite mode": If disabled, the data behind the new digit is shifted to the right. Bit groups are rearranged automatically.

Format-specific information:

- Unsigned: Decimal data format without sign. It is available for I²C, SPI, UART, CAN, LIN and FlexRay protocols. If you enter a decimal number that is too large for the defined bit group, the number is truncated and a message appears. X (do not care) in the decimal column sets all binary digits of the bit group to X.
- Signed: Signed decimal format, available for audio protocols. The first bit represents the sign. You can use the 2's complement or 1's complement format.
- Binary: 0, 1 and X (dont care) is allowed.
- Hex: most common format in the right column.
- Octal: Each digit represents 3 bit.
- ASCII: In the ASCII column, "X" is the character X. The binary X (do not care) is not allowed. If an X is included in the binary value in the left column, the ASCII columns displays "§" to indicate that the value is not defined.

Where applicable, frequently used values are provided in a "Predefined values" list below the pattern table, for example, reserved end words of data packets in the UART protocol.

12.2 I²C

The Inter-Integrated Circuit is a simple, low-bandwidth, low-speed protocol used for communication between on-board devices.

12.2.1 The I²C Protocol

This chapter provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "I2C-bus specification and user manual" available on the NXP manuals web page at http://www.nxp.com/.

I²C characteristics

Main characteristics of I²C are:

- Two-wire design: serial clock (SCL) and serial data (SDA) lines
- Master-slave communication: the master generates the clock and addresses the slaves. Slaves receive the address and the clock. Both master and slaves can transmit and receive data.
- Addressing scheme: each slave device is addressable by a unique address. Multiple slave devices can be linked together and can be addressed by the same master.
- Read/write bit: specifies if the master will read (=1) or write (=0) the data.
- Acknowledge: takes place after every byte. The receiver of the address or data sends the acknowledge bit to the transmitter.

The R&S RTO supports all operating speed modes: high-speed, fast mode plus, fast mode, and standard mode.

Data transfer

The format of a simple I²C message (frame) with 7 bit addressing consists of the following parts:

- Start condition: a falling slope on SDA while SCL is high
- 7-bit address of the slave device that either will be written to or read from
- R/W bit: specifies if the data will be written to or read from the slave
- ACKnowledge bits: is issued by the receiver of the previous byte if the transfer was successful
  Exception: At read access, the master terminates the data transmission with a NACK bit after the last byte.
- Data: a number of data bytes with an ACK bit after every byte

- Stop condition: a rising slope on SDA while SCL is high

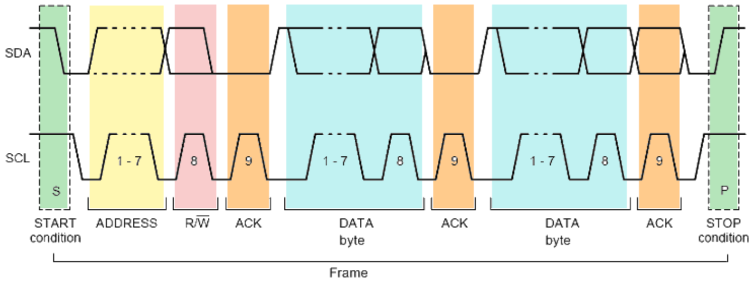


Figure 12-1: I2C write access with 7-bit address

Address types: 7-bit and 10-bit

Slave addresses can be 7 or 10 bits long. A 7-bit address requires one byte, 7 bits for the address followed by the R/W bit.

A 10-bit address for write access requires two bytes: the first byte starts with the reserved sequence 11110, followed by the two MSB of the address and the write bit. The second byte contains the remaining 8 LSB of the address. The slave acknowledges each address byte.

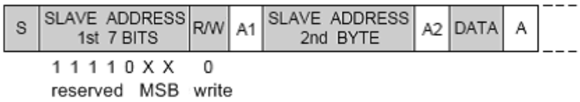


Figure 12-2: 10-bit address, write access

A 10-bit address for read access requires three bytes. The first two bytes are identical to the write access address. The third byte repeats the address bits of the first byte and sets the read bit.

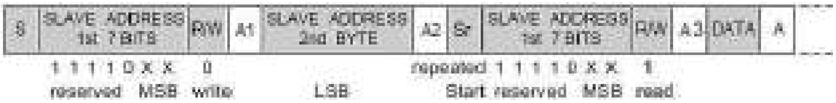


Figure 12-3: 10-bit address, read access

Trigger

The R&S RTO can trigger on various parts of I²C messages. The data and clock lines must be connected to the input channels, triggering on math and reference waveforms is not possible.

You can trigger on:

- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific slave address or address range

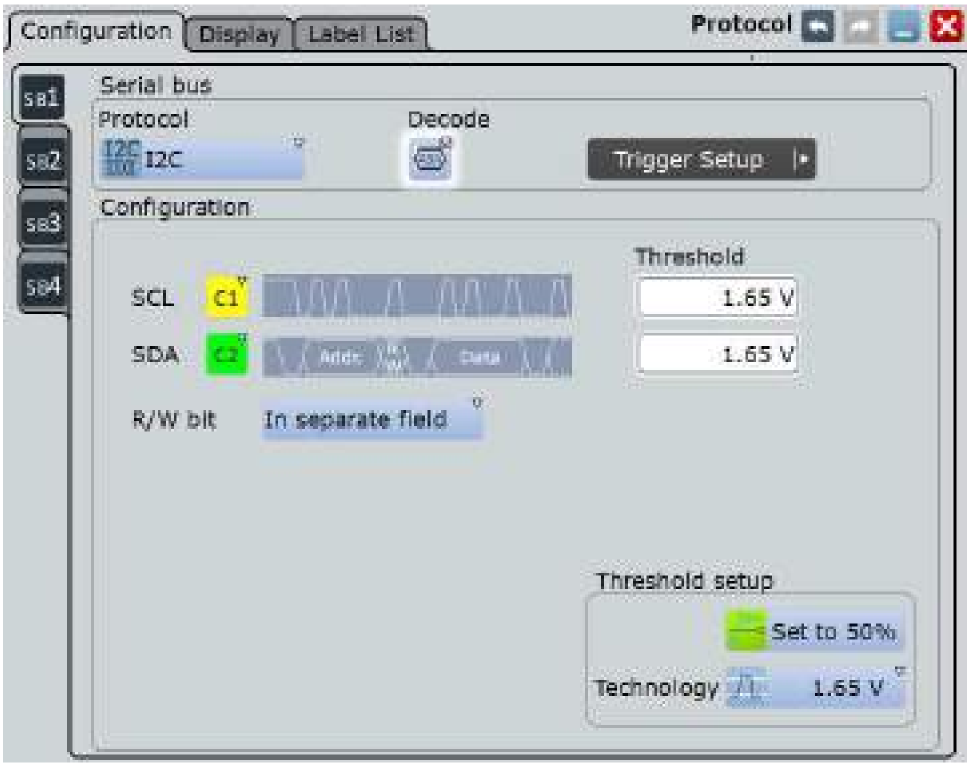
- Specific data pattern in the message

12.2.2 I²C Configuration

12.2.2.1 I²C Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *I2C*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: I2C

SCL: C1

SDA: C2

Threshold: 1.65 V

Threshold: 1.65 V

R/W bit: In separate field

Technology: 1.65 V

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

SDA, SCL

Set the waveforms of the data line (SDA) and clock line (SCL).

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:I2C:SDA:SOURce` on page 1501
`BUS<m>:I2C:SCL:SOURce` on page 1500

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:I2C:SCL:THReshold` on page 1501
`BUS<m>:I2C:SDA:THReshold` on page 1501
`BUS<m>:I2C:TECHnology` on page 1502
`BUS<m>:SETReflevels` on page 1495

R/W bit
Defines if the R/W bit is considered separately or as part of the address. The setting affects the Address setup of the trigger conditions.

Remote command:
`BUS<m>:I2C:RWBit` on page 1502

12.2.2.2 Configuring I²C Protocol

The configuration of the I²C is simple - assign the two lines to input channels, and set the thresholds.

For details on configuration settings, see Chapter 12.2.2, "I²C Configuration", on page 491.

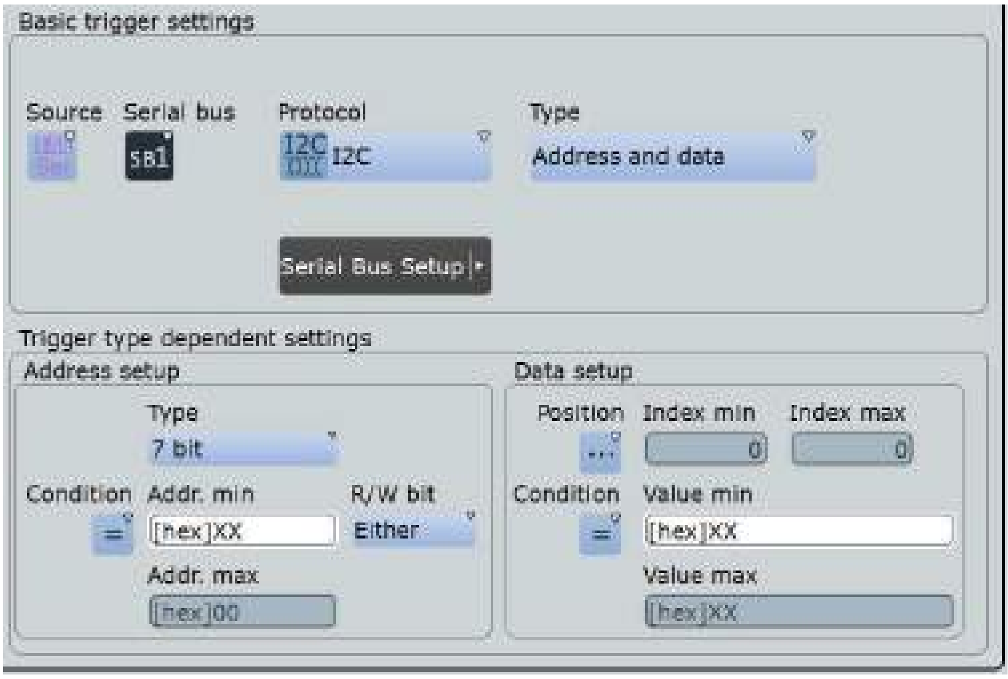
1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.

4. Tap the "Protocol" button and select the protocol: "I2C".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "SDA" button, and select the waveform of the data line.
7. Tap the "SCL" button, and select the waveform of the clock line.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fileds.
9. Enable "Decode", if available.

12.2.3 I²C Trigger

12.2.3.1 I²C Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = I2C"



Basic trigger settings

Source: Serial bus
Serial bus: SB1
Protocol: I2C
Type: Address and data

Trigger type dependent settings

Address setup
Type: 7 bit
Condition: =
Addr. min: [hex]XX
R/W bit: Either
Addr. max: [hex]00

Data setup
Position: ...
Index min: 0
Index max: 0
Condition: =
Value min: [hex]XX
Value max: [hex]XX

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Serial bus

Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1499

Protocol

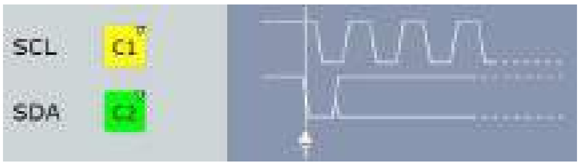
Defines protocol type of the bus for bus configuration and trigger settings.

Remote command:
`BUS<m>:TYPE` on page 1494

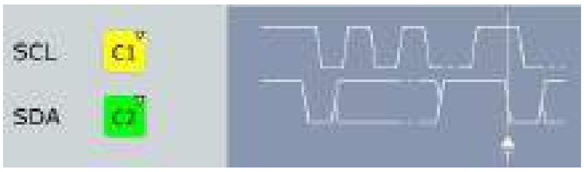
Trigger type

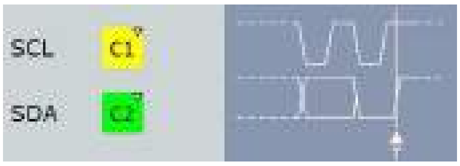
Selects the trigger type for I²C analysis.

"Start" Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.
You can change the SDA and SCL lines here if necessary.



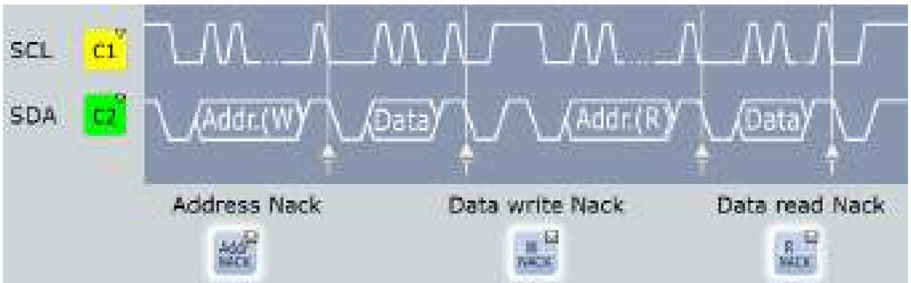
"Repeated start" Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.



"Stop"	Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high. 
"No Ack (Missing Ack)"	Missing acknowledge bit: the instrument triggers if the data line remains HIGH during the clock pulse following a transmitted byte. You can also localize specific missing acknowledge bits by setting the No Ack conditions.
"Address"	Sets the trigger to one specific address condition or a combination of address conditions. The trigger time is the falling clock edge of the acknowledge bit after the address. ● Address type ● Specified address or address range ● Read/Write bit Description of trigger type specific settings: "Address setup" on page 496.
"Address OR"	Triggers on one to four address conditions. Description of trigger type specific settings: "Address OR conditions" on page 497.
"Address and data"	Sets the trigger to a combination of address and data condition. The address conditions are the same as for the "Address" trigger type, see "Address setup" on page 496 and "Data setup" on page 497.

Remote command:
`TRIGger<m>:I2C:MODE` on page 1503

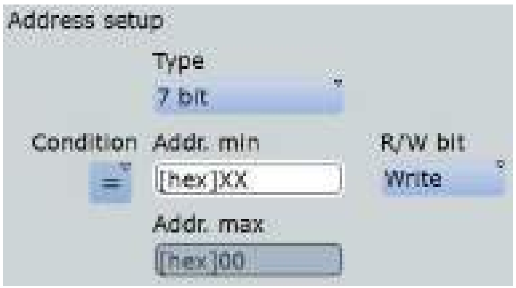
No Ack conditions
Selects which missing acknowledge bits is detected if the trigger type is set to "Missing Ack".



"Address Nack"	No slave recognizes the address.
"Data write Nack"	The addressed slave does not accept the data.
"Data read Nack"	Marks the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Remote command:
`TRIGger<m>:I2C:ADNack` on page 1504
`TRIGger<m>:I2C:DWNack` on page 1505
`TRIGger<m>:I2C:DRNack` on page 1505

Address setup
Specifies the address conditions:



Type ← Address setup
Sets the address length to be triggered on: 7 bit, 7+1 bit, or 10 bit. Available settings depend on the R/W bit setting of the bus configuration.

For "7 bit" and "10 bit", enter the address bits in the Addr. min / Addr. max field, and use the "R/W bit" on page 497 field to select the transfer direction.

For "7+1 bit", enter the seven address bits and also the R/W bit in the "Address" field.

If the trigger type is "Address + data", you can set the address type "Any" to trigger on data only, regardless of the address.

Remote command:
`TRIGger<m>:I2C:AMODe` on page 1505

Addr. min / Addr. max ← Address setup
Defines the bit pattern of the slave device address. The length of the entry is adjusted to the selected address type. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the "Address operator"s "Equal" and "Not equal".

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Depending on the Condition, a specific address or an address range must be defined.

To trigger on any address, set the "Address operator" to "Equal" and enter *X* for each address bit.

Remote command:
`TRIGger<m>:I2C:ADDRess` on page 1506
`TRIGger<m>:I2C:ADDTo` on page 1506

Condition ← Address setup
Sets the operator to set a specific address ("Equal" or "Not equal") or an address range. The address values are set with Addr. min / Addr. max.

Remote command:
`TRIGger<m>:I2C:ACONdition` on page 1505

R/W bit ← Address setup

Toggles the trigger condition between Read and Write access of the master. Select "Either" if the transfer direction is not relevant for the trigger condition.

Remote command:
`TRIGger<m>:I2C:ACCess` on page 1504

Address OR conditions

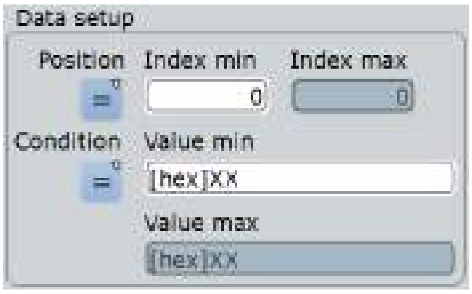
Triggers on one to four address conditions. For each condition to be used, select "Monitor".

Each condition requires an exact address. The definition of address ranges is not possible here. X (don't care) can be used.

Remote command:
`TRIGger<m>:I2C:ADOR<n>:ENABle` on page 1506
`TRIGger<m>:I2C:ADOR<n>:ADRType` on page 1506
`TRIGger<m>:I2C:ADOR<n>[:VALue]` on page 1507
`TRIGger<m>:I2C:ADOR<n>:RWBit` on page 1507

Data setup

Specifies the data conditions:



Position ← Data setup

Operator for the data position within a frame. You can define an exact position, or a position range. Select "Any", if the position of the required pattern is not relevant.

Remote command:
`TRIGger<m>:I2C:DPOPerator` on page 1507

Index min, Index max ← Data setup

Sets the number of data bytes to be skipped after the address. The index 0 is associated with the first data byte. If the Position defines a range, the first and the last byte of interest are defined.

Remote command:
`TRIGger<m>:I2C:DPOSition` on page 1507
`TRIGger<m>:I2C:DPTO` on page 1508

Condition ← Data setup

Selects the operator for the "Data" pattern: "Equal", "Not equal", or a range definition.

Remote command:
`TRIGger<m>:I2C:DCONdition` on page 1508

Value min / Value max ← Data setup

Specifies the data bit pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

The instrument ensures that the max value is always ≥ the min value, and X bits (don't care) are at the same position in both values.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`TRIGger<m>:I2C:DMIN` on page 1508
`TRIGger<m>:I2C:DMAX` on page 1508

12.2.3.2 Triggering on I²C Signals

Prerequesites: A I²C bus is configured, see Chapter 12.2.2.2, "Configuring I²C Protocol", on page 492.

1. Press the TRIGGER key.
   If the "Protocol Configuration" dialog box is open, you can tap the "Trigger Setup" button.
2. Tap the "Source" button and select the "Serial bus" trigger source.
3. Select the serial bus that is set to I²C.
4. Select the "Trigger type".
5. For more complex trigger types, enter the address and/or data conditions: address, acknowledge bits, R/W bit, and data pattern.
   For details, see Chapter 12.2.3, "I²C Trigger", on page 493

12.2.4 I²C Label List

Label lists are protocol-specific. Label lists for ²C are available in CSV and PTT format.

An I²C label file contains three values for each address:

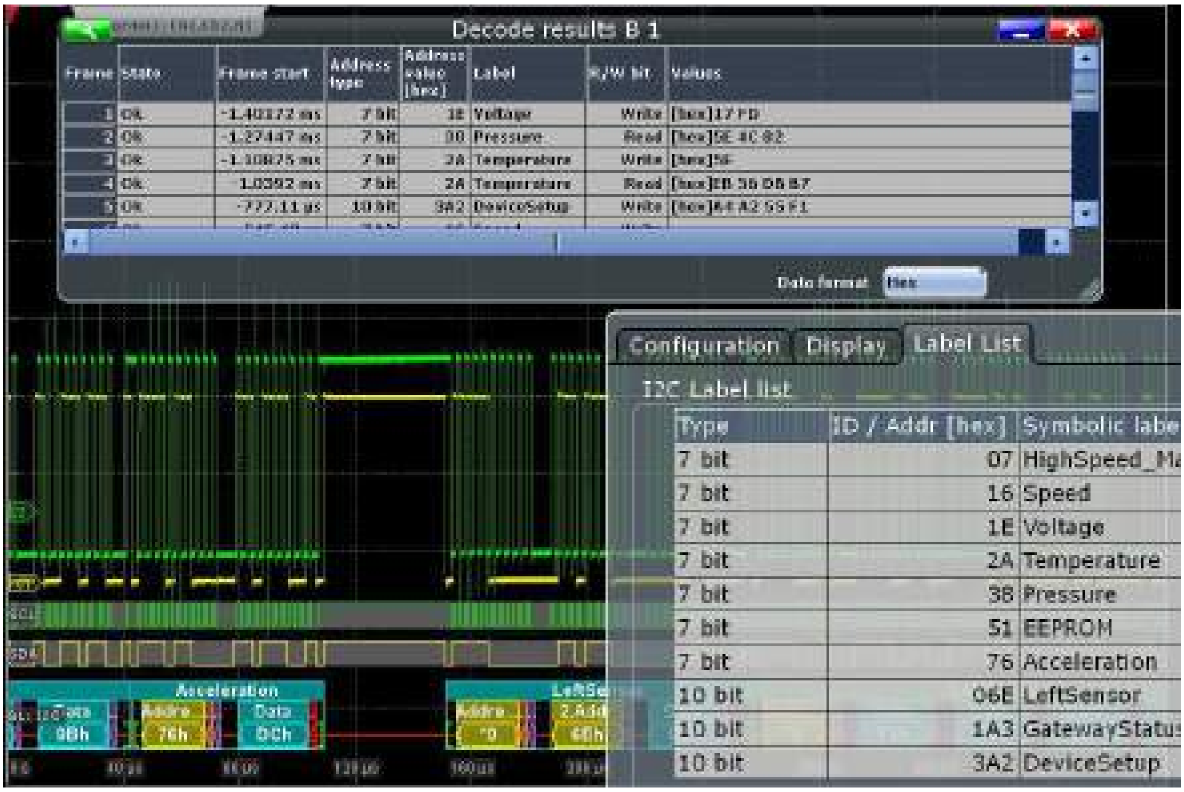
- Address type, 7-bit or 10-bit long
- Address value
- Symbolic label: name of the address, specifiing its function in the bus network.

Example: I²C PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = i2c
# ---------------------------------------------------------------------------
# Labels for I2C protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
7,0x1E,Voltage
```

```
7,38h,Pressure
7,2Ah,Temperature
7,16h,Speed
7,118,Acceleration
7,07h,HighSpeed_Master_0x3
7,51h,EEPROM
10,3A2h,DeviceSetup
10,1A3h,GatewayStatus
10,06Eh,LeftSensor
# ----------------------------------------------------------------------------
```

To use label lists, option R&S RTO-K1 is required.



Decode results B 1

Frame	State	Frame start	Address type	Address value [hex]	Label	R/W bit	Values
1	OK	-1.40172 ms	7 bit	1E	Voltage	Write	[hex]17 FD
2	OK	-1.27447 ms	7 bit	38	Pressure	Read	[hex]5E 4C 82
3	OK	-1.10875 ms	7 bit	2A	Temperature	Write	[hex]5E
4	OK	1.0392 ms	7 bit	2A	Temperature	Read	[hex]EB 35 D8 B7
5	OK	-772.11 µs	10 bit	3A2	DeviceSetup	Write	[hex]A4 A2 55 F1

I2C Label list

Type	ID / Addr [hex]	Symbolic labe
7 bit	07	HighSpeed_Ma
7 bit	16	Speed
7 bit	1E	Voltage
7 bit	2A	Temperature
7 bit	38	Pressure
7 bit	51	EEPROM
7 bit	76	Acceleration
10 bit	06E	LeftSensor
10 bit	1A3	GatewayStatu
10 bit	3A2	DeviceSetup

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:I2C:FRAMe<n>:SYMBol?` on page 1514

12.2.5 I²C Decode Results (Option R&S RTO-K1)

If the option is installed, the "Decode" function in the "Configuration" tab is available.

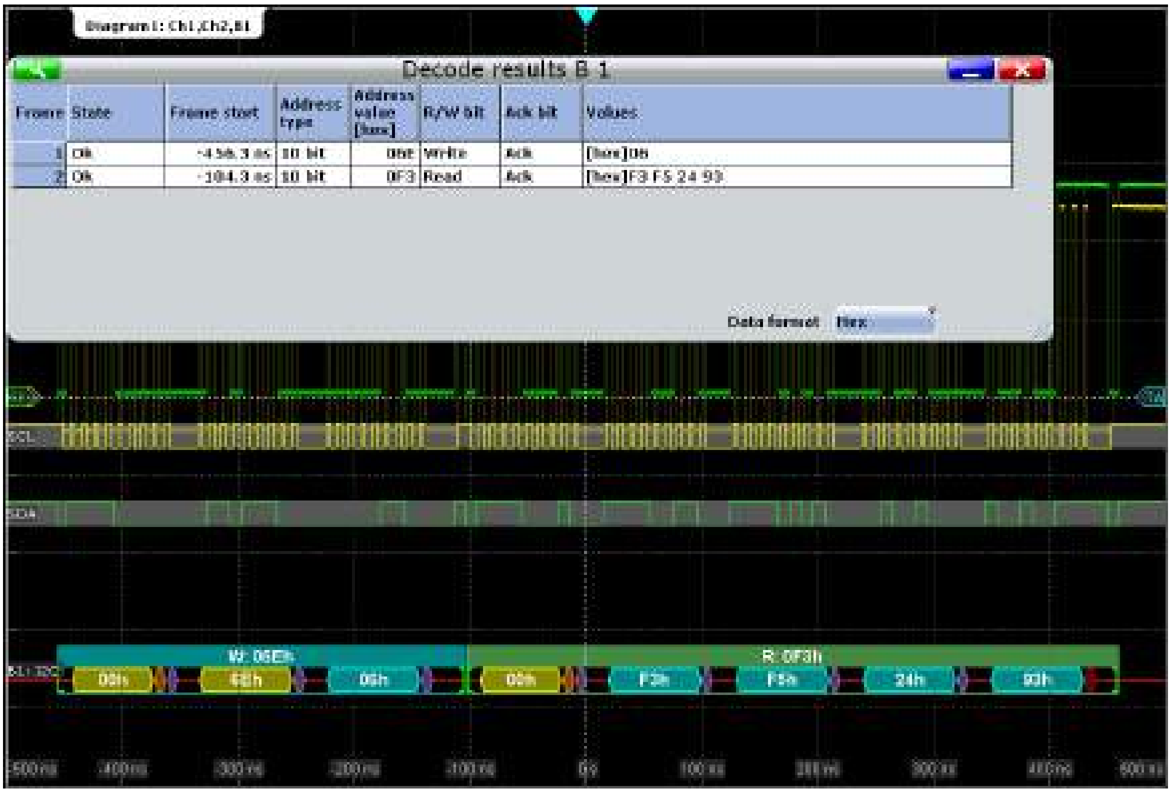
When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

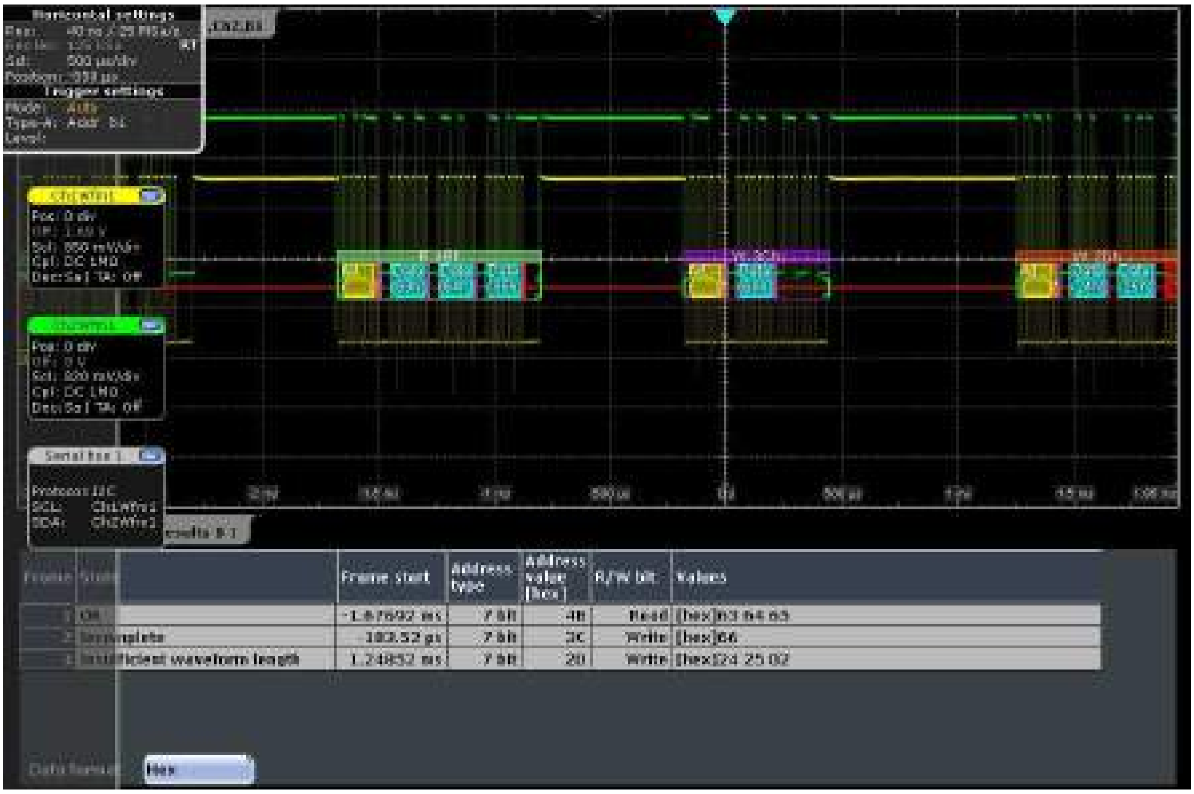


Frame	State	Frame start	Address type	Address value [hex]	R/W bit	Ack bit	Values
1	Ok	-456.3 ns	10 bit	06E	Write	Ack	[hex]06
2	Ok	-104.3 ns	10 bit	0F3	Read	Ack	[hex]F3 F5 24 93

Figure 12-4: Decoded and binary I2C signal, and decode results

green brackets [...] = start and end of frame
blue frame header = write frame ok, with transfer direction and address value
green frame header = read frame ok, with transfer direction and address value
yellow = address
blue = correct data
light orange = R/W bit
purple = acknowledge bit
red = No ack (missing acknowledge bit)

The signal in Figure 12-4 shows a write access followed by a read access, both with 10bit address. The decoded data shows a No Ack bit at the end of the read data. This No Ack bit is sent according to the protocol definition and is not an error. Thus, the decode results in the table indicate "Ack" for the second frame.



Frame	State	Frame start	Address type	Address value [hex]	R/W bit	Values
1	OK	-1.87692 ms	7 bit	48	Read	[hex]83 84 85
2	Incomplete	-183.52 µs	7 bit	3C	Write	[hex]66
3	Insufficient waveform length	1.24852 ms	7 bit	20	Write	[hex]24 25 02

Figure 12-5: Decoded I2C signal with incomplete data, and decode results

magenta frame header	= incomplete frame, missing bits in data words
dark orange frame header	= insufficient frame (end of acquisition before decoding has been completed), with transfer direction and address value
red	= insufficient data word (end of acquisition before end of word)

The "Decode results" box shows the detailed decoded data for each data frame.

Table 12-3: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Frame start	Time of frame start
Address type	Address length, 7 bit or 10 bit
Address value (hex)	Hexadecimal value of the address
Label	Symbolic label name defined in the label list
R/W bit	Value of the R/W bit
Ack bit	Value of the address acknowledge bit
Values	Value of all data bytes of the frame. The data format is selected below the table.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.3.3, "Decode Results (Option R&S RTO-K1)", on page 1509.

12.2.6 Search on Decoded I²C Data

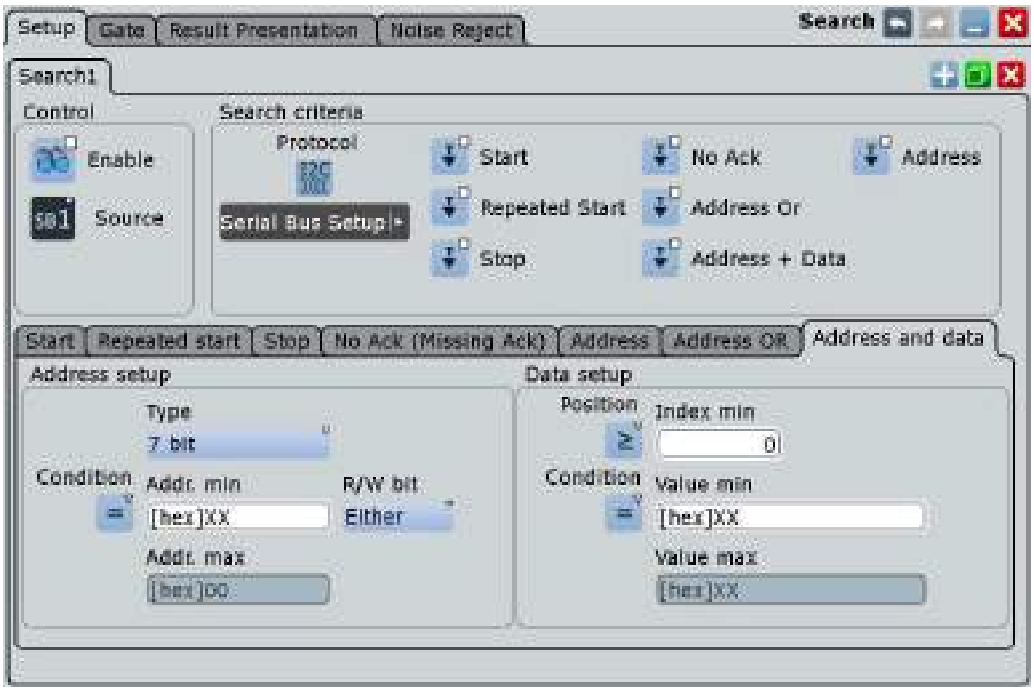
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.2.6.1 I²C Search Setup

Access: SEARCH > "Setup" tab



Type: 7 bit
Condition: =
Addr. min: [hex]XX
R/W bit: Either
Addr. max: [hex]00
Position: ≥
Index min: 0
Condition: =
Value min: [hex]XX
Value max: [hex]XX

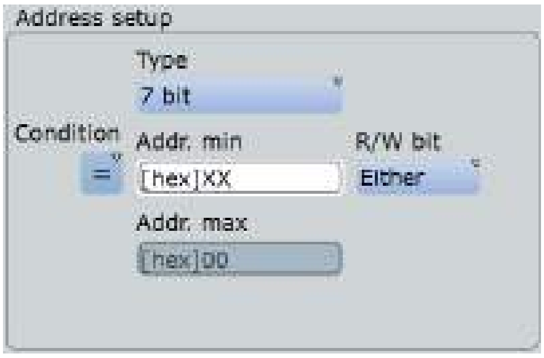
Search criteria
Enable the events to be searched for. Unlike triggering, where you can trigger only on one defined event, you can search for various different events in one search.

"Start"	Searches for the start of the message. The start condition is a falling edge on SDA while SCL is high. The event is the falling edge of the SDA line. You can change the SDA and SCL lines here if necessary.
"Repeated start"	Searches for a start condition without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.
"Stop"	Searches for the end of the message. The stop condition is a rising slope on SDA while SCL is high.
"No ACK (Missing ACK)"	Searches for a missing acknowledge bit: an event is found if the data line remains HIGH during the clock pulse following a transmitted byte. For details, see "No Ack conditions" on page 495.
"Address"	Searches for one specific address condition or a combination of address conditions. The event is the falling edge of the acknowledge bit after the address.
"Address OR"	Searches for one to four address conditions. See "Address OR conditions" on page 497.
"Address and data"	Searches for a combination of address and data conditions.

Remote command:
`SEARch:TRIGger:I2C:SCONdition` on page 1518
`SEARch:TRIGger:I2C:RCONdition` on page 1518
`SEARch:TRIGger:I2C:STCNdition` on page 1518
`SEARch:TRIGger:I2C:NACKnowledge` on page 1518
`SEARch:TRIGger:I2C:SADDress` on page 1519
`SEARch:TRIGger:I2C:ADOR` on page 1519
`SEARch:TRIGger:I2C:ADData` on page 1519

Address setup: Condition, Type, Addr. min, Addr. max, R/W bit
The address setup consists of the condition, type, R/W bit and one or two address patterns.

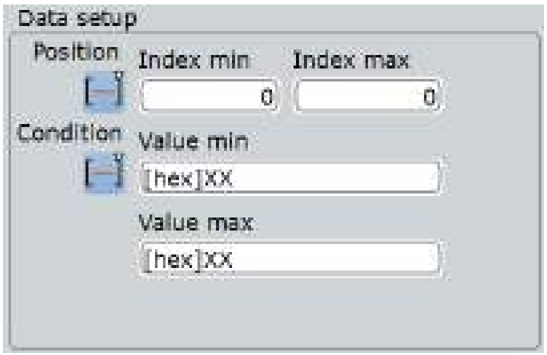
The address setup settings are the same as in the I2C trigger setup, see "Address setup" on page 496.


Address setup
Type: 7 bit
Condition: =
Addr. min: [hex]XX
R/W bit: Either
Addr. max: [hex]00

Remote command:
`SEARch:TRIGger:I2C:ACONdition` on page 1520
`SEARch:TRIGger:I2C:ADDRess` on page 1521
`SEARch:TRIGger:I2C:ADDTo` on page 1521
`SEARch:TRIGger:I2C:AMODe` on page 1520
`SEARch:TRIGger:I2C:ACCess` on page 1521

Data setup: Condition, Position, Index min, Index max, Value min, Value max
The data setup consists of the condition, position, and one or two index/value patterns.

The data setup settings are the same as in the I2C trigger setup, see "Data setup" on page 497.


Data setup

Position

Index min: 0

Index max: 0

Condition

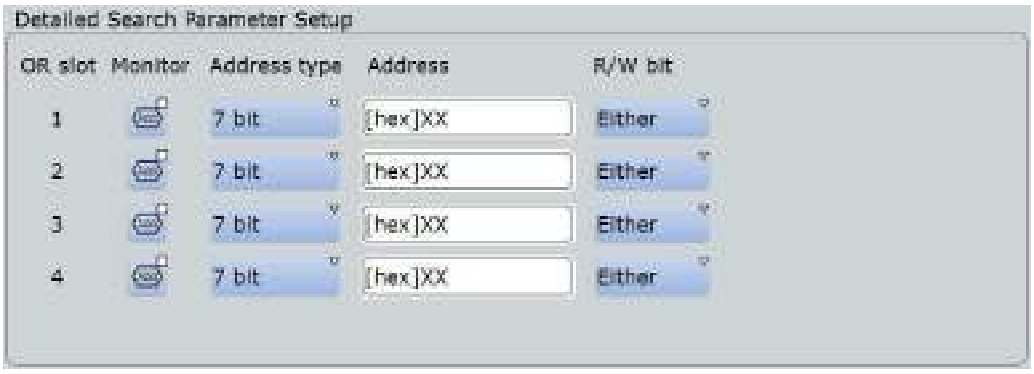
Value min: [hex]XX

Value max: [hex]XX

Remote command:
`SEARch:TRIGger:I2C:DPOPerator` on page 1523
`SEARch:TRIGger:I2C:DPOSition` on page 1523
`SEARch:TRIGger:I2C:DPTO` on page 1524
`SEARch:TRIGger:I2C:DCONdition` on page 1524
`SEARch:TRIGger:I2C:DMIN` on page 1524
`SEARch:TRIGger:I2C:DMAX` on page 1525

Address OR setup: Monitor, Address type, Address, R/W bit
The address OR setup consists of the monitor, address type, address and a R/W bit.

The address OR setup settings are the same as in the I2C trigger setup, see "Address OR conditions" on page 497.

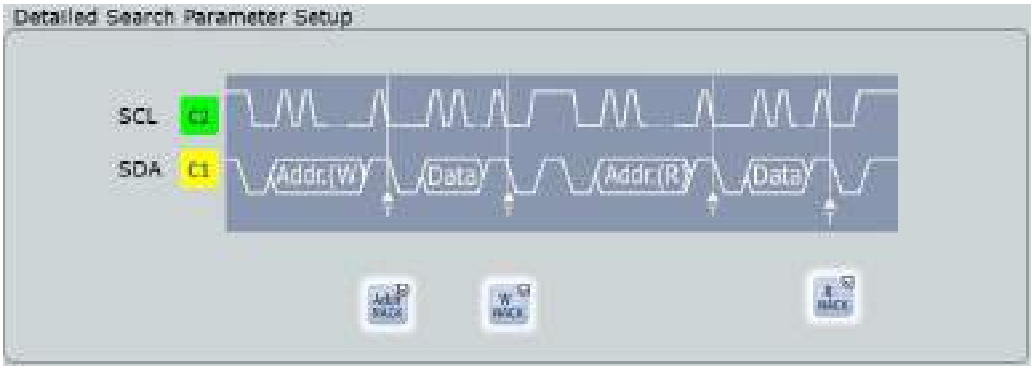

Detailed Search Parameter Setup

OR slot	Monitor	Address type	Address	R/W bit
1		7 bit	[hex]XX	Either
2		7 bit	[hex]XX	Either
3		7 bit	[hex]XX	Either
4		7 bit	[hex]XX	Either

Remote command:
`SEARch:TRIGger:I2C:ADDO<m>:ENABle` on page 1521
`SEARch:TRIGger:I2C:ADDO<m>:ADRType` on page 1522
`SEARch:TRIGger:I2C:ADDO<m>[:VALue]` on page 1522
`SEARch:TRIGger:I2C:ADDO<m>:RWBit` on page 1523

No ACK setup: Addr/W/R NACK
The no ACK setup consists of the Addr/W/R NACK.

The no ACK setup settings are the same as in the I2C trigger setup, see "No Ack conditions" on page 495.



Remote command:
`SEARch:TRIGger:I2C:DRNack` on page 1525
`SEARch:TRIGger:I2C:DWNack` on page 1525
`SEARch:TRIGger:I2C:NACKnowledge` on page 1518

12.2.6.2 I^{2}C Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

The columns in the serach result table are the same as in the decoding table, see Chapter 12.2.5, "I^{2}C Decode Results (Option R&S RTO-K1)", on page 499.

Remote commands:

- `SEARch:RESult:I2C:FCOunt?` on page 1526
- `SEARch:RESult:I2C:FRAMe<m>:STATus?` on page 1526
- `SEARch:RESult:I2C:FRAMe<m>:STARt?` on page 1527
- `SEARch:RESult:I2C:FRAMe<m>:STOP?` on page 1527
- `SEARch:RESult:I2C:FRAMe<m>:SYMBol?` on page 1530

- `SEARch:RESult:I2C:FRAMe<m>:DATA?` on page 1530
- `SEARch:RESult:I2C:FRAMe<m>:ADDRess?` on page 1528
- `SEARch:RESult:I2C:FRAMe<m>:AACCess?` on page 1527
- `SEARch:RESult:I2C:FRAMe<m>:ACCess?` on page 1528
- `SEARch:RESult:I2C:FRAMe<m>:ACOMplete?` on page 1528
- `SEARch:RESult:I2C:FRAMe<m>:ADBStart?` on page 1528
- `SEARch:RESult:I2C:FRAMe<m>:ADEVice?` on page 1529
- `SEARch:RESult:I2C:FRAMe<m>:AMODe?` on page 1529
- `SEARch:RESult:I2C:FRAMe<m>:ASTart?` on page 1529
- `SEARch:RESult:I2C:FRAMe<m>:BCOunt?` on page 1530
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess?` on page 1531
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart?` on page 1531
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete?` on page 1531
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt?` on page 1532
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue?` on page 1532

12.3 SPI Bus

12.3.1 The SPI Protocol

A 4-channel instrument is required for full support of the SPI protocol, or the MSO option R&S RTO-B1.

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

Main characteristics of SPI are:

- Master-slave communication
- No device addressing; The slave is accessed by a chip select, or slave select line.
- No acknowledgement mechanism to confirm receipt of data
- Duplex capability

Most SPI buses have four lines, two data and two control lines:

- Clock line to all slaves (SCLK)
- Slave Select or Chip Select line (SS or CS)
- Master data output, slave data input (MOSI or SDI)

- Master data input, slave data output (MISO or SDO)

When the master generates a clock and selects a slave device, data may be transferred in either or both directions simultaneously.

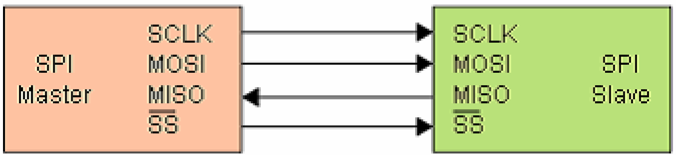


Figure 12-6: Simple configuration of SPI bus

The data bits of a message are grouped by following criteria:

- A word contains a number of successive bits. The word length is defined in the protocol configuration.
- A frame contains a number of successive words, at least one word.

For SPI buses, the R&S RTO provides the following trigger possibilities:

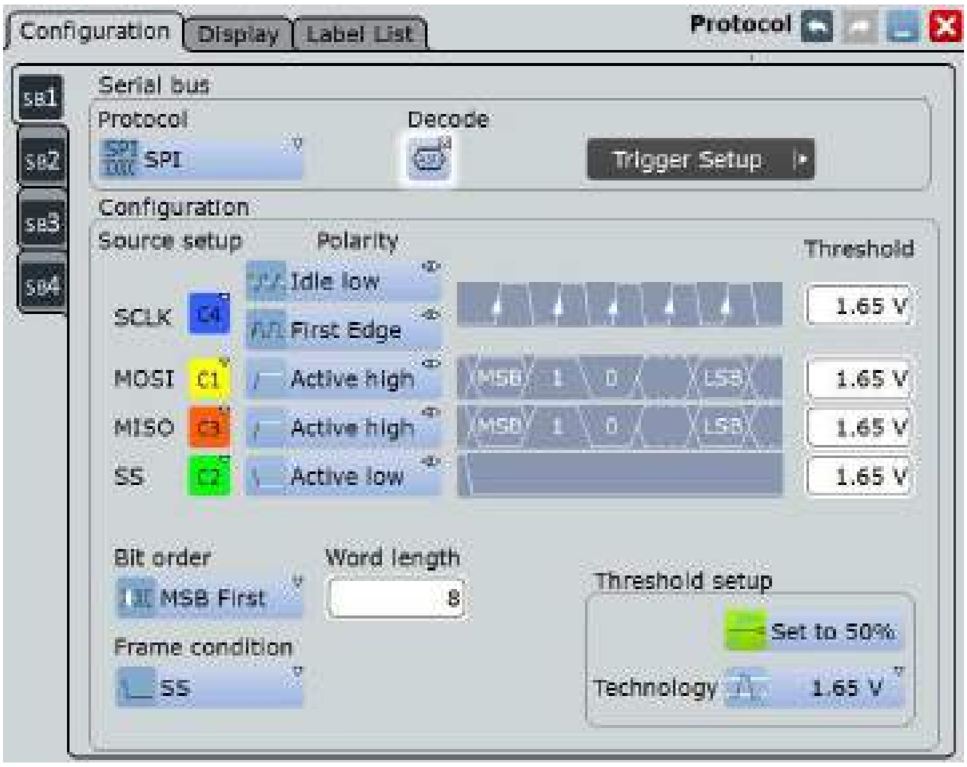
- On frame start
- On a serial pattern at a specified position

12.3.2 SPI Configuration

12.3.2.1 SPI Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *SPI*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

SCLK

Defines the settings for the clock line.

SCLK source ← SCLK

Sets the input channel of the clock line. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used for decoding.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:SPI:SCLK:SOURce` on page 1533

Polarity ← SCLK

Two settings define the clock mode: the clock polarity and the clock phase. Together, they determine the edges of the clock signal on which the data are driven and sampled. A master/slave pair must use the same parameter pair values to communicate.

The clock polarity is "Idle low" (idle = 0) or "Idle high" (idle = 1).

The clock phase defines the slope. It selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

SS, MISO, MOSI

Configures the Slave Select, MISO and MOSI lines.

Source ← SS, MISO, MOSI

Sets the input channel of the selected line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:SPI:SSELect:SOURce` on page 1534
`BUS<m>:SPI:MISO:SOURce` on page 1534
`BUS<m>:SPI:MOSI:SOURce` on page 1535

Polarity ← SS, MISO, MOSI

Selects whether transmitted data or the slave select signal is high active (high = 1) or low active (low = 1).

Remote command:
`BUS<m>:SPI:SSELect:POLarity` on page 1534
`BUS<m>:SPI:MISO:POLarity` on page 1535
`BUS<m>:SPI:MOSI:POLarity` on page 1535

Threshold

Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:SPI:SCLK:THReshold` on page 1536
`BUS<m>:SPI:MISO:THReshold` on page 1536
`BUS<m>:SPI:MOSI:THReshold` on page 1536
`BUS<m>:SPI:SSELect:THReshold` on page 1536

`BUS<m>:SPI:TECHnology` on page 1536
`BUS<m>:SETReflevels` on page 1495

Bit order
Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Remote command:
`BUS<m>:SPI:BORDer` on page 1533

Word length
Sets the number of bits in a word. The maximum length is 32 bit.

Remote command:
`BUS<m>:SPI:WSIZe` on page 1533

Frame condition
Defines the start of a frame. A frame contains a number of successive words, at least one word.

"SS"	Start and end of the frame is defined by the active state of the slave select signal.
"CLK timeout"	Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line. Enter the minimum clock idle time in the field.

Remote command:
`BUS<m>:SPI:FRCondition` on page 1537

Timeout
Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

See also: "Frame condition" on page 510.

Remote command:
`BUS<m>:SPI:TIMeout` on page 1537

12.3.2.2 Configuring SPI Signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Chapter 12.3.2, "SPI Configuration", on page 507.

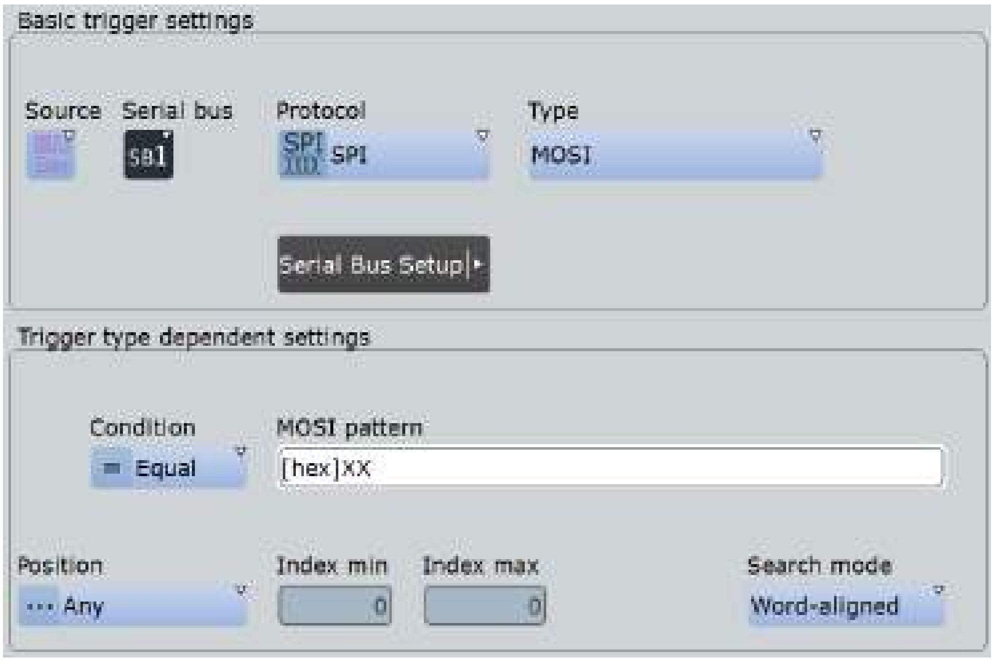
1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "SPI".

5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Tap the "SCLK Source" button, and select the waveform of the clock line.
7. Set the polarity (clock mode) for SCLK.
8. For each of the available SS, MISO and MOSI lines, assign the waveform and define the polarity (active state) of the line.
9. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fileds.
10. Set the "Bit order", "Word length", and "Frame condition" according to your signal.

12.3.3 SPI Trigger

12.3.3.1 SPI Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = SPI"


Basic trigger settings

Source

Serial bus: SB1

Protocol: SPI

Type: MOSI

Trigger type dependent settings

Condition: = Equal

MOSI pattern: [hex]XX

Position: ··· Any

Index min: 0

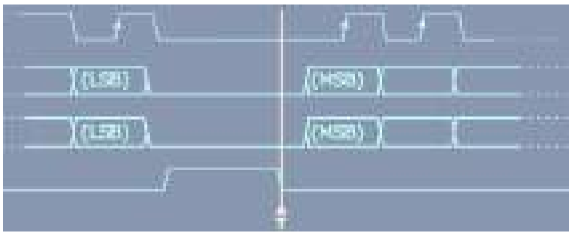
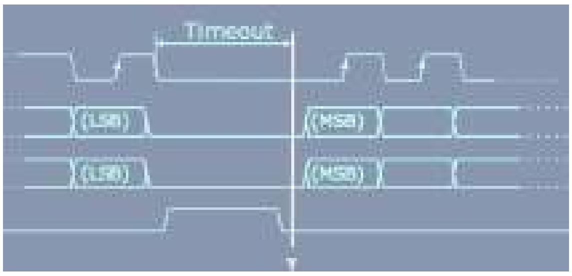
Index max: 0

Search mode: Word-aligned

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type for SPI analysis.

"Frame start (SS)"	Trigger on the start of the frame when the slave select signal SS changes to the active state. This trigger type is available if Frame condition is set to "SS". 
"Frame start (Timeout)"	Triggers on the start of the frame when the clock idle time exceeds the "Timeout" time. This trigger type is available if Frame condition is set to "CLK timeout". 
"MOSI"	Sets the trigger to a specified data pattern expected on the MOSI line. See: "MOSI and MISO data conditions" on page 512.
"MISO"	Sets the trigger to a specified data pattern expected on the MISO line. See: "MOSI and MISO data conditions" on page 512.
"MOSI/MISO"	Sets the trigger to specified data patterns expected on the MOSI and MISO lines on the same time.

Remote command:
`TRIGger<m>:SPI:MODE` on page 1538

MOSI and MISO data conditions

The trigger on MOSI and MISO patterns is defined in the same way:

Condition ← MOSI and MISO data conditions
Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:
`TRIGger<m>:SPI:FCONdition` on page 1539

MOSI pattern, MISO pattern ← MOSI and MISO data conditions
Specify the data patterns to be found on the MOSI and/or MISO line.

If the trigger type is "MOSI" or "MISO" (one pattern is defined), the maximum pattern length is 256 bit. If the trigger type is "MOSI/MISO", two patterns must be found at the same time. Thus, both patterns must have the same length, and the maximum pattern length of each pattern is 128 bit.

Enter the words in msb first bit order. The starting point of the pattern is defined by Index min, Index max and Search mode.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`TRIGger<m>:SPI:MOSipattern` on page 1540
`TRIGger<m>:SPI:MISopattern` on page 1539

Position ← MOSI and MISO data conditions
Operator for the data position. You can define an exact position, a position range, or let the position undefined ("Any").

Remote command:
`TRIGger<m>:SPI:DPOPerator` on page 1538

Index min, Index max ← MOSI and MISO data conditions
The effect of data positioning depends on the Search mode. It sets the number of bits or words before the first word of interest. These offset bits/words are skipped. If the position operator defines a range, the first and the last bit/word of interest are defined. The index 0 is associated with the first data bit or word.

Remote command:
`TRIGger<m>:SPI:DPOSition` on page 1539
`TRIGger<m>:SPI:DPTO` on page 1539

Search mode ← MOSI and MISO data conditions
Defines how the specified data pattern is searched:

"Word-aligned"	The pattern is matched only at word boundaries.
"Bit-aligned"	Bit-by-bit: the pattern can start at any position in the message.

Remote command:
`TRIGger<m>:SPI:PALignment` on page 1538

12.3.3.2 Triggering on SPI

Prerequisites: A bus is configured for the SPI signal to be analyzed.

1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to SPI.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions
For details, see Chapter 12.3.3, "SPI Trigger", on page 511

12.3.4 SPI Decode Results (Option R&S RTO-K1)

If the option is installed, the "Decode" function in the "Configuration" tab is available.

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

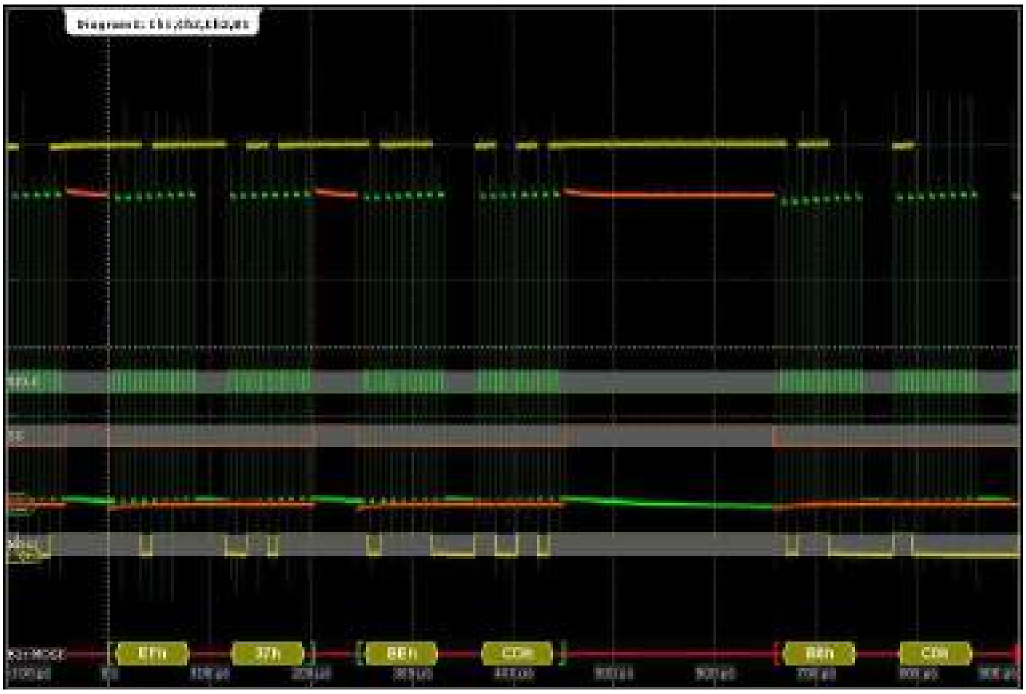
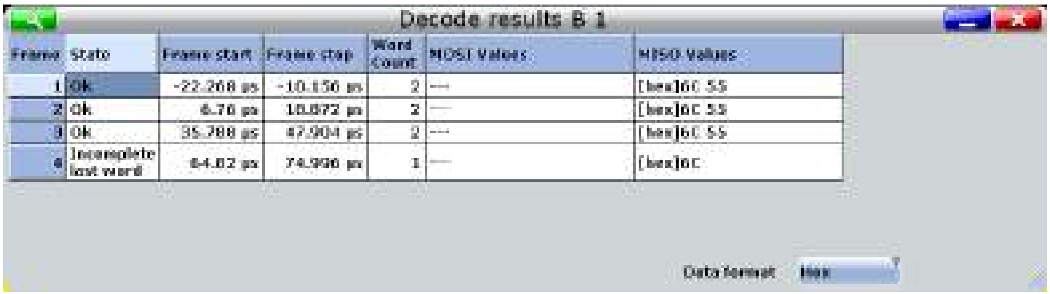


Figure 12-7: Decoded and binary SPI signal with SCLK, MOSI, and SS line

green brackets [...] = start and end of complete frame
red brackets [...] = start and end of incomplete frame
yellow = word
red = error

The "Decode results" box shows the detailed decoded data for each data frame.



Frame	State	Frame start	Frame stop	Word Count	MOSI Values	MISO Values
1	Ok	-22.268 µs	-10.156 µs	2	---	[hex]6C 55
2	Ok	6.76 µs	18.872 µs	2	---	[hex]6C 55
3	Ok	35.788 µs	47.904 µs	2	---	[hex]6C 55
4	Incomplete last word	64.82 µs	74.996 µs	1	---	[hex]6C

Data format: Hex

Figure 12-8: Decode results

In the figure above, the first three frames contain two words each. The fourth frame is incomplete, only one word of the frame was recognized

Table 12-4: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Frame start , Frame stop	Times of frame start and frame end
Word count	Number of words in the frame

Column	Description
MOSI values	Value of the MOSI data words. The data format is selected below the table.
MISO values	Value of the MISO data words. The data format is selected below the table.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.4.3, "SPI Decode Results (Option R&S RTO-K1)", on page 1540.

12.3.5 Search on Decoded SPI Data

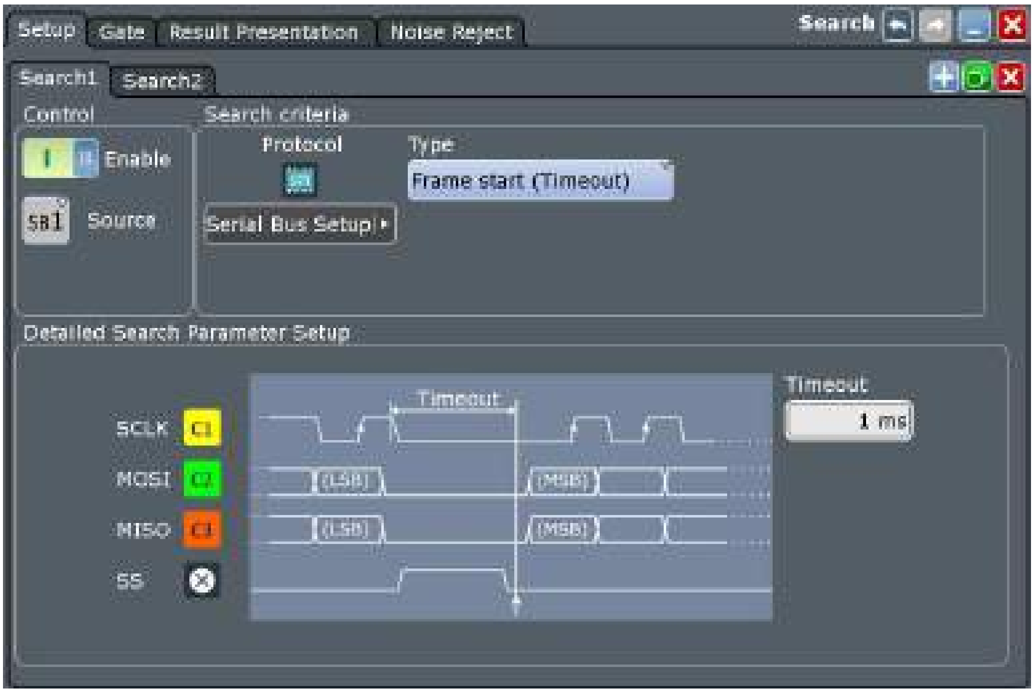
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.3.5.1 SPI Search Setup

Access: SEARCH > "Setup" tab



Type: Frame start (Timeout)

Timeout: 1 ms

Type
Sets the event to be searched for.

"Frame start (SS)"	Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and the frame condition is "SS".
"Frame start (Timeout)"	Searches for the start of the frame when the clock idle time exceeds the timeout. This trigger type is available if frame condition is set to "CLK timeout".
"MOSI"	Searches for a specified data pattern expected on the MOSI line.
"MISO"	Searches for a specified data pattern expected on the MISO line.
"MOSI / MISO"	Searches for specified data patterns expected on the MOSI and MISO lines.

Remote command:
`SEARch:TRIGger:SPI:MODE` on page 1544

MOSI and MISO data search
The MOSI and MISO setup consists of the condition, position, MOSI pattern, MISO pattern, search mode (word-aligned, bit-aligned) and one or two index patterns.

The MOSI and MISO setup settings are the same as in the SPI trigger setup. For details, see "MOSI and MISO data conditions" on page 512.

[hex]XX

[hex]XX

0

1

Remote command:
`SEARch:TRIGger:SPI:FCONdition` on page 1545
`SEARch:TRIGger:SPI:MISopattern` on page 1545
`SEARch:TRIGger:SPI:MOSipattern` on page 1545
`SEARch:TRIGger:SPI:DPOPerator` on page 1546
`SEARch:TRIGger:SPI:DPOSition` on page 1546
`SEARch:TRIGger:SPI:DPTO` on page 1546
`SEARch:TRIGger:SPI:PALignment` on page 1547

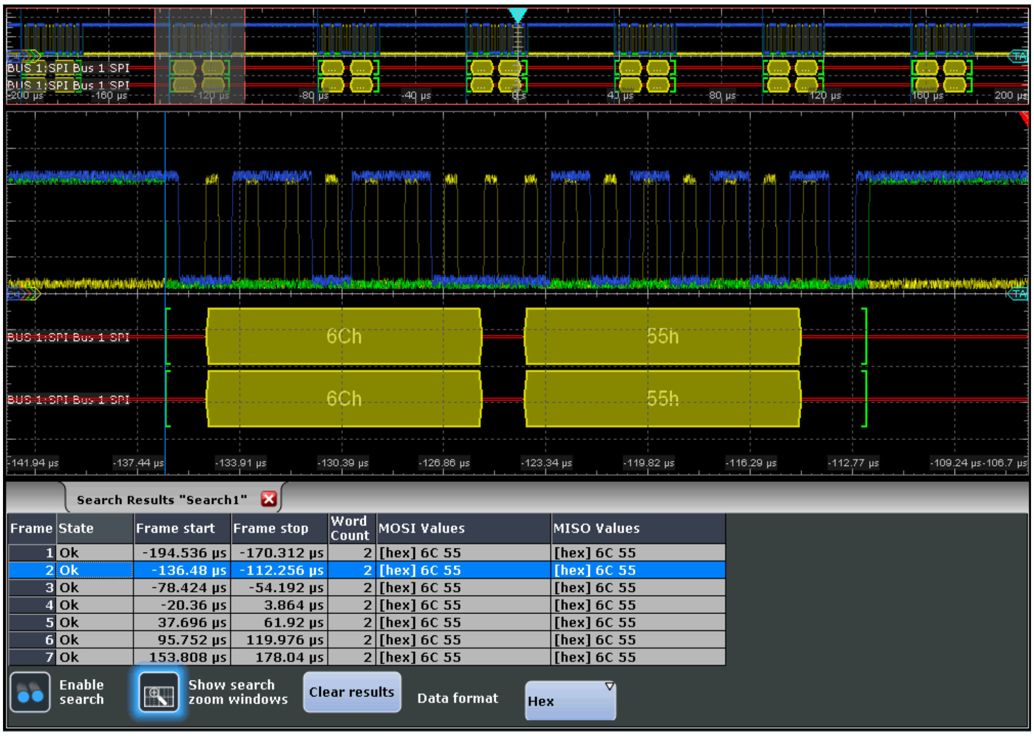
12.3.5.2 SPI Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437



Frame	State	Frame start	Frame stop	Word Count	MOSI Values	MISO Values
1	Ok	-194.536 µs	-170.312 µs	2	[hex] 6C 55	[hex] 6C 55
2	Ok	-136.48 µs	-112.256 µs	2	[hex] 6C 55	[hex] 6C 55
3	Ok	-78.424 µs	-54.192 µs	2	[hex] 6C 55	[hex] 6C 55
4	Ok	-20.36 µs	3.864 µs	2	[hex] 6C 55	[hex] 6C 55
5	Ok	37.696 µs	61.92 µs	2	[hex] 6C 55	[hex] 6C 55
6	Ok	95.752 µs	119.976 µs	2	[hex] 6C 55	[hex] 6C 55
7	Ok	153.808 µs	178.04 µs	2	[hex] 6C 55	[hex] 6C 55

Remote commands are listed in Chapter 20.17.4.5, "SPI Search Results", on page 1547.

12.4 UART / RS232

12.4.1 The UART / RS232 Interface

The Universal Asynchronous Receiver/Transmitter UART converts a word of data into serial data, and vice versa. It is the base of many serial protocols like of RS-232. The UART uses only one line, or two lines for transmitter and receiver.

Data transfer

The data is transmitted in words, also referred to as symbols or characters. Each word consists of a start bit, several data bits, an optional parity bit, and one or more stop bits. Several words can form a package, or frame. The end of a package is marked with a reserved word or by a pause between two words.

Start	Data0	Data1	Data2	Data3	Data4	[Data5]	[Data6]	[Data7]	[Data8]	[Parity]	Stop

Figure 12-9: Bit order in a UART word (symbol)

- The start bit is a logic 0.
- The stop bits and the idle state are always logic 1.

The UART protocol has no clock for synchronization. The receiver synchronizes by means of the start and stop bits, and the bit rate that must be known to the receiver.

Trigger

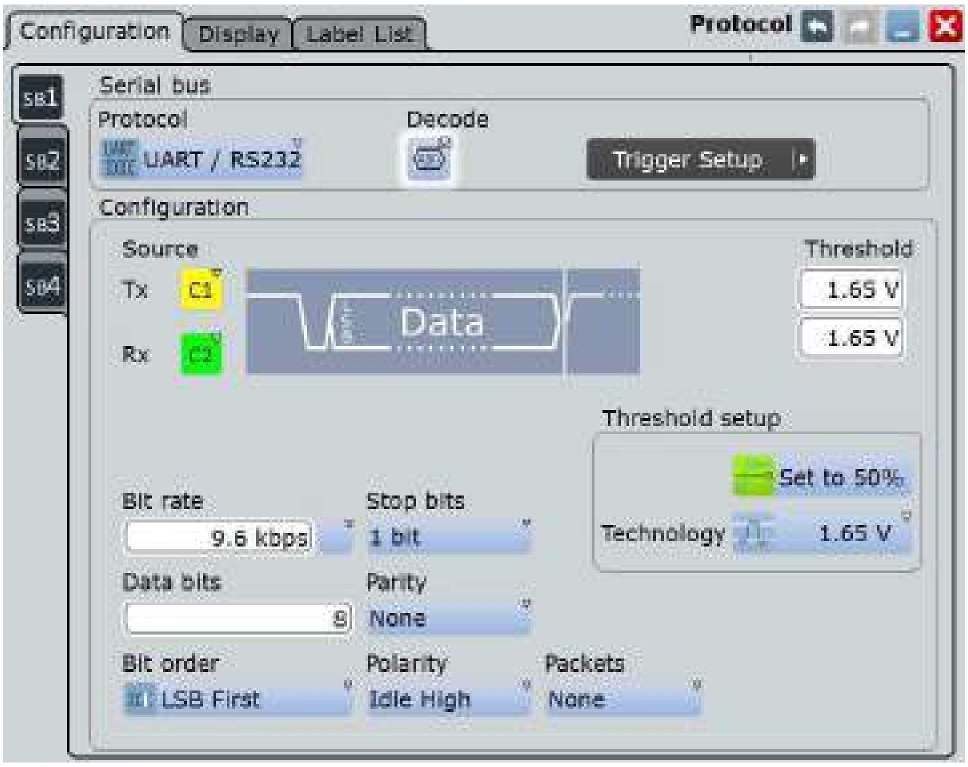
The R&S RTO can trigger on specified parts of UART serial signals:

- Start bit
- Packet start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

12.4.2 UART Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *UART / RS232*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: UART / RS232
Source: Tx C1, Rx C2
Threshold: 1.65 V, 1.65 V
Bit rate: 9.6 kbps
Stop bits: 1 bit
Data bits: 8
Parity: None
Technology: 1.65 V
Bit order: LSB First
Polarity: Idle High
Packets: None

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Source: Tx, Rx
Select the input channels for the transmitter and receiver signals.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:UART:TX:SOURce` on page 1552
`BUS<m>:UART:RX:SOURce` on page 1551

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:UART:RX:THReshold` on page 1552
`BUS<m>:UART:TX:THReshold` on page 1552
`BUS<m>:UART:TECHnology` on page 1553
`BUS<m>:SETReflevels` on page 1495

Polarity
Defines the logic levels of the bus. The idle state corresponds to a logic 1. the start bit to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Remote command:
`BUS<m>:UART:POLarity` on page 1554

Bit rate
Sets the number of transmitted bits per second. To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:UART:BITRate` on page 1553
`BUS<m>:UART:BAUDrate` on page 1553

Data bits
Sets the number of data bits of a word in a range from 5 to 8 bits.

Remote command:
`BUS<m>:UART:SSIZe` on page 1555

Bit order
Defines if a word starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Stop bits
Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Remote command:
`BUS<m>:UART:SBIT` on page 1554

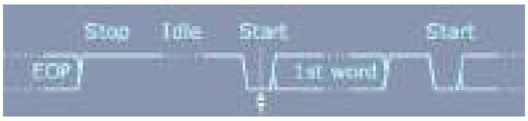
Parity
Defines the optional parity bit that is used for error detection.

"None"	No parity bit is used.
"Odd"	The parity bit is set to "1" if the number of data bits set to "1" is even.
"Even"	The parity bit is set to "1" if the number of data bits set to "1" is odd.
"Mark"	The parity bit is always a logic 1.
"Space"	The parity bit is always a logic 0.
"Don't care"	The parity is ignored.

Remote command:
`BUS<m>:UART:PARity` on page 1554

Packets
Allows to define packets of several words in the data stream.

"None"	Packets are not considered.
"End word"	Defines a pattern as end condition of a packet, for example, a reserved word like CR or LF. The bit pattern editor provides frequently used values in the "Predefined values" list below the pattern table. A new packet starts with the first start bit after the defined end pattern.



"Timeout" Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet.
A new packet starts with the first start bit after the timeout.

Remote command:

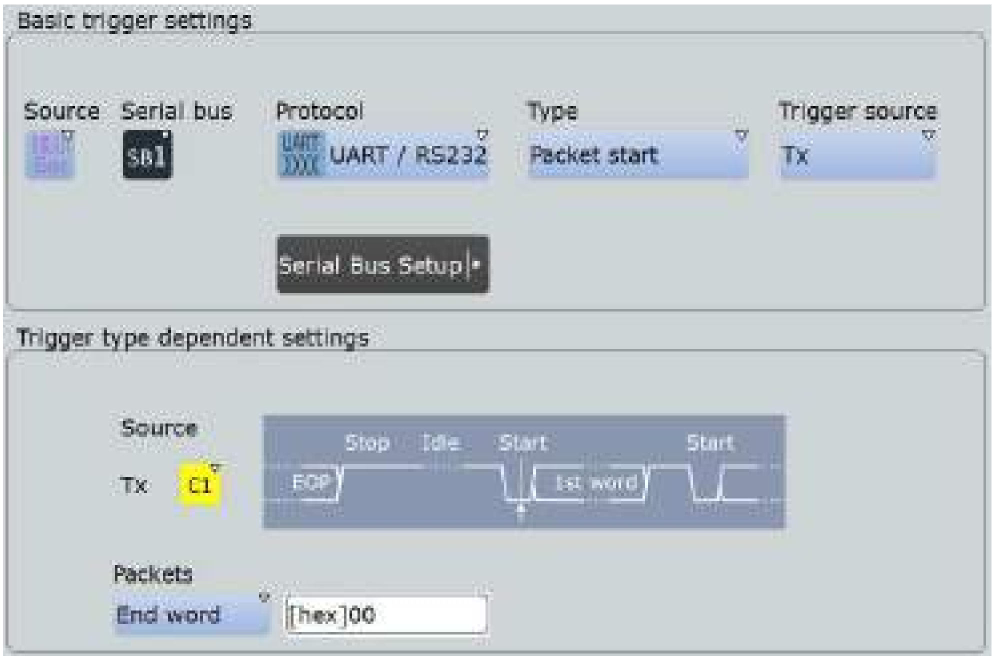
`BUS<m>:UART:PACKets` on page 1555

`BUS<m>:UART:TOUT` on page 1555

`BUS<m>:UART:EWORd` on page 1556

12.4.3 UART Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = UART / RS232"



Basic trigger settings

Source

Serial bus: SB1

Protocol: UART / RS232

Type: Packet start

Trigger source: Tx

Trigger type dependent settings

Source

Tx: C1

Packets: End word [hex]00

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

Selects the trigger type for UART analysis.

"Start bit"	Triggers on a start bit. The start bit is the first low bit after a stop bit.
"Packet start"	Triggers on the begin of a data packet. The frame start is configured with "Packets" on page 522.
"Data"	Trigger on a serial pattern at a defined position in the data packet. The pattern can include several subsequent symbols (data frames). See "Data conditions" on page 524.
"Parity error"	Triggers on a parity error indicating a transmission error. This trigger type is only available if a parity is configured for the UART bus.
"Break condition"	Triggers if a start bit is not followed by a stop bit, the data line remains at logic 0 for longer than a UART word.
"Stop error"	Triggers if the stop bit is a logic 0.

Remote command:

`TRIGger<m>:UART:TYPE` on page 1557

Trigger source

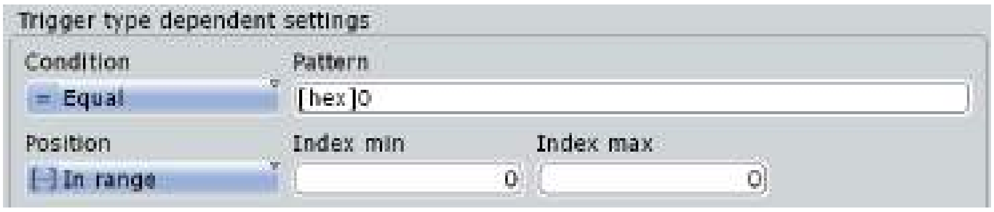
Selects the transmitter or receiver line as trigger source.

Remote command:

`TRIGger<m>:UART:SOURce` on page 1557

Data conditions

Specify the data conditions if the trigger type is set to "Data".



Trigger type dependent settings

Condition: = Equal

Pattern: [hex]0

Position: [-] In range

Index min: 0

Index max: 0

Condition ← Data conditions

Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:

`TRIGger<m>:UART:FCONdition` on page 1558

Pattern ← Data conditions

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order. The starting point of the pattern is defined by Position and Index min, Index max.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:

`TRIGger<m>:UART:DATA` on page 1558

Position ← Data conditions

Operator for the data position. You can define an exact position, or a position range.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger<m>:UART:DPOPerator` on page 1557

Index min, Index max ← Data conditions
Sets the number of words before the first word of interest. These offset words are ignored. If the Position defines a range, the first and the last word of interest are defined.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger<m>:UART:DPOSition` on page 1558
`TRIGger<m>:UART:DPTO` on page 1558

12.4.4 UART Decode Results (Option R&S RTO-K2)

If the option is installed, the "Decode" function in the "Configuration" tab is available.

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

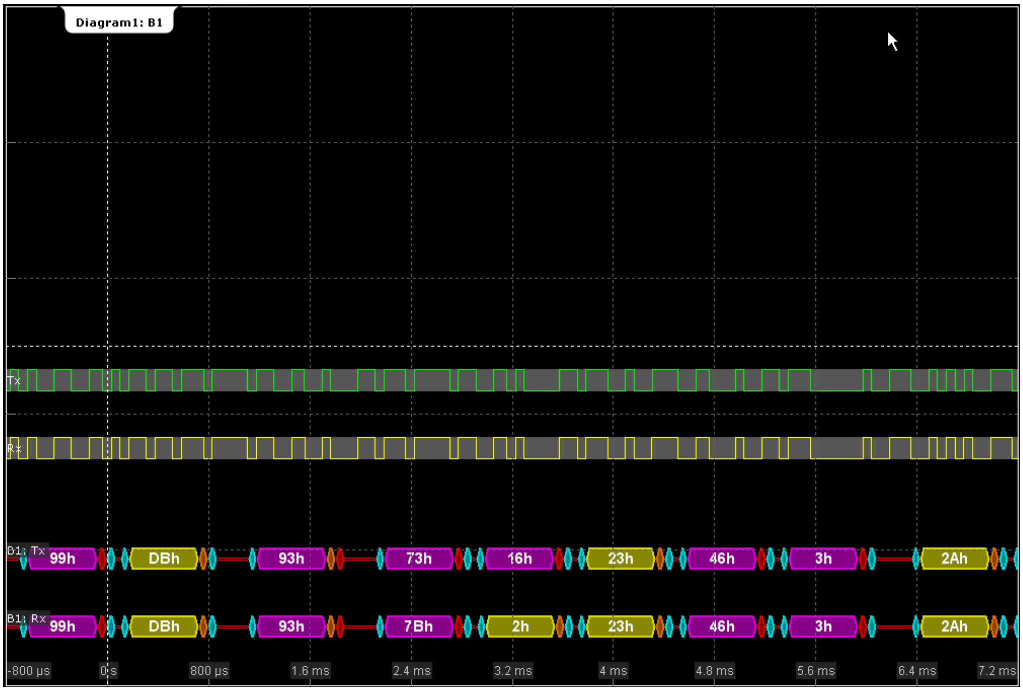
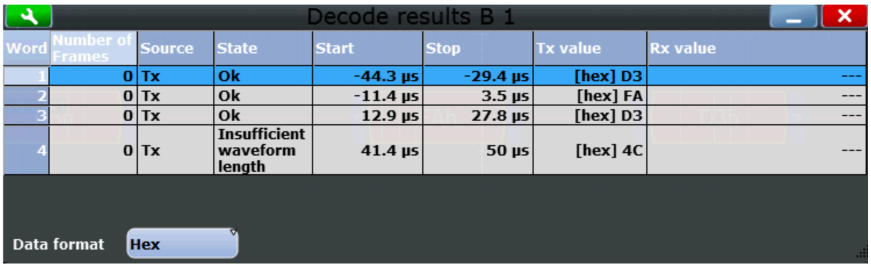


Figure 12-10: Decoded and binary UART signal

blue = start and stop bits if ok
red = start error, stop error, parity error
orange = parity bit if ok
yellow = word ok
magenta = word contains error

The "Decode results" box shows the detailed decoded data for each word.


Decode results B 1

Word	Number of Frames	Source	State	Start	Stop	Tx value	Rx value
1	0	Tx	Ok	-44.3 µs	-29.4 µs	[hex] D3	---
2	0	Tx	Ok	-11.4 µs	3.5 µs	[hex] FA	---
3	0	Tx	Ok	12.9 µs	27.8 µs	[hex] D3	---
4	0	Tx	Insufficient waveform length	41.4 µs	50 µs	[hex] 4C	---

Data format: Hex

Figure 12-11: Decode results of the UART signal

Table 12-5: Content of the "Decode results" table

Column	Description
Number of Frames	
Source	Line, Tx or Rx
State	Decoding state of the word. "Insuffcient waveform length" indicates that the word is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of the word start (start bit)

Column	Description
Stop	Time of the word stop (stop bit)
Tx value	Value of the Tx word. The data format is selected below the table.
Rx value	Value of the Rx word. The data format is selected below the table.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.5.3, "Decode Results (Option R&S RTO-K2)", on page 1558.

12.5 CAN and CAN FD (Options R&S RTO-K3 and -K9)

CAN is the Controller Area Network, a bus system designed by Bosch for use within automotive network architecture, for example, for brake, power train and engine management. Today, it is also used in many other systems, for example, in industrial machines, aerospace, subsea, merchant marine etc..

More than 20 years after the invention of CAN, communication needs have increased, and CAN has reached it's bandwidth limits in some application fields. Therefore, Bosch specified an improved CAN protocol with flexible data rate - CAN FD. It introduces a higher bit rate in the data phase up to 15 Mbit/s and an extended data field from up to 64 bytes.

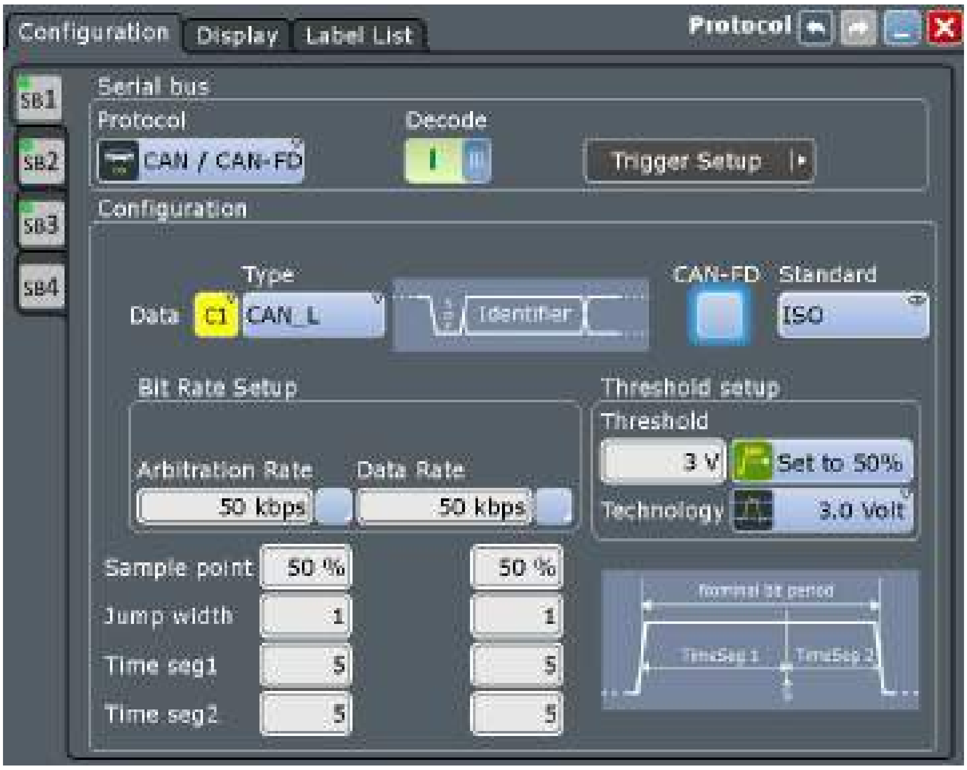
The R&S RTO provides decoding, triggering and searching CAN and CAN FD signals with following options:

- CAN: option R&S RTO-K3
- CAN FD: option R&S RTO-K9, requires CAN option R&S RTO-K3

12.5.1 CAN and CAN-FD Configuration

Access: PROTOCOL key > "Configuration" tab > "Protocol" = "CAN" or "CAN/CAN-FD"

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: CAN / CAN-FD

Data: C1 CAN_L

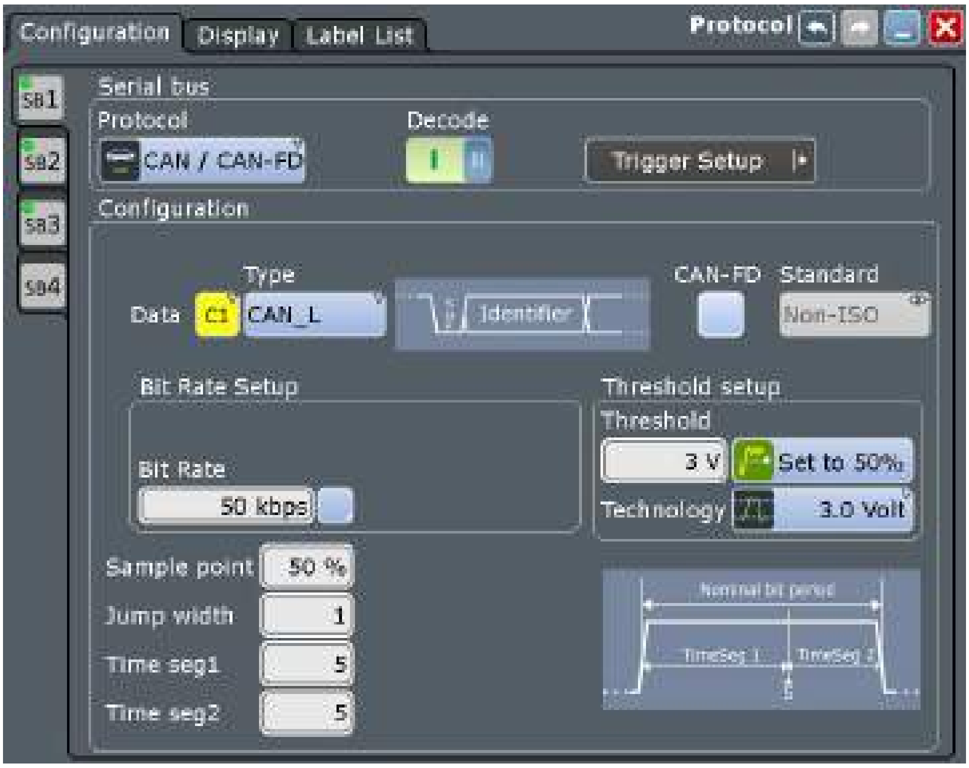
Standard: ISO

Threshold: 3 V

Technology: 3.0 Volt

	Arbitration Rate	Data Rate
	50 kbps	50 kbps
Sample point	50 %	50 %
Jump width	1	1
Time seg1	5	5
Time seg2	5	5

Figure 12-12: Configuration for CAN FD



Protocol: CAN / CAN-FD

Data: C1 CAN_L

Standard: Non-ISO

Bit Rate: 50 kbps

Threshold: 3 V

Technology: 3.0 Volt

Sample point: 50 %

Jump width: 1

Time seg1: 5

Time seg2: 5

Figure 12-13: Configuration for CAN

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data
Sets the source of the selected data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

A math waveform can be used, for example, if you probe on CAN-High and CAN-Low using two single-ended probes, and the difference between high and low is calculated and displayed using a math waveform.

Remote command:
`BUS<m>:CAN:DATA:SOURce` on page 1561

Type
Selects the CAN-High or CAN-Low line. CAN uses both lines for differential signal transmission.

If you measure with a differential probe, connect the probe to both CAN-H and CAN-L lines, and select the data "Type" = *CAN-H*.

If you use a single-ended probe, connect the probe to either CAN_L or CAN_H, and select the data type accordingly.

Remote command:
`BUS<m>:CAN:TYPE` on page 1561

CAN-FD
Enables the CAN FD protocol configuration and displays additional CAN FD parameters.

The setting is available in CAN FD option R&S RTO-K9.

Remote command:
`BUS<m>:CAN:FDATa:ENABle` on page 1563
`BUS<m>:CAN:FDATa:FRAMe<n>:STANdard?` on page 1575

Standard
Only available for CAN FD buses.

"Non-ISO"	Signals are decoded according to the the Bosch CAN FD protocol.
"ISO"	Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence.

Remote command:
`BUS<m>:CAN:FDATa:PSTandard` on page 1562

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false).

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:CAN:DATA:THReshold` on page 1562
`BUS<m>:CAN:TECHnology` on page 1562
`BUS<m>:SETReflevels` on page 1495

Bit rate (CAN) / Arbitration rate (CAN FD)
For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum value of this rate is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

To select a bit rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:BITRate` on page 1563

Data rate
The setting is available in CAN FD option R&S RTO-K9.

Sets the bit rate of the data phase. The data rate can be equal or higher than the arbitration rate; and it is uniform and fixed for a given CAN FD bus.

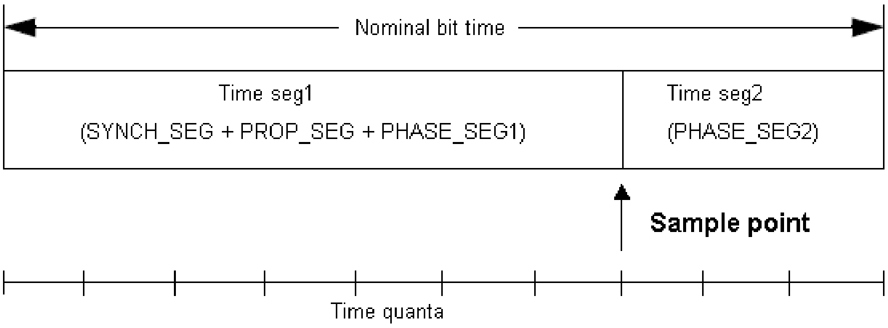
To select a data rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:FDATa:DBITrate` on page 1564

Synchronization: Sample point, Time segments, Jump width
The CAN bus interface uses an asynchronous transmission scheme. The standard specifies a set of rules to resynchronize the local clock of a CAN node to the message.

The sample point divides the nominal bit period into two distinct time segments. The length of the time segments is defined in time quanta according to network and node conditions during CAN development.

For CAN FD signals, you can define the sysnchronization settings separately for the arbitration phase and data phase.



To specify the bit timing, enter either "Time seg1" and "Time seg2", or directly the "Sample point". Additionally, set the "Jump width".

"Time seg1, Time seg2"	Set the number of time quanta before the sample point (Time seg1) and after the sample point (Time seg2). The "Sample point" percentage value is adjusted accordingly. Time seg1 comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard. Time seg2 matches Phase_seg2 from the standard. The maximum sum of Time seg1 and Time seg2 is 25.
"Sample point"	Sets the position of the sample point within the bit in percent ot the nominal bit time. The time quanta values "Time seg1, Time seg2" are adjusted accordingly.
"Jump width"	Time segment1 may be lengthened or time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators. The jump width defines the maximum number of time quanta for phase correction. The maximum value of the jump width is 4, or *Time seg1 - Time seg2* if this difference is lower than 4.

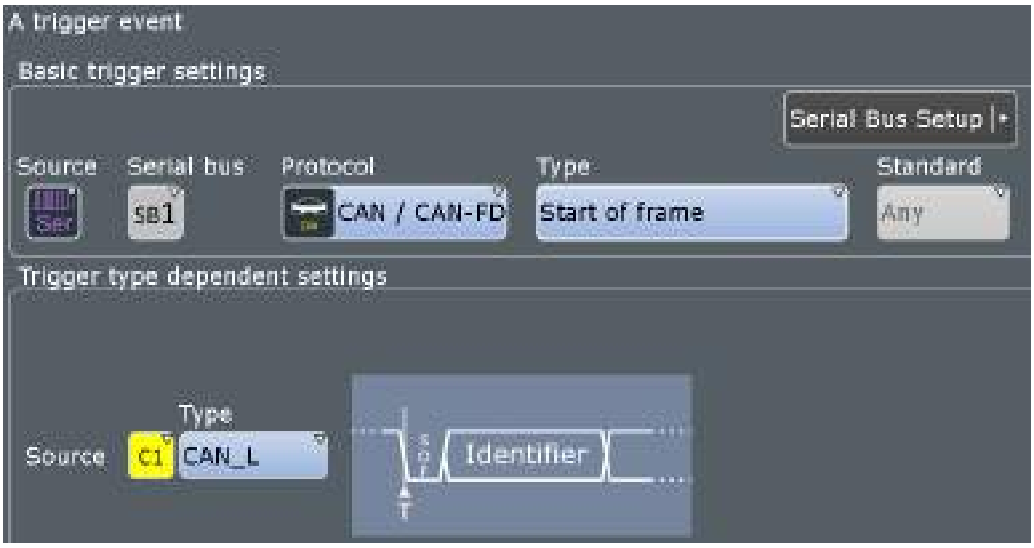
Remote command:
`BUS<m>:CAN:T1Segment` on page 1564
`BUS<m>:CAN:T2Segment` on page 1565
`BUS<m>:CAN:SAMPlepoint` on page 1564
`BUS<m>:CAN:JWIDth` on page 1565
`BUS<m>:CAN:FDATa:T1Segment` on page 1565
`BUS<m>:CAN:FDATa:T2Segment` on page 1566
`BUS<m>:CAN:FDATa:SAMPlepoint` on page 1565
`BUS<m>:CAN:FDATa:JWIDth` on page 1566

12.5.2 CAN / CAN FD Trigger

The R&S RTO can trigger on various events in a CAN or CAN FD frame. Trigger conditions include start of frame, frame ID, data pattern, or error conditions.

12.5.2.1 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = CAN or CAN / CAN FD"



Source Ser
Serial bus SB1
Protocol CAN / CAN-FD
Type Start of frame
Standard Any

Source C1
Type CAN_L

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Serial bus
Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1499

Protocol
Defines protocol type of the bus for bus configuration and trigger settings.

Remote command:
`BUS<m>:TYPE` on page 1494

Trigger type
Selects the trigger type for CAN analysis.

"Start of frame"	Triggers on the first edge of the dominant SOF bit (synchronization bit).

"Frame type"	Triggers on a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered. For details, see: ● "Frame type" on page 533 ● "ID type" on page 534
"Identifier"	Sets the trigger to a specific message identifier or an identifier range. See "Identifier setup: Condition, Identifier min, Identifier max" on page 534.
"Identifier + Data"	Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Identifier min, Identifier max" on page 534. Data conditions are set with "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 536.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 538.
"Symbolic"	The "Symbolic" trigger type is available if a DBC label list file is loaded and applied. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message, see Chapter 12.5.6.1, "Symbolic Trigger", on page 558.

Remote command:
`TRIGger<m>:CAN:TYPE` on page 1567

Standard

Selects the CAN standard: "CAN", "CAN FD", or "Any".

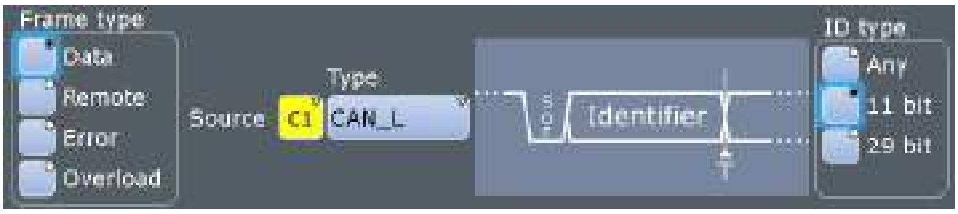
The setting is available in CAN FD option R&S RTO-K9.

Use "Any" to trigger on either CAN or CAN-FD frame. In this case, the trigger configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`TRIGger<m>:CAN:FDATa:STANdard` on page 1567

Frame type

CAN has four frame types which can be used as trigger condition.



For data and remote frames, the identifier format has to be set with ID type.

"Data"	The data frame is the only frame for actual data transmission.

"Remote"	Remote frames are only available in the CAN protocol. The remote frame initiates the transmission of data by another node. The frame format is the same as of data frames but without the data field.
"Error"	When a node recognizes an error, it cancels transmission by sending an error frame. The instrument triggers seven bit periods after the end of the error flag that is marked by a dominant-recessive edge. The ID type is irrelevant for error frames.
"Overload"	When a node needs a delay between data and/or remote frames, it sends and overload frame. The instrument triggers seven bit periods after the end of the overload flag that is marked by a dominant-recessive edge. The ID type is irrelevant for overload frames.

Remote command:
`TRIGger<m>:CAN:FTYPe` on page 1568

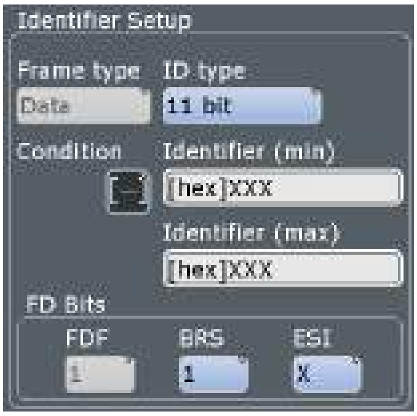
ID type
Selects the length of the identifier:

"11 bit"	Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit (identifier extension flag).
"29 bit"	Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.
"Any"	The ID type and ID pattern are not relevant for the trigger condition. If the trigger type is "Identifier", the instrument triggers on any identifier in the specified frame type. If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to trigger only on data.

Remote command:
`TRIGger<m>:CAN:ITYPe` on page 1568

Identifier setup: Condition, Identifier min, Identifier max
The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The trigger point depends on the ID type.



Identifier Setup

Frame type: Data

ID type: 11 bit

Identifier (min): [hex]XXX

Identifier (max): [hex]XXX

FD Bits

FDF: 1

BRS: 1

ESI: X

Figure 12-14: Identifier setup for CAN FD

"Frame type"	Data frames and remote frames contain an identifier. Select the frame type to be triggered on, or select "Any" if the frame type is not relevant. In CAN FD, only "Data" frames are available.
"ID type"	See: "ID type" on page 534.
"Condition"	Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.
"Identifier min"	Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the conditions "Equal" and "Not equal". The length of the bit patterns is restricted to the selected "ID type". The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Identifier max"	The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".
"FD bits"	See: "FD bits" on page 535.

Remote command:
`TRIGger<m>:CAN:ICONdition` on page 1568
`TRIGger<m>:CAN:IMIN` on page 1569
`TRIGger<m>:CAN:IMAX` on page 1569

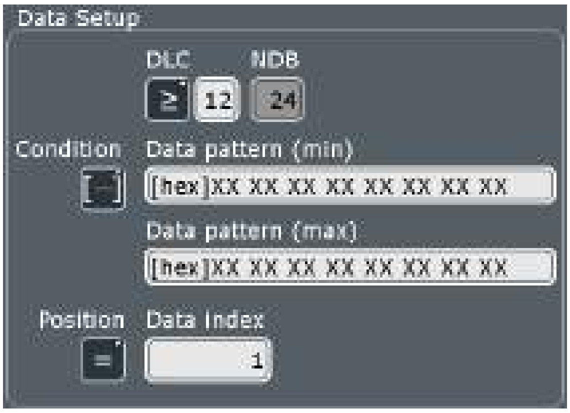
FD bits
For standard settings "CAN FD" and "Any", you can trigger on CAN FD-specific bits.

"FDF"	The bit determines whether a frame is CAN or CAN-FD. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format. If you do not know if the signal is CAN or CAN FD, you can use this bit to identify the format: FDF = 1 is CAN FD, and FDF = 0 is CAN. Set "X" if the format is not relevant.
"BRS"	is the bit rate switch bit. Value 1 means that the bit rate switches from the "Arbitration rate" to the faster "Data rate".
"ESI"	is the error state indicator. Set "X" if the bit is not relevant.

Remote command:
`TRIGger<m>:CAN:FDATa:FDF` on page 1569
`TRIGger<m>:CAN:FDATa:BRS` on page 1569
`TRIGger<m>:CAN:FDATa:ESI` on page 1570

Data setup: DLC, NDB, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.

To trigger only on data, set the "ID type" of the identifier setup to "Any".



DLC: ≥ 12
NDB: 24
Data pattern (min): [hex]XX XX XX XX XX XX XX XX
Data pattern (max): [hex]XX XX XX XX XX XX XX XX
Data Index: 1

Figure 12-15: Data setup for CAN FD

DLC: ≥ 8
NDB: 8
Transfer: Big endian
Data min: [hex]XX XX XX XX XX XX XX XX
Data max: [hex]XX XX XX XX XX XX XX XX

Figure 12-16: Data setup for CAN

"Transfer"	CAN only: Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

"DLC, NDB"	"DLC" sets the Data Length Code, which defines the number of data bytes to be found. "NDB" shows the number of data bytes that is set by the DLC. DLC and NDB are different in CAN FD for DLCs > 8. CAN: For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set. Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*. CAN FD: The data field can have up to 64 bytes, the DLC is defined in the standard. For example, DLC = 9 defines that the data field has 12 bytes, and DLC = 15 sets a 64 byte data field.
"Condition"	Sets the operator to set a specific data pattern ("Equal" or "Not equal") or a data range.
"Data min"	Defines the data pattern. The pattern length is adjusted to the DLC setting (and vice versa). Enter the pattern MSB first and with big endian byte order. In binary format, use the following characters: 1; 0; or X (any bit). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:BORDer` on page 1571
`TRIGger<m>:CAN:DCONdition` on page 1570
`TRIGger<m>:CAN:DMIN` on page 1570
`TRIGger<m>:CAN:DMAX` on page 1570
`TRIGger<m>:CAN:DLCCondition` on page 1571
`TRIGger<m>:CAN:DLC` on page 1571
`TRIGger<m>:CAN:NDBYtes?` on page 1571

Data position

The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTO-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

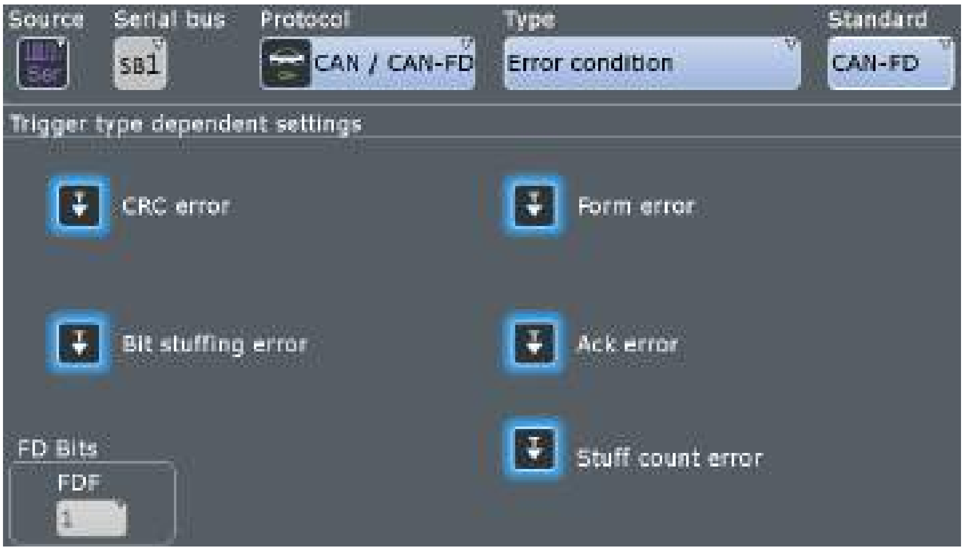
"Position"	Sets the operator to define an exact position ("Equal") or a data range. Use "Any", if the data position is not relevant for the trigger condition.

"Data index (min)"	Defines the number of the first data byte at which the data pattern may start.
"Data index (max)"	Sets the number of the last byte at which the required data pattern may start if the "Position" operator is "In range".

Remote command:
`TRIGger<m>:CAN:FDATa:DPOPerator` on page 1572
`TRIGger<m>:CAN:FDATa:DPOSition` on page 1572
`TRIGger<m>:CAN:FDATa:DPTO` on page 1572

Error conditions

If a CAN detects an error, it transmits an error flag at the next bit. The R&S RTO detects errors in the message and triggers on these errors even if no CAN node sends an error flag.



Source: Ser
Serial bus: SB1
Protocol: CAN / CAN-FD
Type: Error condition
Standard: CAN-FD
FD Bits: FDF 1

- CRC error
  CAN uses the Cyclic Redundancy Check, which is a complex checksum calculation method. The transmitter calculates the CRC and sends the result in the CRC sequence. The receiver calculates the CRC in the same way. A CRC error occurs when the calculated result differs from the received value in the CRC sequence.
- Bit stuffing error
  The frame segments Start Of Frame, Arbitration Field, Control Field, Data Field and CRC Sequence are coded by the bit stuffing method. The transmitter automatically inserts a complementary bit into the bit stream when it detects five consecutive bits of identical value in the bit stream to be transmitted. A stuff error occurs when the 6th consecutive equal bit level in the mentioned fields is detected.
- Form error
  A form error occurs when a fixed-form bit field contains one or more illegal bits.
- Ack error
  An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.
- Stuff count error

A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count. Only relevant for CAN FD signals in ISO standard.

Remote command:
`TRIGger<m>:CAN:CRCerror` on page 1573
`TRIGger<m>:CAN:BITSterror` on page 1573
`TRIGger<m>:CAN:FORMerror` on page 1573
`TRIGger<m>:CAN:ACKerror` on page 1573
`TRIGger<m>:CAN:FDATa:SCERror` on page 1574

12.5.2.2 Triggering on CAN FD Data

The "Identifier + Data" trigger type supports triggering on data bytes of specific value at specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the data pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following examples demonstrate how the data pattern and data position are defined.

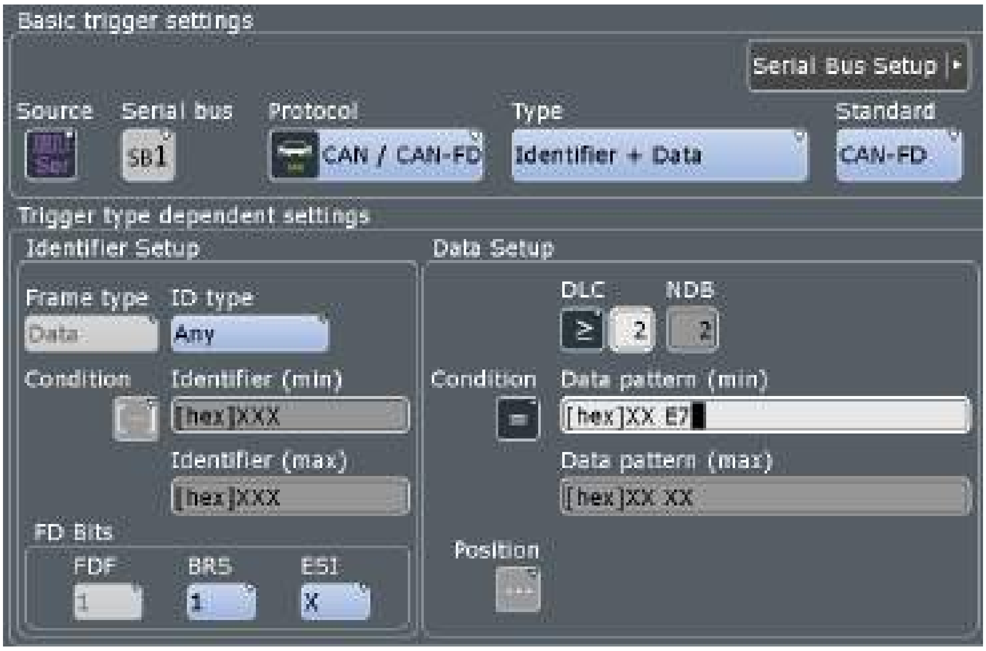
To set up the trigger

1. Set the basic trigger events:
   a) Select the source: "Serial bus".
   b) Select the serial bus.
   c) Select the protocol: "CAN/CAN FD".
   d) Select the trigger type: "Identifier + Data".
   e) Select the standard:"CAN FD" or "Any".
2. In this example, the identifier does not matter. Set the "ID type = Any".
3. Define the data setup as described in the examples.

Example: Triggering on the second data byte

The CAN FD frame has 2 or more data bytes, where the value of the second data byte should be E7.

- Set "DLC ≥ 2".
- Set the data pattern: "= XX E7".



Source: Ser
Serial bus: SB1
Protocol: CAN / CAN-FD
Type: Identifier + Data
Standard: CAN-FD

Frame type: Data
ID type: Any
Condition: =
Identifier (min): [hex]XXX
Identifier (max): [hex]XXX

FDF: 1
BRS: 1
ESI: X

DLC: ≥ 2
NDB: 2
Condition: =
Data pattern (min): [hex]XX E7
Data pattern (max): [hex]XX XX
Position: ...

Figure 12-17: Trigger setup to trigger on the 2nd data byte with value = E7

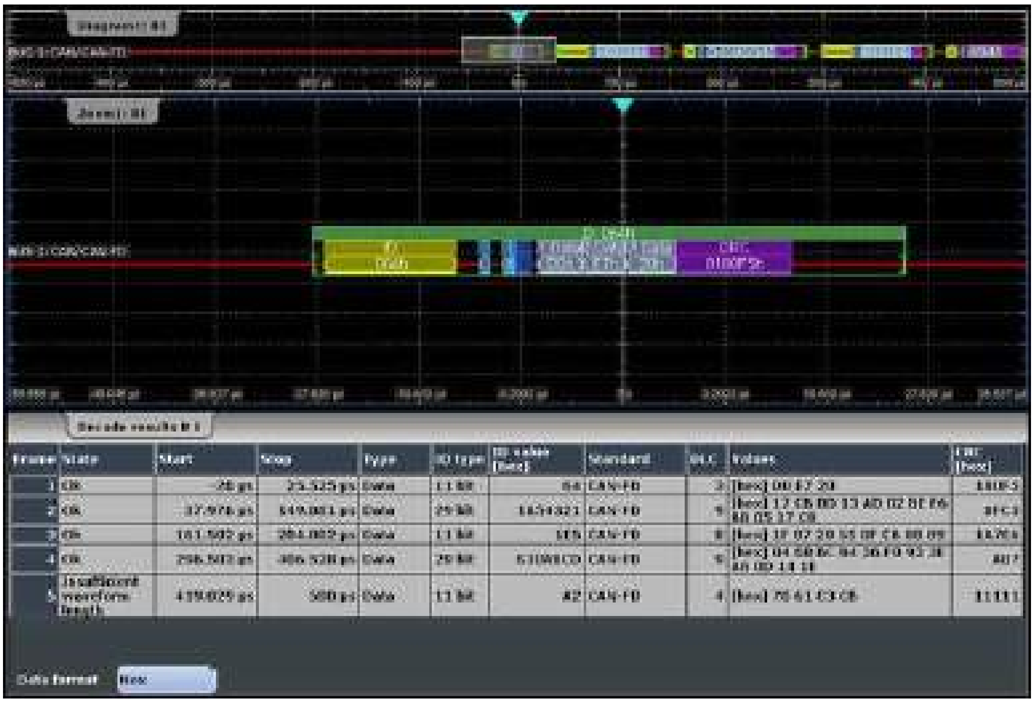
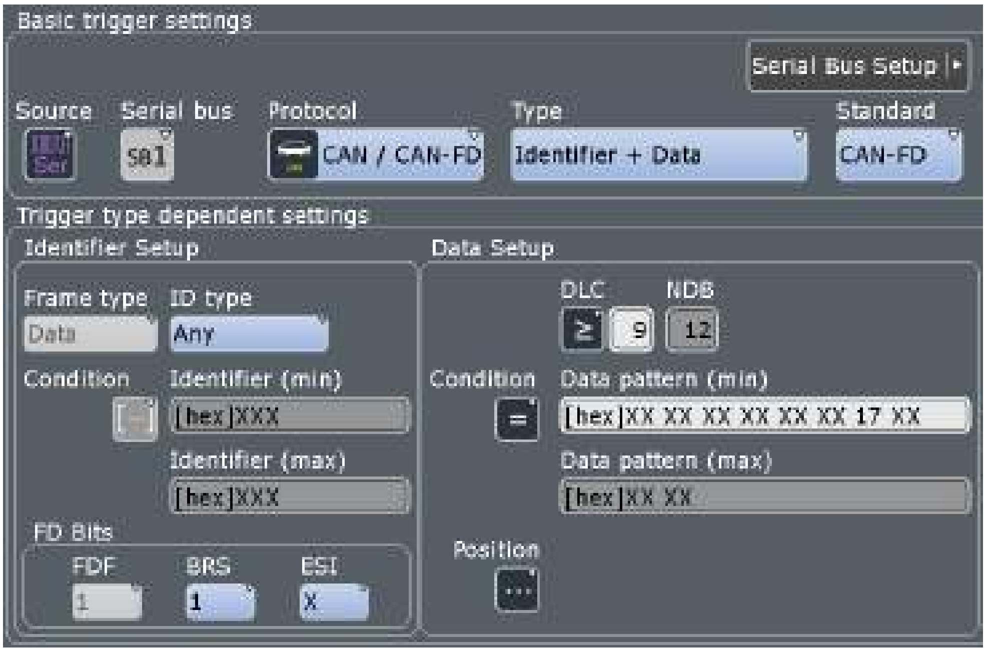


Figure 12-18: Data type trigger on 2nd data byte with value = E7

Example: Triggering on the seventh or later data byte

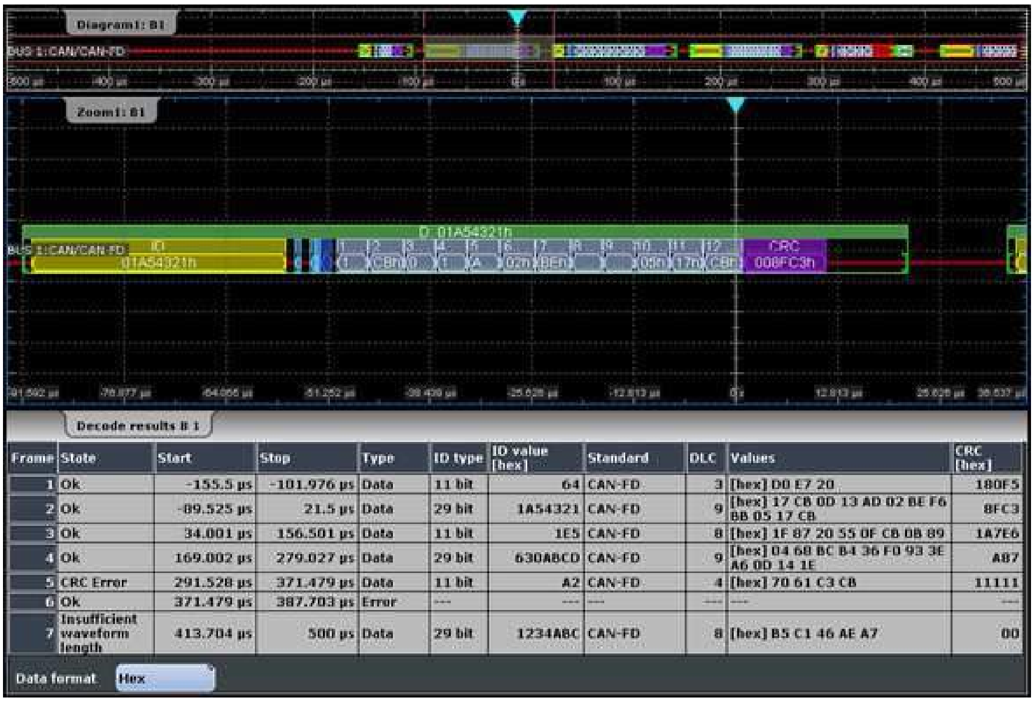
The CAN FD frame has 12 or more data bytes, where the value of the seventh or later data byte should be 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX 17 XX".



Source: Ser
Serial bus: SB1
Protocol: CAN / CAN-FD
Type: Identifier + Data
Standard: CAN-FD
Frame type: Data
ID type: Any
Condition: =
Identifier (min): [hex]XXX
Identifier (max): [hex]XXX
FDF: 1
BRS: 1
ESI: X
DLC: ≥ 9
NDB: 12
Condition: =
Data pattern (min): [hex]XX XX XX XX XX XX 17 XX
Data pattern (max): [hex]XX XX
Position: ...

Figure 12-19: Trigger setup to trigger on the 7th or later data byte with value = 17



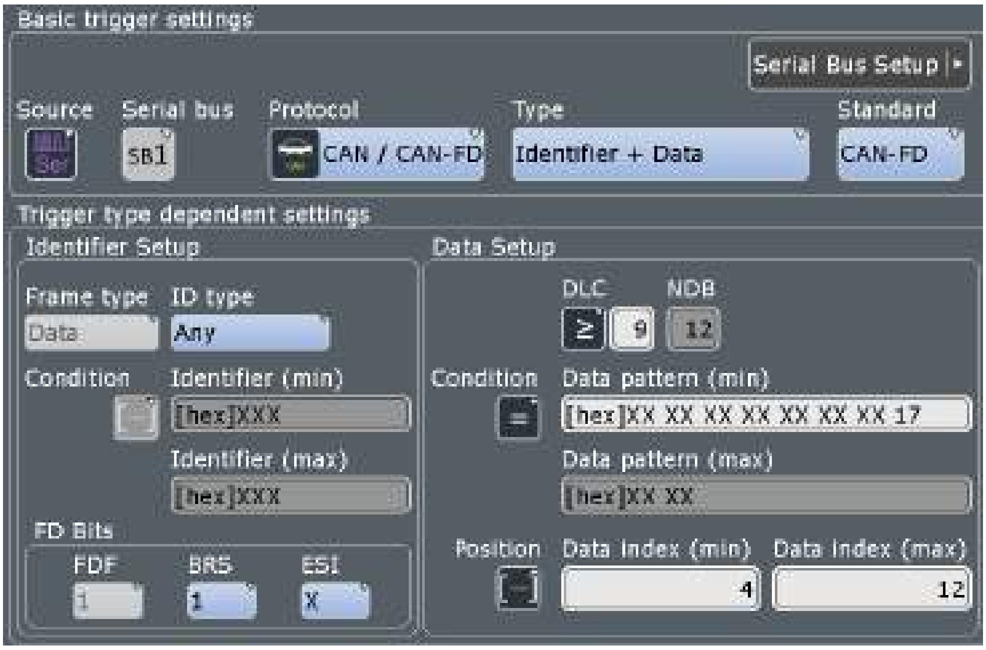
Frame	State	Start	Stop	Type	ID type	ID value [hex]	Standard	DLC	Values	CRC [hex]
1	Ok	-155.5 µs	-101.976 µs	Data	11 bit	64	CAN-FD	3	[hex] D0 E7 20	180F5
2	Ok	-89.525 µs	21.5 µs	Data	29 bit	1A54321	CAN-FD	9	[hex] 17 CB 0D 13 AD 02 BE F6 BB 05 17 CB	8FC3
3	Ok	34.001 µs	156.501 µs	Data	11 bit	1E5	CAN-FD	8	[hex] 1F 87 20 55 0F C8 0B 89	1A7E6
4	Ok	169.002 µs	279.027 µs	Data	29 bit	630ABCD	CAN-FD	9	[hex] 04 68 BC B4 36 F0 93 3E A6 0D 14 1E	A87
5	CRC Error	291.528 µs	371.479 µs	Data	11 bit	A2	CAN-FD	4	[hex] 70 61 C3 CB	11111
6	Ok	371.479 µs	387.703 µs	Error	---	---	---	---	---	---
7	Insufficient waveform length	413.704 µs	500 µs	Data	29 bit	1234ABC	CAN-FD	8	[hex] B5 C1 46 AE A7	00

Figure 12-20: Data type trigger on data byte with the 7th or later byte value = 17

Example: Triggering on a data byte at a given position

The CAN FD frame has 12 or more data bytes. the trigger is set at the 8th data byte starting at the 4th data byte or later, with data byte value = 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX XX 17 ".
- Set the position of the data pattern: "In range", "4" to "12".



Basic trigger settings

Source: Ser

Serial bus: SB1

Protocol: CAN / CAN-FD

Type: Identifier + Data

Standard: CAN-FD

Trigger type dependent settings

Identifier Setup

Frame type: Data

ID type: Any

Identifier (min): [hex]XXX

Identifier (max): [hex]XXX

FD Bits

FDF: 1

BRS: 1

ESI: X

Data Setup

DLC: ≥ 9

NDB: 12

Condition: =

Data pattern (min): [hex]XX XX XX XX XX XX XX 17

Data pattern (max): [hex]XX XX

Data Index (min): 4

Data Index (max): 12

Figure 12-21: Trigger setup to trigger on data byte with value = 17 at 11th data byte location

The instrument skips the first 3 data bytes and starts comparing the data pattern with the 4th data byte. So, the byte with value 17 can be found between the 11th and the 19th data byte.

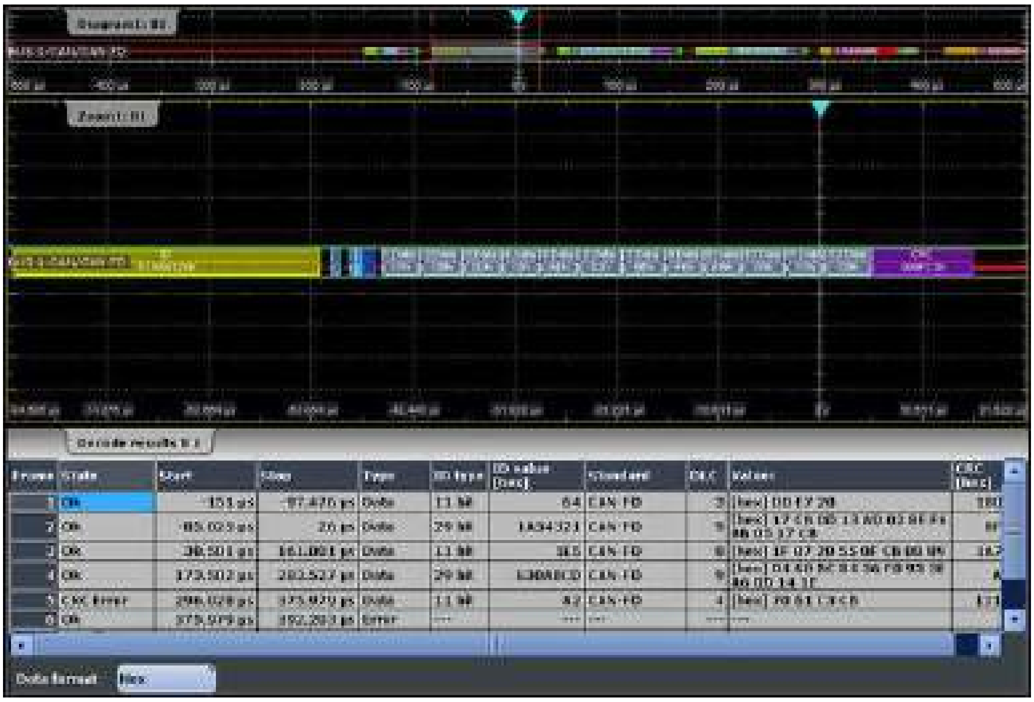


Figure 12-22: Data type trigger on data byte with value = 17 at 11th data byte location

12.5.3 CAN / CAN FD Label List

Label list files (symbolic data files) for CAN and CAN FD protocols are available in PTT and CSV file formats, similar to other serial protocols. In additition, the R&S RTO can read and apply DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

Note: In the following, CAN means both protocols: CAN, and CAN FD.

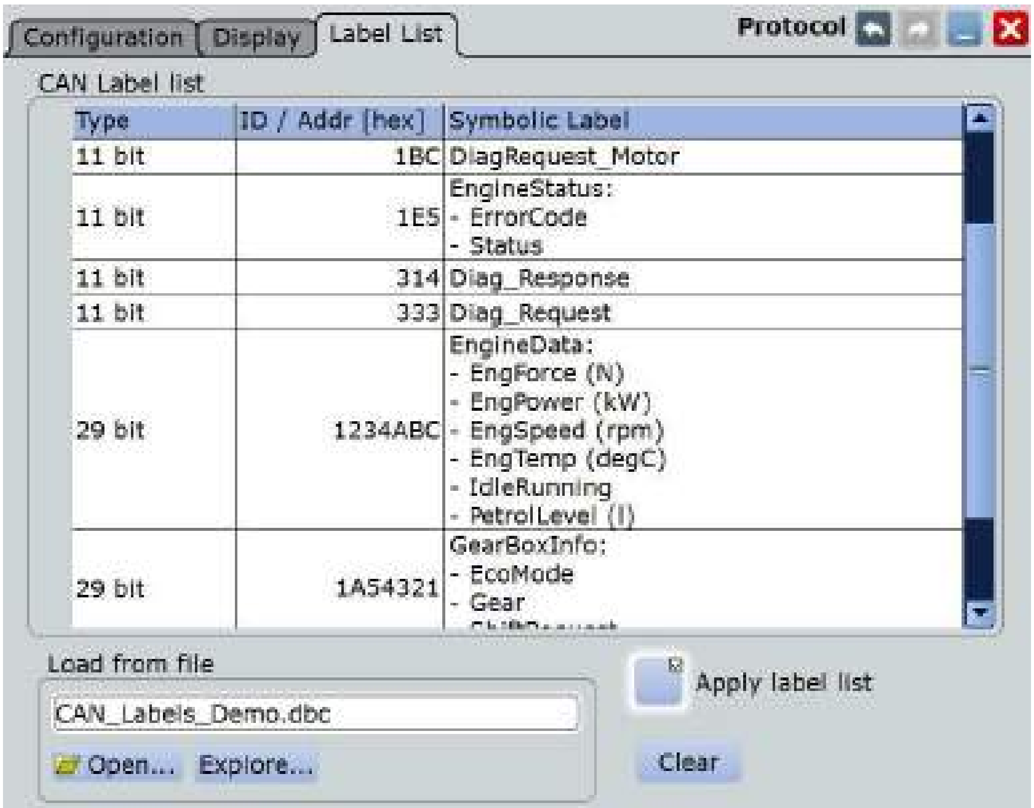
12.5.3.1 DBC files for CAN / CAN FD

Industry-standard DBC files contain more information than PTT and CSV files and translate the abstract decode results to human language. For each frame, the frame ID and the symbolic name of the ID are given; the frames are also called messages in CAN. The data of a CAN message can consist of several "signals". The DBC file provides the label, unit, start bit, length and other indicators for each signal. For state-encoded signals, the meaning of the states is given.

In the demo example, the message "EngineData" has the decimal ID 2,166,573,756 and consists of 8 data bytes. These 8 bytes are defined as 6 signals. The first one, "PetrolLevel", starts at bit #24, has a length of 8 bit, and the unit is liter. The signal "IdleRunning" is state-encoded. It has only one bit. The binary value 0 means "Running", and the binary value 1 means "Idle".

Example: CAN DBC file section

```
BO_ 2166573756 EngineData: 8 Engine
 SG_ PetrolLevel : 24|8@1+ (1,0) [0|255] "l" ...
 SG_ EngPower : 48|16@1+ (0.01,0) [0|350] "kW" ...
 SG_ EngForce : 32|10@1+ (1,0) [0|1000] "N" ...
 SG_ IdleRunning : 23|1@1+ (1,0) [0|1] "" ...
 SG_ EngTemp : 16|7@1+ (2,-50) [-50|150] "degC" ....
 SG_ EngSpeed : 0|13@1+ (1,0) [0|8000] "rpm" ...
....
 VAL_ 2166573756 IdleRunning 0 "Running" 1 "Idle" ;
```



Type	ID / Addr [hex]	Symbolic Label
11 bit	1BC	DiagRequest_Motor
11 bit	1E5	EngineStatus: - ErrorCode - Status
11 bit	314	Diag_Response
11 bit	333	Diag_Request
29 bit	1234ABC	EngineData: - EngForce (N) - EngPower (kW) - EngSpeed (rpm) - EngTemp (degC) - IdleRunning - PetrolLevel (l)
29 bit	1A54321	GearBoxInfo: - EcoMode - Gear

Load from file: CAN_Labels_Demo.dbc

☐ Apply label list

The usage of DBC files is described in Chapter 12.5.6, "Symbolic Trigger, Decode and Search", on page 558.

12.5.3.2 PTT and CSV Files for CAN / CAN FD

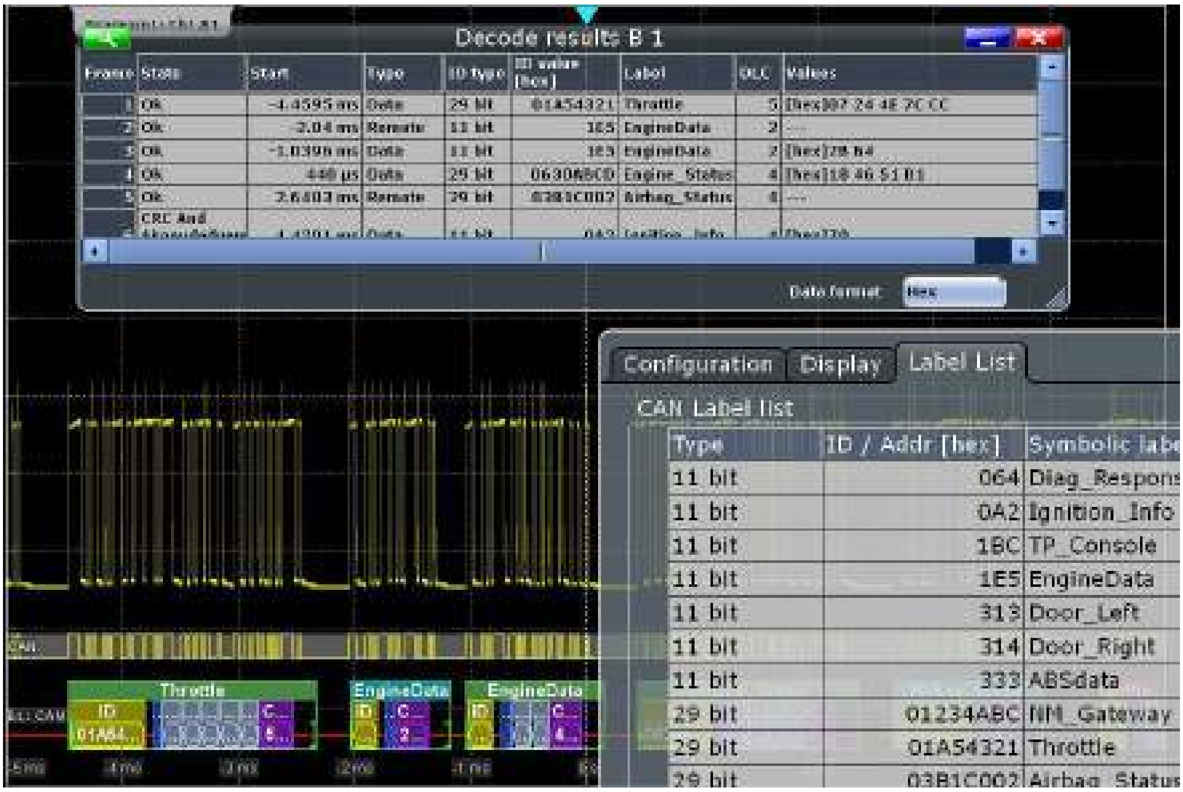
Label list files are protocol-specific. A PTT label file for CAN protocols contains three values for each identifier:

- Identifier type, 11-bit or 29-bit long
- Identifier value
- Label, symbolic name of the identifier, specifying its function in the bus network.

Example: CAN PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = can
# ---------------------------------------------------------------------------
# Labels for CAN protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
11,064h,Diag_Response
11,1E5h,EngineData
11,0A2h,Ignition_Info
11,1BCh,TP_Console
11,333h,ABSdata
```

```
11,313h,Door_Left
11,314h,Door_Right
29,01A54321h,Throttle
29,13A00FA2h,LightState
29,0630ABCDh,Engine_Status
29,03B1C002h,Airbag_Status
29,01234ABCh,NM_Gateway
# ---------------------------------------------------------------------------
```



Decode results B 1

Frame	State	Start	Type	ID type	ID value [hex]	Label	DLC	Values
1	OK	-4.4595 ms	Data	29 bit	01A54321	Throttle	5	[hex]07 24 4E 7C CC
2	OK	-2.04 ms	Remote	11 bit	1E5	EngineData	2	---
3	OK	-1.0398 ms	Data	11 bit	1E5	EngineData	2	[hex]78 B4
4	OK	440 µs	Data	29 bit	0630ABCD	Engine_Status	4	[hex]18 46 51 B1
5	OK	2.6403 ms	Remote	29 bit	03B1C002	Airbag_Status	8	---

Data format: Hex

CAN Label list

Type	ID / Addr [hex]	Symbolic labe
11 bit	064	Diag_Respons
11 bit	0A2	Ignition_Info
11 bit	1BC	TP_Console
11 bit	1E5	EngineData
11 bit	313	Door_Left
11 bit	314	Door_Right
11 bit	333	ABSdata
29 bit	01234ABC	NM_Gateway
29 bit	01A54321	Throttle
29 bit	03B1C002	Airbag_Status

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:CAN:FRAMe<n>:SYMBol?` on page 1577

12.5.4 CAN and CAN FD Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

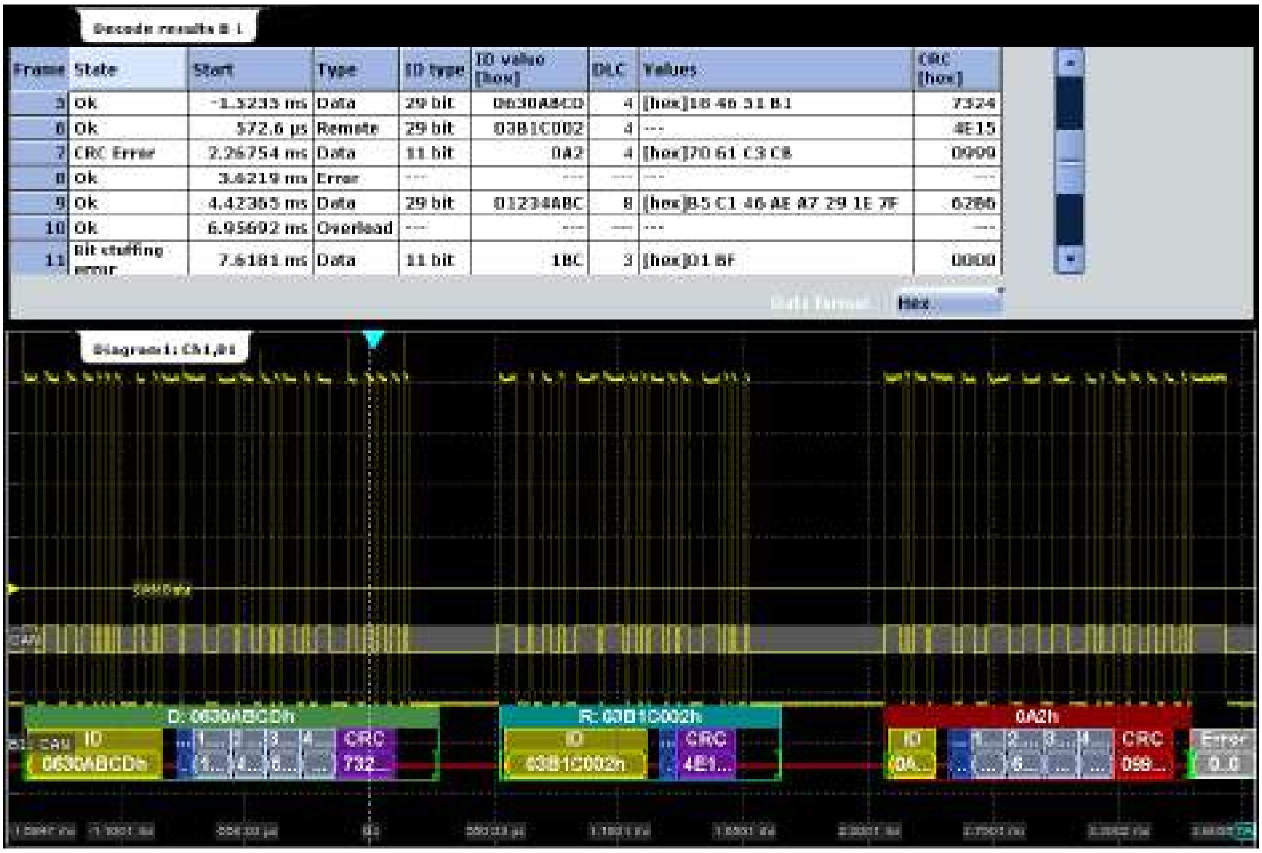
1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The binary results of data bytes are displayed MSB first.

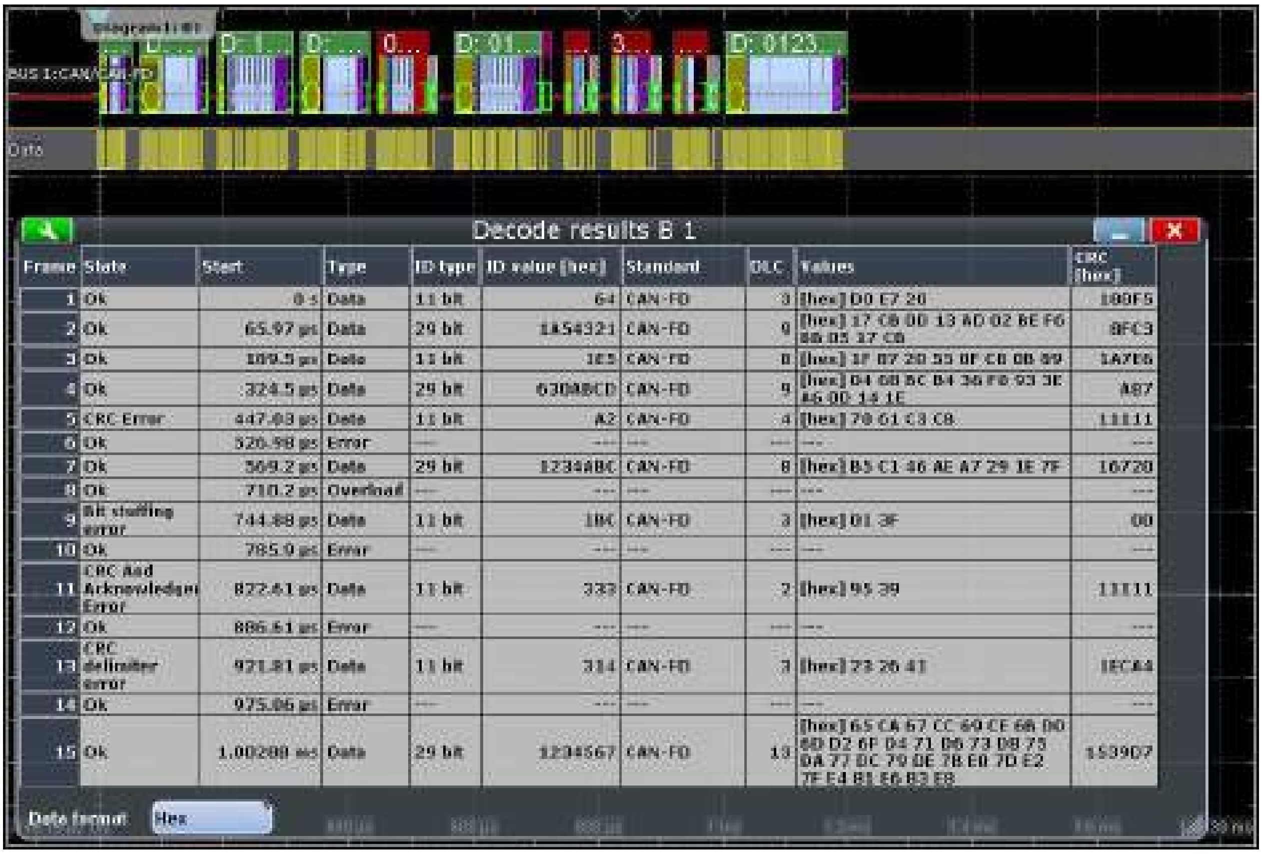
For CAN protocol, the endianness setting ("Transfer") is a trigger setting and not considered for decoding.


Decode results B 1

Frame	State	Start	Type	ID type	ID value [hex]	DLC	Values	CRC [hex]
5	Ok	-1.5233 ms	Data	29 bit	0630ABCD	4	[hex]18 46 31 B1	7324
6	Ok	572.6 µs	Remote	29 bit	03B1C002	4	---	4E15
7	CRC Error	2.26754 ms	Data	11 bit	0A2	4	[hex]70 61 C3 C8	0909
8	Ok	3.6219 ms	Error	---	---	---	---	---
9	Ok	4.42365 ms	Data	29 bit	01234ABC	8	[hex]B5 C1 46 AE A7 29 1E 7F	6286
10	Ok	6.95692 ms	Overload	---	---	---	---	---
11	Bit stuffing error	7.6181 ms	Data	11 bit	1BC	3	[hex]01 BF	0000

Figure 12-23: Decoded and binary CAN signal, and decode results

green brackets [...] = Start and end of frame
green frame header = Data frame, ok
cyan frame header = Remote frame, ok
magenta frame header = Overload frame, ok
red frame header = Frame contains an error
no frame header = Error frame
yellow = Identifier
blue = DLC
gray-blue = data
purple = CRC (checksum)
gray = Error frame
red = Error occured

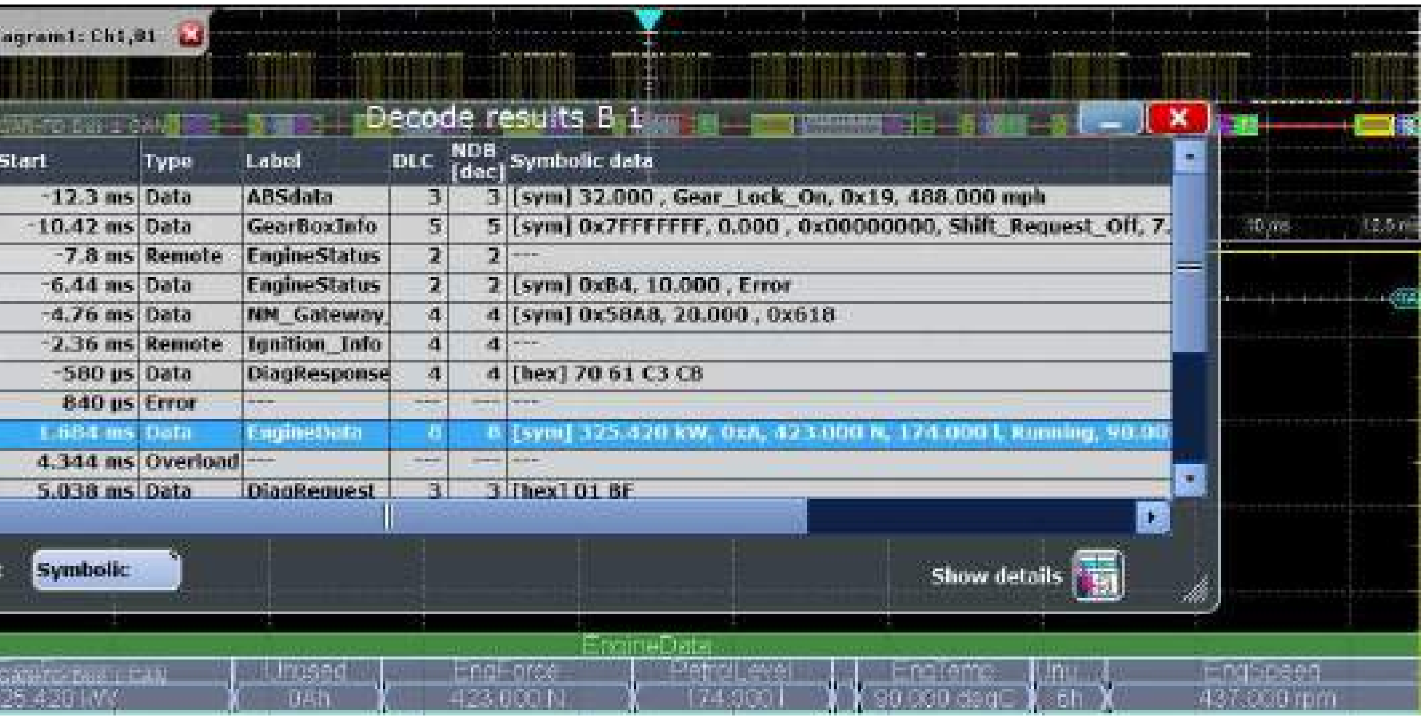


Frame	State	Start	Type	ID type	ID value [hex]	Standard	DLC	Values	CRC [hex]
1	Ok	0 s	Data	11 bit	64	CAN-FD	3	[hex] D0 E7 20	180F5
2	Ok	65.97 µs	Data	29 bit	1A54321	CAN-FD	9	[hex] 17 C8 DD 13 AD 02 BE F6 B8 D5 37 C8	8FC3
3	Ok	189.5 µs	Data	11 bit	1E5	CAN-FD	8	[hex] 1F 87 20 55 0F C8 DB 89	1A7E6
4	Ok	324.5 µs	Data	29 bit	630ABCD	CAN-FD	9	[hex] D4 0B BC B4 36 F8 93 3E A6 0D 14 1E	A87
5	CRC Error	447.03 µs	Data	11 bit	A2	CAN-FD	4	[hex] 70 61 C3 C8	11111
6	Ok	520.98 µs	Error	---	---	---	---	---	---
7	Ok	569.2 µs	Data	29 bit	1234ABC	CAN-FD	8	[hex] B5 C1 46 AE A7 29 1E 7F	16720
8	Ok	710.2 µs	Overload	---	---	---	---	---	---
9	Bit stuffing error	744.88 µs	Data	11 bit	1BC	CAN-FD	3	[hex] 01 3F	00
10	Ok	785.0 µs	Error	---	---	---	---	---	---
11	CRC And Acknowledgement Error	822.61 µs	Data	11 bit	333	CAN-FD	2	[hex] 95 39	11111
12	Ok	886.61 µs	Error	---	---	---	---	---	---
13	CRC delimiter error	921.81 µs	Data	11 bit	314	CAN-FD	3	[hex] 73 26 41	1ECA4
14	Ok	975.06 µs	Error	---	---	---	---	---	---
15	Ok	1.00288 ms	Data	29 bit	1234567	CAN-FD	13	[hex] 65 CA 67 CC 69 CE 6B D0 6D D2 6F D4 71 D6 73 D8 75 DA 77 DC 79 DE 7B E0 7D E2 7F E4 81 E6 83 E8	1539D7

Data format: Hex

Figure 12-24: Decoded CAN FD signal with data type = CAN_L, arbitration rate = 1 Mbps and data rate = 2 Mbps

You can also load and apply industry-standard DBC files. The symbolic names from the file are applied to the display of the decoded data, see Chapter 12.5.6.2, "Symbolic Decode Waveform", on page 560.



Start	Type	Label	DLC	NDB [dec]	Symbolic data
-12.3 ms	Data	ABSdata	3	3	[sym] 32.000 , Gear_Lock_On, 0x19, 488.000 mph
-10.42 ms	Data	GearBoxInfo	5	5	[sym] 0x7FFFFFFF, 0.000 , 0x00000000, Shift_Request_Off, 7.
-7.8 ms	Remote	EngineStatus	2	2	---
-6.44 ms	Data	EngineStatus	2	2	[sym] 0xB4, 10.000 , Error
-4.76 ms	Data	NM_Gateway_	4	4	[sym] 0x58A8, 20.000 , 0x618
-2.36 ms	Remote	Ignition_Info	4	4	---
-580 µs	Data	DiagResponse	4	4	[hex] 70 61 C3 CB
840 µs	Error	---	---	---	---
1.684 ms	Data	EngineData	8	8	[sym] 325.420 kW, 0xA, 423.000 N, 174.000 l, Running, 90.00
4.344 ms	Overload	---	---	---	---
5.038 ms	Data	DiagRequest	3	3	[hex] 01 BF

Figure 12-25: Decoded CAN signal with applied DBC file and "Symbolic" data in the result table

Table 12-6: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of frame start
Type	Frame type: Data, Remote, Error, or Overload
ID type	11 bit standard format or 29 bit extended format
ID value (hex)	Identifier value, hexadecimal value
Standard	Frame format, CAN or CAN FD. Only available in CAN FD option R&S RTO-K9.
Label	Symbolic label name defined in the label list
DLC	Data length code, coded number of data bytes
NDB	Actual number of data bytes
Values	Value of the data frame. The data format is selected below the table. Remote frames do not transmit data, therefore "- - -" is displayed.
Symbolic data	Values of the individual signals that are part of a message. The column is shown instead of the "Values" column, if a DBC file is loaded and the "Data format" is "Symbolic".
SC (dec)	Stuff count value, decimal value. Only available for CAN FD ISO signals, option R&S RTO-K9.

Column	Description
CRC (hex)	Value of the Cyclic Redundance Check (checksum), hexadecimal value
Form error cause	Reason of a form error if a form error occurred

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.6.3, "Decode Results", on page 1574.

12.5.5 Search on Decoded CAN or CAN FD Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

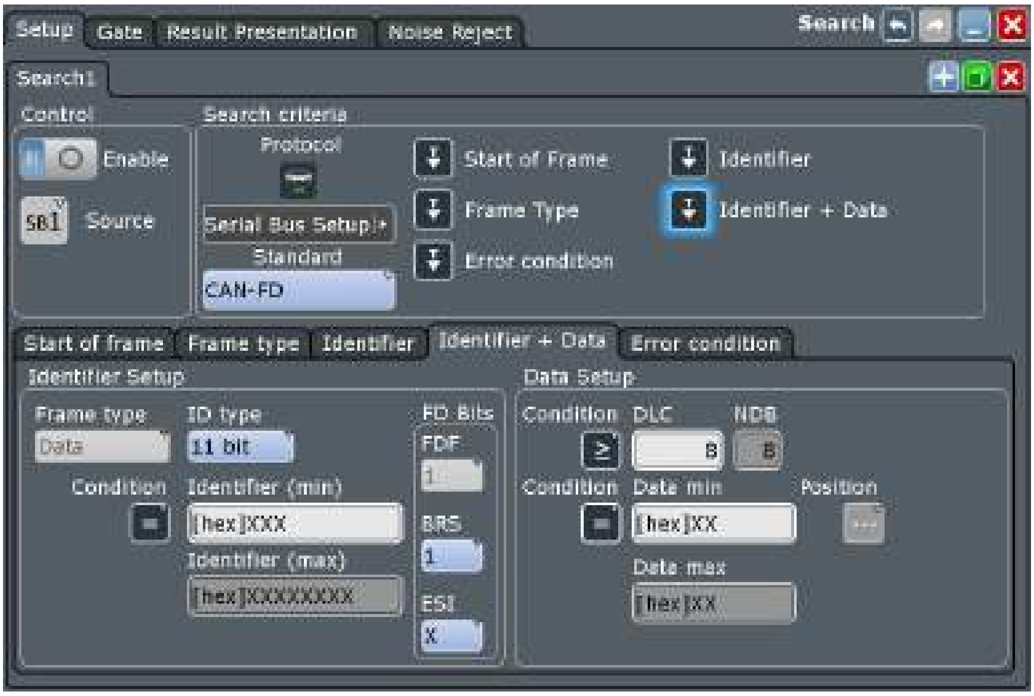
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

12.5.5.1 Search Settings

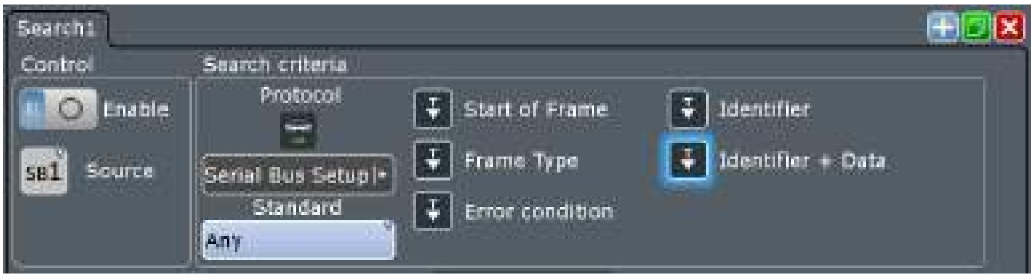
Access: SEARCH > "Setup" tab



Search Criteria

Sets one criterion or an AND-combination of criteria to be searched for. If more than one criterion is selected, all criteria must be fulfilled by a frame for it to be shown in the search results.

If a DBC label list file is applied, an additional criterion "Symbolic" is provided, see Chapter 12.5.6.3, "Symbolic Search", on page 561.



"Start of frame"	Searches for the first edge of the dominant SOF bit (synchronization bit).
"Frame type"	Searches for a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered. For details, see: • "Frame type" on page 552 • "ID type" on page 553
"Identifier"	Searches for a specific message identifier or an identifier range. See "Identifier setup: Condition, Identifier min, Identifier max" on page 553.

"Identifier + Data"
Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" search criteria, see "Identifier setup: Condition, Identifier min, Identifier max" on page 553. Data conditions are set with "Data setup: DLC, NDB, Condition, Data min, Data max" on page 554.

"Error condition"
Identifies various errors in the frame, see "Error conditions" on page 538.

"Symbolic" The "Symbolic" search criteria is available if a DBC label list file is loaded and applied. It allows you to search for specific data messages, or a signal and its value that appears inside the message.
Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.
For details, see Chapter 12.5.6.3, "Symbolic Search", on page 561.

Remote command:
`SEARch:TRIGger:CAN[:SSOFrame]` on page 1583
`SEARch:TRIGger:CAN:SFTYpe` on page 1583
`SEARch:TRIGger:CAN:SFIDentifier` on page 1584
`SEARch:TRIGger:CAN:SIDData` on page 1584
`SEARch:TRIGger:CAN:SERRor` on page 1584
`SEARch:TRIGger:CAN:SSYMbolic` on page 1601

Standard

Selects the CAN standard: "CAN", "CAN FD", or "Any".

The setting is available in CAN FD option R&S RTO-K9.

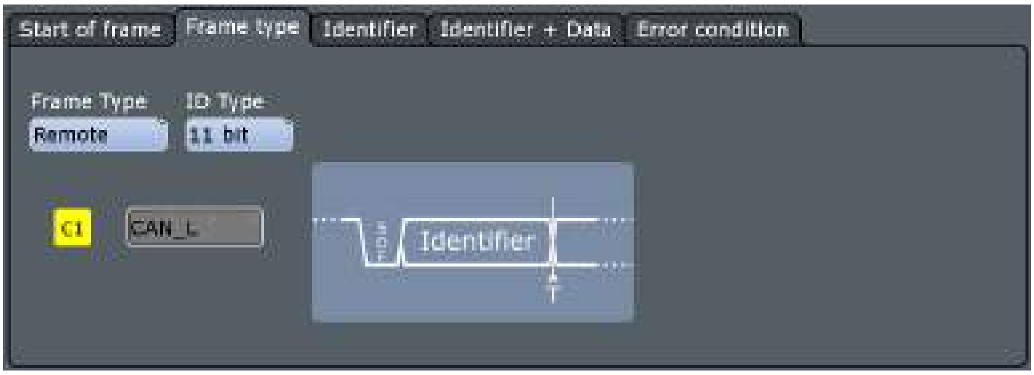
Use "Any" to search for both CAN and CAN-FD frames. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`SEARch:TRIGger:CAN:FDATa:STANdard` on page 1584

Frame type

Selects the frame type.

Remote frames are only available in the CAN protocol.



Frame Type: Remote
ID Type: 11 bit
CAN_L

The frame types are the same as in the CAN trigger setup, see "Frame type" on page 533.

Remote command:
`SEARch:TRIGger:CAN:FTYPe` on page 1585

ID type
Selects the length of the identifier.

"11 bit"	Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit.
"29 bit"	Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.
"Any"	The ID type is not relevant. If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to search only for data.

Remote command:
`SEARch:TRIGger:CAN:ITYPe` on page 1585

Identifier setup: Condition, Identifier min, Identifier max
The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The identifier setup settings are the same as in the CAN trigger setup, see "Identifier setup: Condition, Identifier min, Identifier max" on page 534.

Frame type: Data
ID type: 29 bit
Identifier (min): [hex]XXXXXXXX
Identifier (max): [hex]XXXXXXXX
FDF: X
BRS: X
ESI: X

FD bits: see "FD bits" on page 554.

Remote command:
`SEARch:TRIGger:CAN:ICONdition` on page 1585
`SEARch:TRIGger:CAN:IMIN` on page 1586
`SEARch:TRIGger:CAN:IMAX` on page 1586

FD bits
For standard settings "CAN FD" and "Any", you can search for CAN FD-specific bits.

For details, see "FD bits" on page 535.

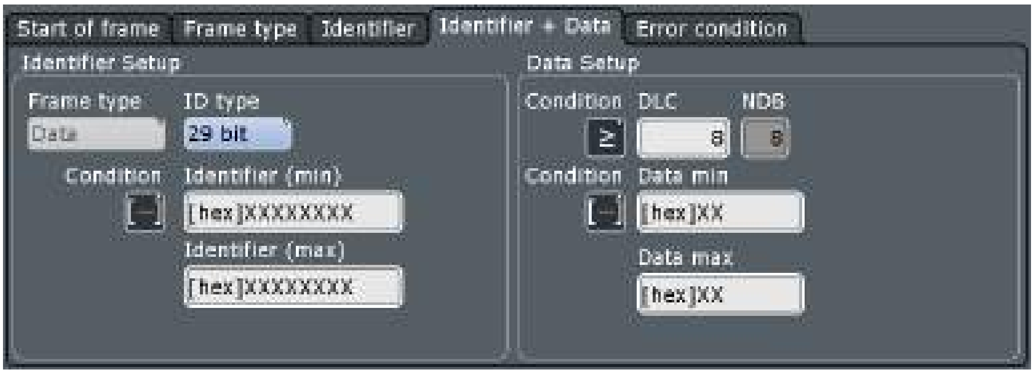
The setting is available in CAN FD option R&S RTO-K9.

Remote command:
`SEARch:TRIGger:CAN:FDATa[:FDF]` on page 1590
`SEARch:TRIGger:CAN:FDATa:BRS` on page 1591
`SEARch:TRIGger:CAN:FDATa:ESI` on page 1591

Data setup: DLC, NDB, Condition, Data min, Data max
The data setup consists of the number of bytes, the condition, and one or two data patterns.

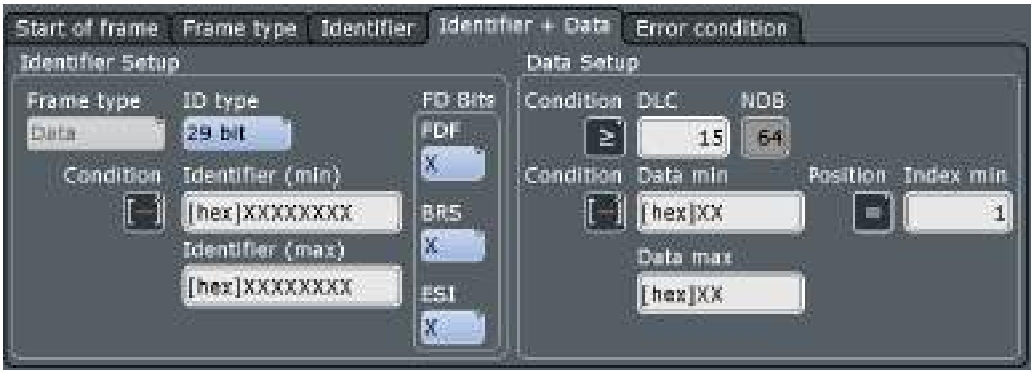
The data setup settings are the same as in the CAN trigger setup, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 536.

The data condition setting is also used for symbolic signal search, see Chapter 12.5.6.3, "Symbolic Search", on page 561.



Frame type: Data
ID type: 29 bit
Identifier (min): [hex]XXXXXXXX
Identifier (max): [hex]XXXXXXXX
Condition: ≥
DLC: 8
NDB: 8
Data min: [hex]XX
Data max: [hex]XX

Figure 12-26: Identifier + Data search setup for CAN signals



Frame type: Data
ID type: 29 bit
Identifier (min): [hex]XXXXXXXX
Identifier (max): [hex]XXXXXXXX
FDF: X
BRS: X
ESI: X
Condition: ≥
DLC: 15
NDB: 64
Data min: [hex]XX
Data max: [hex]XX
Index min: 1

Figure 12-27: Identifier + Data search setup for CAN FD signals

Remote command:
SEARch:TRIGger:CAN:DCONdition on page 1586
SEARch:TRIGger:CAN:DMIN on page 1586
SEARch:TRIGger:CAN:DMAX on page 1587
SEARch:TRIGger:CAN:DLCCondition on page 1587
SEARch:TRIGger:CAN:DLC on page 1587
SEARch:RESult:CAN:FRAMe<m>:NDBYtes? on page 1588

Data position
The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTO-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

For details, see "Data position" on page 537.

Remote command:
SEARch:TRIGger:CAN:FDATa:DPOPerator on page 1588
SEARch:TRIGger:CAN:FDATa:DPOSition on page 1588
SEARch:TRIGger:CAN:FDATa:DPTO on page 1589

Error Condition
Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the CAN trigger setup, see "Error conditions" on page 538.

Remote command:
SEARch:TRIGger:CAN:CRCerror on page 1590
SEARch:TRIGger:CAN:BITSterror on page 1589
SEARch:TRIGger:CAN:FORMerror on page 1590
SEARch:TRIGger:CAN:ACKerror on page 1589
SEARch:TRIGger:CAN:FDATa:SCERror on page 1590

12.5.5.2 Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

- `SEARch:RESult:CAN:FCOunt?` on page 1592
- `SEARch:RESult:CAN:FRAMe<m>:STATus?` on page 1597
- `SEARch:RESult:CAN:FRAMe<m>:FERCause?` on page 1595
- `SEARch:RESult:CAN:FRAMe<m>:ACKState?` on page 1592
- `SEARch:RESult:CAN:FRAMe<m>:ACKValue?` on page 1593
- `SEARch:RESult:CAN:FRAMe<m>:BSEPosition?` on page 1593
- `SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe?` on page 1593
- `SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue?` on page 1593
- `SEARch:RESult:CAN:FRAMe<m>:CSSTate?` on page 1594
- `SEARch:RESult:CAN:FRAMe<m>:CSValue?` on page 1594
- `SEARch:RESult:CAN:FRAMe<m>:DATA?` on page 1594
- `SEARch:RESult:CAN:FRAMe<m>:DLCState?` on page 1594
- `SEARch:RESult:CAN:FRAMe<m>:DLCValue?` on page 1595
- `SEARch:RESult:CAN:FRAMe<m>:IDSTate?` on page 1595
- `SEARch:RESult:CAN:FRAMe<m>:IDTYpe?` on page 1596
- `SEARch:RESult:CAN:FRAMe<m>:IDValue?` on page 1596
- `SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard?` on page 1597
- `SEARch:RESult:CAN:FRAMe<m>:STARt?` on page 1597
- `SEARch:RESult:CAN:FRAMe<m>:STOP?` on page 1597
- `SEARch:RESult:CAN:FRAMe<m>:SYMBol?` on page 1598
- `SEARch:RESult:CAN:FRAMe<m>:TYPE?` on page 1598

12.5.5.3 Searching CAN FD Data

The "Identifier + Data" search supports the search for data bytes of specific value at a specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following example demonstrates how the data pattern and data position is defined.

To set up the search

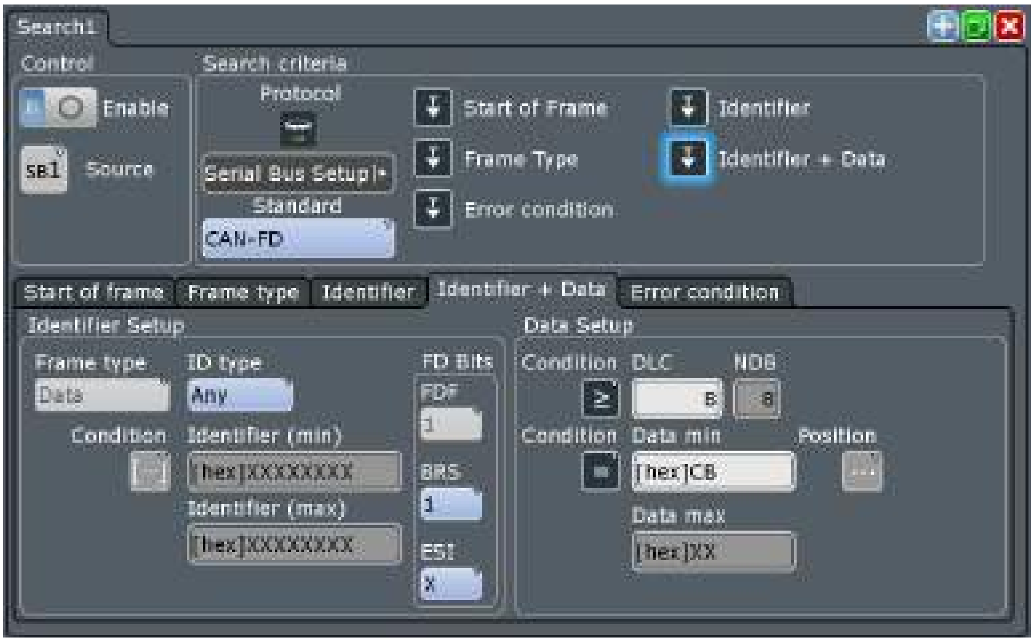
1. Set the "Source", the signal to be searched: "SerBus". Select the bus that is configured for CAN FD.

2. Set the search criteria:
   a) Select the standard: "CAN FD".
   b) Select the search type: "Identifier + Data".
3. In this example, the identifier does not matter. Set the "ID type = Any".
4. Define the data setup as described in the example.

Example: Searching for a specific byte anywhere in the frame

The CAN FD frame has 8 or more data bytes, containing at least one data byte with value = CB anywhere in the data field.

- Set "DLC ≥ 8".
- Set the data pattern: "= CB".



Source: SB1
Protocol: Serial Bus Setup
Standard: CAN-FD
Frame type: Data
ID type: Any
Identifier (min): [hex]XXXXXXXX
Identifier (max): [hex]XXXXXXXX
FDF: 1
BRS: 1
ESI: X
Condition: ≥ DLC: 8 NDB: 8
Condition: = Data min: [hex]CB
Data max: [hex]XX

Figure 12-28: Search setup to find all data bytes with value = CB

Figure 12-29: Search result

12.5.6 Symbolic Trigger, Decode and Search

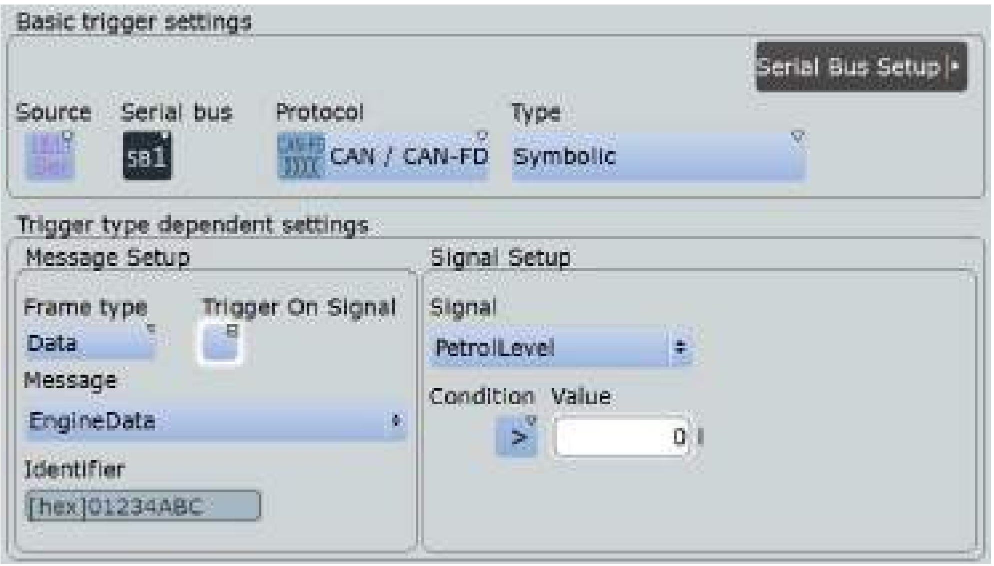
The R&S RTO can read and apply industry-standard DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

For a description of DBC files, see Chapter 12.5.3.1, "DBC files for CAN / CAN FD", on page 544.

12.5.6.1 Symbolic Trigger

The "Symbolic" trigger type is available if a DBC label list file is loaded and applied, see Chapter 12.5.3, "CAN / CAN FD Label List", on page 544. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message.

Access: TRIGGER > "Source" = "Serial Bus" and "Protocol" = "CAN" or "CAN / CAN FD" > "Type" = "Symbolic"



Source: Ser
Serial bus: SB1
Protocol: CAN / CAN-FD
Type: Symbolic
Frame type: Data
Trigger On Signal: ☐
Message: EngineData
Identifier: [hex]01234ABC
Signal: PetrolLevel
Condition: >
Value: 0

The "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Specific settings for the symbolic trigger are:

Message

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:

`TRIGger<m>:CAN:SYMBolic:MSGValue` on page 1599

Trigger on signal

Enables the trigger on a specific signal value that is part of the selected message.

Remote command:

`TRIGger<m>:CAN:SYMBolic:TSIGnals` on page 1599

Signal

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:

`TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1599

Condition
Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

Remote command:
`TRIGger<m>:CAN:DCONdition` on page 1570

Value, Value min
Defines the data pattern or selects a symbolic data value.

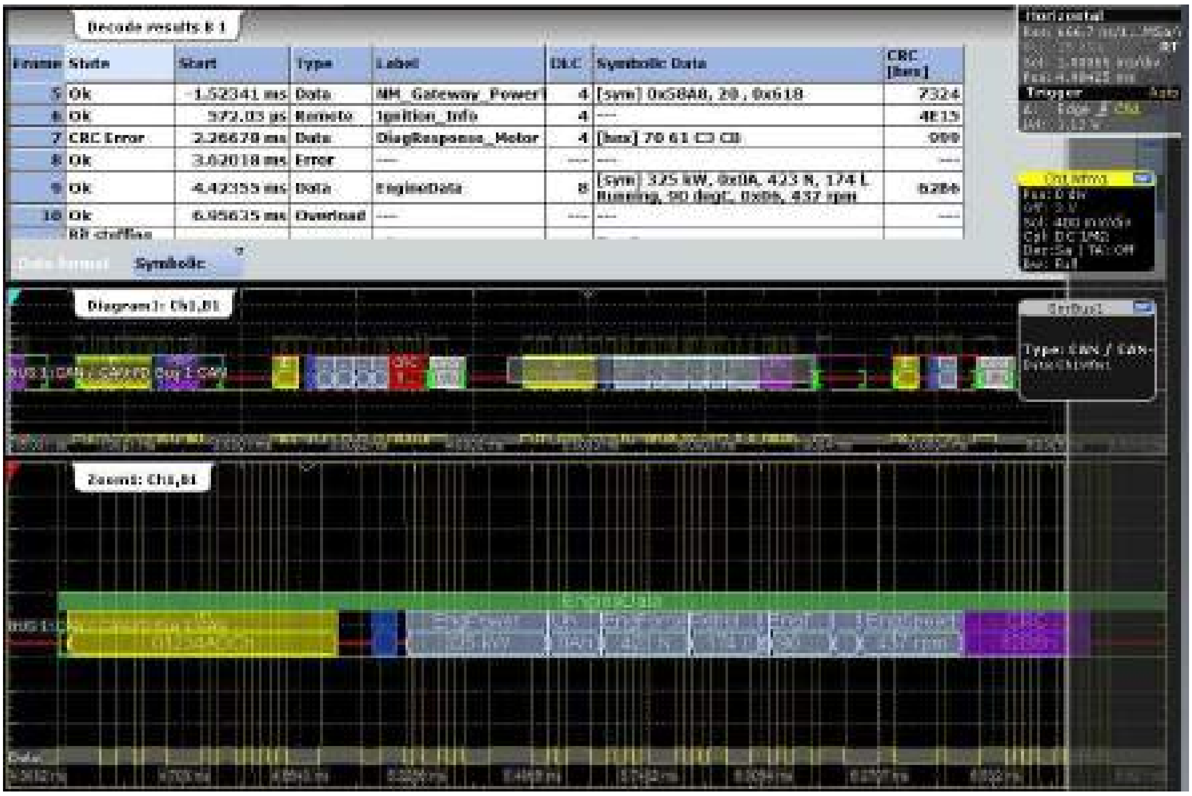
Remote command:
`TRIGger<m>:CAN:SYMBolic:DMIN` on page 1600
`TRIGger<m>:CAN:SYMBolic:SGEValue` on page 1600

Value max
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:SYMBolic:DMAX` on page 1599

12.5.6.2 Symbolic Decode Waveform

If a DBC file is applied, the symbolic names from the file are applied to the display of the decoded data. The result table lists the signal values and units in the "Symbolic Data" column, and the comb display shows the signal names in addition to the signal values and units.



Frame	State	Start	Type	Label	DLC	Symbolic Data	CRC [hex]
5	Ok	-1.52341 ms	Data	NM_Gateway_PowerT	4	[sym] 0x58A8, 20 , 0x618	7324
6	Ok	572.03 µs	Remote	Ignition_Info	4	---	4E15
7	CRC Error	2.26678 ms	Data	DiagResponse_Motor	4	[hex] 70 61 C3 C8	000
8	Ok	3.62018 ms	Error	---	---	---	---
9	Ok	4.42355 ms	Data	EngineData	8	[sym] 325 kW, 0x0A, 423 N, 174 L Running, 90 degC, 0x06, 437 rpm	6286
10	Ok	6.95635 ms	Overload	---	---	---	---
	Bit stuffing						

Figure 12-30: Result table and decoded CAN signal with applied DBC file and zoom on EngineData message

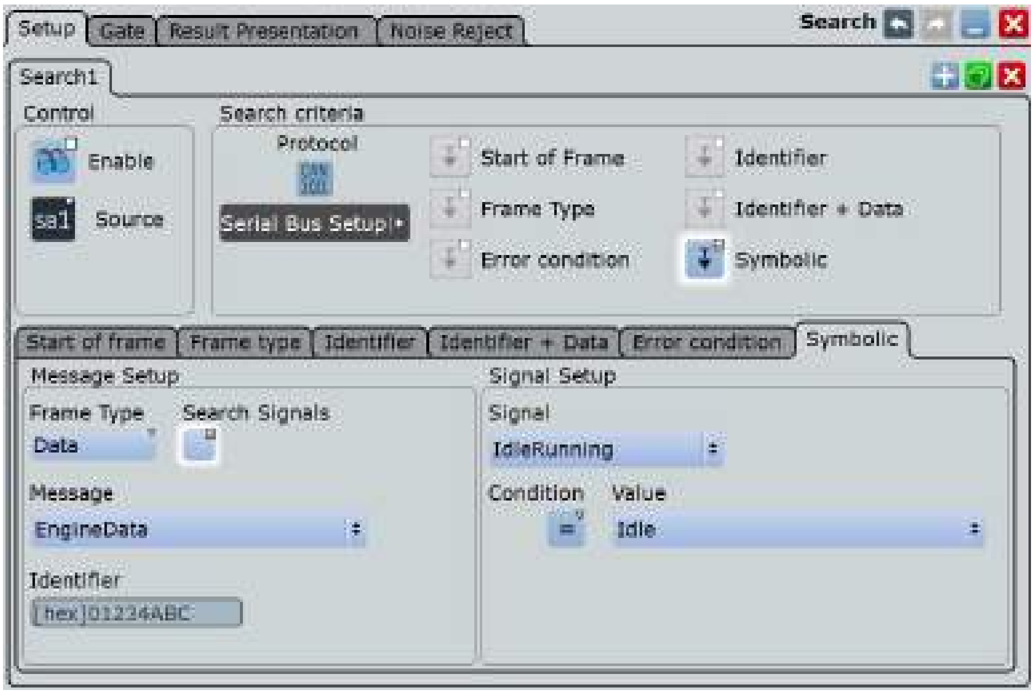
Remote command:

- `BUS<m>:CAN:FRAMe<n>:SDATa?` on page 1600

12.5.6.3 Symbolic Search

Access: SEARCH > "Setup" tab > "Symbolic" = on

If a DBC file is applied, the symbolic search for messages and signal, which are defined in the DBC file, is available. Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.



Frame Type: Data

Message: EngineData

Identifier: [hex]01234ABC

Signal: IdleRunning

Condition: =

Value: Idle

If symbolic search is active, the "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Symbolic

Enables the symbolic search and disables all other search criteria.

Remote command:
`SEARch:TRIGger:CAN:SSYMbolic` on page 1601

Message

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1601

Search signals

Enables the search for a specific signal value that is part of the selected message.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:SSIGnals` on page 1602

Signal

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1602

Condition
Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

This condition is also used to search for data, see "Data setup: DLC, NDB, Condition, Data min, Data max" on page 554.

Remote command:
`SEARch:TRIGger:CAN:DCONdition` on page 1586

Value, Value (min)
Defines the data pattern or selects a symbolic data value.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMIN` on page 1602
`SEARch:TRIGger:CAN:SYMBolic:SGEValue` on page 1603

Value (max)
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMAX` on page 1603

12.5.6.4 Symbolic Search Results

If a DBC file is applied, you can search for symbolic messages and signals as described in Chapter 12.5.6.3, "Symbolic Search", on page 561. As ususal, the search results are shown in a table. You can enable the search zoom window to view the frame with the selected result in more detail.

Frame	State	Start	Type	Label	DLC	Symbolic Data	CRC [hex]
1	Ok	6.42355 ms	Data	EngineData	8	[illegible]	0286

Figure 12-31: Search results table and search zoom window. Search for signal "IdleRunning" with value "Running" (bit value = 0)

The figure shows the result of a search for an "EngineData" message and the signal "IdleRunning = Running" inside the message. The result marker (blue line) ist set to the start of the frame that fulfills the search condition. The search zoom window Search1 is active. It has been moved to the right until the "IdleRunning" bit with value 0 is visible in the zoom.

Remote command:

- `SEARch:RESult:CAN:FRAMe<m>:SDATa?` on page 1601

12.6 LIN (Option R&S RTO-K3)

The Local Interconnect Network (LIN) is a simple, low-cost bus system used within automotive network architectures. LIN is usually a sub-network of a CAN bus. The primary purpose of LIN is the integration of uncritical sensors and actuators with low bandwidth requirements. Common applications in a motor vehicle are the control of doors, windows, wing mirrors, and wipers.

12.6.1 The LIN Protocol

This chapter provides an overview of protocol characteristics, frame format, identifiers and trigger possibilities. For detailed information, order the LIN specification on http://www.lin-subbus.org/ (free of charge).

LIN characteristics

Main characteristics of LIN are:

- Single-wire serial communications protocol, based on the UART byte-word interface
- Single master, multiple slaves - usually up to 12 nodes
- Master-controlled communication: master coordinates communication with the LIN schedule and sends identifier to the slaves
- Synchronization mechanism for clock recovery by slave nodes without crystal or ceramics resonator

The R&S RTO supports several versions of the LIN standard: v1.3, v2.0, v2.1 and the American SAE J2602.

Data transfer

Basic communication concept of LIN:

- Communication in an active LIN network is always initiated by the master.
- Master sends a message header including the synchronization break, the synchronization byte, and the message identifier.
- The identified node sends the message response: one to eight data bytes and one checksum byte.
- Header and response form the message frame.

The data is transmitted in bytes using the UART byte-word interface without the parity bit. Each byte consists of a start bit, 8 bits and a stop bit.

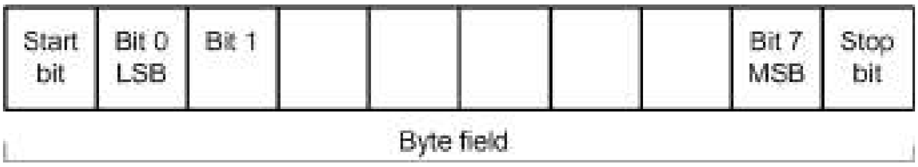


Figure 12-32: Structure of a byte field

Data bytes are transmitted LSB first.

The identifier byte consists of 6 bits for the frame identifier and two parity bits. This combination is known as protected identifier.

Trigger

The R&S RTO can trigger on various parts of LIN frames. The data line must be connected to an input channel, triggering on math and reference waveforms is not possible.

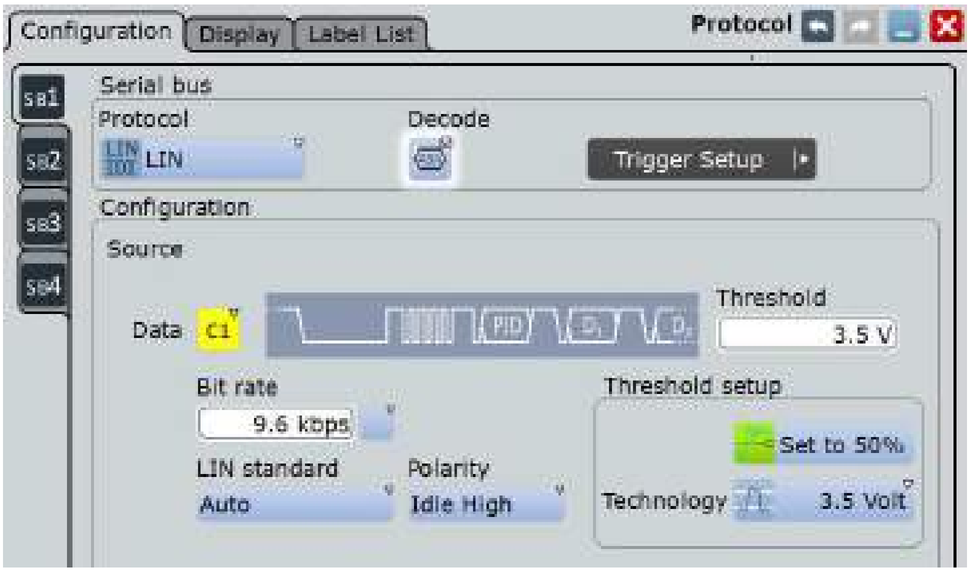
You can trigger on:

- Frame start (synchronization field)
- Specific slave identifier or identifier range
- Data pattern in the message
- Wake up signal
- Checksum error (error in data), parity error (error in identifier)

12.6.2 LIN Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *LIN*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data

Sets the source waveform of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:LIN:DATA:SOURce` on page 1604

Threshold

Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:LIN:DATA:THReshold` on page 1604
`BUS<m>:LIN:TECHnology` on page 1604
`BUS<m>:SETReflevels` on page 1495

Bit rate

Sets the number of transmitted bits per second. The maximum bit rate for LIN is 20 kbit/s.

To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

If the "LIN standard" is "J2602", the bit rate is 10.417 kbit/s and cannot be changed.

Remote command:
`BUS<m>:LIN:BITRate` on page 1605

LIN standard

Selects the version of the LIN standard that is used in the DUT. The setting mainly defines the checksum version used during decoding.

The most common version is LIN 2.x. For mixed networks, or if the standard is unknown, set the LIN standard to "Auto".

Remote command:
`BUS<m>:LIN:STANdard` on page 1605

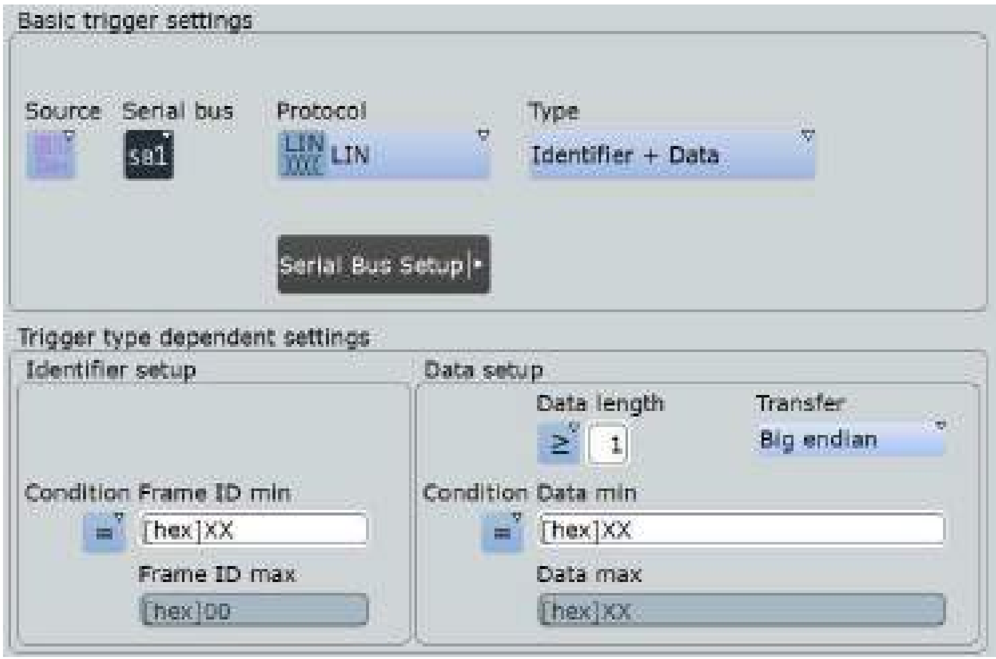
Polarity

Defines the idle state of the bus. The idle state is the rezessive state and corresponds to a logic 1.

Remote command:
`BUS<m>:LIN:POLarity` on page 1605

12.6.3 LIN Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = LIN"

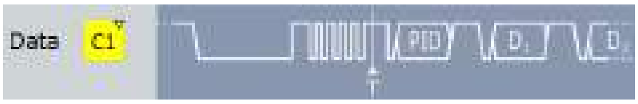


Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type
Selects the trigger type for LIN analysis.

"Start of frame (Sync)"	Triggers on the stop bit of the sync field.



"Identifier"	Sets the trigger to one specific identifier or an identifier range. Enter only the 6 bit identifier without parity bits, not the protected identifier. Description of trigger type specific settings: "Identifier setup: Condition, Frame ID min, Frame ID max" on page 569.
"Identifier OR"	Sets the trigger to a combination of up to four identifiers. Description of trigger type specific settings: "Identifier OR setup: Monitor, Frame ID" on page 569

"Identifier + Data"	Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see Identifier setup: Condition, Frame ID min, Frame ID max. Data conditions are set with Data setup: Data length, Transfer, Condition, Data min, Data max.
"Wakeup frame"	Triggers after a wakeup frame.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 571.

Remote command:
`TRIGger<m>:LIN:TYPE` on page 1606

Identifier setup: Condition, Frame ID min, Frame ID max

The identifier setup consists of the condition and one or two identifier pattern.

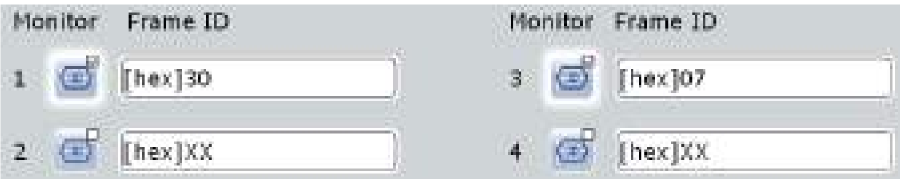
Condition Frame ID min
[hex]20
Frame ID max
[hex]38

"Condition"	Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.
"Frame ID min / Frame ID"	Defines the bit pattern of the slave identifier. Enter only the 6 bit identifier without parity bits, not the protected identifier. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Frame ID max"	The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:LIN:ICONdition` on page 1607
`TRIGger<m>:LIN:IMIN` on page 1608
`TRIGger<m>:LIN:IMAX` on page 1608

Identifier OR setup: Monitor, Frame ID

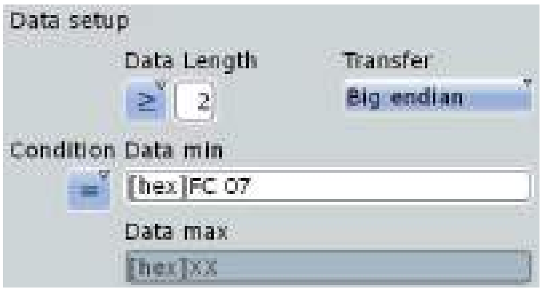
Sets the trigger to a combination of up to four identifiers. Enter the patterns in the "Frame ID" fields. In binary and hex format, characters 1, 0, and X (don't care) are allowed. For each identifier pattern to be triggered on, enable "Monitor".



Monitor	Frame ID	Monitor	Frame ID
1	[hex]30	3	[hex]07
2	[hex]XX	4	[hex]XX

Remote command:
`TRIGger<m>:LIN:IDOR<n>:ENABle` on page 1610
`TRIGger<m>:LIN:IDOR<n>[:VALue]` on page 1610

Data setup: Data length, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.



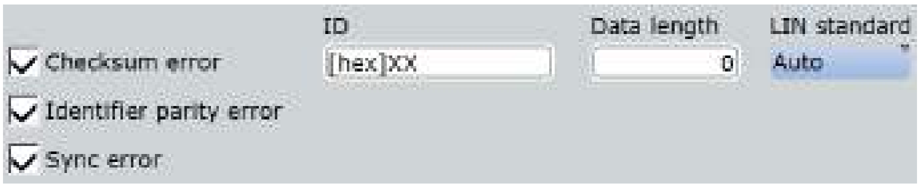
Data Length ≥ 2
Transfer: Big endian
Condition: =
Data min: [hex]FC 07
Data max: [hex]XX

"Transfer"	Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word. According to the standard, LIN data is transmitted in little endian transfer order. The "Little endian" setting allows you to enter the required data word directly into "Data min", and the instrument triggers correctly.
"Data length"	Sets the length of the bit pattern to be found, in bytes. For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set. Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.
"Condition"	Sets the operator to define a specific data pattern ("Equal" or "Not equal") or an data range.
"Data min"	Defines the data pattern. The pattern length is adjusted to the data length setting (and vice versa), maximum is 8 bytes. Enter the pattern MSB first and with big endian byte order, and set the correct "Transfer" direction. The data is compared byte by byte. In binary format, use the following characters: 1; 0; or X (don't care). The use of X is restricted to the operators "Equal" and "Not equal".
"Data max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:LIN:BORDer` on page 1609
`TRIGger<m>:LIN:DLECondition` on page 1609
`TRIGger<m>:LIN:DLENgth` on page 1609
`TRIGger<m>:LIN:DCONdition` on page 1608
`TRIGger<m>:LIN:DMIN` on page 1608
`TRIGger<m>:LIN:DMAX` on page 1608

Error conditions
Triggers if one or more of the following errors occur:

- Checksum error
  The checksum verifies the correct data transmission. It is the last byte of the frame response. The checksum includes not only the data but also the protected identifier (PID). To identify checksum errors caused by data, additional settings are required: Enter the bit pattern of the slave identifier ("Frame ID"), the number of data bytes ("Data length"), and select the used "LIN standard". See also: "LIN standard" on page 567.
- Identifier parity error
  Parity bits are the bits 6 and 7 of the identifier. They verify the correct transmission of the identifier.
- Sync error
  Synchronization error



☑ Checksum error
ID: [hex]XX
Data length: 0
LIN standard: Auto
☑ Identifier parity error
☑ Sync error

Remote command:
`TRIGger<m>:LIN:CHKSerror` on page 1611
`TRIGger<m>:LIN:ERRPattern` on page 1611
`TRIGger<m>:LIN:CRCDatalen` on page 1612
`TRIGger<m>:LIN:STANdard` on page 1612
`TRIGger<m>:LIN:IPERror` on page 1610
`TRIGger<m>:LIN:SYERror` on page 1610

12.6.4 LIN Label List

Label lists are protocol-specific. Label lists for LIN are available in CSV and PTT format.

A LIN label file contains two values for each identifier:

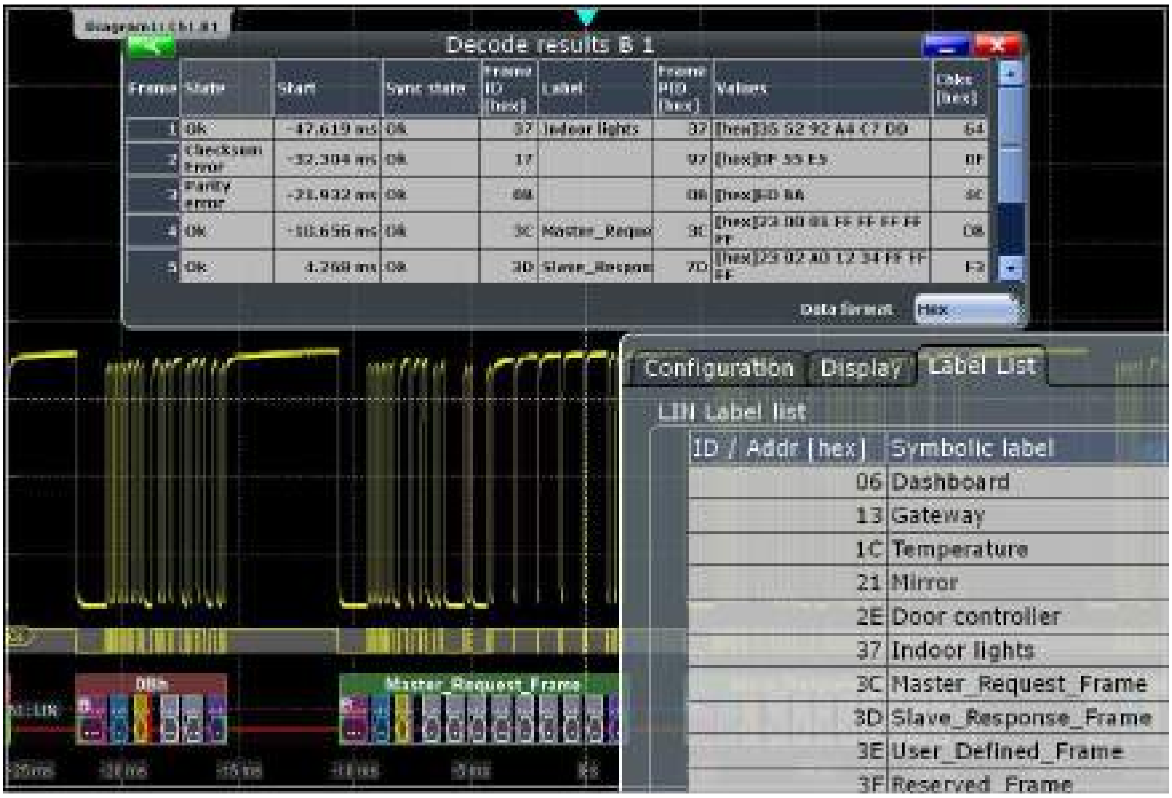
- Identifier value
- Symbolic name for the identifier

Example of a LIN PTT file

```
# ---------------------------------------------------------------------------
@FILE_VERSION = 1.0
```

```
@PROTOCOL_NAME = lin
# ----------------------------------------------------------------------------
# Labels for LIN protocol
#   Column order: Identifier, Label
# ----------------------------------------------------------------------------
# Labels for standard addresses
0x3F,Temperature
1Ch,Left brake
20h,Right brake
# Following ID is provided as integer
33,Mirror
0x37,Indoor lights
# Labels for reserved addresses
0x3C,Master_Request_Frame
0x3D,Slave_Response_Frame
# ----------------------------------------------------------------------------
```

For general information on label lists, see Chapter 12.1.3, "Label Lists", on page 484.



ID / Addr [hex]	Symbolic label
06	Dashboard
13	Gateway
1C	Temperature
21	Mirror
2E	Door controller
37	Indoor lights
3C	Master_Request_Frame
3D	Slave_Response_Frame
3E	User_Defined_Frame
3F	Reserved_Frame

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:LIN:FRAMe<n>:SYMBol?` on page 1614

12.6.5 LIN Decode Results

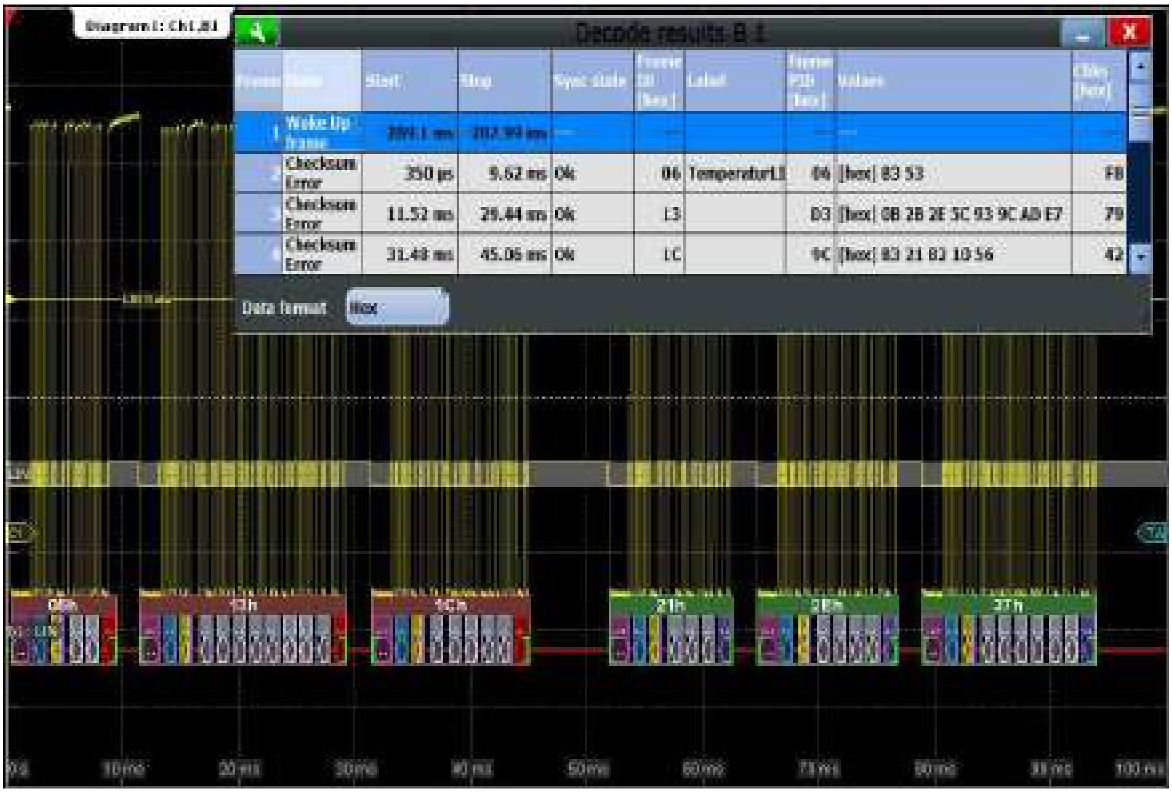
When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The endianness setting ("Transfer") is a trigger setting and not considered for decoding. The binary results of data bytes are displayed MSB first.



Frame	State	Start	Stop	Sync state	Frame ID [hex]	Label	Frame PID [hex]	Values	Chks [hex]
1	Wake Up frame	[illegible]	[illegible]	---	---		---	---	---
2	Checksum Error	350 µs	9.62 ms	Ok	06	Temperatur11	06	[hex] 83 53	F8
3	Checksum Error	11.52 ms	29.44 ms	Ok	13		D3	[hex] 0B 2B 2E 5C 93 9C AD E7	79
4	Checksum Error	31.48 ms	45.06 ms	Ok	1C		9C	[hex] 83 21 83 10 56	42

Data format: Hex

Figure 12-33: Decoded and binary LIN signal, and decode results

green brackets [...] = start and end of frame
green frame header = frame state is ok
red frame header = error in frame
magenta frame header = wakeup frame
magenta = break
blue = sync
yellow = frame ID ok

grey = data bytes
purple = parity bit, or checksum ok
red = error in frame ID, or checksum, or parity bit

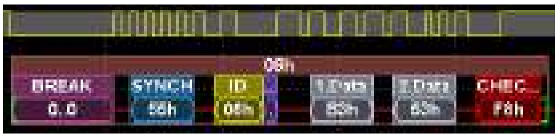


Figure 12-34: Decoded frame with checksum error (frame No 1 in figure above)

Table 12-7: Content of the "Decode results" table

Column	Description
State	Overall state of the frame.
Start	Time of frame start
Stop	Time of frame stop
Label	Symbolic label name defined in the label list
Sync state	Result of synchronization
Frame ID (hex)	Identifier value
Label	Symbolic label name defined in the label list
Frame PID (hex)	Protected identifier
Values	Value of the data bytes. The data format is selected below the table.
Chks (hex)	Checksum value

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.7.3, "Decode Results", on page 1612.

12.6.6 Search on Decoded LIN Data

Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.6.6.1 LIN Search Setup

Access: SEARCH > "Setup" tab

Type: Start of frame (Sync)

Search criteria
Sets the type to be searched for.

"Start of frame (Sync)"	Searches for the stop bit of the sync field.
"Identifier"	Searches for one specific identifier or an identifier range. See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 576
"Identifier OR"	Searches for a combination of up to four identifiers. See "Identifier OR setup: Monitor, Frame ID" on page 577
"Identifier + Data"	Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 569. Data conditions are set with "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 570.

"Wakeup frame"	Searches for wakeup frames.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 571.

Remote command:
`SEARch:TRIGger:LIN:SSOFrame` on page 1619
`SEARch:TRIGger:LIN:SFIDentifier` on page 1619
`SEARch:TRIGger:LIN:IDENtifieror` on page 1619
`SEARch:TRIGger:LIN:SIDData` on page 1620
`SEARch:TRIGger:LIN:WUFRame` on page 1620
`SEARch:TRIGger:LIN:SERRor` on page 1620

Identifier setup: Condition, Frame ID min, Frame ID max

The identifier setup consists of the condition and one or two frame ID patterns.

The identifier setup settings are the same as in the LIN trigger setup, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 569.

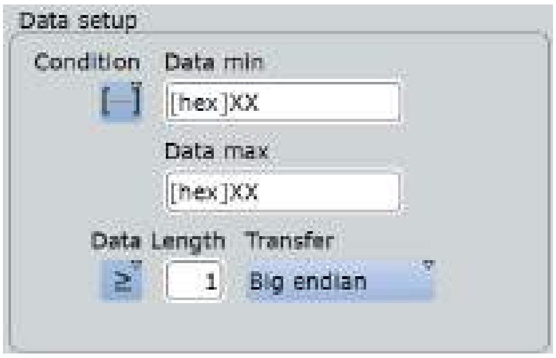
Identifier setup
Condition: =
Frame ID min: [hex]XX
Frame ID max: [hex]00

Remote command:
`SEARch:TRIGger:LIN:ICONdition` on page 1620
`SEARch:TRIGger:LIN:IMIN` on page 1621
`SEARch:TRIGger:LIN:IMAX` on page 1621

Data setup: Condition, Data min, Data max, Data length, Transfer

The data setup consists of the transfer direction, the data length, the condition, and one or two data patterns.

The data setup settings are the same as in the LIN trigger setup, see "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 570.

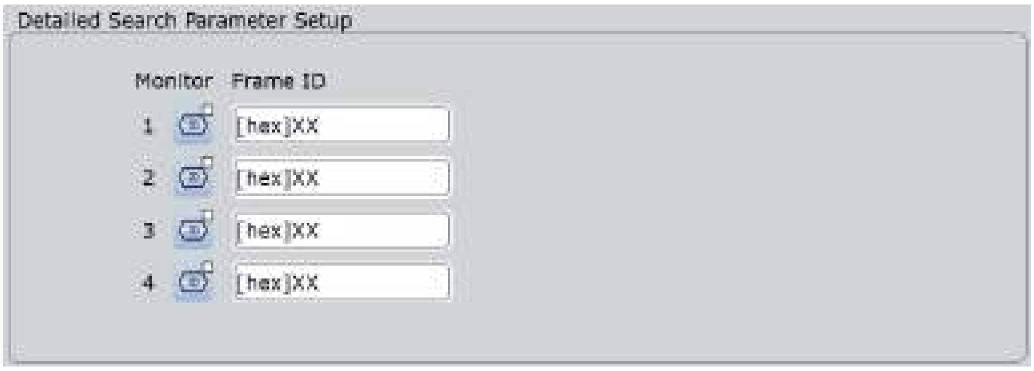


Data setup
Condition: [–]
Data min: [hex]XX
Data max: [hex]XX
Data Length: ≥ 1
Transfer: Big endian

Remote command:
`SEARch:TRIGger:LIN:DCONdition` on page 1622
`SEARch:TRIGger:LIN:DMIN` on page 1622
`SEARch:TRIGger:LIN:DMAX` on page 1623
`SEARch:TRIGger:LIN:DLECondition` on page 1623
`SEARch:TRIGger:LIN:DLENgth` on page 1624
`SEARch:TRIGger:LIN:BORDer` on page 1623

Identifier OR setup: Monitor, Frame ID
The identifier OR setup consists of the monitor and frame ID.

The identifier OR setup settings are the same as in the LIN trigger setup, see "Identifier OR setup: Monitor, Frame ID" on page 569

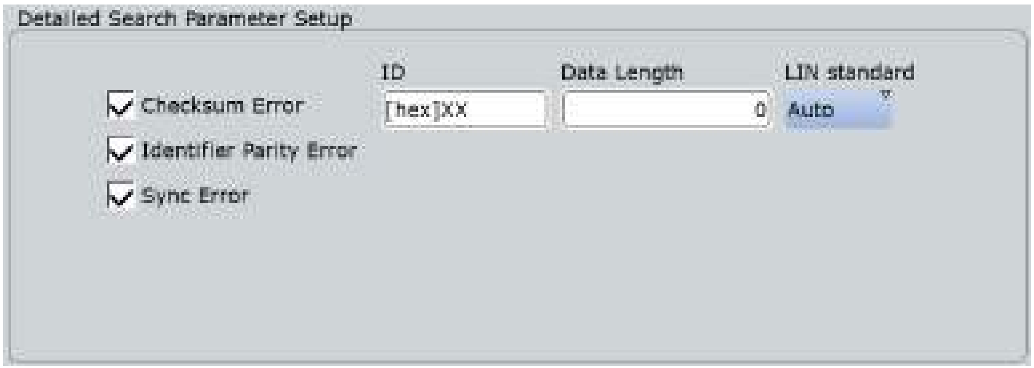


Monitor	Frame ID
1	[hex]XX
2	[hex]XX
3	[hex]XX
4	[hex]XX

Remote command:
`SEARch:TRIGger:LIN:IDOR<m>:ENABle` on page 1621
`SEARch:TRIGger:LIN:IDOR<m>[:VALue]` on page 1622

Error Condition
Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the LIN trigger setup, see "Error conditions" on page 571.



☑ Checksum Error
☑ Identifier Parity Error
☑ Sync Error

ID: [hex]XX
Data Length: 0
LIN standard: Auto

Remote command:
`SEARch:TRIGger:LIN:IPERror` on page 1624
`SEARch:TRIGger:LIN:SYERror` on page 1624
`SEARch:TRIGger:LIN:CHKSerror` on page 1625

`SEARch:TRIGger:LIN:ERRPattern` on page 1625
`SEARch:TRIGger:LIN:CRCDatalen` on page 1625
`SEARch:TRIGger:LIN:STANdard` on page 1626

12.6.6.2 LIN Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

The columns in the serach result table are the same as in the decoding table, see Chapter 12.6.5, "LIN Decode Results", on page 573.

Remote commands:

- `SEARch:RESult:LIN:FCOunt?` on page 1626
- `SEARch:RESult:LIN:FRAMe<m>:STATus?` on page 1627
- `SEARch:RESult:LIN:FRAMe<m>:STARt?` on page 1627
- `SEARch:RESult:LIN:FRAMe<m>:STOP?` on page 1627
- `SEARch:RESult:LIN:FRAMe<m>:DATA?` on page 1627
- `SEARch:RESult:LIN:FRAMe<m>:CSSTate?` on page 1628
- `SEARch:RESult:LIN:FRAMe<m>:CSValue?` on page 1628
- `SEARch:RESult:LIN:FRAMe<m>:IDSTate?` on page 1628
- `SEARch:RESult:LIN:FRAMe<m>:IDValue?` on page 1629
- `SEARch:RESult:LIN:FRAMe<m>:IDPValue?` on page 1629
- `SEARch:RESult:LIN:FRAMe<m>:SYMBol?` on page 1629
- `SEARch:RESult:LIN:FRAMe<m>:SYSTate?` on page 1629
- `SEARch:RESult:LIN:FRAMe<m>:VERSion?` on page 1630
- `SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe?` on page 1630
- `SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue?` on page 1630

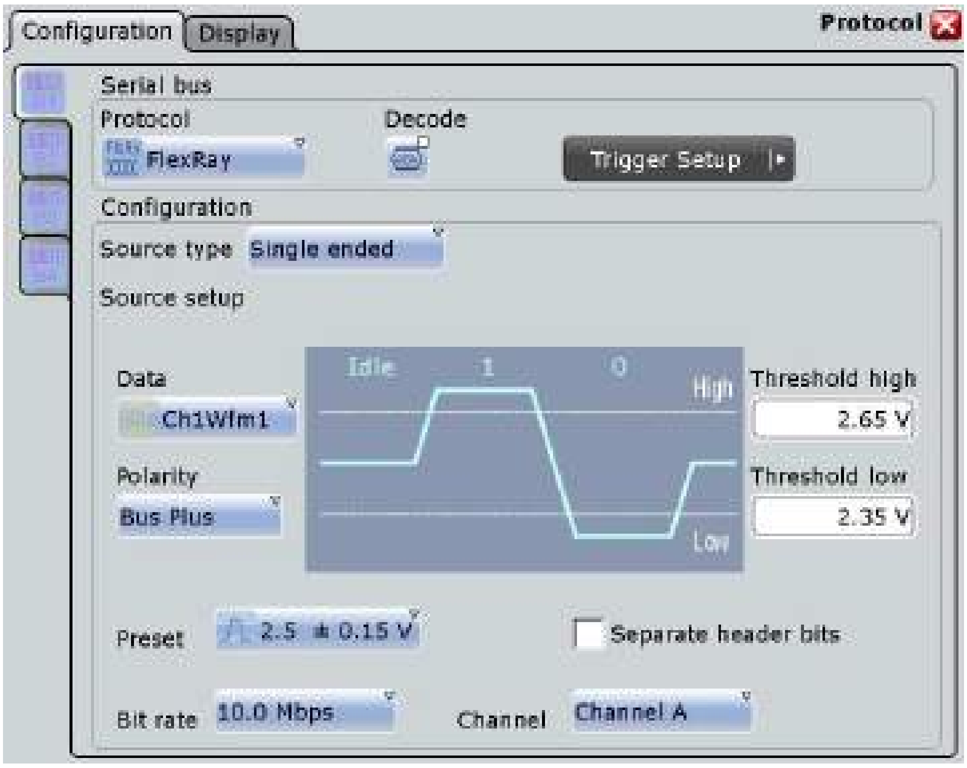
12.7 FlexRay (Option R&S RTO-K4)

FlexRay is designed for use in safety-related distributed applications in the automotive industry. It is applied in real-time applications when higher data rates and reliable communication are required. In particular, FlexRay supports x-by-wire applications, for example, steer-by-wire or brake-by-wire.

12.7.1 FlexRay Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *FlexRay*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: FlexRay
Source type: Single ended
Data: Ch1Wfm1
Polarity: Bus Plus
Threshold high: 2.65 V
Threshold low: 2.35 V
Preset: 2.5 ± 0.15 V
☐ Separate header bits
Bit rate: 10.0 Mbps
Channel: Channel A

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Source type
Sets the type of measurement. The instrument adjusts the thresholds to the selected source type.

"Single-ended"	For measurements with single-ended probes, or single-ended voltage measurements with differential probes on the FlexRay bus. Two thresholds have to be defined as absolute voltage levels.
"Differential"	For differential measurements on the FlexRay bus. This is the most common measurement. Two thresholds have to be defined as differential voltages.
"Logic"	For measurements of logic signals, for example, of the logic signal inside the FlexRay node, between the communication controller and the bus driver. If MSO option R&S RTO-B1 is installed, you can use digital input channels. It is possible to measure simultaneously on a data line and on the enable line. Each line requires its own threshold.

Remote command:
`BUS<m>:FLXRay:SRCType` on page 1631

Data
Sets the input channel of the bus signal, or of the data line in case of a "Logic" source type. Usually, the source is one of the analog channels. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

If the source type is "Logic", digital channels can be used (MSO option R&S RTO-B1 is required). Digital and analog channels cannot be used at the same time in a bus.

Remote command:
`BUS<m>:FLXRay:SOURce<n>` on page 1632

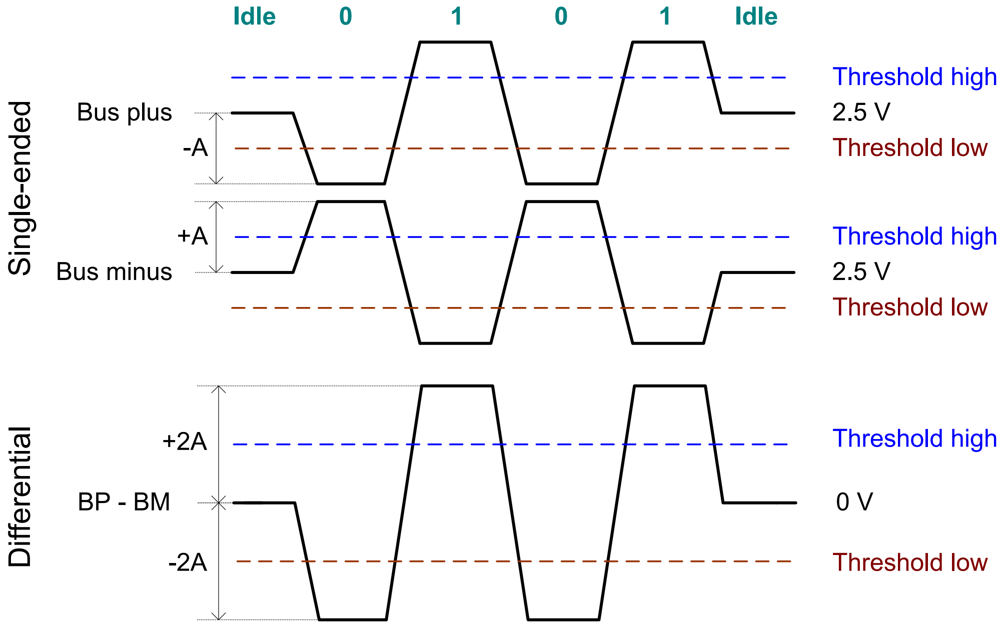
Enable
Sets the input channel of the enable line in case of a "Logic" source type. The enable line transfers the control signal of the bus guardian to the bus driver. None, or one of the analog channels can be used. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

Alternatively to analog channels, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time in a bus.

Remote command:
`BUS<m>:FLXRay:SOURce<n>` on page 1632

Thresholds
Threshold values are used for digitization of the signal.

For measurements on a FlexRay bus, two thresholds are required to distinguish the three possible states of the signal - high, low and idle. If the signal value on the line is higher than the upper threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the lower threshold. If the value is between the threshold, the signal is in idle state.



For measurements inside the FlexRay node (with "Source type" = "Logic"), each line requires its threshold level.

There are two ways to set the thresholds: selection of a predefined value, or direct entry of a value.

- "Preset"
  Selects default threshold voltages from a list. The predefined values depend on the selected source type. The value is set to "Manual" if at least one threshold was entered directly.
- "Threshold high" and "Threshold low"
  Upper and lower levels for single-ended or differential source types. You can enter the values directly in the fields.
- "Threshold data" and "Threshold enable"
  Levels for data and enable line in case of logic source type. You can enter the values directly in the fields.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:FLXRay:PRSingle` on page 1633
`BUS<m>:FLXRay:PRDiff` on page 1633
`BUS<m>:FLXRay:PRLogic` on page 1634
`BUS<m>:FLXRay:THReshold<n>` on page 1632
`BUS<m>:FLXRay:THData` on page 1633
`BUS<m>:FLXRay:THENable` on page 1632
`BUS<m>:SETReflevels` on page 1495

Polarity
Selects the wire on which the bus signal is measured in case of "Single-ended" measurement: "Bus plus" or "Bus minus". The setting affects the digitization of the signal.

Remote command:
`BUS<m>:FLXRay:POLarity` on page 1634

Bit rate
Selects the number of transmitted bits per second from a list.

Remote command:
`BUS<m>:FLXRay:BITRate` on page 1634

Channel
Selects the FlexRay channel on which the signal is measured, either cahnnel A or channel B. The setting is considered in the calculation of the frame CRC.

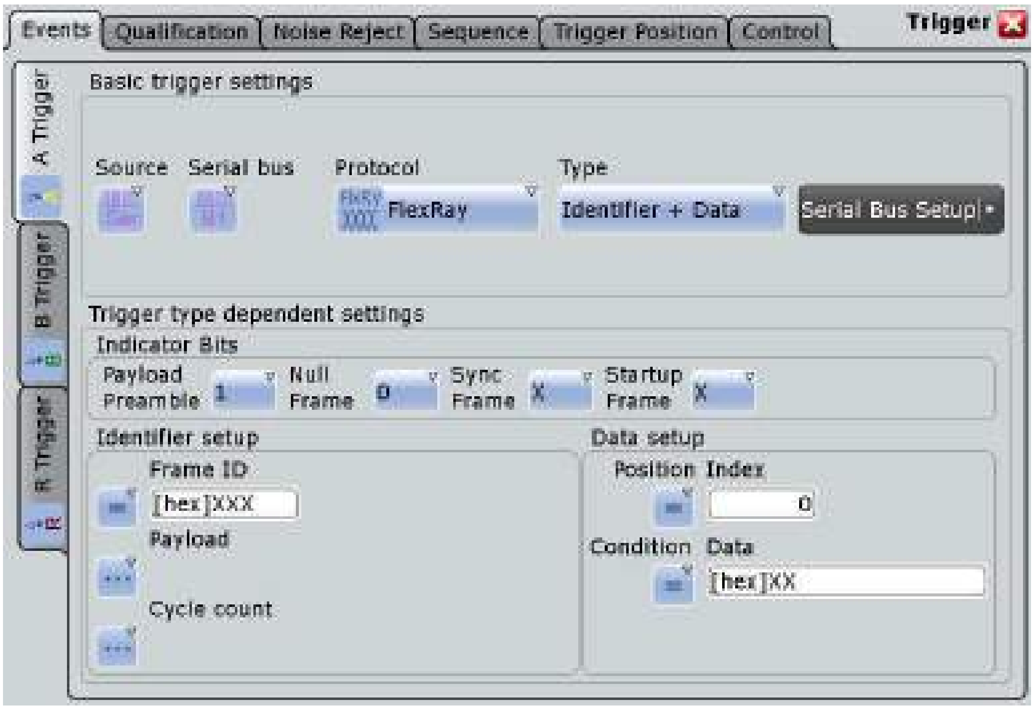
Remote command:
`BUS<m>:FLXRay:CHTYpe` on page 1635

Separate header bits
The setting affects the decoding and its display. If enabled, the leading five indicator bits of the header are decoded as five single bits. Otherwise, the indicator bits are shown as one word with word length five bits.

Remote command:
`BUS<m>:FLXRay:SEHB` on page 1635

12.7.2 FlexRay Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = FlexRay"



Protocol: FlexRay
Type: Identifier + Data
Payload Preamble: 1
Null Frame: 0
Sync Frame: X
Startup Frame: X
Frame ID: [hex]XXX
Position Index: 0
Condition Data: [hex]XX

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type for FlexRay analysis.

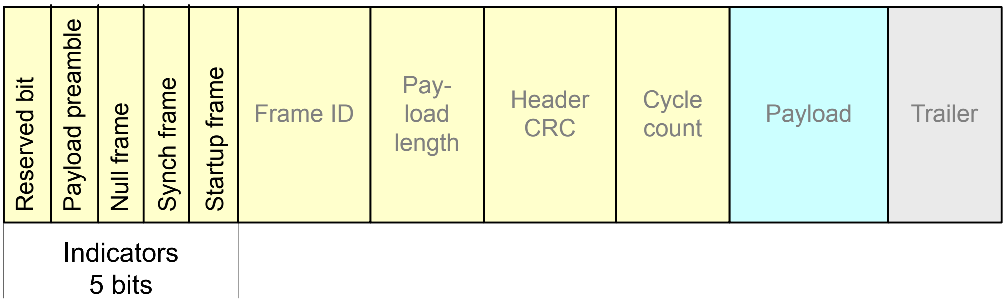
"Start of frame"	Triggers on the first rising edge after the transmission start sequence (TSS).
"Identifier +data"	Triggers on the decoded frame content, on header and payload data: • Indicator bits, see "Indicator bits" on page 583 • Frame identifier, see "Frame ID (min/max)" on page 584 • Payload length, see "Payload length (min/max)" on page 584 • Cycle count, see "Cycle count (min, max), Step" on page 585 • Data position, see "Position, Index (min, max) - Data setup" on page 585 • Data bit pattern, see "Condition, Data (min, max) - Data setup" on page 585
"Symbol"	Triggers on a symbol or wakeup pattern, see "Symbol" on page 586.
"Error condition"	Triggers on one or more errors that are detected in the decoded data, see "Error conditions" on page 586.

Remote command:
`TRIGger<m>:FLXRay:TYPE` on page 1636

Indicator bits

Triggers on one or more indicator bits at the beginning of the header segment. Each bit can be set to 0, 1, or X (don't care).

Trigger type: "Identifier + data"



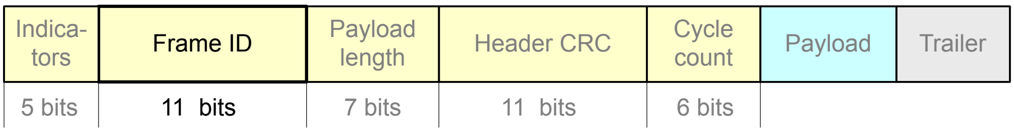
"Payload preamble"	Indicates a Network Management Vector in the payload segment. The NMV allows the host processor to send data directly, without processing by the communication controller.

"Null frame"	Indicates a frame without usable data.
"Sync frame"	Indicates that the frame is used for synchronization of the FlexRay system. Only sync nodes can send this frame type.
"Startup frame"	Indicates a startup frame used for startup of the network. Only specific start nodes can send this frame type.

Remote command:
`TRIGger<m>:FLXRay:PLPReamble` on page 1637
`TRIGger<m>:FLXRay:NUFRame` on page 1638
`TRIGger<m>:FLXRay:SYFRame` on page 1638
`TRIGger<m>:FLXRay:STFRame` on page 1638

Frame ID (min/max)

The frame ID contains the number of the slot in which the frame is transmitted. Each frame ID occurs only once during a FlexRay cycle.



Indicators	**Frame ID**	Payload length	Header CRC	Cycle count	Payload	Trailer
5 bits	**11 bits**	7 bits	11 bits	6 bits		

To trigger on a frame ID, you have to define a condition and one or two identifier patterns. The second identifier pattern is required to specify a range with conditions "In range" and "Out of range". In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the conditions "Equal" and "Not equal". If the identifier is not relevant for the trigger setup, set it to "Off".

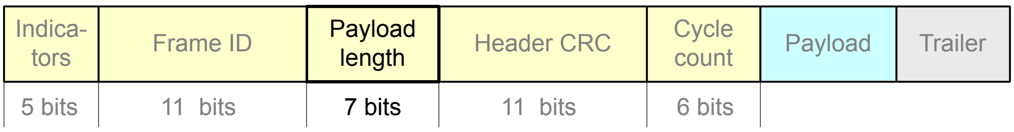
The maximum length of the pattern is 11 bit. The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:FCONdition` on page 1638
`TRIGger<m>:FLXRay:FMIN` on page 1639
`TRIGger<m>:FLXRay:FMAX` on page 1639

Payload length (min/max)

The payload length contains the number of of words transmitted in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.



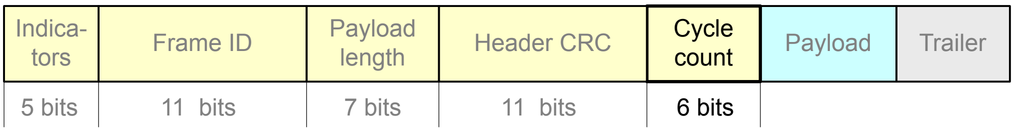
Indicators	Frame ID	**Payload length**	Header CRC	Cycle count	Payload	Trailer
5 bits	11 bits	**7 bits**	11 bits	6 bits		

To trigger on the payload length, you have to define a condition and one or two numbers of words. The second number is required to specify a range with conditions "In range" and "Out of range". If the payload length is not relevant for the trigger setup, set it to "Off".

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:PCONdition` on page 1639
`TRIGger<m>:FLXRay:PMIN` on page 1640
`TRIGger<m>:FLXRay:PMAX` on page 1640

Cycle count (min, max), Step
The cycle count contains the number of the current FlexRay cycle.



Indica-tors	Frame ID	Payload length	Header CRC	Cycle count	Payload	Trailer
5 bits	11 bits	7 bits	11 bits	6 bits		

To trigger on the cycle count, you have to define a condition and one or two numbers. If the condition is a range ("In range" or "Out of range"), a second number "Cycle count max" is required.

Additionally, you can define a "Step" to trigger on each n-th cycle inside the given range. This allows for specific triggering if slot multiplexing is used.

If the cycle count is not relevant for the trigger setup, set it to "Off".

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:CENable` on page 1640
`TRIGger<m>:FLXRay:CMIN` on page 1641
`TRIGger<m>:FLXRay:CMAX` on page 1641
`TRIGger<m>:FLXRay:CSTep` on page 1641

Position, Index (min, max) - Data setup
Sets the position of the first byte of data bit pattern within the payload segment. You can define an exact position, or a position range.

Trigger type: "Identifier + data"

"Position"	Operator for the data position. Select "Off", if the position of the required pattern is not relevant for the trigger condition.
"Index"	Sets the number of data bytes to be skipped after start of the payload segment if "Position" is "Equal" or "Greater or equal". The index 0 is associated with the first data byte.
"Index min, Index max"	If the "Position" operator defines a range, the indexes of the first and the last byte are defined between which the required bit pattern may start.

Remote command:
`TRIGger<m>:FLXRay:DPOPerator` on page 1642
`TRIGger<m>:FLXRay:DPOSition` on page 1642
`TRIGger<m>:FLXRay:DPTO` on page 1642

Condition, Data (min, max) - Data setup
Specifies the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by "Position, Index (min, max) - Data setup" on page 585. The pattern comparision is byte-aligned, and the instrument triggers at the end of a byte.

"Condition"	Sets the operator to set a specific data pattern ("Equal" or "Not equal") or a data range. Select "Off", if the data pattern is not relevant for the trigger condition.
"Data (min/max)"	Enter the bytes in msb first bit order. The maximum pattern length is 8 bytes. In binary format, you can use the following characters: 1; 0; or X (any bit). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`TRIGger<m>:FLXRay:DCONdition` on page 1642
`TRIGger<m>:FLXRay:DMIN` on page 1643
`TRIGger<m>:FLXRay:DMAX` on page 1643

Symbol

Triggers on a symbol or on a wakeup pattern.

Trigger type: "Symbol"

"CAS/MTS"	Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.
"Wakeup Pattern"	The wakeup pattern is sent to activate the nodes of the system.

Remote command:
`TRIGger<m>:FLXRay:SYMBol` on page 1643

Error conditions

Triggers on one or more errors in the frame.

Trigger type: "Error conditions"

"FSS"	Error in a Frame Start Sequence. FSS follows the Transmission Start Sequence TSS at the beginning of each frame.
"BSS"	Error in a Byte Start Sequence. The BSS is transmitted before each byte.
"FES"	Error in Frame End Sequence. FES indicates the end of each frame.
"Header CRC"	Error in a cyclic redundancy check code of the header data which covers mainly frame ID and payload length.
"Payload CRC"	Error in a cyclic redundancy check code of the complete frame.

Remote command:
`TRIGger<m>:FLXRay:FSSerror` on page 1644
`TRIGger<m>:FLXRay:BSSerror` on page 1644
`TRIGger<m>:FLXRay:FESerror` on page 1644
`TRIGger<m>:FLXRay:HCRCerror` on page 1644
`TRIGger<m>:FLXRay:PCRCerror` on page 1644

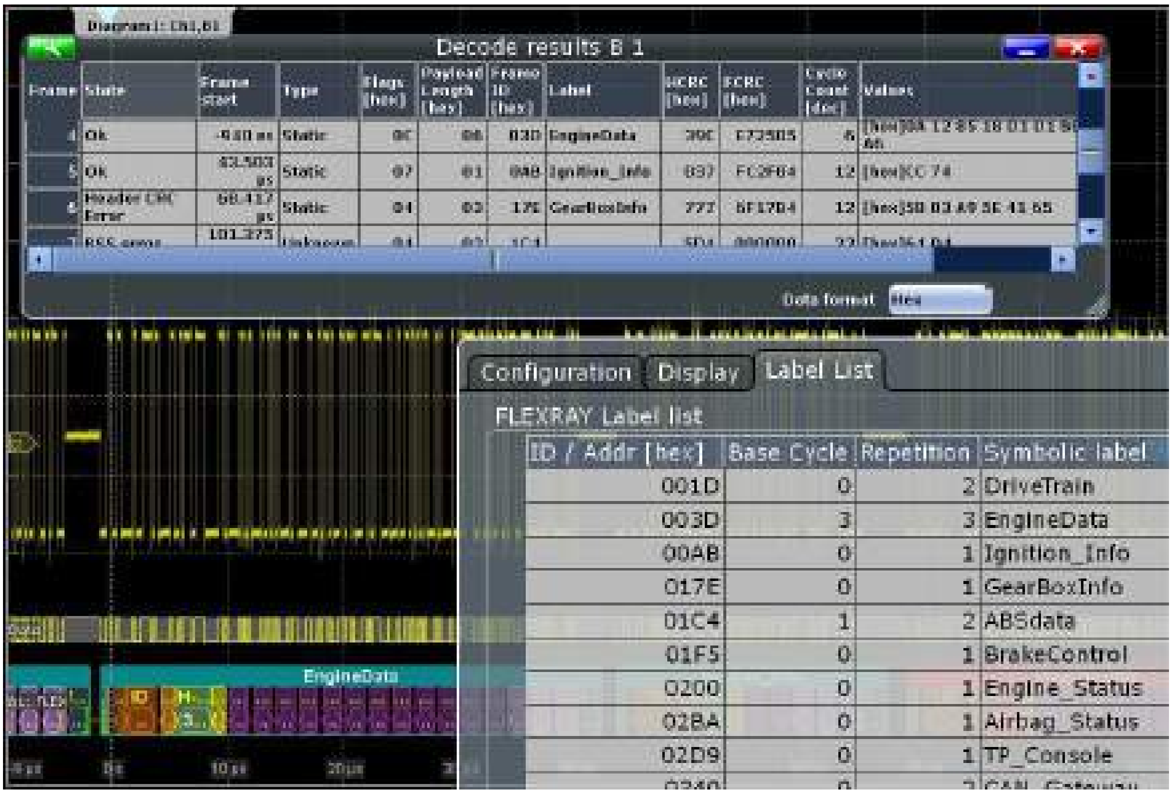
12.7.3 FlexRay Label List

Label lists are protocol-specific. A FlexRay label file contains four values for each identifier:

- "ID / Addr": number of the slot in which the frame is transmitted
- "Base cycle" and "Repetition": define the cycle indexes for which the identifier applies. Base cycle defines the first applied cycle.
  There are 64 cycles in a FlexRay communication. The same identifier can be shared by different devices, and each device uses the identifier at different cycles.
  For example:
  0x0AB,0,2,Ignition_Info: uses cycles 0,2,4,6,...,62
  0x0AB,1,2,GearBoxInfo: uses cycles 1,3,5,7,...,63
- "Symbolic label": symbolic name of the identifier, specifying the device function.

Example: FlexRay PTT file

```
# ---------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = flexray
# ---------------------------------------------------------------------------
# Labels for FlexRay protocol
#   Column order: Identifier, Base cycle, Cycle repetition, Label
# ---------------------------------------------------------------------------
# ----Definition----
0x01D,0,2,DriveTrain
0x03D,3,3,EngineData
0x0AB,0,2,Ignition_Info
0x0AB,1,2,GearBoxInfo
0x1C4,1,2,ABSdata
0x1F5,0,1,BrakeControl
0x200,0,1,Engine_Status
0x2BA,0,1,Airbag_Status
0x2D9,0,1,TP_Console
0x340,0,2,CAN_Gateway
0x38B,55,1,MOST_Gateway
0x3EA,0,1,PressureInfo
# ---------------------------------------------------------------------------
```



ID / Addr [hex]	Base Cycle	Repetition	Symbolic label
001D	0	2	DriveTrain
003D	3	3	EngineData
00AB	0	1	Ignition_Info
017E	0	1	GearBoxInfo
01C4	1	2	ABSdata
01F5	0	1	BrakeControl
0200	0	1	Engine_Status
02BA	0	1	Airbag_Status
02D9	0	1	TP_Console

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:FLXRay:FRAMe<n>:SYMBol?` on page 1646

12.7.4 FlexRay Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

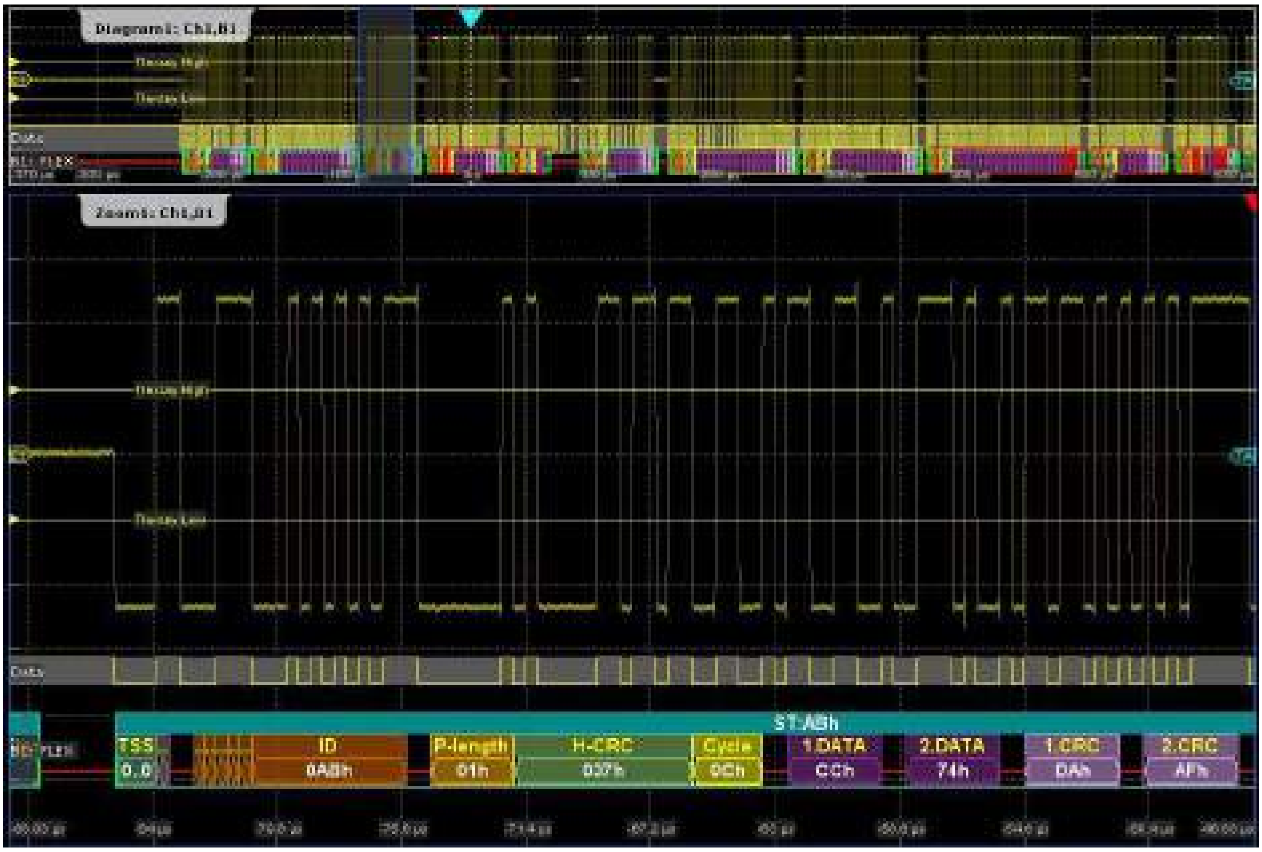


Figure 12-35: FlexRay - decoded static slot

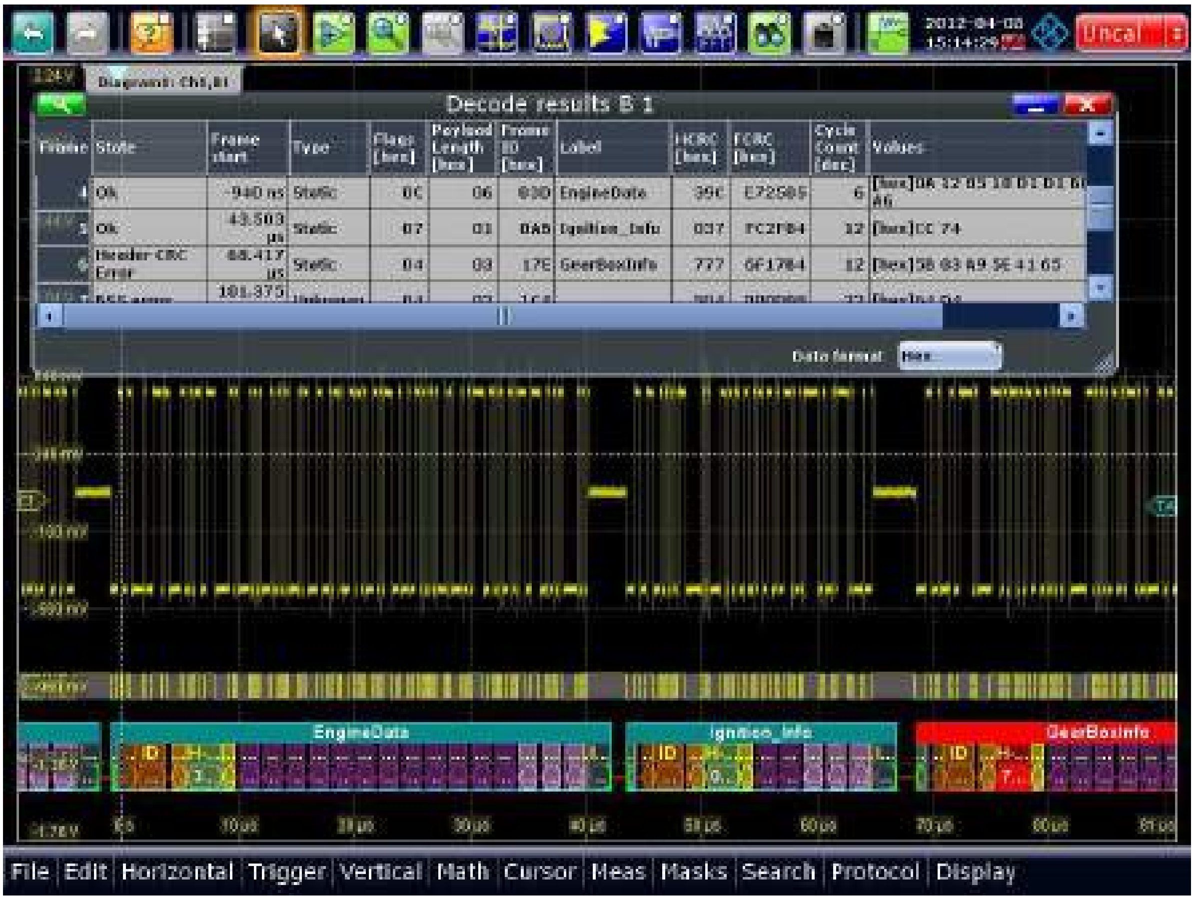
Data is decoded and displayed in the order of its reception. The "Decode results" box shows the detailed decoded data for each frame as it is received.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Figure 12-36: FlexRay - decoded dynamic slot and results table

Table 12-8: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Frame start	Time of frame start
Type	Frame type: Frame of the static segment, frame of the dynamic segment, wakeup frame, symbol in the frame
Flags	State of indicator bits
Payload length	Number of data words in the payload segment.
Frame ID	Value of the frame ID (slot number)
Label	Symbolic label name defined in the label list
HCRC	Value of the header CRC
FCRC	Value of the frame CRC
Cycle count	Number of the current FlexRay cycle
Values	Value of the data bytes. The data format is selected below the table. Wakeup and symbol frames frames do not transmit data, therefore "- - -" is displayed.



Frame	State	Frame start	Type	Flags [hex]	Payload Length [hex]	Frame ID [hex]	Label	HCRC [hex]	FCRC [hex]	Cycle Count [dec]	Values
4	Ok	-940 ns	Static	0C	06	03D	EngineData	39C	E72585	6	[hex]06 12 05 10 D1 D1 6 A6
5	Ok	43.503 µs	Static	07	01	0A5	Ignition_Info	037	FC2F84	12	[hex]CC 74
6	Header CRC Error	88.417 µs	Static	04	03	17E	GearBoxInfo	777	6F1784	12	[hex]58 03 A9 5E 41 65

Figure 12-37: FlexRay - decode results with applied label list

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.8.3, "Decode Results", on page 1644.

12.7.5 Search on Decoded FlexRay Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

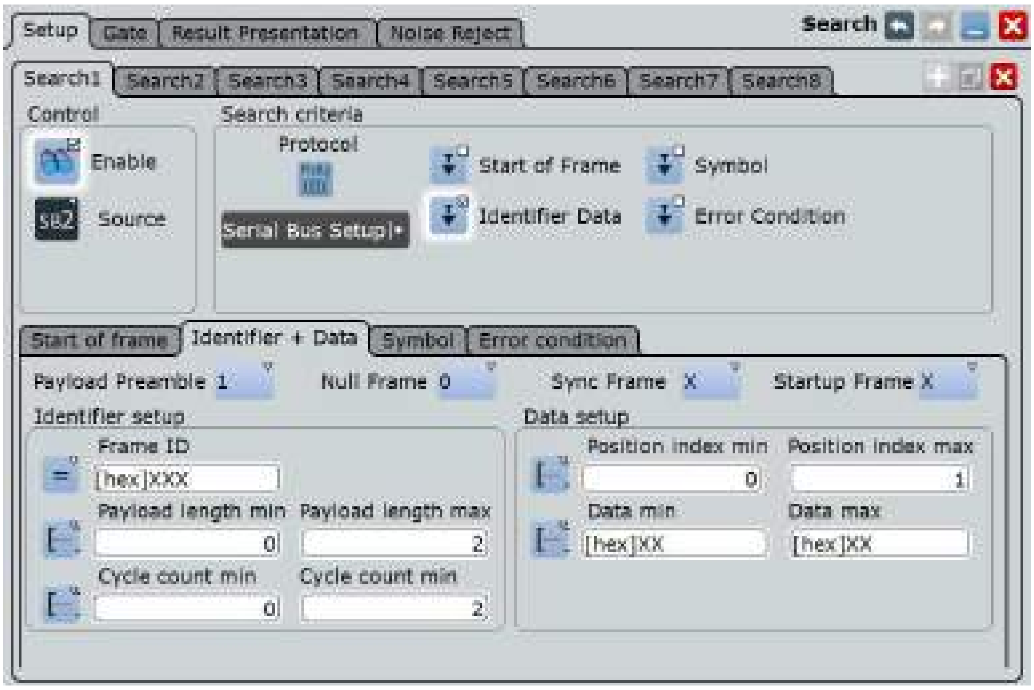
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

12.7.5.1 FlexRay Search Setup

Access: SEARCH > "Setup" tab



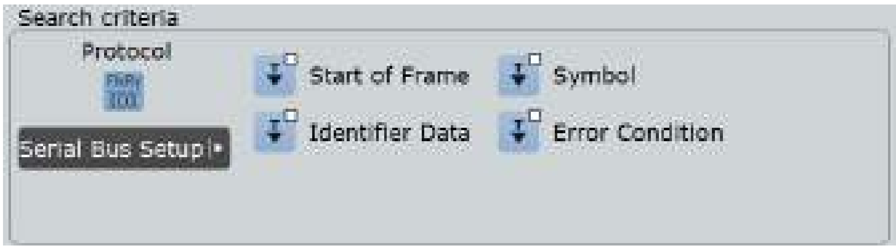
Source: SB2

Payload Preamble: 1
Null Frame: 0
Sync Frame: X
Startup Frame: X

Frame ID: [hex]XXX
Payload length min: 0
Payload length max: 2
Cycle count min: 0
Cycle count min: 2

Position index min: 0
Position index max: 1
Data min: [hex]XX
Data max: [hex]XX

Search Criteria
Sets one criterion or an AND-combination of criteria to be searched for. If more than one criterion is selected, all criteria must be fulfilled by a frame for it to be shown in the search results.

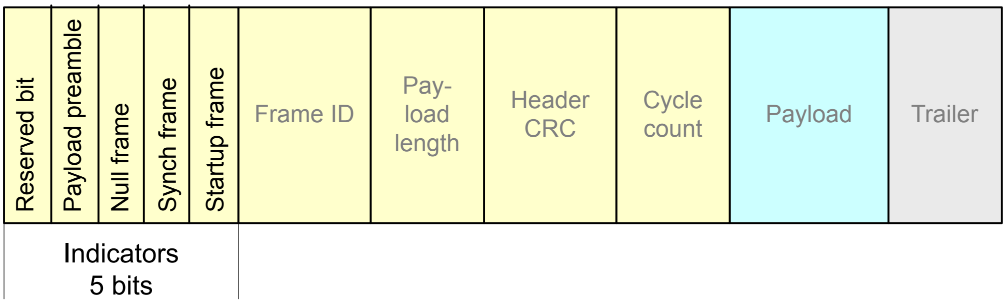


"Start of frame"	Searches for the first rising edge after the transmission start sequence (TSS).

"Identifier+data"	Searches for the decoded frame content, on header and payload data: - Indicator bits, see "Indicator bits" on page 593 - Frame identifier, see "Frame ID (min/max)" on page 594 - Payload length, see "Payload length (min/max)" on page 594 - Cycle count, see "Cycle count (min, max), Step" on page 594 - Data position, see "Position, Index (min, max) - Data setup" on page 594 - Data bit pattern, see "Condition, Data (min, max) - Data setup" on page 595
"Symbol"	Searches for a symbol or wakeup pattern, see "Symbol" on page 595.
"Error condition"	Searches for one or more errors that are detected in the decoded data, see "Error Condition" on page 595.

Remote command:
`SEARch:TRIGger:FLXRay[:SSOFrame]` on page 1652
`SEARch:TRIGger:FLXRay:SSYMbol` on page 1652
`SEARch:TRIGger:FLXRay:SIDData` on page 1652
`SEARch:TRIGger:FLXRay:SERRor` on page 1652

Indicator bits
Searches for one or more indicator bits at the beginning of the header segment. Each bit can be set to 0, 1, or X (don't care).



"Payload preamble"	Indicates a Network Management Vector in the payload segment. The NMV allows the host processor to send data directly, without processing by the communication controller.
"Null frame"	Indicates a frame without usable data.
"Sync frame"	Indicates that the frame is used for synchronization of the FlexRay system. Only sync nodes can send this frame type.
"Startup frame"	Indicates a startup frame used for startup of the network. Only specific start nodes can send this frame type.

Remote command:
`SEARch:TRIGger:FLXRay:PLPReamble` on page 1657
`SEARch:TRIGger:FLXRay:NUFRame` on page 1657

`SEARch:TRIGger:FLXRay:SYFRame` on page 1659
`SEARch:TRIGger:FLXRay:STFRame` on page 1659

Frame ID (min/max)
The frame ID contains the number of the slot in which the frame is transmitted. Each frame ID occurs only once during a FlexRay cycle.

The setup conditions are the same as in the FlexRay trigger setup, see "Frame ID (min/max)" on page 584.

Remote command:
`SEARch:TRIGger:FLXRay:FCONdition` on page 1656
`SEARch:TRIGger:FLXRay:FMIN` on page 1657
`SEARch:TRIGger:FLXRay:FMAX` on page 1657

Payload length (min/max)
The payload length contains the number of of words transmitted in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

The setup conditions are the same as in the FlexRay trigger setup, see "Payload length (min/max)" on page 584.

Remote command:
`SEARch:TRIGger:FLXRay:PCONdition` on page 1658
`SEARch:TRIGger:FLXRay:PMIN` on page 1658
`SEARch:TRIGger:FLXRay:PMAX` on page 1658

Cycle count (min, max), Step
The cycle count contains the number of the current FlexRay cycle.

The setup conditions are the same as in the FlexRay trigger setup, see "Cycle count (min, max), Step" on page 585.

Remote command:
`SEARch:TRIGger:FLXRay:CENable` on page 1653
`SEARch:TRIGger:FLXRay:CMIN` on page 1653
`SEARch:TRIGger:FLXRay:CMAX` on page 1653
`SEARch:TRIGger:FLXRay:CSTep` on page 1654

Position, Index (min, max) - Data setup
Sets the position of the first byte of data bit pattern within the payload segment. You can define an exact position, or a position range.

The setup conditions are the same as in the FlexRay trigger setup, see "Position, Index (min, max) - Data setup" on page 585.

Remote command:
`SEARch:TRIGger:FLXRay:DPOPerator` on page 1655
`SEARch:TRIGger:FLXRay:DPOSition` on page 1656
`SEARch:TRIGger:FLXRay:DPTO` on page 1656

Condition, Data (min, max) - Data setup

Specifies the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by "Position, Index (min, max) - Data setup" on page 594. The pattern comparision is byte-aligned, and the instrument triggers at the end of a byte.

The setup conditions are the same as in the FlexRay trigger setup, see "Condition, Data (min, max) - Data setup" on page 585.

Remote command:
`SEARch:TRIGger:FLXRay:DCONdition` on page 1654
`SEARch:TRIGger:FLXRay:DMIN` on page 1655
`SEARch:TRIGger:FLXRay:DMAX` on page 1655

Symbol

Searches for a symbol or a wakeup pattern.

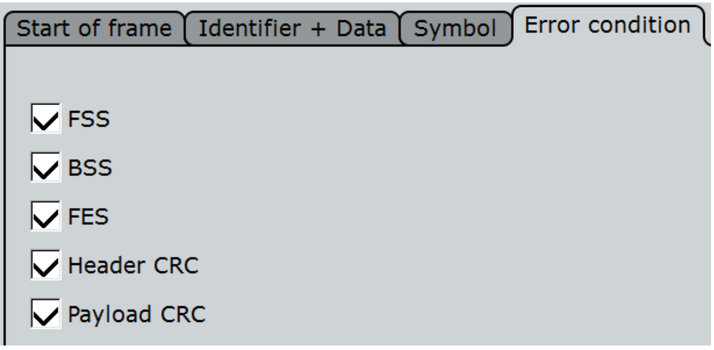
"CAS/MTS"	Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.
"Wakeup Pattern"	The wakeup pattern is sent to activate the nodes of the system.

Remote command:
`SEARch:TRIGger:FLXRay:SYMBol` on page 1659

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the FlexRay trigger setup, see "Error conditions" on page 586.



☑ FSS
☑ BSS
☑ FES
☑ Header CRC
☑ Payload CRC

Remote command:
`SEARch:TRIGger:FLXRay:BSSerror` on page 1660
`SEARch:TRIGger:FLXRay:FESerror` on page 1660
`SEARch:TRIGger:FLXRay:FSSerror` on page 1660
`SEARch:TRIGger:FLXRay:HCRCerror` on page 1661
`SEARch:TRIGger:FLXRay:PCRCerror` on page 1661

12.7.5.2 FlexRay Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

- `SEARch:RESult:FLXRay:FCOunt?` on page 1662
- `SEARch:RESult:FLXRay:FRAMe<m>:ADID?` on page 1662
- `SEARch:RESult:FLXRay:FRAMe<m>:CSSTate?` on page 1662
- `SEARch:RESult:FLXRay:FRAMe<m>:CSValue?` on page 1662
- `SEARch:RESult:FLXRay:FRAMe<m>:CYCount?` on page 1663
- `SEARch:RESult:FLXRay:FRAMe<m>:DATA?` on page 1663
- `SEARch:RESult:FLXRay:FRAMe<m>:FCSTate?` on page 1663
- `SEARch:RESult:FLXRay:FRAMe<m>:FCValue?` on page 1663
- `SEARch:RESult:FLXRay:FRAMe<m>:FLAGs?` on page 1664
- `SEARch:RESult:FLXRay:FRAMe<m>:PAYLength?` on page 1664
- `SEARch:RESult:FLXRay:FRAMe<m>:STATus?` on page 1664
- `SEARch:RESult:FLXRay:FRAMe<m>:STARt?` on page 1665
- `SEARch:RESult:FLXRay:FRAMe<m>:STOP?` on page 1665
- `SEARch:RESult:FLXRay:FRAMe<m>:SYMBol?` on page 1666
- `SEARch:RESult:FLXRay:FRAMe<m>:TYPE?` on page 1666

12.8 Audio Signals (Option R&S RTO-K5)

The R&S RTO can analyze several standard and de-facto industry standard signals: I²S Inter-IC Sound standard audio format, left justified and right justified data formats and Time Division Multiplexed (TDM) audio format.

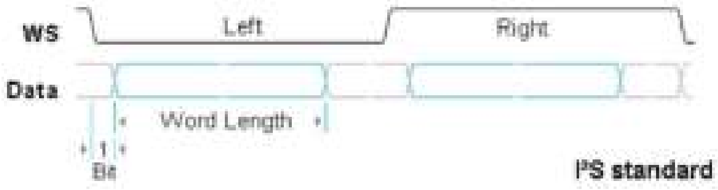
12.8.1 Audio Protocols

All audio protocols use 3 lines:

- The clock line generates the bit clock.
- The word select line (WS, also known as word clock) defines the frame start and the maximum length of the data word.
  For pulse code modulated signals (I²S standard, left and right justified data formats), the level of the WS signal assigns the data words to the left and right channels.
  TDM uses frame synchronization pulses on the WS line to identify the beginning of a frame.
- The data line transmits the audio data in time-multiplexed data channels.

12.8.1.1 I²S Standard

I²S standard interfaces transmit two PCM coded audio channels. The WS line selects the channel being transmitted - left or right channel. Usually, 32 bits are transmitted on each channel. The data word can be shorter than the channel length, and the receiver ignores the remaining bits. The first byte of the audio word is delayed one clock period from the leading edge of the word select pulse. The R&S RTO can decode I²S standard signals with MSBF and LSBF bit order.



12.8.1.2 Left Justified Data Format

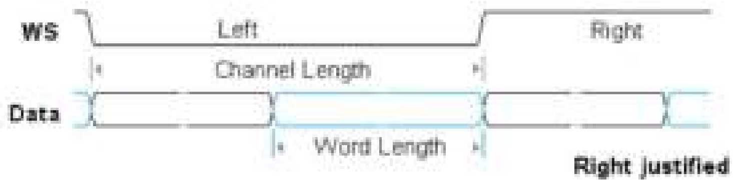
The left justified data format is very similar to the I²S standard, but the first byte of the audio word is aligned with the leading edge of the word select pulse. Thus the audio word is left justified within the frame. The data word can be shorter than the channel length.

In addition to the standard configuration, the R&S RTO can analyze also left justified data formats which send the data word with offset to the WS edge. The bit order can be MSBF or LSBF.

12.8.1.3 Right Justified Data Format

The right-justified data format is similar to the left-justified, but the last byte of the word in the frame is aligned with the trailing edge of the word select pulse. Thus the audio word is right-aligned within the frame.

The R&S RTO can decode right justified signals with MSBF and LSBF bit order.



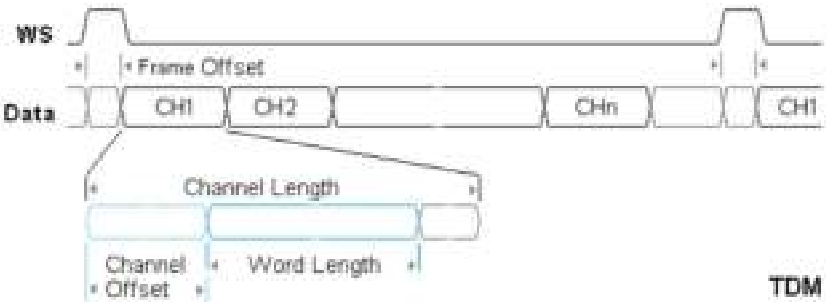
12.8.1.4 TDM

The Time Division Multiplexed (TDM) audio format is not standardized and provides high flexibility for transfer of more than two audio data channels on one line. On the word select line, it uses frame synchronization pulses to identify the beginning of a frame. On the data line, channel blocks of a defined length are transmitted. Each block contains an audio word that can be shorter than the channel length.

Each frame can start with frame offset bits, which preceed the first channel. Inside the channel, the audio word also can have an offset to the channel start.

Channel length, channel offset and word length are dependent values:

Channel length ≥ Word length + Channel offset



12.8.2 Audio Signal Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *Audio*

In the "Configuration" tab you configure the audio signal. Several audio signal variants are available: the I²S standard signal, the left- and right-justified data formats, and the TDM interface.

For all audio signal variants, you define the line sources and their polarities. Additionally, if coupling is active, one threshold for all sources; if coupling is not enabled, three thresholds for each source.

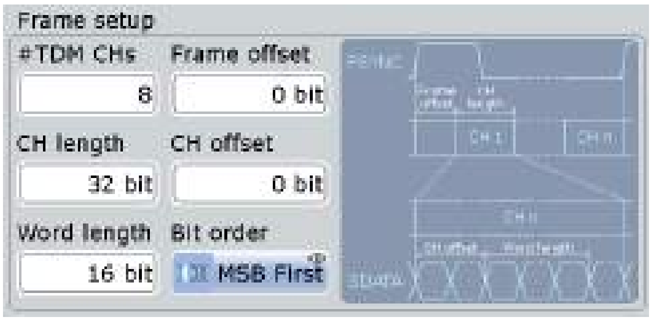
Specific settings for I²S standard signals are:

- "Channel order" on page 602
- "Word length" on page 602
- "Bit order" on page 602
- For left-justified data:
  "Channel offset" on page 602
- For right-justified data:
  "CH length" on page 603

Protocol: Audio
Audio Variant: I2S Standard
SCLK: C1 Rising
WS: C2 Normal
SDATA: C3 Active hig
Threshold: 1.6 V
Word length: 8 bit
Channel order: Left first
Bit order: MSB First

Specific settings for TDM audio signals are:

- "Word length" on page 602
- "Bit order" on page 602
- "Channel offset" on page 602
- "#TDM CHs" on page 603
- "Frame offset" on page 603
- "CH length" on page 603



Frame setup

#TDM CHs: 8

Frame offset: 0 bit

CH length: 32 bit

CH offset: 0 bit

Word length: 16 bit

Bit order: MSB First

Make sure that the tab of the correct serial bus is selected on the left side.

Audio Variant

Selects the protocol variant of the audio signal. The configuration possibilities exceed the definitions of the standards.

"I2S Standard"	Inter-IC Sound standard audio format. It uses the SCLK, WS and SDATA lines. The first byte of the audio word is delayed one clock period from the leading edge of the word select pulse.
"Left justified"	The left-justified data format uses the same lines as I²S standard. The first byte of the audio word is aligned with the leading edge of the word select pulse, or left-justified within the frame. The format is word-length independent.
"Right justified"	The right-justified data format is similar to the left-justified, but the last byte of the last word in the frame is aligned with the trailing edge of the word select pulse, or right-aligned within the frame. This format is not word-length independent.
"TDM"	The Time Division Multiplexed audio format is not standardized and provides high flexibility for transfer of up to 8 audio data channels on one line. Instead of word select, it uses frame synchronization pulses to identify the beginning of a frame. On the data line, channel blocks of a defined length are transmitted. Each block contains an audio word followed by a number of zero bits to complete the block.

Remote command:
`BUS<m>:I2S:AVARiant` on page 1667

SCLK

Selects the source of the clock line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:I2S:CLOCk:SOURce` on page 1667

SCLK Polarity
Sets th polarity of the clock signal, that is the edge at which the instrument samples the data on the data line. Usually, the rising edge is used. The R&S RTO can also analyze the converse setup.

Remote command:
`BUS<m>:I2S:CLOCk:POLarity` on page 1667

WS / FSYNC
Selects the source of the word select line for I²S standard, left- und right-justified data formats, or the source of the frame synchronization pulse for TDM audio signals. The same waveforms as for SCLK are available, and the same restrictions are applied.

Remote command:
`BUS<m>:I2S:WSELect:SOURce` on page 1668

WS / FSYNC Polarity
For a word select line, the polarity defines the word select values assigned to the left and right channels.
- "Normal": usually, 0 indicates the left channel, and 1 indicates the right channel.
- "Inverted": 0 indicates the right channel, and 1 the left channel.

For an FSYNC line (TDM), the polarity defines the edge of the FSYNC pulse that identifies the beginning of a frame. The frame starts exactly at the next clock edge following the selected FSYNC edge.
- "Normal": usually, the frame begins with a rising edge.
- "Inverted": the frame begins with a falling edge.

Remote command:
`BUS<m>:I2S:WSELect:POLarity` on page 1668

SDATA
Selects the source of the audio data line. The same waveforms as for SCLK are available, and the same restrictions are applied.

Remote command:
`BUS<m>:I2S:DATA:SOURce` on page 1668

SDATA Polarity
Defines the interpretation of high and low signal states.
- "Active high": HIGH (signal level above the threshold level) = 1 and LOW (signal level below the threshold level) = 0
- "Active low": HIGH = 0 and LOW = 1

Remote command:
`BUS<m>:I2S:DATA:POLarity` on page 1669

Threshold setup
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the polarity.

There are three ways to set the threshold:
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
  This option is only available for analog sources.
- "Coupling"
  Sets all thresholds to the same value. Enter the value in the "Threshold" field.
- "Threshold"
  Enter individual values for each line directly in the fields.

Remote command:
`BUS<m>:I2S:TCOupling` on page 1669
`BUS<m>:I2S:CLOCk:THReshold` on page 1669
`BUS<m>:I2S:DATA:THReshold` on page 1670
`BUS<m>:I2S:WSELect:THReshold` on page 1670
`BUS<m>:SETReflevels` on page 1495

Channel order
Defines if the left or the right channel is the first channel in the frame.

The setting is not available for TDM audio signals.

Remote command:
`BUS<m>:I2S:CHANnel:ORDer` on page 1670

Word length
Defines the number of bits in an audio data word. The minimum length is 4 bit, the maximum is 32 bit.

Remote command:
`BUS<m>:I2S:WLENgth` on page 1670

Bit order
Sets the bit order in the audio data words. Usually, the MSB is transmitted first.

Remote command:
`BUS<m>:I2S:BORDer` on page 1671

Channel offset
Sets the number of bits between the channel start and the start of the audio word. The setting is available for left-justified data format and TDM audio signals.

For TDM, possible values depend on the channel size and the word size. The maximum delay is *Channel length - Word length*.

Remote command:
`BUS<m>:I2S:CHANnel:OFFSet` on page 1671

#TDM CHs
Sets the number of channels transmitted on the TDM audio line.

Remote command:
`BUS<m>:I2S:CHANnel:TDMCount` on page 1671

Frame offset
Sets the number of bits between the frame start and the start of the first channel of a TDM audio line. The maximum offset is 256 bit. Each FSYNC edge restarts the offset count.

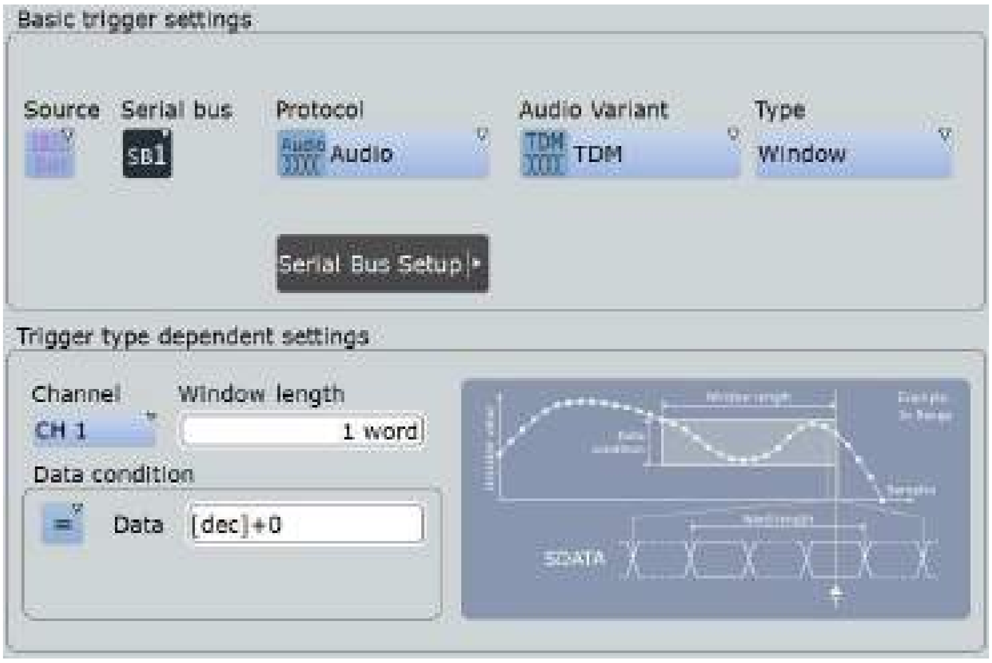
Remote command:
`BUS<m>:I2S:FOFFset` on page 1671

CH length
Sets the number of bits in a channel block for right-justified data format and TDM audio signals.

Remote command:
`BUS<m>:I2S:CHANnel:LENGth` on page 1672

12.8.3 Audio Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = Audio"



Serial bus: SB1
Protocol: Audio
Audio Variant: TDM
Type: Window
Channel: CH 1
Window length: 1 word
Data: = [dec]+0

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

Selects the trigger type.

"Data"

Sets the trigger on a data word or a data range that occurs on a specified channel or on any channel. The instrument triggers on the last bit of the specified data pattern.

Description of specific trigger type settings:
- "Channel" on page 605
- "Data condition" on page 605

"Window"

This trigger checks if the decoded data values stay inside a "window" that is formed by a data range and a time specified by a number of subsequent words. It considers a selected channel or all channels. The instrument triggers at the end of the last word. Thus, for example, you can trigger on a pause.

Description of specific trigger type settings:
- "Channel" on page 605
- "Data condition" on page 605
- "Window length" on page 606

"Frame condition"

Sets the trigger on an AND combination of data conditions on different channels. The instrument triggers if all conditions are met inside one frame.

AND slot	Channel	Condition	Min	Max
1.	Left	[–]	[dec]+10	[dec]+20
2.	Right	[–]	[dec]+0	[dec]+10

Description of specific trigger type settings:
- "Channel" on page 605
- "Data condition" on page 605

Description of specific trigger type settings: "Channel" on page 605 and .

"Word select"	Triggers on the selected edge of the WS line, that is, on the beginning of the left or right channel (I²S, left- and right-justified). For TDM signals, it triggers on the selected edge of the FSYNC line - on the beginning of a TDM frame. The trigger time is the first clock edge after the selected WS/FSYNC edge. Description of specific trigger type settings: "Word select: Slope" on page 606.
"Error condition"	The oscilloscope uses the WS or FSYNC line to monitor the channel and frame length. An error is detected when two consecutive frames have different length. The instrument triggers on the first clock edge after error detection.

Figure 12-38: Trigger on errors in I²S standard signal with clock polarity "Rising"

Remote command:
`TRIGger<m>:I2S:TYPE` on page 1672

Channel
Selects the audio channel on which the instrument looks for the specified data condition.

The setting is relevant for trigger types Data, Window and Frame condition.

Note: For TDM signals. the number of available channels depends on the configuration of the audio bus, see "#TDM CHs" on page 603.

Remote command:
`TRIGger<m>:I2S:TCONdition<n>:CHANnel` on page 1673

Data condition
The data condition setup consists of the operator and one or two data patterns.

Min data [dec]+10
Max data [dec]+100

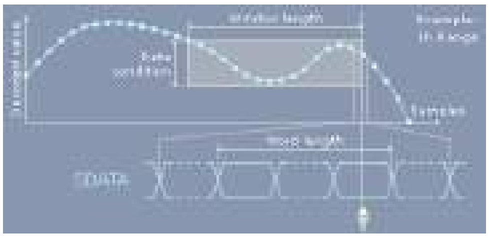
The settings are relevant for trigger types Data, Window and Frame condition.

"Operator"	Defines the operator to set a specific data word ("Equal" or "Not equal") or a data range.

"Min data"	Defines the data pattern. The data length is limited to the word length. Enter the pattern using the bit order defined in the signal configuration. X (don't care) is not allowed. Usually, audio words are signed numbers in 2's complement format. The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Max data"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:I2S:TCONdition<n>:CONDtion` on page 1674
`TRIGger<m>:I2S:TCONdition<n>:DMIN` on page 1675
`TRIGger<m>:I2S:TCONdition<n>:DMAX` on page 1675

Window length
Sets the number of words that is used as time limit for the "Window" trigger type. The instrument triggers if the data condition is fulfilled on the same channel for the given number of subsequent frames.



Remote command:
`TRIGger<m>:I2S:SOWords` on page 1675

Word select: Slope
Sets the edge of the WS or FSYNC signal as trigger condition. The instrument triggers on the first clock edge after the specified edge.

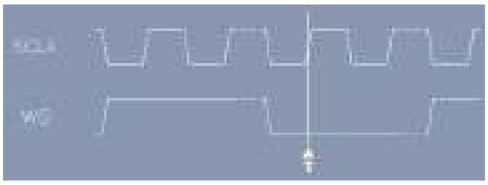


Figure 12-39: Word select trigger on I^2S standard signal with clock polarity "Rising" and "Normal" WS polarity (left = 0)

The WS edge indicates the start of the left or right channel. The FSYNC edge indicates the frame start. Consider the WS / FSYNC Polarity setting in the "Protocol Configuration" dialog box.

Remote command:
`TRIGger<m>:I2S:WSSLope` on page 1676

12.8.4 Audio Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

Decode results B 1

Data format: Hex

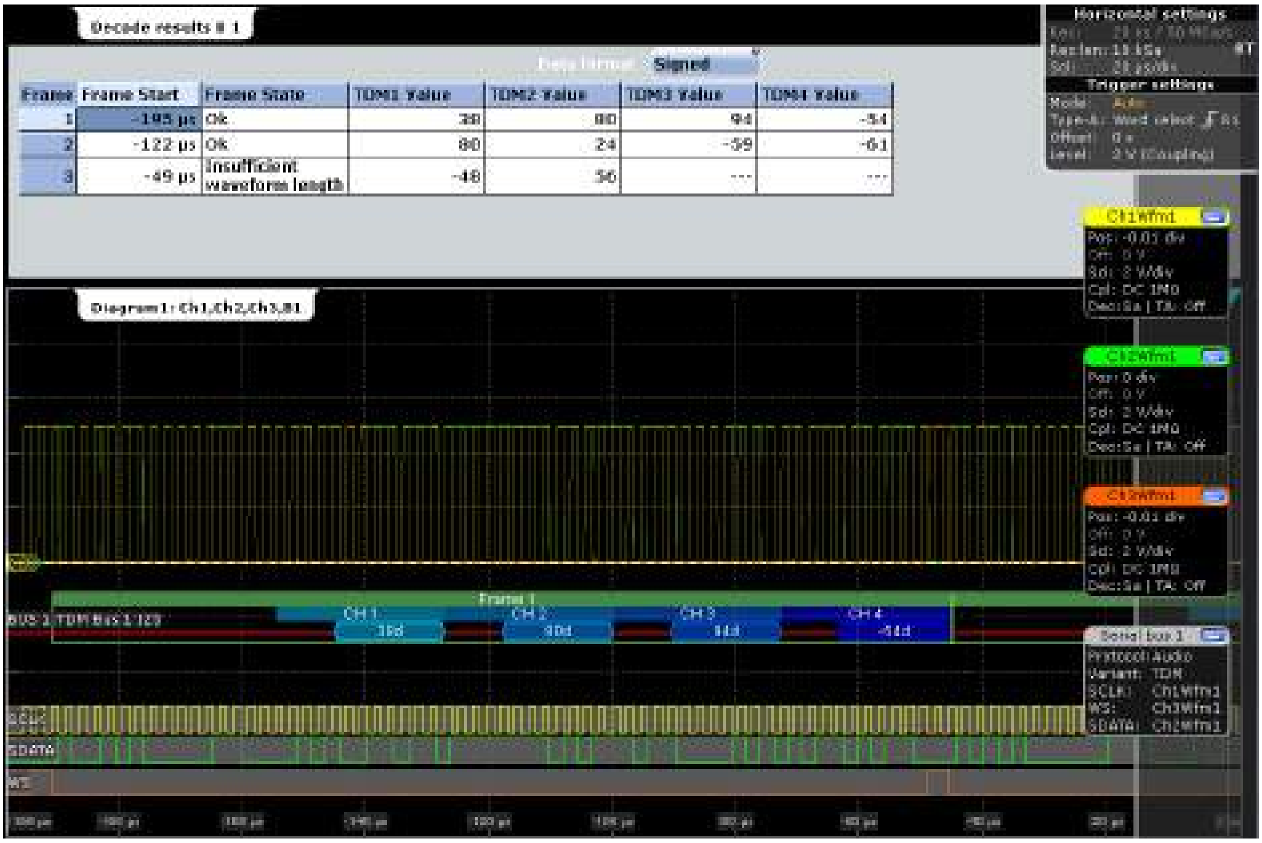
Frame	Frame Start	Frame State	Left Value	Right Value
1	-362.77 µs	OK	7222	E40F
2	-204.05 µs	OK	AAFA	F079
3	-45.32 µs	OK	E88A	7BF5
4	113.4 µs	OK	418F	A1E5
5	272.13 µs	Insufficient waveform length	---	---

Figure 12-40: Decoded audio signal, right-justified data format

green = frame
blue = left channel
violet = right channel
orange = frame/channel is not completely contained in the acquisition
red = error

Table 12-9: Content of the "Decode results" table

Column	Description
Frame Start	Time of the frame start
Frame State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition.
Left Value	Data value of the left channel
Right Value	Data value of the right channel



Decode results # 1

Data format: Signed

Frame	Frame Start	Frame State	TDM1 Value	TDM2 Value	TDM3 Value	TDM4 Value
1	-195 µs	Ok	38	80	94	-54
2	-122 µs	Ok	80	24	-59	-61
3	-49 µs	Insufficient waveform length	-48	56	---	---

Figure 12-41: Decoded TDM signal with 4 channels, frame offset 16 bit, channel offset 4 bit, word length 8 bit and inverted FSYNC and SDATA polarity

Table 12-10: Content of the "Decode results" table

Column	Description
Frame Start	Time of the frame start
Frame State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition.
TDM<x> Value	Data value of the TDM channel

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.9.3, "Decode Results", on page 1676.

12.8.5 Track and Trend

12.8.5.1 Track

The track is a waveform that shows measurement values in time-correlation to the audio signal. It is the graphical interpretation of all measurement values of a single acquisition. For audio signals, the measurement values on the vertical axis are the decoded values of the audio channels, the time scale is equivalent to the scale of the source waveforms.

You can display the values of several channels in one track, or create one track for each channel and display them in parallel.

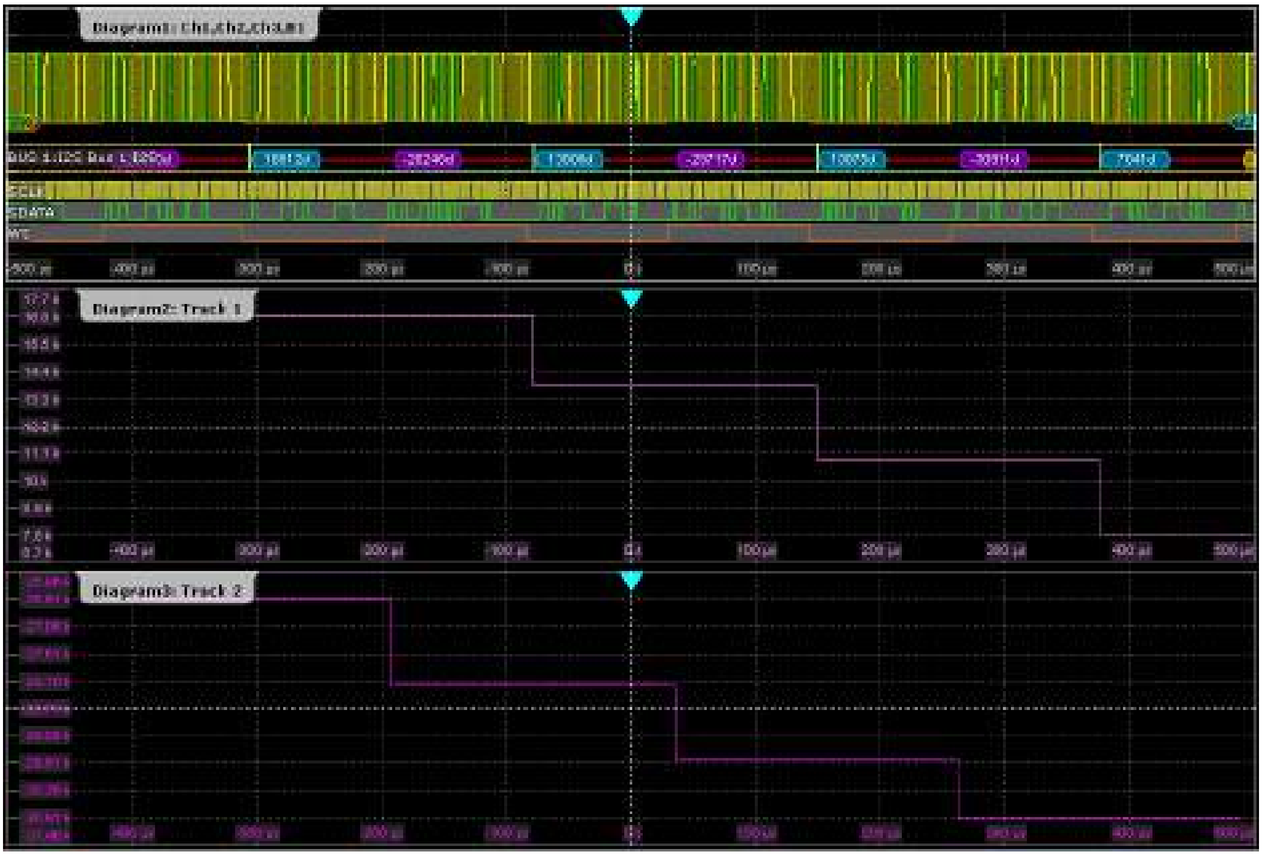


Figure 12-42: Tracks of left and right channel of I²S standard signal

The track is a special measurement waveform, so it can be used for further analysis like cursor measurements and zoom.

The instrument uses the bus data format to interpret audio data ("Display" tab > "Data format"). If the "Signed" data format ist set, decoded data is displayed as signed integers in the comb display and in the result table. For all other data formats, unsigned integers are used.

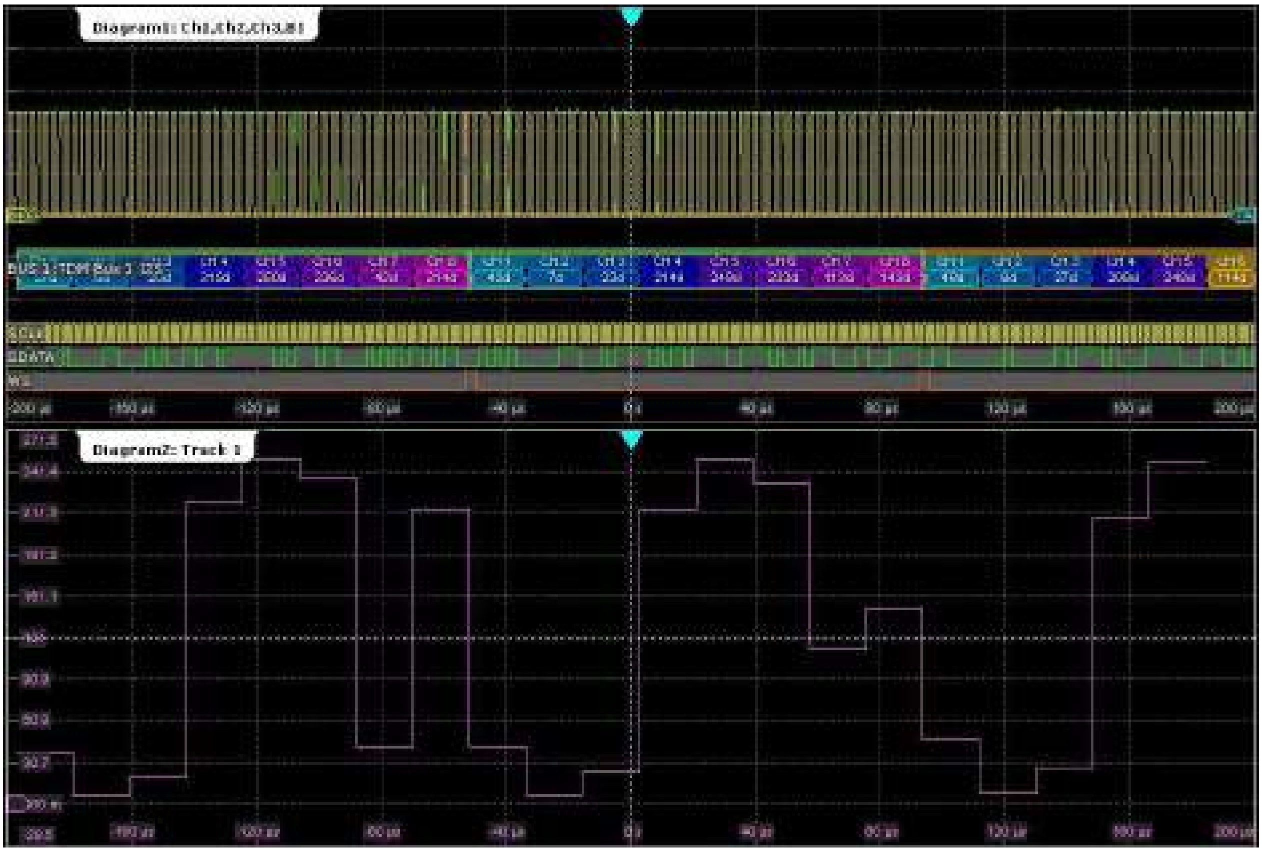


Figure 12-43: Track of all 8 channels of a TDM signal

Displaying and Configuring a Track

To get a first impression of the track, you can display it quickly. For further analysis, some configuration settings are available.

1. Press the PROTOCOL key.
2. Select the "Display" tab.
3. Tap the "Show Track Waveform(s)" button.
4. Select the "Audio channel" to be tracked.

   The track waveform with default settings is enabled and displayed.

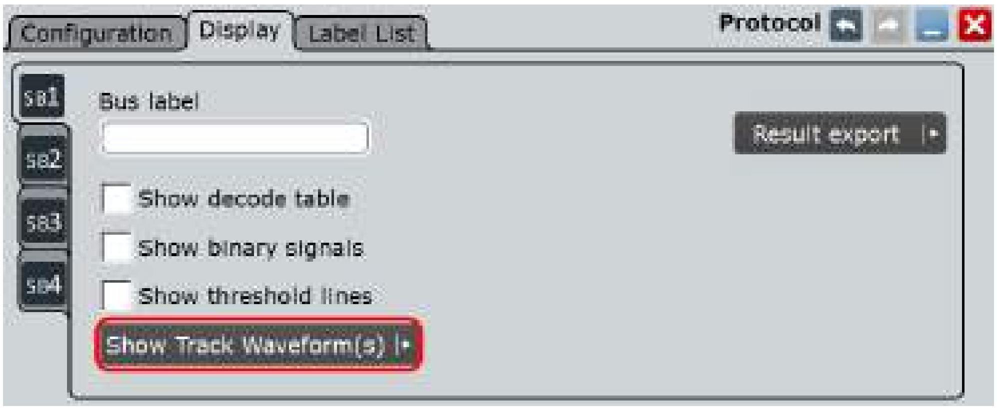
   Tip: Alternatively, you can enable the track in the "Measurements" dialog box, on the "LongTerm/Track" tab if the audio serial bus is selected as source of the measurement on the "Setup" tab.
5. If you want to change the track settings, tap "Track Setup".
6. By default, the track is displayed using "Continuous auto scale". If you want to change the scaling, proceed as follows:
   - a) Select the "LongTerm/Track" tab.
   - b) Disable "Continuous auto scale".

c) Adjust "Vertical scale" and "Vertical offset".

Track Settings in Protocol Setup

You can enable the track waveforms in the protocol display settings. As the track is based on measurement, you can use the "Measurement" dialog box alternatively, see "Track Enabling in Measurement Setup" on page 613.

Access: PROTOCOL > "Display tab"



To set the vertical scale of the track waveform, use the measurement scale settings on the "Measurements - Long Term/Track" tab, see "Meas scaling" on page 359.

Show Track Waveform(s)
Enables and displays the track(s) for the seleceted channels of the decoded bus for the current acquisition using unsigned data format and continuous auto scale.

See also: Chapter 12.8.5.1, "Track", on page 609.

Remote command:
`BUS<m>:I2S:TRACk:LEFT` on page 1679
`BUS<m>:I2S:TRACk:RIGHt` on page 1679
`BUS<m>:I2S:TRACk:TD1Ch` on page 1679
`BUS<m>:I2S:TRACk:TD2Ch` on page 1679
`BUS<m>:I2S:TRACk:TD3Ch` on page 1679
`BUS<m>:I2S:TRACk:TD4Ch` on page 1679
`BUS<m>:I2S:TRACk:TD5Ch` on page 1679

`BUS<m>:I2S:TRACk:TD6Ch` on page 1679

`BUS<m>:I2S:TRACk:TD7Ch` on page 1680

`BUS<m>:I2S:TRACk:TD8Ch` on page 1680

Track and Trend Settings in Measurement Setup

As track and trend are based on measurements, the main settings are available in the "Measurement" dialog box.

Access: "Meas" menu > "Setup" > "Protocol" subtab

Protocol type: Audio

Audio Variant: Left Justified

Audio channel: Right

Protocol type, Audio variant
Show the current protocol settings for information

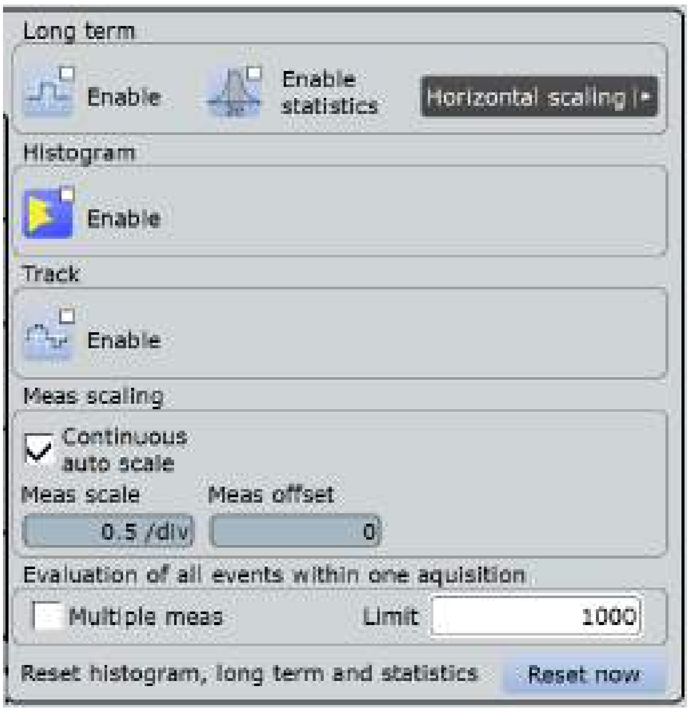
Audio channel
Selects the channel that is shown in the track and trend waveforms.

Show Result Box
Hides or shows the measurement result box. For track and trend, no numerical results are available in the result box, so you can hide it.

Track Enabling in Measurement Setup

As the track is based on measurement, it can be set up in the "Long Term/Track" tab of the "Measurement" dialog box. Alternatively, you can enable the track in the protocol display settings, see "Track Settings in Protocol Setup" on page 612.

Access: "Meas" menu > "LongTerm/Track"



To set the vertical scale of the track waveform, use the measurement scale settings on "LongTerm/Track" tab, see "Meas scaling" on page 359.

Enable (Track)
Enables the track measurement and displays the track of the selected waveform.

The track functionality requires at least one option:
- Option R&S RTO-K31 Power Analysis
  Enables the track for amplitude and time measurements.
- Option R&S RTO-K12 Basic Jitter Analysis
  Enables the track for amplitude and time measurements. You can use tracks to display the jitter measurement results as a time-correlated waveform, see Chapter 16.1.5, "Track of Jitter Measurement Results", on page 1045.
- Option R&S RTO-K5 I²S Audio Signals
  Enables the track for protocol measurements on decoded audio buses, see Chapter 12.8.5.1, "Track", on page 609.

Remote command:
`MEASurement<m>:TRACk[:STATe]` on page 1381

12.8.5.2 Trend

The trend is a special long term measurement that shows the evolution of measurement values in a running continuous acquisitions. For audio signals, each decoded channel value is a measurement result that creates a point on the trend curve. You can configure the number of points that builds the complete trend curve.

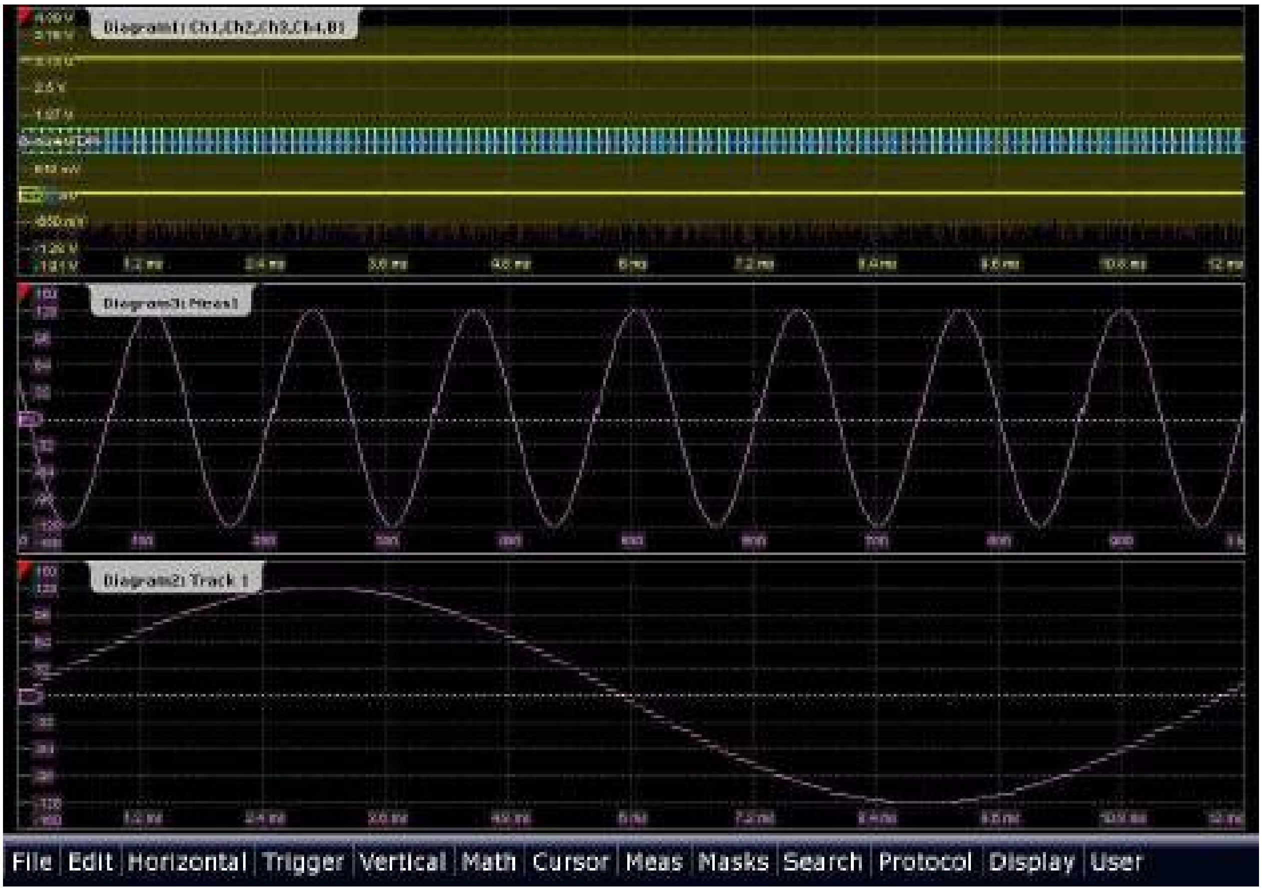


Figure 12-44: Trend (Diagram3) and track of an audio signal

Displaying and Configuring the Trend

If an audio bus is configured, the MEAS key and the "Measurement" icon can identify the bus and preconfigure the measurement. The following procedure describes the complete trend setup using the "Meas" menu.

1. On the "Meas" menu, select "Setup".
2. Select the "Source" of the measurement: "Serial bus".
3. Select the "Audio channel" for which you want to analyze the trend.
4. Enable "State".

Protocol type: Audio

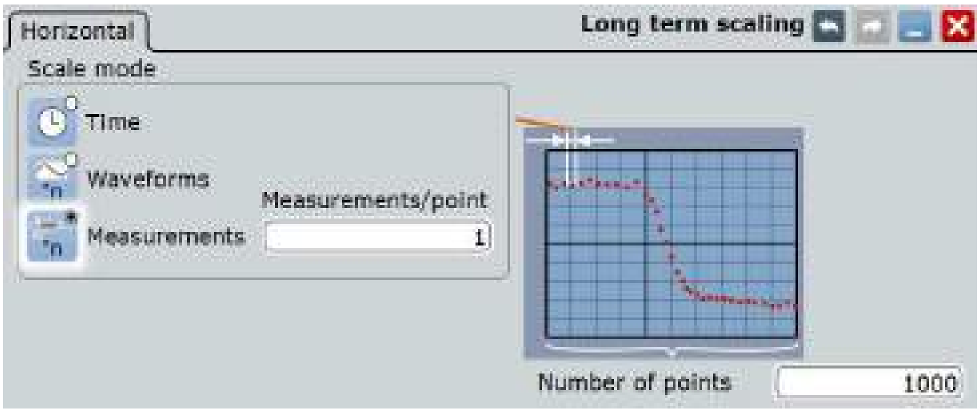
Protocol measurement

Audio Variant: Left justified

Audio channel: Right

Show Result Box

5. Select the "Long term/Track" tab.
6. Tap "Horizontal scaling".
7. Set the scale mode to "Measurements" and the number of "Measurements/point" to *1*.

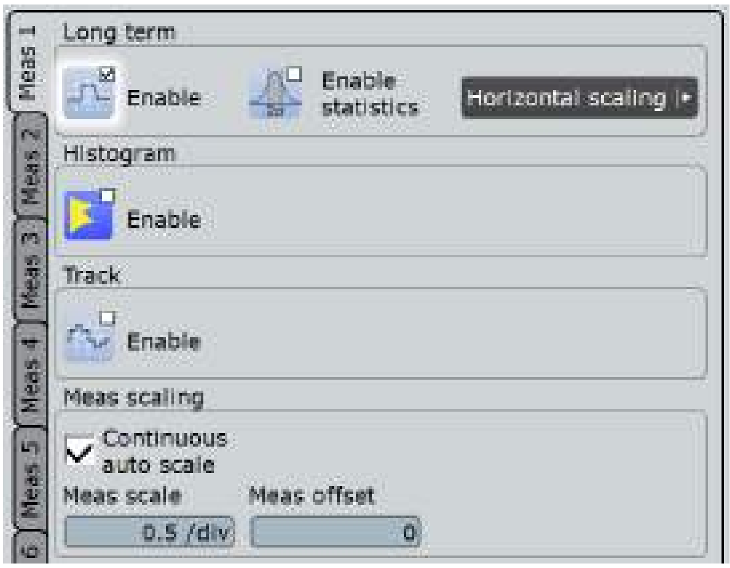


Scale mode: Measurements

Measurements/point: 1

Number of points: 1000

8. Tap "Long term/Track".
9. Set the "Vertical scaling" to "Continuous auto scale".
10. Under "Long term", select "Enable".



☑ Continuous auto scale

Meas scale: 0.5 /div

Meas offset: 0

An empty trend diagram is displayed.

11. Start continuous acquisition.

    The trend fills up with measurement points from left to right.

12. If you want to change the vertical scaling of the trend curve, disable "Continuous auto scale" and adjust "Vertical scale" and "Vertical offset".

12.9 MIL-1553 (Option R&S RTO-K6)

12.9.1 The MIL-STD-1553

The MIL-STD-1553 specification defines the characteristics of a serial data bus originally designed for use in the military avionics. Nowadays it is also used in spacecraft on-board data handling.

The bus is a 2-wire bus that uses differential signals.

A MIL-STD-1553 system consists of the following components:

- Bus Controller (BC): initiates and coordinates the data flow in the system.
- Remote Terminal (RT): interfaces various subsystems with the data bus. A system can consists of up to 31 RTs and each RT can have 31 subaddresses.
  The subaddresses 0 and 31 refer to a mode code command.
- Bus Monitor (BM) (optional): listens to all messages and can record selected data for real-time or off-line analysis.

The information is transmitted over the bus in defined series of words using Manchester code, where each bit is transmitted as high-low for a logical 1 or a low-high for a logical 0. There are three types of words: command, data and status.

Command Word

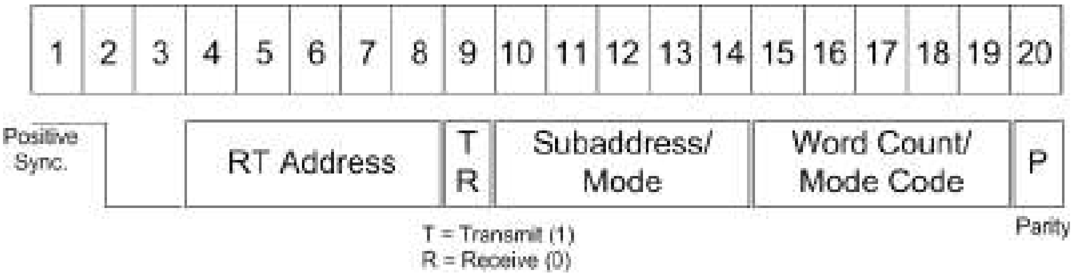


Figure 12-45: Structure of a command word

The format of a command word consists of the following parts (see Figure 12-45):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Transmit/Receive (T/R): indicates the action required from the RT.
- Subaddress/Mode Code: indicates the RT subaddress. The subaddresses 0 and 31 signalize the transmission of a mode code.
- Data Word Count /Mode Code: indicates the number of words that are sent/ received by the RT. A maximum of 32 words is allowed. This field may be used for the transmission of the mode code value.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Data Word

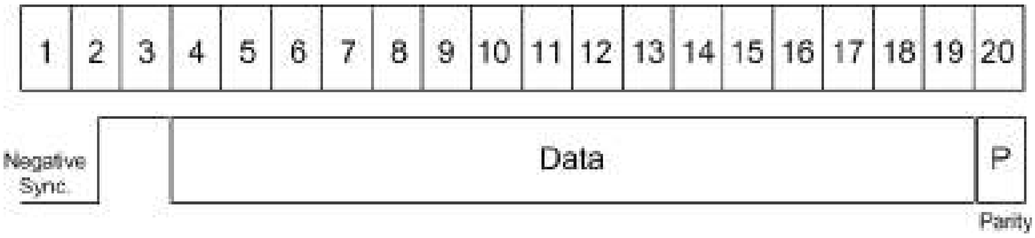


Figure 12-46: Structure of a data word

The format of a data word consists of the following parts (see Figure 12-46):

- Sync: an invalid Manchester waveform.
- Data: the transferred information (16 bit).
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Status Word

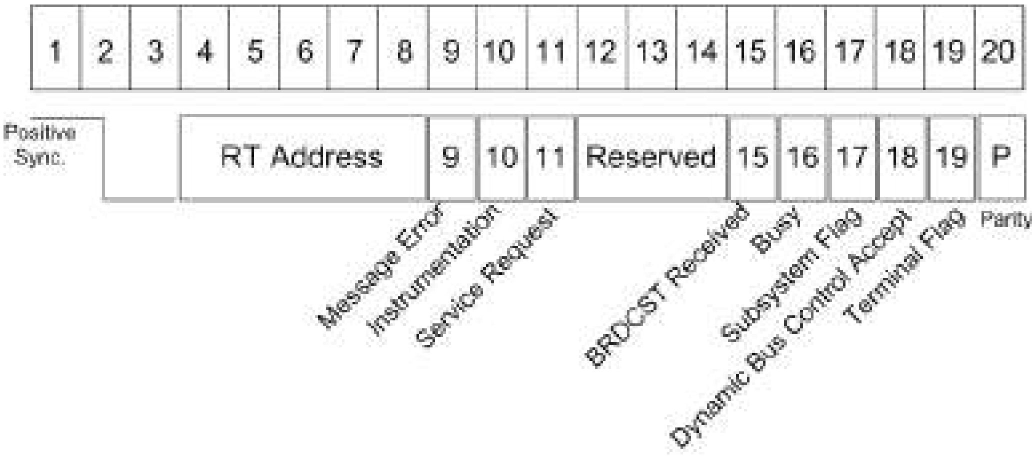


Figure 12-47: Structure of a status word

The format of a status word consists of the following parts (see Figure 12-47):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Message error: indicates an error in the command/data word transmission from the BC. A logic 1 indicates presence of a message error and a logic 0 indicates its absence.
- Instrumentation: helps to distinguish between a status word and a command word. The logic state of this bit shall be 0.
- Service Request: indicates that the RT requires service. A logic 1 indicates a presence of a service request and logic 0 indicates its absence.
- Reserved: bits reserved for future uses.
- Broadcast Command: a logic 1 indicates that the preceding valid command word was a broadcast command and a logic 0 that it wasn't.
- Busy: a busy state indicates that the RT or the subsystem is not able to transfer data. A logic 1 indicates a presence of a busy condition and logic 0 indicates its absence.
- Subsystem Flag: flags a subsystem fault. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Dynamic Bus Control Acceptance: a logic 1 indicates acceptance of a dynamic bus control and a logic 0 a rejection.
- Terminal Flag: flags an RT fault condition. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

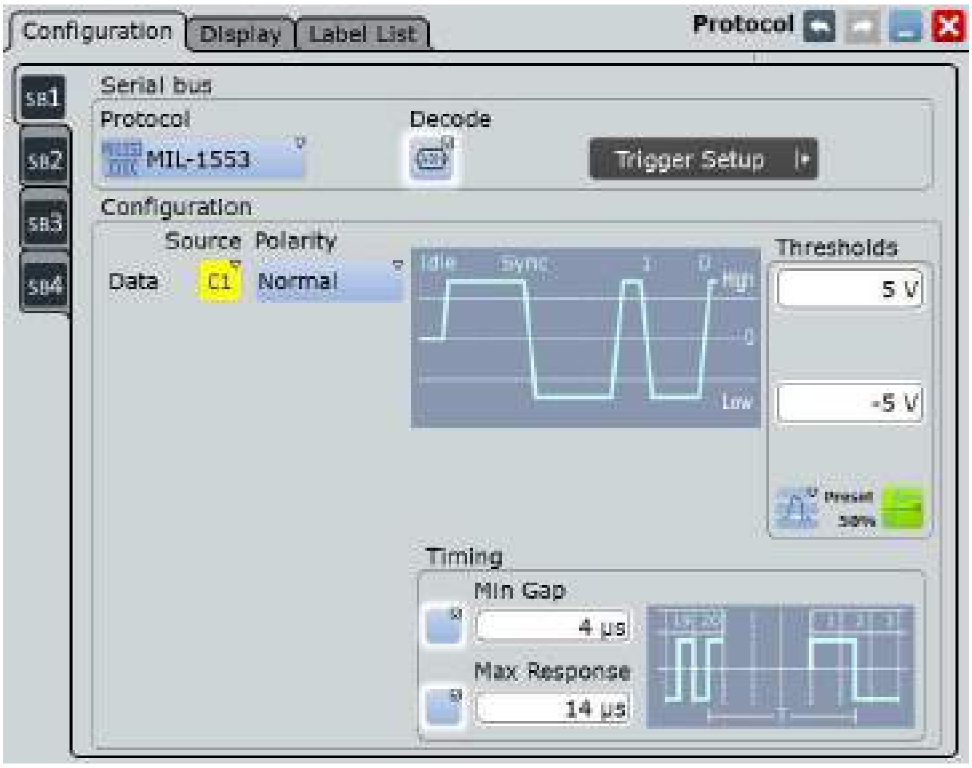
For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

12.9.2 MIL-STD-1553 Configuration

12.9.2.1 MIL-STD-1553 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *MIL-STD-1553*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: MIL-1553

Data: Source C1, Polarity Normal

Thresholds: 5 V, -5 V

Min Gap: 4 µs

Max Response: 14 µs

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data

Sets the source of the selected data line. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used.

For triggering on a serial bus, a channel signal is required.

Remote command:

`BUS<m>:MILStd:SOURce` on page 1681

Polarity

Selects the wire on which the bus signal is measured : "Normal" or "Inverted". The setting affects the digitization of the signal.

Remote command:

`BUS<m>:MILStd:POLarity` on page 1683

Thresholds
Threshold values are used for digitization of the signal.

Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the thresholds:

- "High" and "Low"
  Upper and lower threshold levels. You can enter the values directly in the fields.
- "Preset"
  Selects the default threshold voltage from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:MILStd:THReshold:HIGH` on page 1683
`BUS<m>:MILStd:THReshold:LOW` on page 1683
`BUS<m>:MILStd:PRESet` on page 1683

Min Gap
Selects and sets a value for the intermessage gap beween the last bit of a message and the following command word sync. The time is measured between the mid bit zero crossings. According to the standard, the minimum idle time is 4 µs.

The minimum gap time is relevant for protocol configuration and error trigger.

If "Min Gap" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shrter than specified.

Remote command:
`BUS<m>:MILStd:MINGap:BITS` on page 1682
`BUS<m>:MILStd:MINGap:SELect` on page 1682
`TRIGger<m>:MILStd:MINGap:BITS` on page 1692
`TRIGger<m>:MILStd:MINGap:SELect` on page 1692

Max Response
Selects and sets a value for the maximum response time between the last bit of a word and the following status word sync. The time is measured between the mid bit zero crossings. According to the standard, the RT shall respond to a valid command word within the time period of 4 to 12 µs.

The max response time is relevant for protocol configuration and error trigger.

If "Max response" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the response time is longer than specified.

Remote command:
`BUS<m>:MILStd:MAXResponse:BITS` on page 1681
`BUS<m>:MILStd:MAXResponse:SELect` on page 1682

`TRIGger<m>:MILStd:MAXResponse:BITS` on page 1692
`TRIGger<m>:MILStd:MAXResponse:SELect` on page 1692

12.9.2.2 Configuring MIL-STD-1553

For configuration assign the line to the input channel, set the threshold and the timing conditions.

For details on configuration settings, see Chapter 12.9.2.1, "MIL-STD-1553 Configuration Settings", on page 620.

To display the decoded signal, option R&S RTO-K6 is required.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "MIL-STD-1553".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Polarity" button, and select the waveform of the data line.
7. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
8. If required tap the "Min Gap" button to select it and set the minimum gap time.
9. If required tap the "Max Response" button to select it and set the maximum response time.

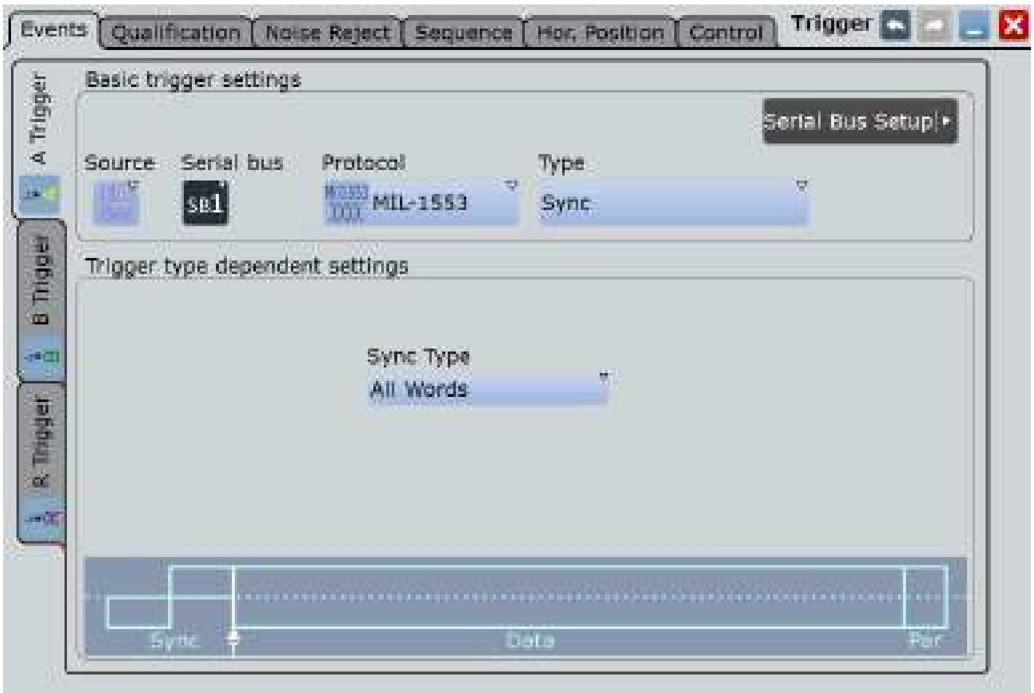
12.9.3 MIL-STD-1553 Trigger

12.9.3.1 Trigger Settings MIL-STD-1553

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = MIL-1553 "

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.



Source

Serial bus: SB1

Protocol: MIL-1553

Type: Sync

Sync Type: All Words

Trigger Type

Selects the trigger type for MIL-STD-1553 analysis.

"Sync"	Triggers on a sync impulse.
"Word"	Triggers on the selected word type.
"Data Word"	Triggers on a specified data word or data word range.
"Command/ Status Word"	Triggers on a specified command word or on a status word.
"Command Word"	Triggers on a specified command word.
"Status Word"	Triggers on a specified status word.
"Error Condition"	Triggers on any combination of protocol errors.

Remote command:

`TRIGger<m>:MILStd:TYPE` on page 1685

Sync Type / Word Type

Triggers on a sync impulse or word type. You can select to trigger on "Command/ Status", on "All" or on "Data" sync pulses / word types.

Remote command:

`TRIGger<m>:MILStd:TPSPecifier` on page 1694

Remote Terminal Address

The RTA setup consists of the condition and one or two RTA patterns.

Remote Terminal Address

RTA Min

[hex]00

RTA Max

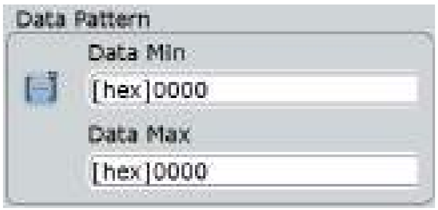
[hex]00

"Condition"	Defines the operator to set a specific RTA ("Equal" or "Not equal") or an RTA range.
"RTA Min/ RTA"	Defines the bit pattern of the RTA. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"RTA Max"	The second RTA pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MILStd:CDST:RCONdition` on page 1685
`TRIGger<m>:MILStd:CDST:RMAX` on page 1686
`TRIGger<m>:MILStd:CDST:RMIN` on page 1686
`TRIGger<m>:MILStd:CMD:RCONdition` on page 1685
`TRIGger<m>:MILStd:CMD:RMAX` on page 1686
`TRIGger<m>:MILStd:CMD:RMIN` on page 1686
`TRIGger<m>:MILStd:DATA:RCONdition` on page 1685
`TRIGger<m>:MILStd:DATA:RMAX` on page 1686
`TRIGger<m>:MILStd:DATA:RMIN` on page 1686

Data Pattern

The data pattern setup consists of the condition and one or two data patterns.



Data Pattern

Data Min

[hex]0000

Data Max

[hex]0000

"Condition"	Defines the operator to set a specific data pattern ("Equal" or "Not equal") or a data patter range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MILStd:DATA:DCONdition` on page 1689
`TRIGger<m>:MILStd:DATA:DMAX` on page 1690
`TRIGger<m>:MILStd:DATA:DMIN` on page 1690

Data Index

The MIL-MIL-STD-1553 standard defines the length of a message to a series of up to 32 words. Data index sets the range within this series of the data words that is considered for the analysis. The data index setup consists of the condition and one or two data index values.

Index Min: 1

Index Max: 32

"Condition"	Defines the operator to set a specific data ("Equal") or a data range.
"Index Min/Index"	Defines the minimum index.
"Index Max"	The second data pattern is required to specify a range with conditions "In range".

Remote command:
`TRIGger<m>:MILStd:DATA:ICONdition` on page 1690
`TRIGger<m>:MILStd:DATA:IMAX` on page 1691
`TRIGger<m>:MILStd:DATA:IMIN` on page 1691

11-Bit Information

The 11-Bit information sets bits 9 to 19 in case of a command or status word. The 11-Bit information consists of the condition and one or two 11-Bit information patterns.

Info Min: [hex]000

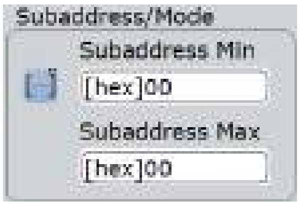
Info Max: [hex]000

"Condition"	Defines the operator to set a specific info ("Equal" or "Not equal") or an info range.
"Info Min/Info"	Defines the bit pattern of the 11-Bit information. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Info Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MILStd:CDST:ICONdition` on page 1689
`TRIGger<m>:MILStd:CDST:IMAX` on page 1689
`TRIGger<m>:MILStd:CDST:IMIN` on page 1689

Subaddress/ Mode

The subaddress/mode setup consists of the condition and one or two subaddress/ mode patterns.



Subaddress Min: [hex]00

Subaddress Max: [hex]00

"Condition"	Defines the operator to set a specific subaddress/mode ("Equal" or "Not equal") or a subaddress range.
"Subaddress Min / Subaddress/Mode"	Defines the bit pattern of the subaddress/mode. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Subaddress Max"	The second subaddress/mode pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

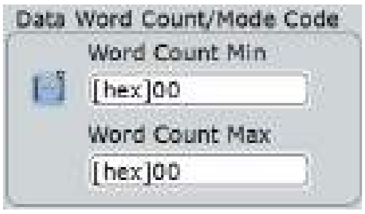
`TRIGger<m>:MILStd:CMD:SCONdition` on page 1687

`TRIGger<m>:MILStd:CMD:SMAX` on page 1688

`TRIGger<m>:MILStd:CMD:SMIN` on page 1688

Data Word Count/Mode Code

The data word count/ mode code setup consists of the condition and one or two patterns.



Word Count Min: [hex]00

Word Count Max: [hex]00

"Condition"	Defines the operator to set a specific data word count/ mode code ("Equal" or "Not equal") or a range.
"Word Count Min/ Count Code"	Defines the bit pattern of the data. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Word Count Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

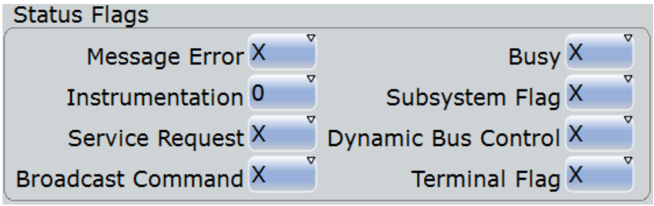
Remote command:
`TRIGger<m>:MILStd:CMD:CCONdition` on page 1686
`TRIGger<m>:MILStd:CMD:CMAX` on page 1687
`TRIGger<m>:MILStd:CMD:CMIN` on page 1687

T/R (Transmit/receive)
Toggles the data direction of the selected command: 1 (transmit), 0 (receive), or X (either).

Remote command:
`TRIGger<m>:MILStd:CMD:TR` on page 1688

Status Flags
Specifies the values of the status flags. You can use the following characters: 1; 0; or X (don't care).

For details, see "Status Word" on page 619.



Status Flags
Message Error X
Instrumentation 0
Service Request X
Broadcast Command X
Busy X
Subsystem Flag X
Dynamic Bus Control X
Terminal Flag X

Remote command:
`TRIGger<m>:MILStd:STATus:BCReceived` on page 1693
`TRIGger<m>:MILStd:STATus:BUSY` on page 1693
`TRIGger<m>:MILStd:STATus:DBCaccept` on page 1693
`TRIGger<m>:MILStd:STATus:INSTrument` on page 1693
`TRIGger<m>:MILStd:STATus:MERRor` on page 1693
`TRIGger<m>:MILStd:STATus:SREQuest` on page 1694
`TRIGger<m>:MILStd:STATus:SUBSystem` on page 1694
`TRIGger<m>:MILStd:STATus:TERMinal` on page 1694

Error Condition
Specify the error conditions to be triggered on.

☑ Synchronization Error
☑ Manchester Coding Error
☑ Parity Error
Timing
Min Gap 4 µs
Max Response 14 µs

Synchronization Error ← Error Condition
Triggers if a sync impulse doesn't fulfill the technical requirements or when the transmission is not valid.

Remote command:
`TRIGger<m>:MILStd:ERRor:SYNC` on page 1692

Manchester Coding Error ← Error Condition
Triggers if there is an error in the Manchester coding of the signal.

Remote command:
`TRIGger<m>:MILStd:ERRor:MANChester` on page 1691

Parity Error ← Error Condition
Checks the parity of every word and triggers if the parity is even.

Remote command:
`TRIGger<m>:MILStd:ERRor:PARity` on page 1691

Min Gap ← Error Condition
Selects and sets a value for the intermessage gap beween the last bit of a message and the following command word sync. The time is measured between the mid bit zero crossings. According to the standard, the minimum idle time is 4 µs.

The minimum gap time is relevant for protocol configuration and error trigger.

If "Min Gap" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shrter than specified.

Remote command:
`BUS<m>:MILStd:MINGap:BITS` on page 1682
`BUS<m>:MILStd:MINGap:SELect` on page 1682
`TRIGger<m>:MILStd:MINGap:BITS` on page 1692
`TRIGger<m>:MILStd:MINGap:SELect` on page 1692

Max Response ← Error Condition
Selects and sets a value for the maximum response time between the last bit of a word and the following status word sync. The time is measured between the mid bit zero crossings. According to the standard, the RT shall respond to a valid command word within the time period of 4 to 12 µs.

The max response time is relevant for protocol configuration and error trigger.

If "Max response" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the response time is longer than specified.

Remote command:
`BUS<m>:MILStd:MAXResponse:BITS` on page 1681
`BUS<m>:MILStd:MAXResponse:SELect` on page 1682
`TRIGger<m>:MILStd:MAXResponse:BITS` on page 1692
`TRIGger<m>:MILStd:MAXResponse:SELect` on page 1692

12.9.3.2 Triggering on MIL-STD-1553

Prerequisites: A bus is configured for the MIL-STD-1553 signal to be analyzed.

1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to MIL-STD-1553.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions.
   For details, see Chapter 12.9.3.1, "Trigger Settings MIL-STD-1553", on page 622.

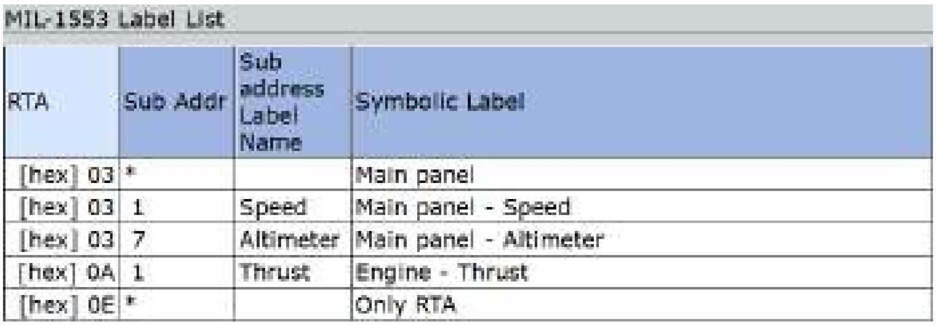
12.9.4 MIL-STD-1553 Label List

Label lists are protocol-specific. A MIL-STD-1553 label file contains four values for each identifier:

- "RTA": hexadecimal remote terminal address value
- "Sub Addr": hexadecimal sub address value
- "Sub Address Label Name": the label name corresponding to the value of the subaddress.
- "Symbolic label": symbolic name of addressed device, specifying the device function, and the label of the sub address.

Example: MIL PTT file

```
# ------------------------------------------------------------
# Labels for MIL.1553 protocol
# Column order: RT address, RT label, Subaddress, Subaddress Label
# ----------------------------------------------------------------------
@PROTOCOL_NAME = mil1553
0Ah,Engine,01x,Thrust
03h,Main panel,07x,Altimeter
03h,Main panel,01x,Speed
0Eh,Only RTA
```



MIL-1553 Label List

RTA	Sub Addr	Sub address Label Name	Symbolic Label
[hex] 03	*		Main panel
[hex] 03	1	Speed	Main panel - Speed
[hex] 03	7	Altimeter	Main panel - Altimeter
[hex] 0A	1	Thrust	Engine - Thrust
[hex] 0E	*		Only RTA

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:MILStd:WORD<n>:SYMBol?` on page 1697

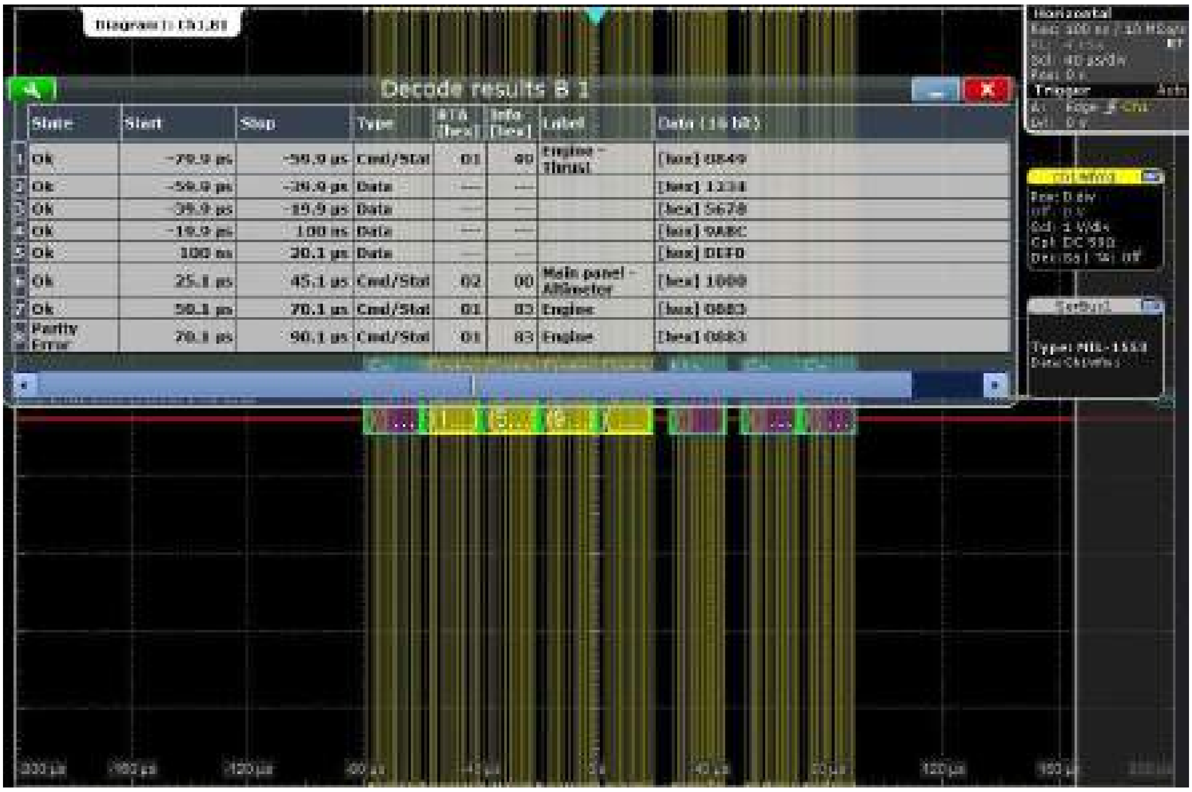
12.9.5 MIL-STD-1553 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.



	State	Start	Stop	Type	RTA [hex]	Info [hex]	Label	Data (16 bit)
1	Ok	-79.9 µs	-59.9 µs	Cmd/Stat	01	00	Engine - Thrust	[hex] 0849
2	Ok	-59.9 µs	-39.9 µs	Data	---	---		[hex] 1234
3	Ok	-39.9 µs	-19.9 µs	Data	---	---		[hex] 5678
4	Ok	-19.9 µs	100 ns	Data	---	---		[hex] 9ABC
5	Ok	100 ns	20.1 µs	Data	---	---		[hex] DEF0
6	Ok	25.1 µs	45.1 µs	Cmd/Stat	02	00	Main panel - Altimeter	[hex] 1000
7	Ok	50.1 µs	70.1 µs	Cmd/Stat	01	03	Engine	[hex] 0883
8	Parity Error	70.1 µs	90.1 µs	Cmd/Stat	01	03	Engine	[hex] 0883

Figure 12-48: Decoded MIL-1553 signal with applied lebel list and results table. The last frame contains an error.

Table 12-11: Content of the decode result table

Column	Description
State	Overall state of the word
Start	Time of word start in relation to the trigger point
Stop	Time of word stop in relation to the trigger point
Type	Word type
RTA	Remote terminal address

Column	Description
Info	The hexadecimal value of the 9th to 1th bit of a command/status word
Label	Symbolic label name defined in the label list
Data	The values of the data bytes

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.10.3, "Decode Results", on page 1694.

12.9.6 Search on Decoded MIL Data

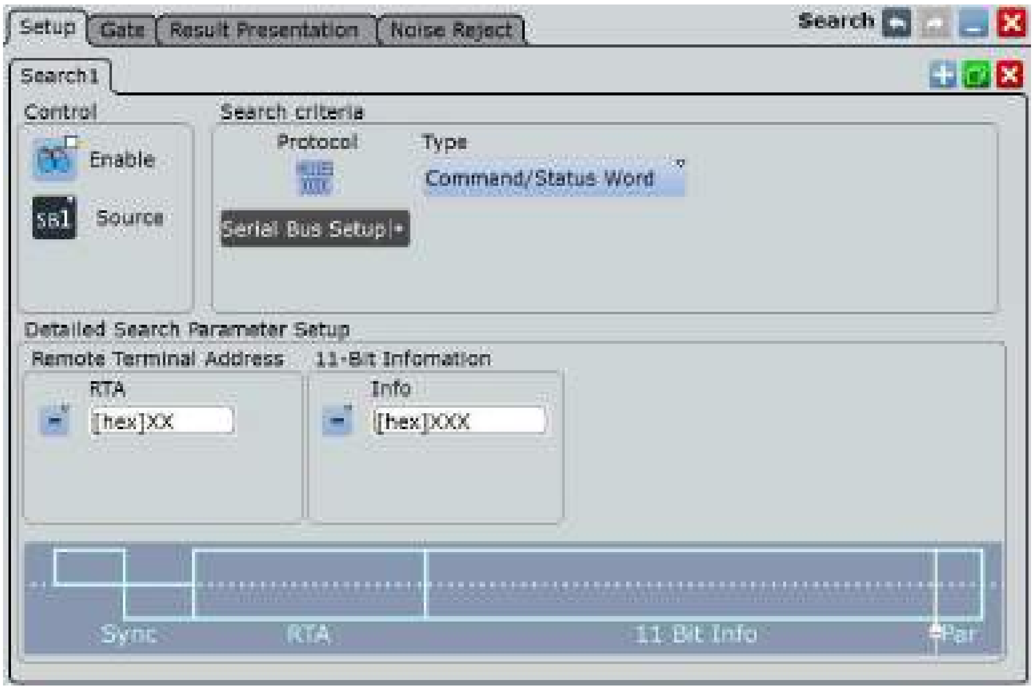
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.9.6.1 MIL Search Setup

Access: SEARCH > "Setup" tab



Type: Command/Status Word

RTA: [hex]XX

Info: [hex]XXX

Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".

Type: Sync

"Sync"	Searches for a sync impulse.
"Word"	Searches for the selected word type.
"Data Word"	Searches for the specified data word. Additonal search parameters: remote terminal address, data pattern and data index.
"Command / Status Word"	Searches for command or status words.Additonal search parameters: remote terminal address, and 11-bit information.
"Command Word"	Searches for a command word. Additonal search parameters: remote terminal address, subaddress / mode, and data word count / mode code.
"Status Word"	Searches for a status word.Additonal search parameters: remote terminal address, and status flags.
"Error condition"	Identifies various errors in the frame, see "Error Condition" on page 627.

Remote command:
`SEARch:TRIGger:MILStd:TYPE` on page 1699

Sync Type / Word Type
Searches for a sync impulse/ word type. You can search for "Command/Status", "All" or "Data" sync pulses/ word types.

Remote command:
`SEARch:TRIGger:MILStd:TPSPecifier` on page 1704

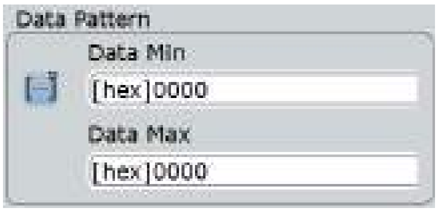
Remote terminal address setup: Condition, RTA
The remote terminal address setup consists of the condition and one or two RTA patterns.

The RTA setup settings are the same as in the MIL trigger setup, see "Remote Terminal Address" on page 623.

Remote command:
`SEARch:TRIGger:MILStd:CDST:RCONdition` on page 1699
`SEARch:TRIGger:MILStd:CMD:RCONdition` on page 1699
`SEARch:TRIGger:MILStd:DATA:RCONdition` on page 1699
`SEARch:TRIGger:MILStd:CDST:RMIN` on page 1700
`SEARch:TRIGger:MILStd:CMD:RMIN` on page 1700
`SEARch:TRIGger:MILStd:DATA:RMIN` on page 1700
`SEARch:TRIGger:MILStd:CDST:RMAX` on page 1700
`SEARch:TRIGger:MILStd:CMD:RMAX` on page 1700
`SEARch:TRIGger:MILStd:DATA:RMAX` on page 1700

Data pattern setup: Condition, Data min, Data max
The data pattern setup consists of the condition and one or two data patterns.

The data pattern setup settings are the same as in the MIL trigger setup, see "Data Pattern" on page 624.



Remote command:

`SEARch:TRIGger:MILStd:DATA:DCONdition` on page 1701

`SEARch:TRIGger:MILStd:DATA:DMIN` on page 1701

`SEARch:TRIGger:MILStd:DATA:DMAX` on page 1702

Data index setup: Condition, Index min, Index max

The data index setup consists of the condition and one or two index patterns.

The data index setup settings are the same as in the MIL trigger setup, see "Data Index" on page 625.

Remote command:

`SEARch:TRIGger:MILStd:DATA:ICONdition` on page 1702

`SEARch:TRIGger:MILStd:DATA:IMIN` on page 1702

`SEARch:TRIGger:MILStd:DATA:IMAX` on page 1702

11-Bit information setup: Condition, Info min, Info max

The 11-bit information setup consists of the condition and one or two 11-bit information patterns.

The 11-bit information setup settings are the same as in the MIL trigger setup, see "11-Bit Information" on page 625.

Remote command:

`SEARch:TRIGger:MILStd:CDST:ICONdition` on page 1701

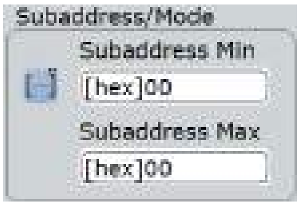
`SEARch:TRIGger:MILStd:CDST:IMIN` on page 1701

`SEARch:TRIGger:MILStd:CDST:IMAX` on page 1701

Subaddress / Mode setup: Condition, Subaddress min, Subaddress max

The subaddress/mode setup consists of the condition and one or two subaddress/ mode patterns.

The subaddress/mode setup settings are the same as in the MIL trigger setup, see "Subaddress/ Mode" on page 626.



Subaddress/Mode

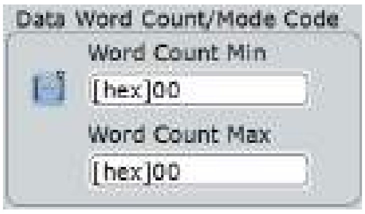
Subaddress Min: [hex]00

Subaddress Max: [hex]00

Remote command:
`SEARch:TRIGger:MILStd:CMD:SCONdition` on page 1701
`SEARch:TRIGger:MILStd:CMD:SMIN` on page 1701
`SEARch:TRIGger:MILStd:CMD:SMAX` on page 1702

Data word count / Mode code setup: Condition, Word count min, Word count max
The data word count/mode code setup consists of the condition and one or two patterns.

The subaddress/mode setup settings are the same as in the MIL trigger setup, see "Data Word Count/Mode Code" on page 626.



Data Word Count/Mode Code

Word Count Min: [hex]00

Word Count Max: [hex]00

Remote command:
`SEARch:TRIGger:MILStd:CMD:CCONdition` on page 1701
`SEARch:TRIGger:MILStd:CMD:CMIN` on page 1701
`SEARch:TRIGger:MILStd:CMD:CMAX` on page 1701

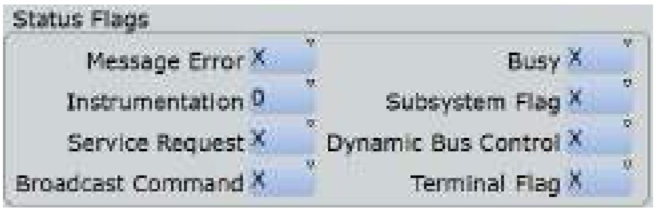
T/R (Transmit/receive)
Specifies the data direction of the selected command.

For details, see "T/R (Transmit/receive)" on page 627.

Remote command:
`SEARch:TRIGger:MILStd:CMD:TR` on page 1703

Status flags setup
Specifies the values (X, 0, 1) of the status flags.

The status flags setup settings are the same as in the MIL trigger setup, see "Status Flags" on page 627.



Status Flags

Message Error X
Instrumentation 0
Service Request X
Broadcast Command X
Busy X
Subsystem Flag X
Dynamic Bus Control X
Terminal Flag X

Remote command:
`SEARch:TRIGger:MILStd:STATus:BCReceived` on page 1703
`SEARch:TRIGger:MILStd:STATus:BUSY` on page 1703
`SEARch:TRIGger:MILStd:STATus:DBCaccept` on page 1704
`SEARch:TRIGger:MILStd:STATus:INSTrument` on page 1704
`SEARch:TRIGger:MILStd:STATus:MERRor` on page 1704
`SEARch:TRIGger:MILStd:STATus:SREQuest` on page 1704
`SEARch:TRIGger:MILStd:STATus:SUBSystem` on page 1704
`SEARch:TRIGger:MILStd:STATus:TERMinal` on page 1704

Error Condition
Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the MIL trigger setup, see "Error Condition" on page 627

Detailed Search Parameter Setup

☑ Synchronization Error
☑ Timing Error
☑ Manchester Coding Error
☑ Parity Error

Remote command:
`SEARch:TRIGger:MILStd:ERRor:MANChester` on page 1703
`SEARch:TRIGger:MILStd:ERRor:PARity` on page 1703
`SEARch:TRIGger:MILStd:ERRor:SYNC` on page 1703
`SEARch:TRIGger:MILStd:ERRor:TIMing` on page 1703

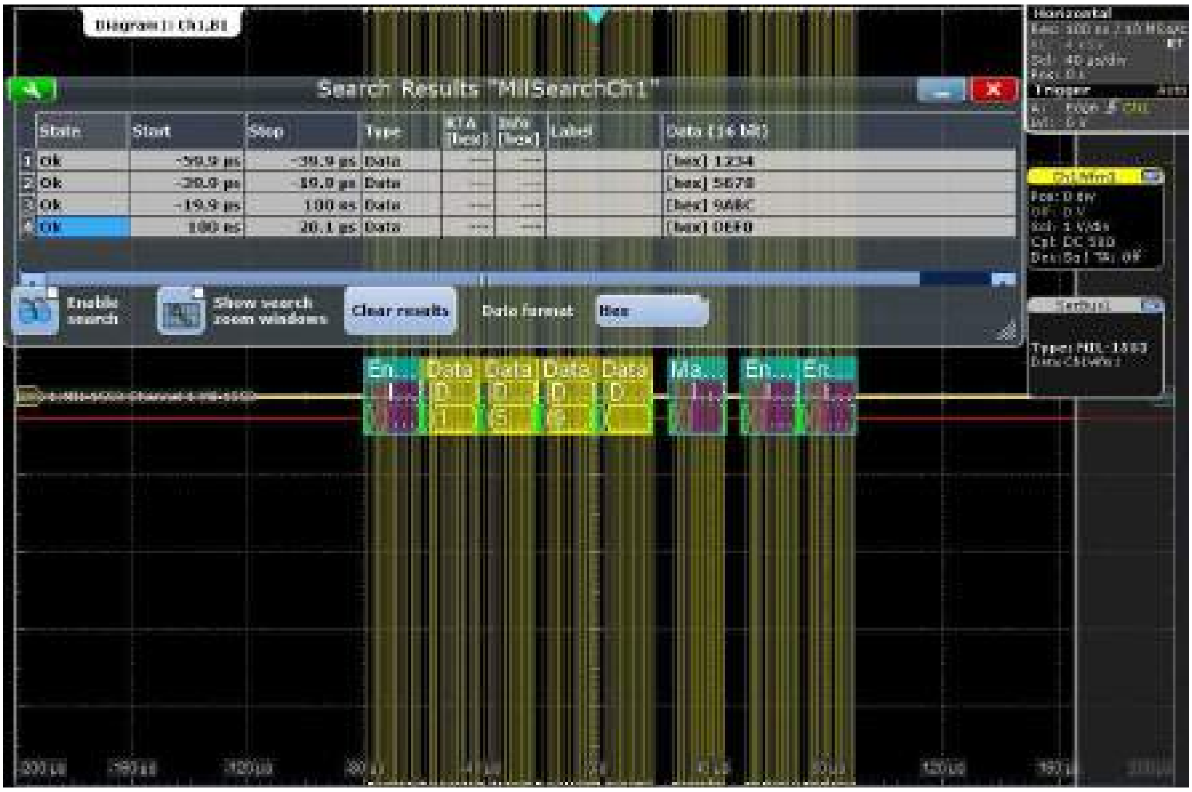
12.9.6.2 MIL Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437



	State	Start	Stop	Type	RTA [hex]	Info [hex]	Label	Data (16 bit)
1	Ok	-59.9 µs	-39.9 µs	Data	---	---		[hex] 1234
2	Ok	-39.9 µs	-19.9 µs	Data	---	---		[hex] 5678
3	Ok	-19.9 µs	100 ns	Data	---	---		[hex] 9ABC
4	Ok	100 ns	20.1 µs	Data	---	---		[hex] DEF0

Figure 12-49: Results of a search for all data words (any RTA and any data pattern)

Remote commands:

- `SEARch:RESult:MILStd:WCOunt` on page 1705
- `SEARch:RESult:MILStd:WORD<m>:INFO?` on page 1707
- `SEARch:RESult:MILStd:WORD<m>:RTADdress?` on page 1706
- `SEARch:RESult:MILStd:WORD<m>:STARt?` on page 1705
- `SEARch:RESult:MILStd:WORD<m>:STATus?` on page 1705
- `SEARch:RESult:MILStd:WORD<m>:STOP?` on page 1706
- `SEARch:RESult:MILStd:WORD<m>:SYMBol?` on page 1706
- `SEARch:RESult:MILStd:WORD<m>:TYPE?` on page 1705

12.10 ARINC 429 (Option R&S RTO-K7)

12.10.1 ARINC 429 Basics

The ARINC 429 is a specification that defines the characteristics of an avionic data bus used on commercial and transport aircraft.

In an ARINC 429 system, a single transmitter/source is connected to 1-20 receivers/sinks on one twisted wire pair. The bus uses differential signals. The ARINC 429 standard uses a simplex communication - data may be transmitted in only one direction. The information is transmitted over the bus in defined series of words.

Word Format

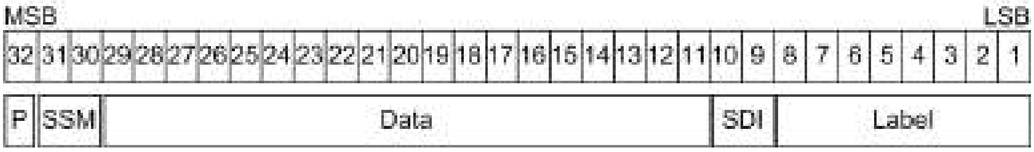


Figure 12-50: Structure of an ARINC 429 word

An ARINC 429 word is 32-bits and consists of the following parts (see Figure 12-50):

- Parity: the most significant bit (MSB). Checks if there are bit errors during the transmission. The total number of logic 1 bits for the word shall be odd.
- Sign/Status Matrix (SSM): the value of these bits depend on the data type. It may be used to report the status of hardware equipment.
- Data:
  - Binary (BNR): stores the data as a binary number.
  - Binary Coded Decimal (BCD): uses 4 data field bits to represent a decimal digit.
  - Discrete data: a combination of BNR and/ or BCD or individual bits that express specific equipment conditions.
  - Maintenance data and acknowledgment
  - Williamsburg / Buckhorn protocol: a bit-oriented protocol that is used for file transfer.
- Source/Destination Identifier (SDI): indicates the intended receiver or the transmitting subsystem.
- Label: gives information about the word's data type.

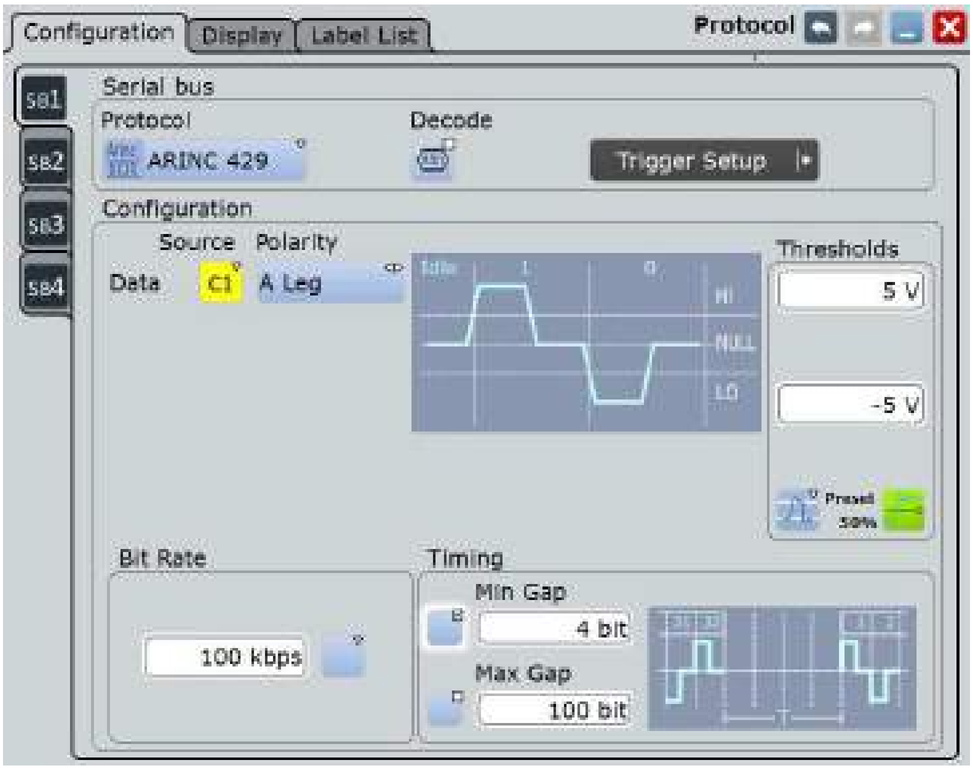
For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

12.10.2 ARINC 429 Configuration

12.10.2.1 ARINC 429 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *ARINC 429*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data
Sets the source of the selected data line. Usually, the source is one of the analog channels. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

For triggering on a serial bus, a channel signal is required.

Remote command:
`BUS<m>:ARINc:SOURce` on page 1708

Polarity
Selects the wire on which the bus signal is measured : "A Leg" or "B Leg". The setting affects the digitization of the signal.

Remote command:
`BUS<m>:ARINc:POLarity` on page 1709

Thresholds
Sets the threshold value for digitization of the data signal. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the thresholds:

- "High" and "Low"
  Upper and lower threshold levels. You can enter the values directly in the fields.
- "Preset"
  Selects the default threshold voltage from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.
- "Set to 50%"
  Sets the thresholds to the middle reference level of the measured amplitudes.

Remote command:
`BUS<m>:ARINc:THReshold:HIGH` on page 1710
`BUS<m>:ARINc:THReshold:LOW` on page 1710
`BUS<m>:ARINc:PRESet` on page 1710

Bit Rate
Selects the number of transmitted bits per second. The value can be set to high speed (100 kbps) or low speed (12.0- 14.5 kbps).

Remote command:
`BUS<m>:ARINc:BRValue` on page 1708
`BUS<m>:ARINc:BRMode` on page 1708

Timing: Min gap, Max gap
Defines the idle time between two words, which is needed for word synchronization. The beginning of the first bit after the gap marks the start of a new word.

You can define a minimum idle time "Min gap", and/or a maximum time "Max gap". The standard defines a minimum of 4 bit times to separate two subsequent words.

Timing settings are relevant for protocol configuration and error trigger.

If "Min gap" and/or "Max gap" are enabled, the instrument detects the specified gaps during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shorter or longer than the specified gaps, respectively.

Remote command:
`BUS<m>:ARINc:MAXGap:BITS` on page 1709
`BUS<m>:ARINc:MAXGap:SELect` on page 1708
`BUS<m>:ARINc:MINGap:BITS` on page 1709
`BUS<m>:ARINc:MINGap:SELect` on page 1709
`TRIGger<m>:ARINc:MINGap:BITS` on page 1713
`TRIGger<m>:ARINc:MINGap:SELect` on page 1713
`TRIGger<m>:ARINc:MAXGap:BITS` on page 1713
`TRIGger<m>:ARINc:MAXGap:SELect` on page 1713

12.10.2.2 Configuring ARINC 429 Signals

For configuration assign the line to the input channel, set the threshold and the timing conditions.

For details on configuration settings, see Chapter 12.10.2.1, "ARINC 429 Configuration Settings", on page 639.

To display the decoded signal, option R&S RTO-K7 is required.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "ARINC 429".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Polarity" button, and select the waveform of the data line.
7. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
8. Tap the "Bit Rate" button and set it for high or low speed.
9. If required tap the "Min Gap" button to select it and set the minimum gap time.
10. If required tap the "Max Response" button to select it and set the maximum response time.

12.10.3 ARINC 429 Trigger

12.10.3.1 Triggering on ARINC 429

Prerequisites: A bus is configured for the ARINC 429 signal to be analyzed.

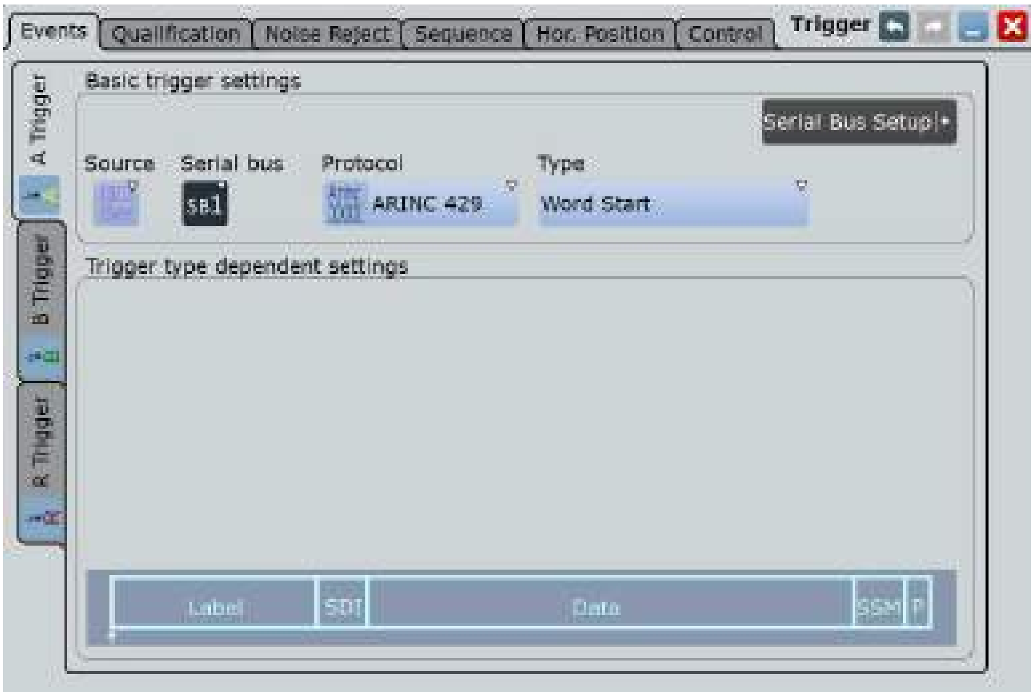
1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to ARINC 429.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions.
   For details, see Chapter 12.10.3.2, "ARINC 429 Trigger Settings", on page 642.

12.10.3.2 ARINC 429 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = ARINC 429"

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.



Source

Serial bus: SB1

Protocol: ARINC 429

Type: Word Start

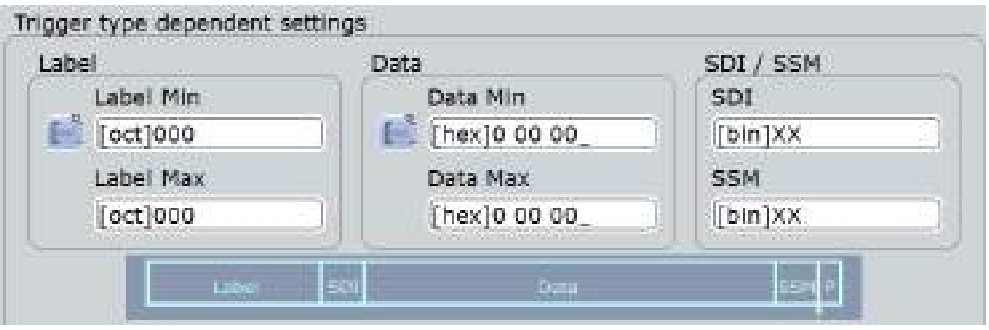
Trigger Type

Selects the trigger type for ARINC 429 analysis.

"Word Start"	Sets the trigger to the start of the word.
"Word Stop"	Sets the trigger to the stop of the word.
"Label + Data"	Sets the trigger on a defined word format. You can define the label, the data and the SDI / SSM bits separately, see "Label + Data" on page 643.
"Error Condition"	Identifies various errors in the word, see "Error Conditions" on page 644.

Remote command:
`TRIGger<m>:ARINc:TYPE` on page 1711

Label + Data



Label Min: [oct]000
Label Max: [oct]000
Data Min: [hex]0 00 00_
Data Max: [hex]0 00 00_
SDI: [bin]XX
SSM: [bin]XX

Label setup: Condition, Label Min, Label Max ← Label + Data
The label setup consists of the condition and one or two label patterns.

"Condition"	Defines the operator to set a specific label ("Equal" or "Not equal") or a label range.
"Label Min"	Defines the bit pattern of the label. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Label Max"	The second label pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:ARINc:LABel:CONDition` on page 1712
`TRIGger<m>:ARINc:LABel:MIN` on page 1712
`TRIGger<m>:ARINc:LABel:MAX` on page 1713

Data setup: Condition, Data Min, Data Max ← Label + Data
The data setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data ("Equal" or "Not equal") or a data range.
"Data Min"	Defines the bit pattern of the data. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:ARINc:DATA:CONDition` on page 1711
`TRIGger<m>:ARINc:DATA:MIN` on page 1711
`TRIGger<m>:ARINc:DATA:MAX` on page 1712

SDI / SSM ← Label + Data
Sets the values for the source/destination identifier (SDI) and the sign/status matrix (SSM) bits.

Remote command:
`TRIGger<m>:ARINc:SDI` on page 1714
`TRIGger<m>:ARINc:SSM` on page 1714

Error Conditions
Specifies the error conditions to be triggered on.

Coding error ← Error Conditions
Triggers on a coding error.

Remote command:
`TRIGger<m>:ARINc:ERRor:CODing` on page 1712

Parity Error ← Error Conditions
Checks the parity and triggers if the parity is even.

Remote command:
`TRIGger<m>:ARINc:ERRor:PARity` on page 1712

Timing: Min gap, Max gap ← Error Conditions
Defines the idle time between two words, which is needed for word synchronization. The beginning of the first bit after the gap marks the start of a new word.

You can define a minimum idle time "Min gap", and/or a maximum time "Max gap". The standard defines a minimum of 4 bit times to separate two subsequent words.

Timing settings are relevant for protocol configuration and error trigger.

If "Min gap" and/or "Max gap" are enabled, the instrument detects the specified gaps during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shorter or longer than the specified gaps, respectively.

Remote command:
`BUS<m>:ARINc:MAXGap:BITS` on page 1709
`BUS<m>:ARINc:MAXGap:SELect` on page 1708
`BUS<m>:ARINc:MINGap:BITS` on page 1709
`BUS<m>:ARINc:MINGap:SELect` on page 1709
`TRIGger<m>:ARINc:MINGap:BITS` on page 1713
`TRIGger<m>:ARINc:MINGap:SELect` on page 1713
`TRIGger<m>:ARINc:MAXGap:BITS` on page 1713
`TRIGger<m>:ARINc:MAXGap:SELect` on page 1713

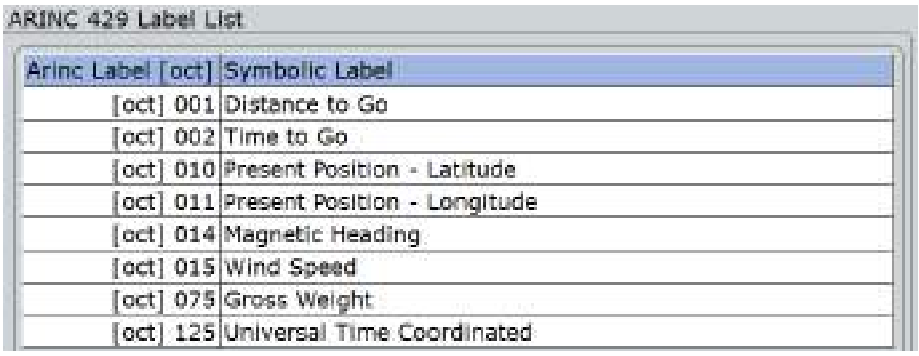
12.10.4 ARINC 429 Label List

Label lists are protocol-specific. An ARINC 429 label file contains two values for each identifier:

- "Arinc Label": the Arinc 429 label value, that identifies the data type and the parameters associated with it. The usual data format is octal.
- "Symbolic label": symbolic name of the label, specifying its function.

Example: ARINC 429 PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = arinc429
# ----------------------------------------------------------------------------
# Labels for ARINC 429 protocol
#   Column order: Arinc Label, Symbolic Label
# ----------------------------------------------------------------------------
# ----Definition----
001o, Distance to Go
002o, Time to Go
010o, Present Position - Latitude
011o, Present Position - Longitude
014o, Magnetic Heading
015o, Wind Speed
075o, Gross Weight
125o, Universal Time Coordinated
# ----------------------------------------------------------------------------
```


ARINC 429 Label List

Arinc Label [oct]	Symbolic Label
[oct] 001	Distance to Go
[oct] 002	Time to Go
[oct] 010	Present Position - Latitude
[oct] 011	Present Position - Longitude
[oct] 014	Magnetic Heading
[oct] 015	Wind Speed
[oct] 075	Gross Weight
[oct] 125	Universal Time Coordinated

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:ARINc:WORD<n>:SYMBol?` on page 1717

12.10.5 ARINC 429 Decode Results

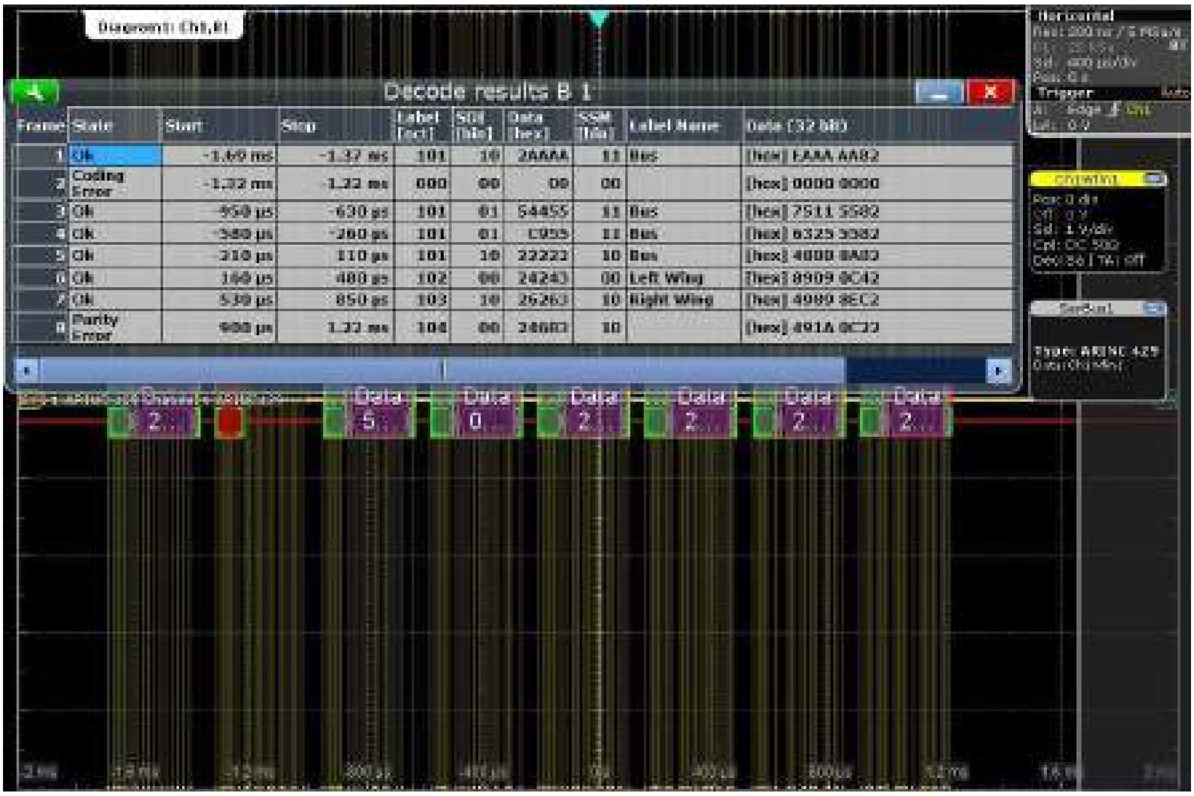
When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.



Frame	State	Start	Stop	Label [oct]	SDI [bin]	Data [hex]	SSM [bin]	Label Name	Data (32 Bit)
1	Ok	-1.69 ms	-1.37 ms	101	10	2AAAA	11	Bus	[hex] EAAA AA82
2	Coding Error	-1.22 ms	-1.22 ms	000	00	00	00		[hex] 0000 0000
3	Ok	-950 µs	-630 µs	101	01	54455	11	Bus	[hex] 7511 5582
4	Ok	-580 µs	-260 µs	101	01	C955	11	Bus	[hex] 6325 5582
5	Ok	-210 µs	110 µs	101	10	22222	10	Bus	[hex] 4800 8A82
6	Ok	160 µs	480 µs	102	00	24243	00	Left Wing	[hex] 8909 0C42
7	Ok	530 µs	850 µs	103	10	26263	10	Right Wing	[hex] 4989 8EC2
8	Parity Error	900 µs	1.22 ms	104	00	24683	10		[hex] 491A 0C22

Figure 12-51: Decoded ARINC 429 signal with applied lebel list and results table. The second and eight frame contain errors.

Table 12-12: Content of the "Decode results" table

Column	Description
State	Overall state of the frame.
Start	Time of word start in relation to the trigger point
Stop	Time of word stop in relation to the trigger point
Label	The value of the label bytes
SDI	The state of the SDI bits
DATA	All 32 bits of the word.
SSM	The state of the SSM bits

Column	Description
Label Name	The label name
Data	The value of the data bytes

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.11.3, "Decode Results", on page 1714.

12.10.6 Search on Decoded ARINC 429 Data

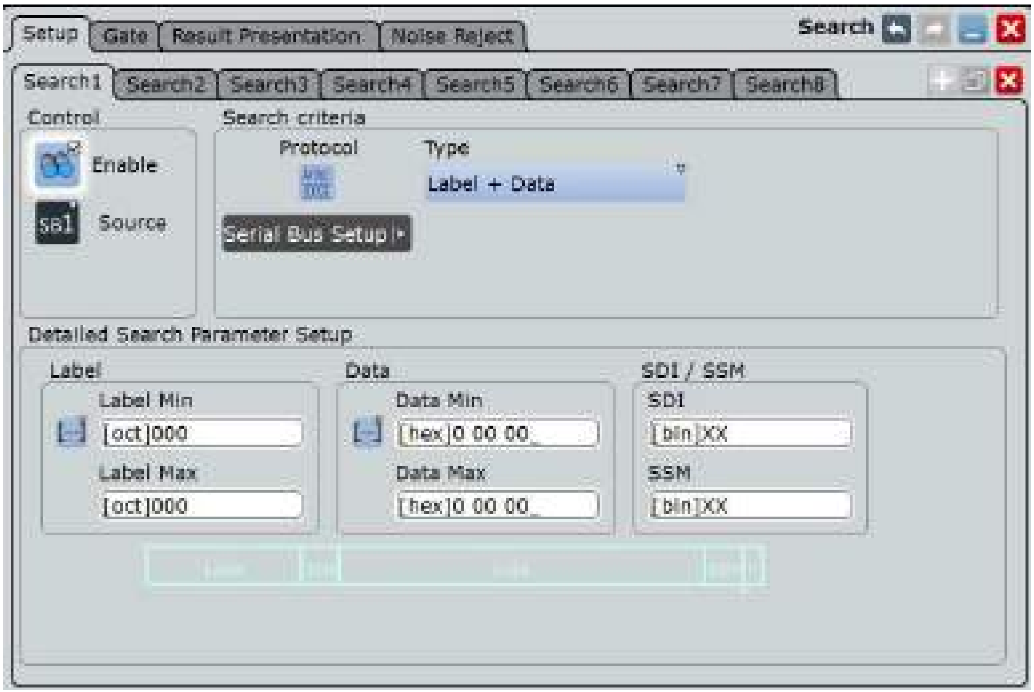
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.10.6.1 ARINC 429 Search Setup

Access: SEARCH > "Setup" tab



Type: Label + Data

Label Min: [oct]000

Label Max: [oct]000

Data Min: [hex]0 00 00_

Data Max: [hex]0 00 00_

SDI: [bin]XX

SSM: [bin]XX

Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".

Type: Label + Data

"Word Start"	Searches for the start word.
"Word Stop"	Searches for the stop word.
"Label + Data"	Searches for a defined word format. You can search for the label, the data, the SDI, and SSM bits separately. For details, see "Label + Data" on page 643.
"Error condition"	Identifies various errors in the frame, see "Error Conditions" on page 644.

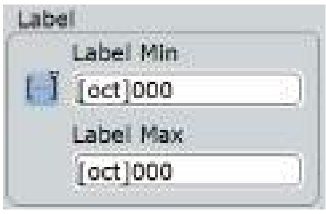
Remote command:

`SEARch:TRIGger:ARINc:TYPE` on page 1718

Label setup: Condition, Label min, Label max

The label setup consists of the condition and one or two label patterns.

The label setup settings are the same as in the ARINC trigger setup, see "Label setup: Condition, Label Min, Label Max" on page 643.

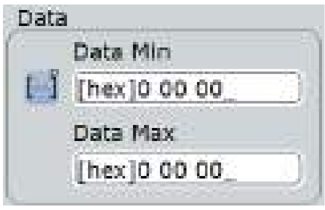


Label
Label Min
[oct]000
Label Max
[oct]000

Remote command:
`SEARch:TRIGger:ARINc:LABel:CONDition` on page 1718
`SEARch:TRIGger:ARINc:LABel:MIN` on page 1718
`SEARch:TRIGger:ARINc:LABel:MAX` on page 1719

Data setup: Condition, Data min, Data max
The data setup consists of the condition and one or two data patterns.

The data setup settings are the same as in the ARINC trigger setup, see "Data setup: Condition, Data Min, Data Max " on page 643.

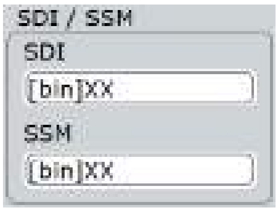


Data
Data Min
[hex]0 00 00_
Data Max
[hex]0 00 00_

Remote command:
`SEARch:TRIGger:ARINc:DATA:CONDition` on page 1718
`SEARch:TRIGger:ARINc:DATA:MIN` on page 1718
`SEARch:TRIGger:ARINc:DATA:MAX` on page 1719

SDI / SSM setup: SDI, SSM
The SDI / SSM setup consists of the SDI and SSM.

The SDI / SSM setup settings are the same as in the ARINC trigger setup, see "SDI / SSM" on page 644.



SDI / SSM
SDI
[bin]XX
SSM
[bin]XX

Remote command:
`SEARch:TRIGger:ARINc:SDI` on page 1719
`SEARch:TRIGger:ARINc:SSM` on page 1719

Error Condition
Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the ARINC trigger setup, see "Error Conditions" on page 644

Remote command:
`SEARch:TRIGger:ARINc:ERRor:CODing` on page 1719
`SEARch:TRIGger:ARINc:ERRor:PARity` on page 1720
`SEARch:TRIGger:ARINc:ERRor:TIMing` on page 1720

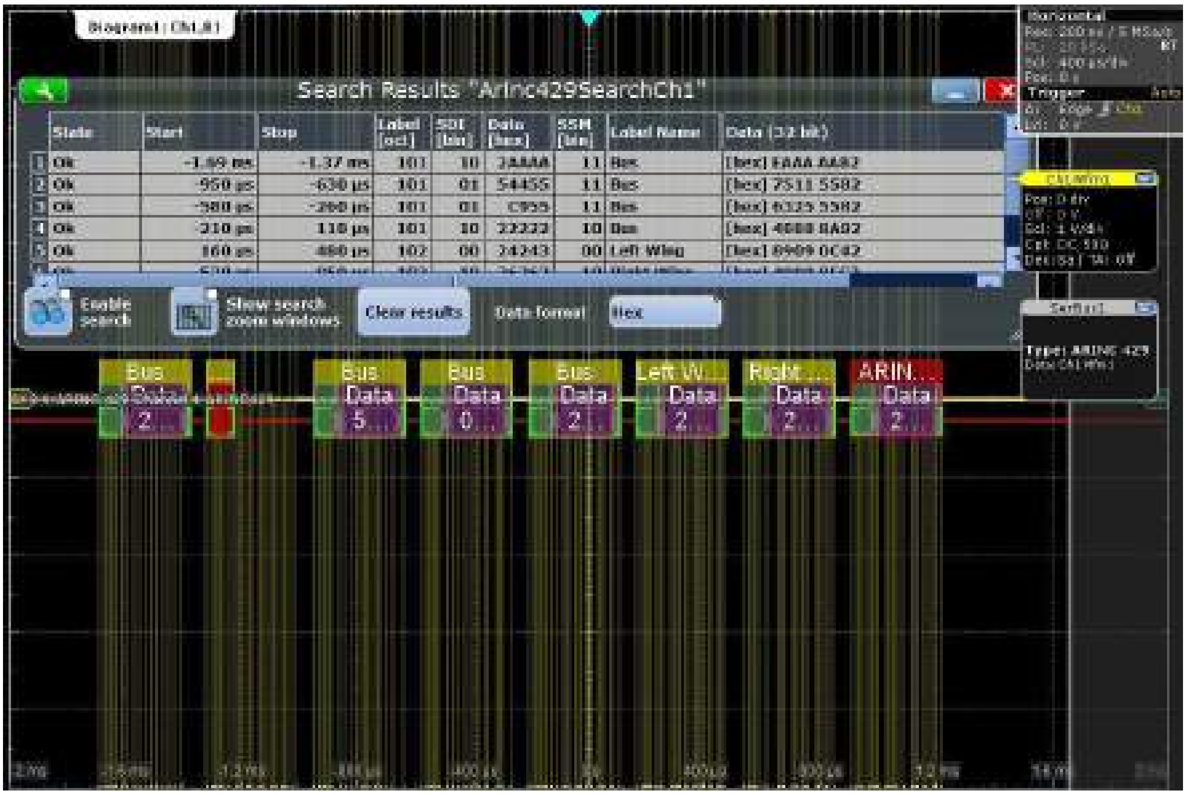
12.10.6.2 ARINC Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437



Search Results "Arinc429SearchCh1"

	State	Start	Stop	Label [oct]	SDI [bin]	Data [hex]	SSM [bin]	Label Name	Data (32 bit)
1	Ok	-1.69 ms	-1.37 ms	101	10	2AAAA	11	Bus	[hex] EAAA AA82
2	Ok	-950 µs	-630 µs	101	01	54455	11	Bus	[hex] 7511 5582
3	Ok	-580 µs	-260 µs	101	01	C955	11	Bus	[hex] 6325 5582
4	Ok	-210 µs	110 µs	101	10	22222	10	Bus	[hex] 4888 8A82
5	Ok	160 µs	480 µs	102	00	24243	00	Left Wing	[hex] 8909 0C42

Figure 12-52: Results of a general "Label +data" search with applied label list. All frames are found that contain any label, any data, and any SDI/SSM bits.

Remote commands:

- `SEARch:RESult:ARINc:WCOunt` on page 1722
- `SEARch:RESult:ARINc:WORD<m>:DATA?` on page 1721
- `SEARch:RESult:ARINc:WORD<m>:LABel?` on page 1721
- `SEARch:RESult:ARINc:WORD<m>:PATTern?` on page 1721
- `SEARch:RESult:ARINc:WORD<m>:SDI?` on page 1722
- `SEARch:RESult:ARINc:WORD<m>:SSM?` on page 1721
- `SEARch:RESult:ARINc:WORD<m>:STARt?` on page 1723
- `SEARch:RESult:ARINc:WORD<m>:STATe?` on page 1723
- `SEARch:RESult:ARINc:WORD<m>:STOP?` on page 1722
- `SEARch:RESult:ARINc:WORD<m>:SYMBol?` on page 1722

12.11 Ethernet 10BASE-T and 100BASE-TX (Option R&S RTO-K8)

Twisted-pair Ethernet technologies are based on the family of standards IEEE 802.3, issued by the Institute of Electrical and Electronics Engineers (IEEE).

R&S RTO-K8 is a firmware option that enables the R&S RTO to analyze Ethernet protocol variants 10BASE-T and 100BASE-TX, by decoding the signal and searching within the decoded events. To trigger the signal, use the edge trigger on the source channel. The option is compatible with the standards IEEE 802.3i of 1990 (10BASE-T) and IEEE 802.3u of 1995 (100BASE-TX). R&S RTO-K8 supports bit rates up to 10 Mbit/s for 10BASE-T and up to 100 Mbit/s for 100BASE-TX.

12.11.1 The Ethernet Protocol

The two Ethernet protocol variants that R&S RTO-K8 can process have the following features:

- 10BASE-T uses Manchester coding (or phase encoding, PE). In terms of a logical Boolean operation, the Manchester value of each bit is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.
- 100BASE-TX uses a 4B5B Multi-Level Transmit (MLT-3) encoding. This protocol sequentially cycles through a sequence of the voltage levels -1 V, 0 V, +1 V, and 0 V. To transmit a "1" bit, MLT-3 moves to the next state; to transmit a "0" bit, it stays in the same state. 4B5B block coding is used to map groups of four bits onto groups of five bits. Additionally, the signal is scrambled.

All Ethernet-over-twisted-pair technologies use wires with four twisted pairs of cables (and 8P8C connectors), but 10BASE-T and 100BASE-TX only require two pairs of wires.

12.11.2 Ethernet Configuration

If you need information on how to get started with configuring the Ethernet setup, see Chapter 12.11.2.3, "Configuring Ethernet Signals", on page 656. Otherwise proceed with the configuration settings.

12.11.2.1 Ethernet Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *Ethernet*

Make sure that the tab of the correct serial bus is selected on the left side.

Protocol: Ethernet
Ethernet Variant: 10BASE-T
Data — Source: C1, Polarity: Normal
Thresholds: 1.25 V, -1.25 V

Figure 12-53: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

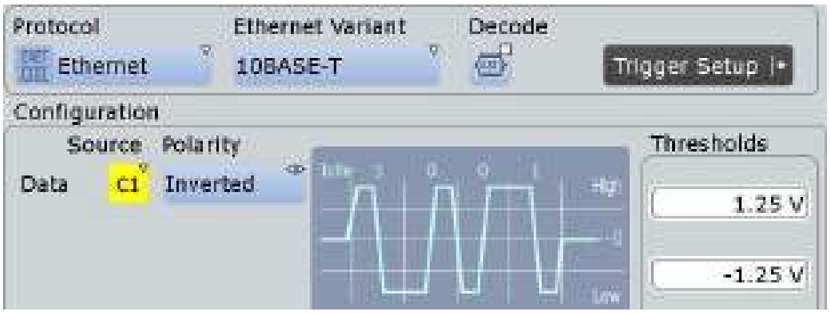
Ethernet Variant

Defines the Ethernet protocol variant and transmission speed.

Note: Note that no triggering on the serial bus is available.
To trigger the signal, use the edge trigger on the source channel.

"10BASE-T"

Selects the Ethernet protocol variant 10BASE-T (standard data rate 10 Mbit/s).



Protocol: Ethernet
Ethernet Variant: 10BASE-T
Data — Source: C1, Polarity: Inverted
Thresholds: 1.25 V, -1.25 V

Figure 12-54: Ethernet 10BASE-T protocol configuration (here with inverted polarity)

"100BASE-TX"

Selects the Ethernet protocol variant 100BASE-TX, which provides 100 Mbit/s use data rate. Due to 4b/5b encoding, the raw data rate on the line is 125 Mbit/s. This value is used by R&S RTO-K8 as the bit rate default for 100BASE-TX.

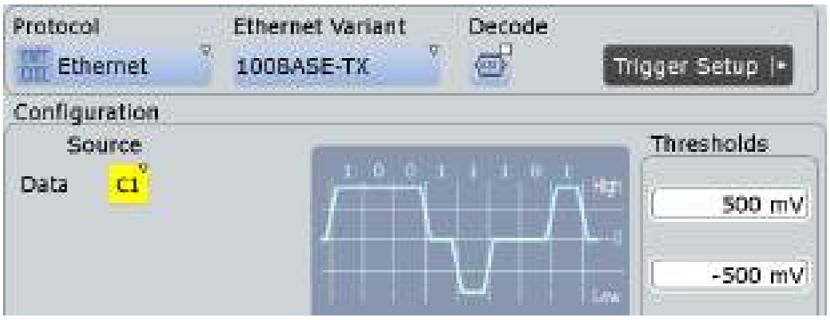

Protocol: Ethernet
Ethernet Variant: 100BASE-TX
Configuration
Source: Data C1
Thresholds: 500 mV, -500 mV

Figure 12-55: Ethernet 100BASE-TX protocol configuration

Remote command:
`BUS<m>:ETHernet:VARiant` on page 1724

Source

Defines the source settings for the data signal.

Permitted source selections are the analog, mathematical, and reference channels.

Remote command:
`BUS<m>:ETHernet:SOURce` on page 1724

Polarity

Defines the polarity ("Normal" or "Inverted") of the data signal. This setting is only available in 10BASE-T.

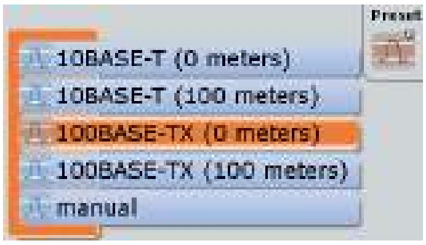
Remote command:
`BUS<m>:ETHernet:POLarity` on page 1724

Thresholds

Sets the threshold value for the digitization of each signal line. If the signal value on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal value is below the lower threshold, the signal state is considered low.

There are four ways to set the threshold:

- "Thresholds"
  Enter the values directly: upper threshold in the upper field, lower threshold in the lower field.
- "Preset"
  Either allows to set individual voltages by selecting "manual",
  or sets the voltages to one out of four pre-defined levels:
  - 10BASE-T (0 meters): *±1.25 V*
  - 10BASE-T (100 meters): *±750 mV*
  - 100BASE-TX (0 meters): *±500 mV*
  - 100BASE-TX (100 meters): *±350 mV*



The "Preset" levels depend on:

- the Ethernet variant
- the distance from the transmitter. "0 meters" represents "voltage at transmitter" and "100 meters" represents "voltage at the maximum cable length", according to the standard.

As soon as any non-predefined threshold is set, the "Preset" value automatically changes to manual (without affecting anything else).

- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
  Couples threshold settings between upper and lower threshold.

Remote command:

`BUS<m>:ETHernet:THReshold:HIGH` on page 1725

`BUS<m>:ETHernet:THReshold:LOW` on page 1725

`BUS<m>:ETHernet:PRESet` on page 1725

Bit rate

Defines the transmission speed setting for the data signal:

- 10BASE-T: default bit rate 10 Mbps
- 100BASE-TX: default bit rate 125 Mbps

In both variants, the permitted bit rates range from 10 kbps to 150 Mbps. Switching the variant adjusts the bit rate, independent of the previous setting.

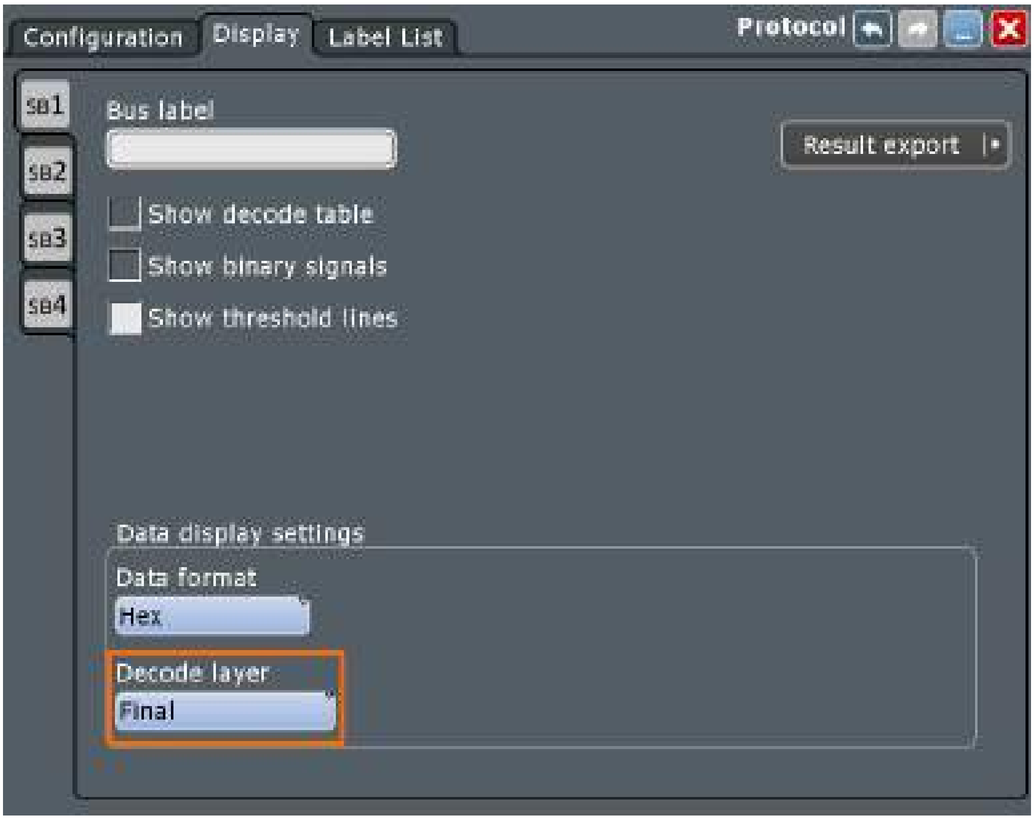
Remote command:

`BUS<m>:ETHernet:BITRate` on page 1726

12.11.2.2 Ethernet Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = Ethernet" > "Display" tab

To enhance the decode possibilities of the Ethernet protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Bus label

☐ Show decode table

☐ Show binary signals

☑ Show threshold lines

Data format: Hex

Decode layer: Final

Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

12.11.2.3 Configuring Ethernet Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "Ethernet".
5. Optionally, you can enter a "Bus label" in the "Display" tab.

6. Tap "Ethernet Variant" and select the variant ("10BASE-T" or "100BASE-TX") you want to set up.

   Note: Note that no triggering on the serial bus is available.
   To trigger the signal, use the edge trigger on the source channel.
7. In case of the variant "10BASE-T", select the polarity ("Normal" or "Inverted") of the data signal.
8. Set the logical thresholds, see "Thresholds" on page 654.
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.11.2.1, "Ethernet Configuration Settings", on page 652.

12.11.3 Ethernet Label List

Label lists are protocol-specific. An Ethernet label file contains two values for each identifier:

- "Ethernet Header Display": the ethernet header display value that i
- "Symbolic label": symbolic name of the header, specifying its function

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = ethernet
# ---------------------------------------------------------------------------
# Labels for Ethernet protocol
#   Column order: Ethernet Header Display, Label
#-----------------------------------------------------------------------------
# Supported MAC Address Format
# xx:xx:xx  standard 24 bit manufactory header
# xx:xx:xx:xx:xx:xx/yy  support other length headers
# yy should be the header length in decimal
# yy should be between 24 - 48
# ---------------------------------------------------------------------------
00:00:0C, Cisco
00:01:13, Olympus
00:01:14, KandaTsu
00:04:07, TopconPo
00:0B:64, KiebackP
00:1B:C5:06:C0:00/36, LuxconSy
00:1B:C5:06:D0:00/36, TesElect
00:1B:C5:06:E0:00/36, TwoDimen
00:1B:C5:06:F0:00/36, LlcEmzio
00:1F:BE, Shenzhen
00:21:8F, Avantgar
```

```
00:21:90, GoliathS
00:21:91, D-Link
00:21:92, BaodingG
00:50:C2:5F:60:00/36, Cambridg
00:50:C2:5F:70:00/36, Metrolog
00:50:C2:5F:80:00/36, GrupoEpe
18:42:2F, AlcatelL
18:44:62, RiavaNet
18:46:17, SamsungE
18:8E:D5, TpVision
18:E7:F4, Apple
40:D8:55:1C:80:00/36, SensataT
40:D8:55:1C:90:00/36, Andy-L
40:D8:55:1C:A0:00/36, RigelEng
40:D8:55:1C:B0:00/36, MgSRL
40:D8:55:1C:D0:00/36, YxlonInt
40:D8:55:1C:E0:00/36, PeterHub
40:D8:55:1C:F0:00/36, OmnikNew
40:D8:55:1D:00:00/36, WebeasyB
FC:F8:B7, TronteqE
FC:FA:F7, Shanghai
FC:FB:FB, Cisco
FC:FE:77, HitachiR
FF:FF:FF:FF:FF:FF/48, BroadCast
```

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

12.11.4 Ethernet Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-56 shows decoded and binary signals in Ethernet 10BASE-T.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Decode results details 1

State Ok
Start 133.8 µs
Stop 202.6 µs

Destination Address [MAC] EE:EE:EE:EE:EE:EE
Source Address [MAC] F0:E0:D0:C0:B0:A0
Type/Length [hex] 800
Data

Byte	
55	100
56	101
57	102
58	103
59	104
	105

Figure 12-56: Ethernet 10BASE-T: decoded and binary signal, with decode results table and details

green brackets [...] = start / end of frame
blue frame = frame ok
red frame = error frame
grey = preamble / SFD / FrameCheck
green = destination address
purple = source address
brown = address
yellow = data

The screenshot in Figure 12-57 is a view of Figure 12-56 without the decode results table and details.

The screenshot in Figure 12-58 is a zoomed view of Figure 12-57.

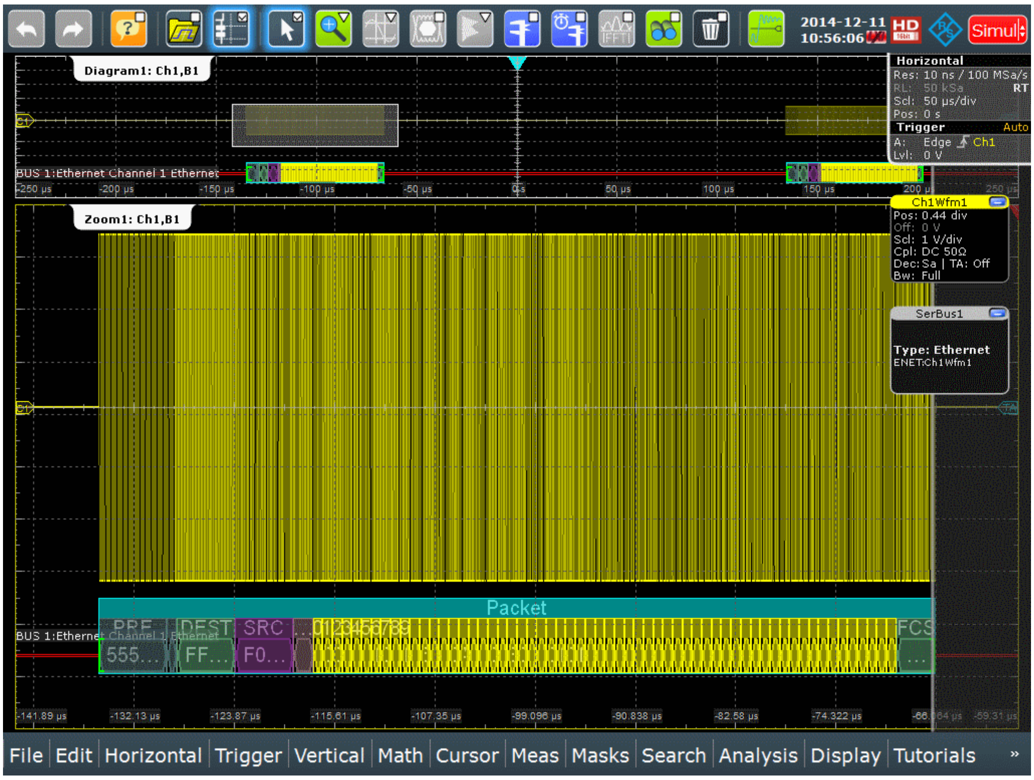


Figure 12-57: Ethernet 10BASE-T: decoded and binary signal

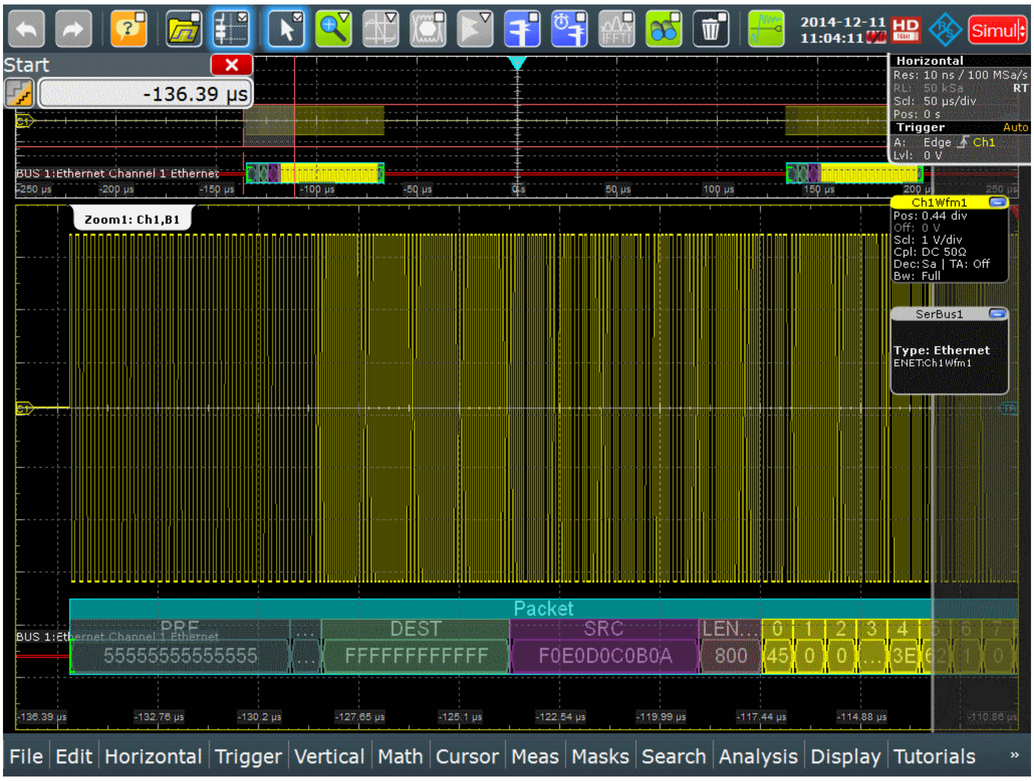


Figure 12-58: Ethernet 10BASE-T: decoded and binary signal (zoomed view)

The example in Figure 12-59 shows a zoomed view of binary signals and decode results in Ethernet 100BASE-TX.

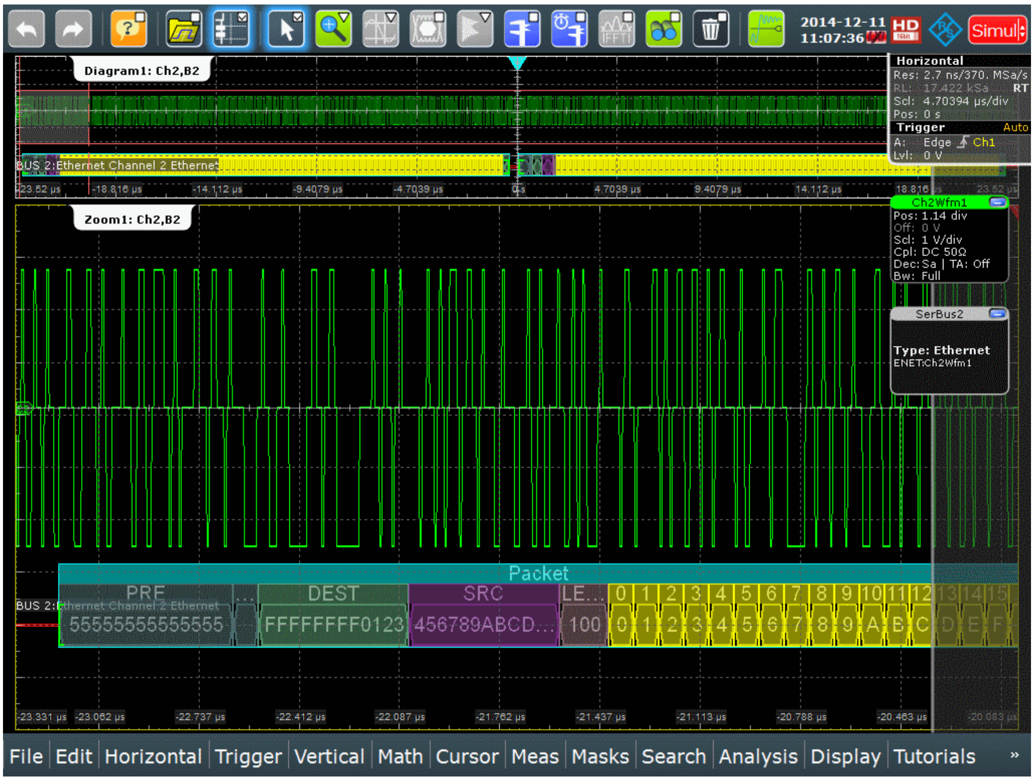


Figure 12-59: Ethernet 100BASE-TX: decoded and binary signal (zoomed view)

green brackets [...] = start / end of frame
blue frame = frame ok
red frame = error frame
grey = preamble / SFD / FrameCheck
green = destination address
purple = source address
brown = address
yellow = data

The content of the "Decode results" table in Figure 12-56 is described in Table 12-13:

Table 12-13: Content of the "Decode results" table

Column	Description
Type	Frame type
State	Overall state of the frame: either OK or the relevant error condition (preamble, length)
Start	Start time of the frame
Stop	Stop time of the frame
Destination Address	Destination address of the frame
Source Address	Source address of the frame

Column	Description
Type/Length	The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of this field is ambivalent. It could either be the word type (specific for the sub-protocol) or the word length.
Data	Values of the data bytes in a frame. The table shows a truncated version; to see all the bytes in a separate data table, activate "Show details". The data format is always hexadecimal.
CRC	FrameCheck (Cyclic Redundancy Code, CRC)
Destination Symbol	Translation (or symbolic label) of the destination address, if the label list is enabled.
Source Symbol	Translation (or symbolic label) of the source address, if the label list is enabled.
Number of Words	Number of words in the frame

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.12.2, "Decode Results", on page 1726.

12.11.5 Search on Decoded Ethernet Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

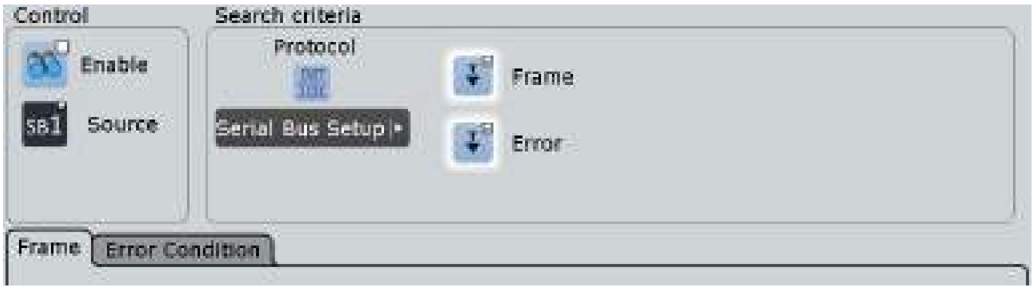
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

If you need information on how to get started with searching Ethernet data, see Chapter 12.11.5.3, "Searching Ethernet Data", on page 665. Otherwise proceed with the Ethernet search setup.

12.11.5.1 Ethernet Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for Ethernet

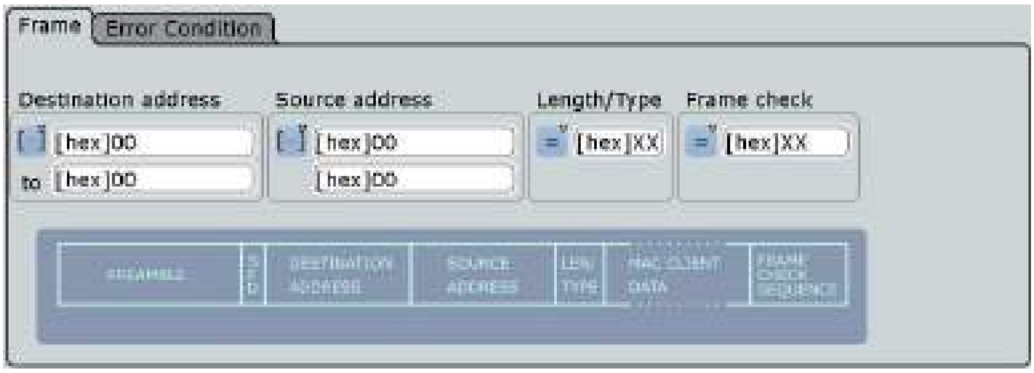
Search criteria
Use the "Search criteria" dialog to define the event types to be searched. Available event types are "Frame" and "Error".



Individual search parameters, which do not depend on the Ethernet protocol variant, can be specified in the tabs below the "Search criteria" dialog.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:SELect` on page 1732
`SEARch:TRIGger:ETHernet:ERRor:SELect` on page 1736

Frame
Searches for four different frame conditions: "Destination address", "Source address", "Length/Type", or "Frame check".



Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:SELect` on page 1732

Destination address ← Frame
To search for a destination address, an address pattern or optionally an address range have to be specified.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:DCONdition` on page 1732
`SEARch:TRIGger:ETHernet:FRAMe:DMIN` on page 1732
`SEARch:TRIGger:ETHernet:FRAMe:DMAX` on page 1733

Source address ← Frame
To search for a source address, an address pattern or optionally an address range have to be specified.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:SCONdition` on page 1733
`SEARch:TRIGger:ETHernet:FRAMe:SMIN` on page 1733
`SEARch:TRIGger:ETHernet:FRAMe:SMAX` on page 1734

Length/Type ← Frame
To search for a frame length or frame type, a type/length pattern or optionally a range of type/length patterns have to be specified.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:TCONdition` on page 1734
`SEARch:TRIGger:ETHernet:FRAMe:TMIN` on page 1734
`SEARch:TRIGger:ETHernet:FRAMe:TMAX` on page 1735

Frame check ← Frame
To search for a specific pattern, this pattern or optionally a range of patterns have to be specified.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:CCONdition` on page 1735
`SEARch:TRIGger:ETHernet:FRAMe:CMIN` on page 1735
`SEARch:TRIGger:ETHernet:FRAMe:CMAX` on page 1736

Error Condition
Searches for two error conditions: "Preamble Error" or "Length Error".

Preamble Error ← Error Condition
Searches for any preamble errors.

Remote command:
`SEARch:TRIGger:ETHernet:ERRor:PREamble` on page 1736

Length Error ← Error Condition
Searches for any preamble errors.

Remote command:
`SEARch:TRIGger:ETHernet:ERRor:LENGth` on page 1736

12.11.5.2 Ethernet Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

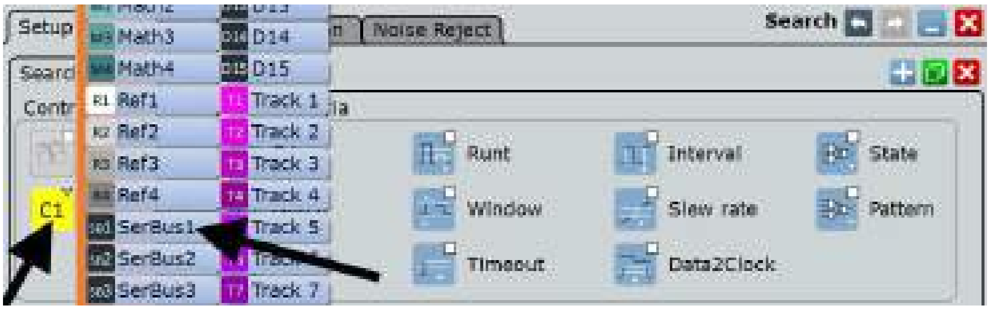
- `SEARch:RESult:ETHernet:WCOunt` on page 1737
- `SEARch:RESult:ETHernet:WORD<m>:TYPE?` on page 1739
- `SEARch:RESult:ETHernet:WORD<m>:FTYPe?` on page 1739
- `SEARch:RESult:ETHernet:WORD<m>:STATe?` on page 1737
- `SEARch:RESult:ETHernet:WORD<m>:STARt?` on page 1738
- `SEARch:RESult:ETHernet:WORD<m>:STOP?` on page 1738
- `SEARch:RESult:ETHernet:WORD<m>:DESTaddress?` on page 1739
- `SEARch:RESult:ETHernet:WORD<m>:SRCaddress?` on page 1739
- `SEARch:RESult:ETHernet:WORD<m>:DATA?` on page 1740
- `SEARch:RESult:ETHernet:WORD<m>:CRC?` on page 1740
- `SEARch:RESult:ETHernet:WORD<m>:DSYMbol?` on page 1740
- `SEARch:RESult:ETHernet:WORD<m>:SSYMbol?` on page 1741
- `SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue?` on page 1741

12.11.5.3 Searching Ethernet Data

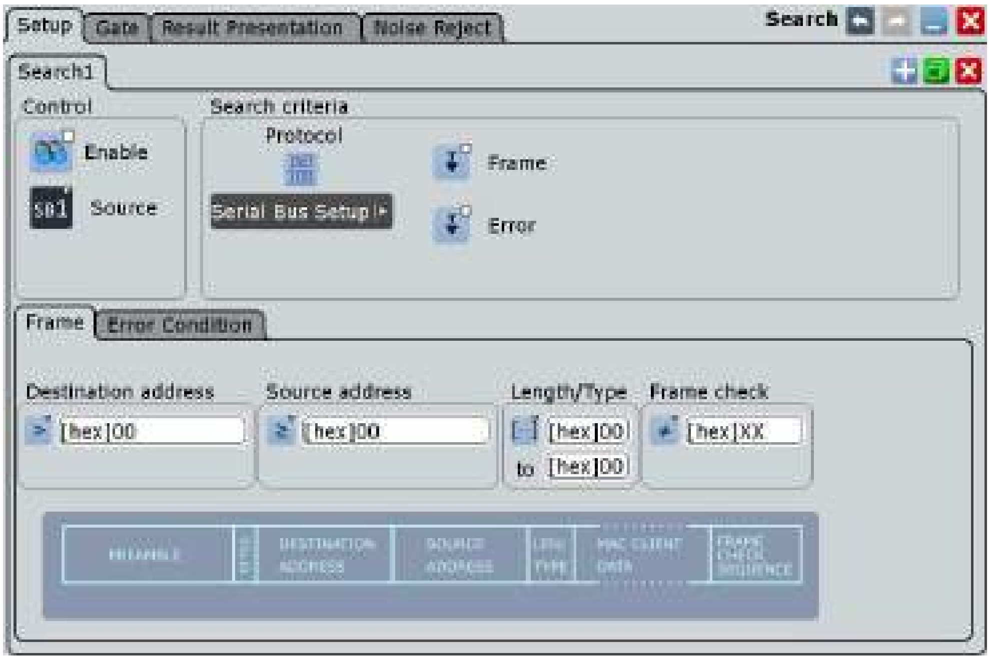
Prerequisite: A serial bus is configured for the Ethernet signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to Ethernet (e.g. "SerBus1", unless already selected).



The search dialog for Ethernet protocol analysis is opened.



Destination address: [hex]00
Source address: [hex]00
Length/Type: [hex]00 to [hex]00
Frame check: [hex]XX

4. Specify search criteria according to Chapter 12.11.5.1, "Ethernet Search Setup", on page 663.

5. To acquire a waveform, press SINGLE.

   The R&S RTO performs an Ethernet decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).

6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.12 SENT (Option R&S RTO-K10)

Single Ended Nibble Transmission (SENT) is a serial transmission interface protocol originally specified for the communication of sensors and control units in automotive electronics.

SENT is a protocol standard governed by Society of Automotive Engineers (SAE J2716). For detailed information, refer to the SENT standard specification on http://www.sae.org.

The SENT protocol is used exclusively in automotive applications, as for example electrical power steering, advanced driver assistance like parking assist or sensing of pressure, throttle position, pedal position, airflow mass, liquid level, etc.

The R&S RTO option R&S RTO-K10 provides serial triggering, decoding and a highly customizable search on decoded SENT signals.

12.12.1 The SENT Protocol

This chapter provides an overview of the protocol characteristics, encoding scheme, identifiers and trigger possibilities.

The SENT protocol transmits signal values point-to-point from a sensor to a controller (electronic control unit ECU), unidirectional. In contrast to conventional measurements, you can receive multiple data parameters via the SENT interface in a single transmission. Nevertheless, SENT is characterized by its simplicity and yet very high customizability to meet the individual requirements of the applications.

SENT operates via a three wire connection, a signal line, a supply voltage line for the sensor and a ground line. It transmits data digitally in variable timing units and evaluates the time between two falling edges (single edges). The signal is amplitude modulated with a constant amplitude voltage. Thus influences of interfering signals are not critical.

SENT key features

Main characteristics of SENT are:

- serial communication protocol
- 3 wires: SENT (signal line), 5V (voltage line), GND (ground line)
- output only, from sensor to receiver
- point-to-point transmission, no bus
- digital transmission
- high baud rate
- data transmission in variable timing units of 4 bits (1 nibble) between two falling edges
- transmitter-specific clock period (tick)
- time measured between single falling edges

12.12.1.1 SENT Transmission Concept

A sensor converts the analog measured data to a digital signal, and thus transmits a series of pulses to the receiver. The receiver, e.g. an ECU processes the received signal also digitally.

The format of a SENT message frame has a fixed pulse order and a transmitter-specific clock period. The total transmission time varies depending on the clock variation of the transmitter and the transmitted data values. The data pulses embedded in the transmission sequence represent one or multiple data parameters to be communicated. The last pulses in a message frame are the CRC check pulse, allowing the receiver to perform a number of diagnostic tests, and an optional pause pulse.

A SENT transmission starts without a request from the receiver. Consecutive sequences are transmitted continuously after the falling edge of the last pulse.

The SENT protocol distinguishes between two channel types:

- **Fast channel:** transmits primary data, i.e. sensor readings like temperature, pressure, mass air flow, throttle position.
- **Slow channel:** transmits secondary data consisting of transfer characteristics, sensor ID, type, manufacturer diagnostic, etc.
  The slow channel transmission provides two serial message formats *Short* and *Enhanced* for customizing the secondary data.

The data of both, the fast and the slow channels is transmitted simultaneously, by including two bits of a slow channel message in the message frame of the fast channel. Even though it requires many fast channel messages to complete a slow channel message, you can use this function to transmit several slow channel messages with minimal impact on the primary sensor data and the data rate.

12.12.1.2 SENT Message Definitions

SENT terms

See the specific terms and definition used in SENT protocol:

- **Tick (clock tick):** basic unit of time
  - transmitter-specific nominal clock period
  - 3 μs < clock tick <90 μs, with max. 20 % clock variation
- **Nibble:** minimum unit of data
  - used to transmit data
  - variable timing units between two falling edges

SENT Fast Channel

The SENT protocol enables you to transmit measurements of multiple sensors in one transmission sequence with data signals of varying length. The diagram in Figure 12-60 shows, for example, the encoding scheme for two 12-bit data signals.

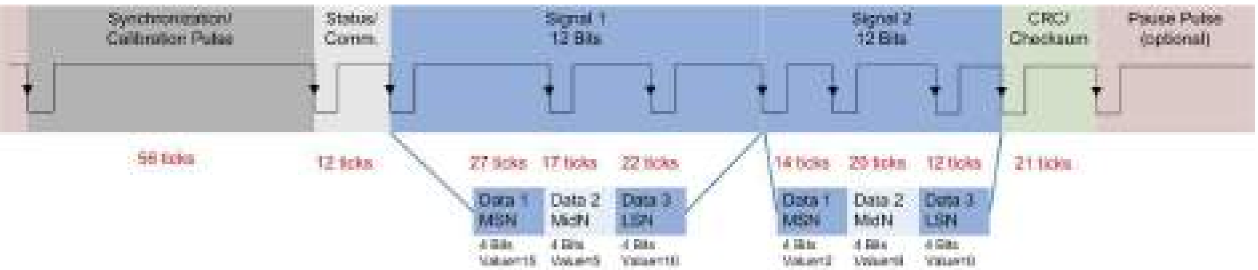


Figure 12-60: Example of a SENT transmission sequence

The format of a SENT transmission sequence consists of the following pulses:

- **Synchronization/Calibration Pulse:**
  - initial sequence of the receiver
  - the start condition is the falling edge of the last pulse (CRC or Pause)
  - nominal pulse period is 56 clock ticks
  - measures the actual clock variation of the transmitter and calculates the tick timing
- **Status/Communication Pulse (Nibble)**
  - one 4 bit pulse
  - communicates status and enables the sensor to include slow channel message bits
    0: (LSB) specific application
    1: specific application
    2: Serial Data message or specific application (e.g. Infineon TLE4998S)
    3: (MSB) 1= message start; 0=Serial Data message or specific application (e.g. Infineon TLE4998S)
  - 12 to 27 clock ticks
  - not included in CRC frame calculation
- **Data Pulses (Nibbles)**
  - one up to six 4 bit data nibbles
  - 12 to 27 clock ticks pulse period
  - initial logic 0 time with ≥5 ticks, subsequent logical 1 with variable duration
- **CRC/Checksum**
  - one 4 bit pulse
  - used for error checking of data nibbles (status nibble not included)
  - detects single bit, odd number of nonconsecutive and single burst errors
- **Pause Pulse**
  - one optional pulse
  - variable pulse length: 12 to 768 clock ticks
  - can be used to create a transmission with constant number of clock ticks

SENT Slow Channel

Short Serial Messages

For transmission of a slow channel message, 2 bits are included in a fast channel message, see the status nibble (Bit 2,3) in Figure 12-61.

A short serial message needs 16 fast channel messages until it is completely transmitted. Prerequisite for the complete transmission of the slow channel message are 16 consecutive error-free fast channel transmissions.

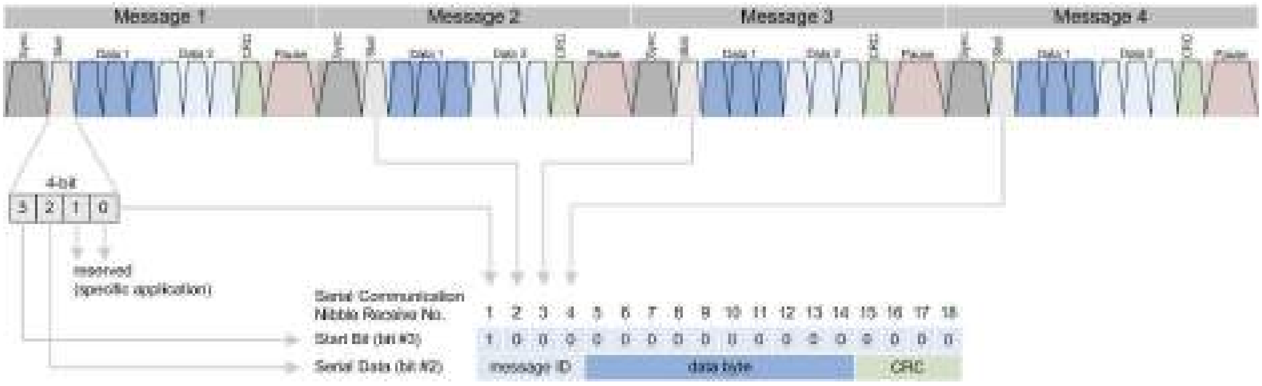


Figure 12-61: One serial message, composed of 16 SENT consecutive fast channel transmissions

Enhanced Serial Messages

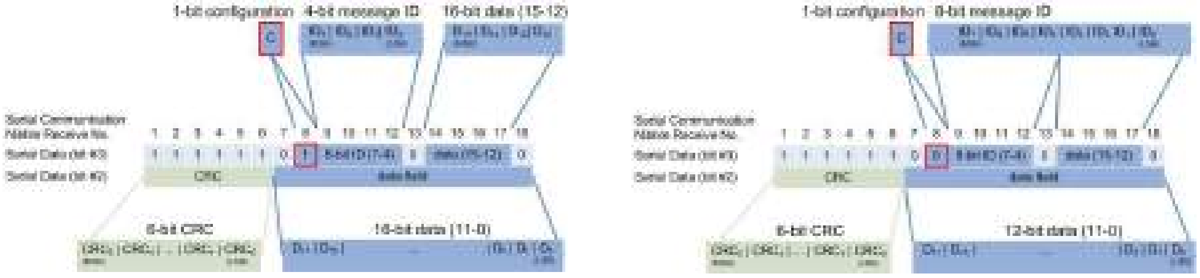
The transmission of an enhanced serial message format requires 18 fast channel transmissions. Each slow channel message is assigned a message ID, which is transmitted with the data.

The enhanced serial message format provides two alternatives for configuring the message:

- 4 bit ID and 16 bit data
- 8 bit ID and 12 bit data

The graphs below illustrate the variants.

Table 12-14: Enhanced serial message formats



16 bit data and 4 bit message ID

12 bit data and 8 bit message ID

Trigger

The R&S RTO can trigger on various parts of SENT pulses. The data line must be connected to an input channel, triggering on math and reference waveforms is not possible.

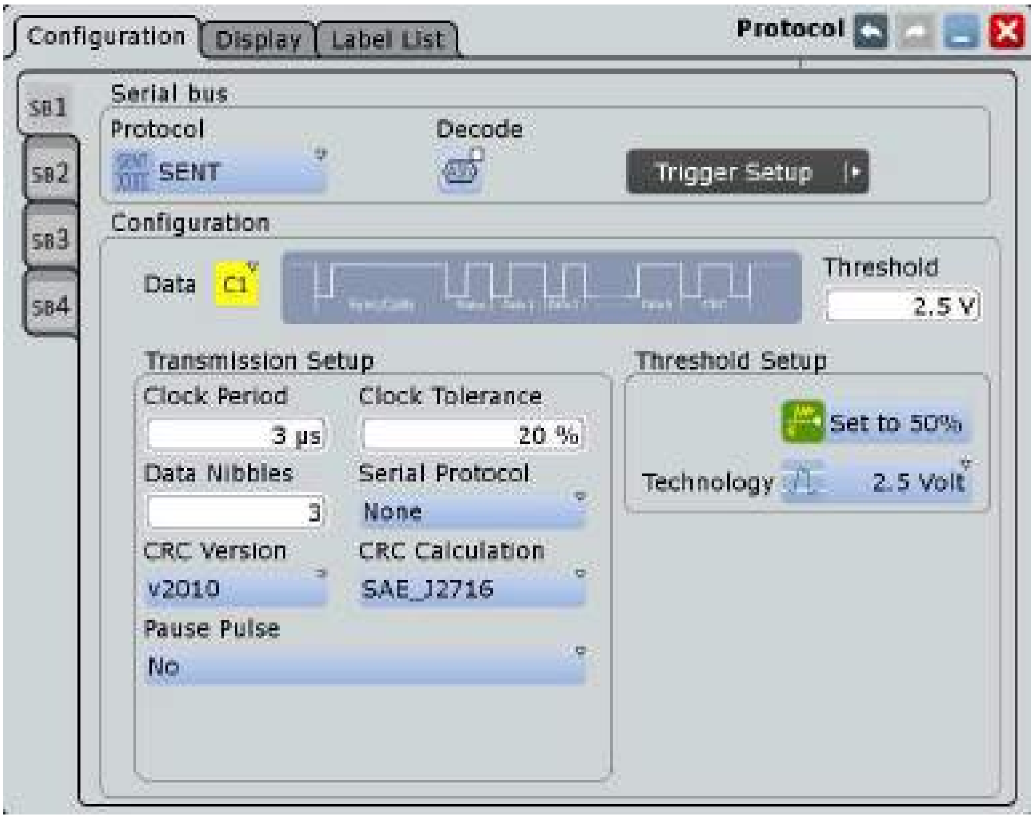
SENT enables you to trigger on:

- Calibration/synchronization pulse
- Transmission sequence
- Serial messages
- Error conditions

12.12.2 SENT Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *SENT*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: SENT

Data: C1

Threshold: 2.5 V

Clock Period: 3 µs

Clock Tolerance: 20 %

Data Nibbles: 3

Serial Protocol: None

CRC Version: v2010

CRC Calculation: SAE_J2716

Pause Pulse: No

Technology: 2.5 Volt

Figure 12-62: SENT protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data

Sets the source of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Remote command:

`BUS<m>:SENT:DATA:SOURce` on page 1742

Threshold

Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold.

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Remote command:

`BUS<m>:SENT:DATA:THReshold` on page 1742

`BUS<m>:SENT:TECHnology` on page 1742

`BUS<m>:SETReflevels` on page 1495

Clock Period

Sets the transmitter specific nominal clock period (clock tick).

The clock period and signal length determine the speed of transmission.

Remote command:

`BUS<m>:SENT:CLKPeriod` on page 1743

Clock Tolerance

Specifies a tolerated deviation of the clock.

Remote command:

`BUS<m>:SENT:CLKTolerance` on page 1743

Data Nibbles

Sets the number of data units in a single transmission sequence.

The maximum number of data nibbles is 6.

Remote command:

`BUS<m>:SENT:DNIBbles` on page 1743

Serial Protocol

Selects the protocol format in the transmitted signal.

"Short"	Short serial messages.
"Enhanced"	Enhanced serial messages.
"None"	No serial messages. Transmission sequences only.

Remote command:
`BUS<m>:SENT:SFORmat` on page 1744

CRC Version

Selects the version the CRC check is based on.

"Legacy"	Based on the crc calculation version used earlier than 2010.
"v2010"	Based on the recent crc calculation version updated in 2010.

Remote command:
`BUS<m>:SENT:CRCVersion` on page 1744

CRC Calculation

Selects the method for CRC calculation.

SENT CRC calculates the checksum over all nibbles except the communication and status nibble.

"SAE_J2716"	Calculates the CRC according to the SAE standard.
"TLE_4998X"	Calculates the CRC according to the standard computing method for Infineon TLE_4998X sensors.

Remote command:
`BUS<m>:SENT:CRCMethod` on page 1744

Pause Pulse

Determines whether a pause pulse is transmitted after the checksum nibble.

You can use this pulse to create a transmission with a constant number of clock ticks. The pause pulse length can be between a minimum of 12 clock ticks up to 768 (3*256) ticks at a maximum.

"No"	No pause pulse between the transmission sequences.
"Yes"	Pause pulse with fixed length at the end of each transmission sequence. The R&S RTO computes the length of the pause pulse automatically.
"For constant frame length"	Pause pulse with dynamic length to maintain a fixed transmission sequence length. To define the constant frame length, set the number of clock ticks under Frame Length in clock ticks.

Remote command:
`BUS<m>:SENT:PPULse` on page 1744

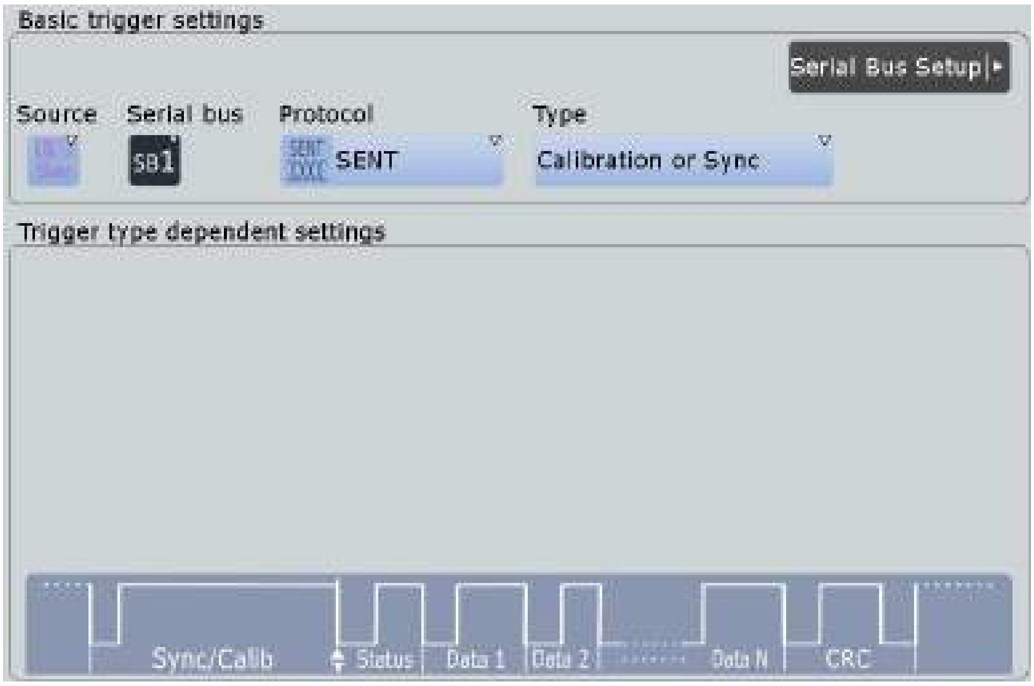
Frame Length in clock ticks

Determines the frame length in terms of ticks. The dialog displays this settings parameter, if the signal has a constant frame length.

Remote command:
`BUS<m>:SENT:PPFLength` on page 1745

12.12.3 SENT Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = SENT"



Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

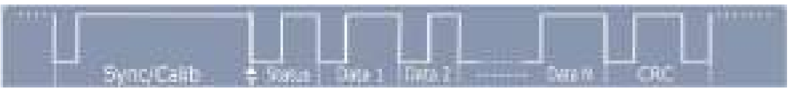
Type

Selects the event of the SENT transmission sequence or message to be triggered on.

The RTO triggers always on the falling edge of a pulse, i.e. at the end of the selected type nibble in a transmission sequence.

"Calibration or Sync"

Triggers at the end of the "Synchronization/Calibration" pulse.

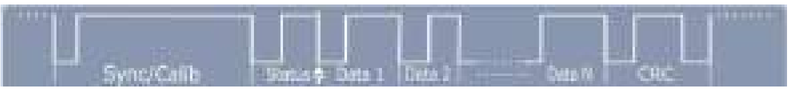


This setting does not require any input parameters.

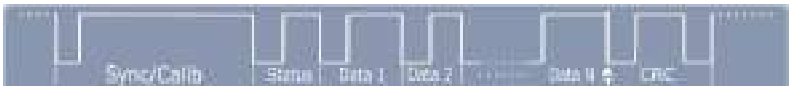
"Transmission Sequence"

Triggering depends on the additionally selectable "Sequence" parameter:

- "Sequence > Status": triggers at the end of the "Status" nibble.



- "Sequence > Status+Data": triggers at the end of the last data nibble.

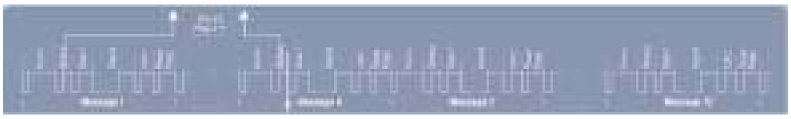


Description of trigger type specific settings: "Transmission Sequence setup" on page 676

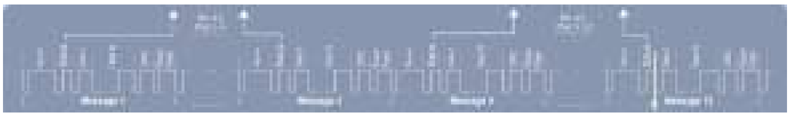
"Serial Message"

Triggering on a serial message depends on the serial protocol selected with Serial Protocol > Short | Enhanced and the associated setting parameters:

- "Short" serial message
  - "Sequence > Identifier": triggers at the end of the "ID".

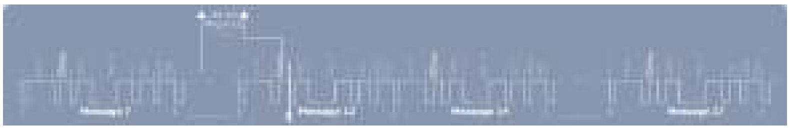


  - "Sequence > ID+Data": triggers at the end of the "ID and Data".



Description of trigger type specific settings: "Serial Message setup" on page 677

- "Enhanced" serial message
  - "Sequence > Identifier": triggers at the end of the "ID".



  - "Sequence > ID+Data": triggers at the end of the "ID and Data".

Description of trigger type specific settings: "Serial Message setup" on page 677

"Error condition"

Triggers if certain errors occur.

You can select the following error events for triggering:

- "Form Error"
- "Calibration Pulse Error"
- "Pulse Period Error"
- "CRC Error"
- "Irregular Frame Length Error"

Description of error specific trigger conditions, see "Error conditions setup" on page 679.

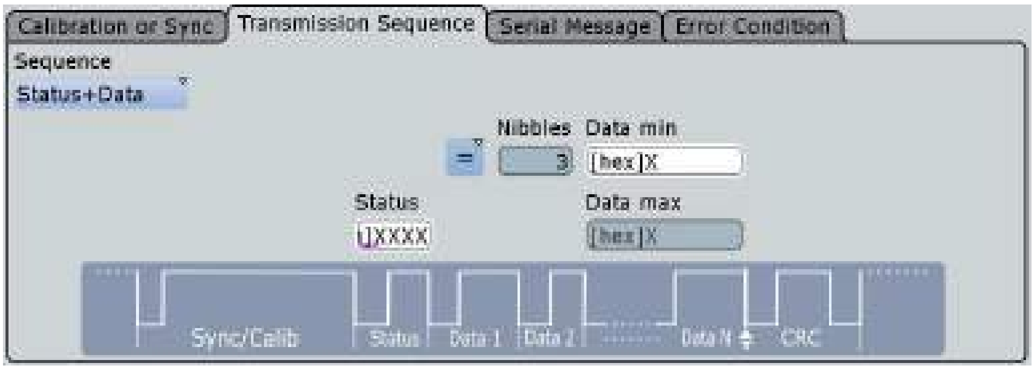
Remote command:

`TRIGger<m>:SENT:TYPE` on page 1746

Transmission Sequence setup

Configures the trigger conditions for trigger type transmission sequence.

Note: The displayed parameters depend on the selected "Sequence". The instrument displays the data setting parameters when you select "Status+Data", see "Type" on page 674.



Sequence: Status+Data

Nibbles: = 3

Data min: [hex]X

Status: []XXXX

Data max: [hex]X

Figure 12-63: Trigger setting parameters of a transmission sequence

Sequence ← Transmission Sequence setup

Selects the condition for triggering in a single transmission sequence.

You can trigger on the end of the status nibble or the combination of the status and data nibble(s).

Remote command:

`TRIGger<m>:SENT:TTYPe` on page 1746

Status ← Transmission Sequence setup

Defines the data bits for the status nibble.

Remote command:

`TRIGger<m>:SENT:STATus` on page 1747

Condition ← Transmission Sequence setup

Selects the operator to define a specific data pattern or a data range.

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`TRIGger<m>:SENT:TDCN` on page 1747

Nibbles ← Transmission Sequence setup
Displays the number of data nibbles of the transmission sequence.

Remote command:
`BUS<m>:SENT:DNIBbles` on page 1743

Data min ← Transmission Sequence setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`TRIGger<m>:SENT:TDMN` on page 1747

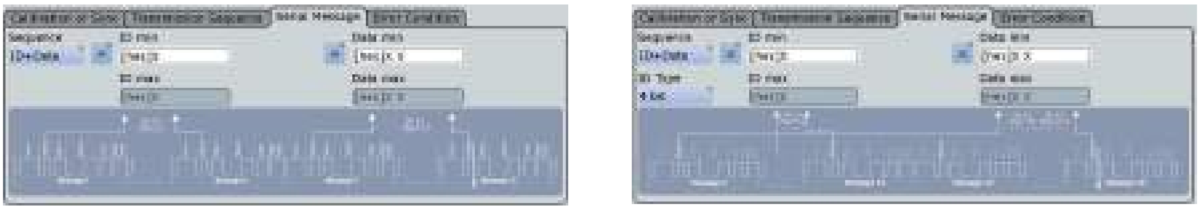
Data max ← Transmission Sequence setup
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SENT:TDMX` on page 1748

Serial Message setup
Configures the trigger conditions for a serial message.

Note: The displayed parameters depend on the selected "Sequence". The instrument indicates the data setting parameters when you select "ID+Data", see "Type" on page 674.

Trigger setting parameters of the serial message types



Short Serial Message

Enhanced Serial Message

Sequence ← Serial Message setup
Selects the condition for triggering in a serial message.

You can trigger on the end of an identifier nibble or the combination of the identifier and data nibble(s).

Remote command:
`TRIGger<m>:SENT:STYPe` on page 1748

ID Type ← Serial Message setup

Selects the message ID format for the enhanced serial message type.

You can select either 4 bit or 8 bit message ID.

Remote command:
`TRIGger<m>:SENT:SIDType` on page 1748

Identifier Condition ← Serial Message setup

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`TRIGger<m>:SENT:SICN` on page 1748

Identifier min ← Serial Message setup

Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit).

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`TRIGger<m>:SENT:SIMN` on page 1749

Identifier max ← Serial Message setup

The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SENT:SIMX` on page 1749

Data Condition ← Serial Message setup

Selects the operator to set a specific data pattern or a data range.

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`TRIGger<m>:SENT:SCONdition` on page 1749

Data min ← Serial Message setup

Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

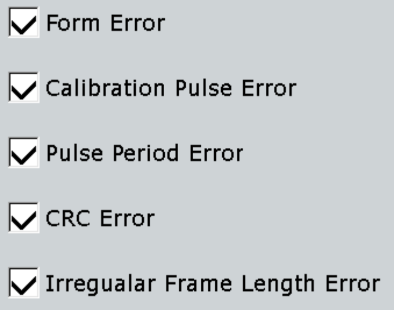
Remote command:
`TRIGger<m>:SENT:SDMN` on page 1750

Data max ← Serial Message setup

The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SENT:SDMX` on page 1750

Error conditions setup



☑ Form Error

☑ Calibration Pulse Error

☑ Pulse Period Error

☑ CRC Error

☑ Irregualar Frame Length Error

Executes a trigger event if one or more of the following errors occur:

- "Form Error"
  Detects a form error in serial messages (short and enhanced).
  An error occurs when at least one of the transmission sequences that form a serial message has an error.
- "Calibration Pulse Error"
  Detects a calibration pulse error in transmission sequences.
  An error occurs when
  - the duration of the "Calibration/Sync" pulse (in ticks) is less than 56*(1-clock tolerance) or more than 56*(1+clock tolerance)
  - the "Calibration/Sync" pulse duration of frame (–1) varies by more than 1.5625% from the "Calibration/Sync" pulse duration of frame (n)
- "Pulse Period Error"
  Detects an error in the "Calibration/Sync" pulse in transmission sequences.
  An error occurs when a nibble has any of the following:
  - number of ticks at low is less than 4 ticks.
  - nibble value < 0 (less than 12 ticks) or > 15 (more than 27 ticks).
- "CRC Error"
  Detects a checksum error in both, the transmission sequences and serial messages.
  The CRC length is 4 bits for transmission sequences and short serial messages, and 6 bit of enhanced serial messages.
- "Irregular Frame Length Error"
  Detects frame length errors in transmission sequences when pause pulse mode constant frame length is set, see "Pause Pulse" on page 673.
  A frame length error occurs, when the total length of the transmission sequence (including pause pulse) does not match the frame length setting, see "Frame Length in clock ticks" on page 673.

Remote command:
`TRIGger<m>:SENT:FORMerror` on page 1750
`TRIGger<m>:SENT:PULSeerror` on page 1750
`TRIGger<m>:SENT:PPERioderror` on page 1751

`TRIGger<m>:SENT:CRCerror` on page 1751
`TRIGger<m>:SENT:IRFLength` on page 1751

12.12.4 SENT Label List

SENT label lists provide a very useful way of translating the decoded data into user format. The label lists are highly customizable. The format of supplying the label list description is through a `.xml` file and is explained with an example, see "Label List Structure for SENT Protocol" on page 680.

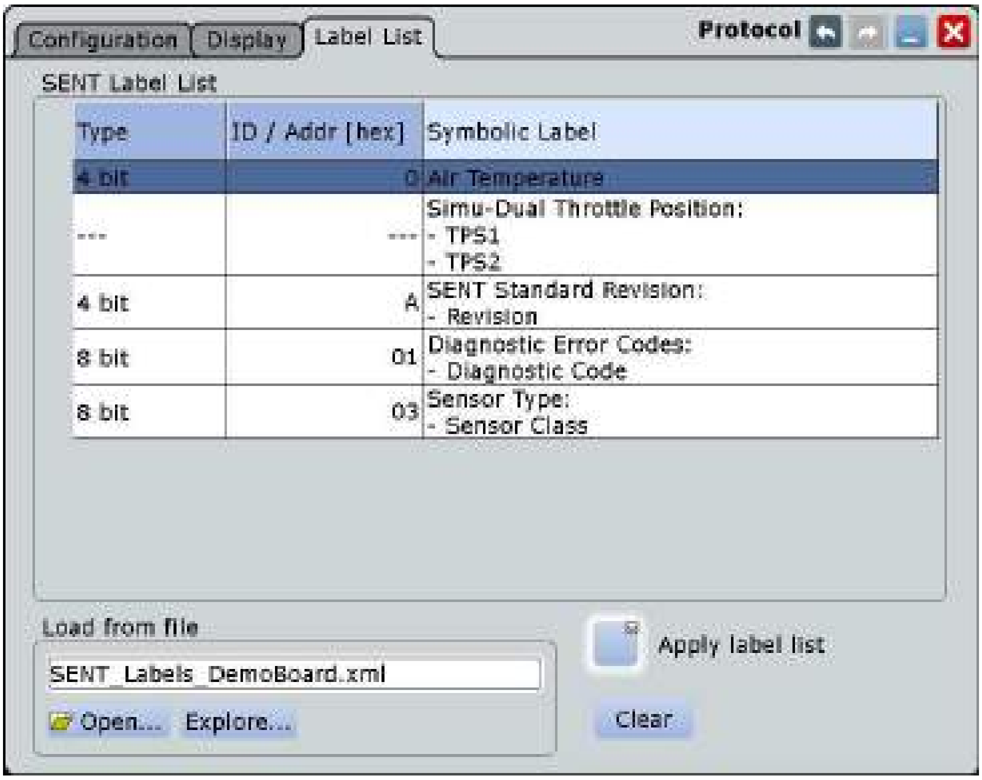
For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Label List Structure for SENT Protocol

```
<sb:FRAME NAME="Diagnostic Error Codes" STATE="ON">
  <!-- Start of a Frame Definition -->
  <!-- This block defines the information of a Transmission Sequence
   or Serial Message:
   NAME => Symbolic Label of the Frame
   STATE [ON/OFF] => When ON, this frame Translation is taken into consideration.
                     When OFF, this frame Translation is skipped.-->
<sb:DESCRIPTION> used to diagnose the current SENT System</sb:DESCRIPTION>
  <!-- Doesn't affect the Translation -->
<sb:ID-VALUE>01</sb:ID-VALUE>
  <!-- ID Value of the Serial Message (in decimal) -->
  <!-- Absence of the ID-VALUE field implies that the current Frame Translation
   is to be used for Transmission Sequences and not for a Serial Message -->
<sb:ID-LENGTH>8</sb:ID-LENGTH>
  <!-- ID Length of the Serial Message (in bits) -->
<sb:DATA-SIZE>12</sb:DATA-SIZE>
  <!-- Data Length of the Serial Message (in bits) -->
<sb:SIGNALS>
  <!-- This block defines the information of the Signals embedded
   in the Data Field of the Frame (Transmission Sequence or Serial Message) -->
<sb:SIGNAL ID="Diagnostic">
  <!-- Unique ID of the Signal (no effect on Translation) -->
<sb:SHORT-NAME>Diagnostic Code</sb:SHORT-NAME>
  <!-- Name of the Signal -->
<sb:DESCRIPTION></sb:DESCRIPTION>
  <!-- Info Field (no effect on Translation) -->
<sb:BIT-POSITION>11</sb:BIT-POSITION>
  <!-- Starting Bit position of the Signal
   (The whole Data Field is represented as MSB -> LSB Sequence) -->
<sb:BIT-LENGTH>12</sb:BIT-LENGTH>
  <!-- Number of Bits representing the Signal Value -->
<sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
  <!-- Byte Order of the Signal Value [MSB or LSB], Default: MSB -->
```

```
<sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
  <!-- Representation of the Bits [ENUM, UNSIGNED_INT, INT, FLOAT, DOUBLE],
   Default: UNSIGNED_INT
   The Signal Value is calculated according to the following:
   Translated_Value = Encoded_Value * FACTOR + OFFSET -->
<sb:FACTOR>1.0</sb:FACTOR>
  <!-- Signal Factor (decimal value)-->
<sb:OFFSET>0.0</sb:OFFSET>
  <!-- Signal Offset (decimal value)-->
<sb:MIN>0</sb:MIN>
  <!-- Minimum Signal Value (decimal value) -->
<sb:MAX>4096</sb:MAX>
  <!-- Maximum Signal Value (decimal value) -->
<sb:ENUM-VALUES>
  <!-- This block is only valid (and taken into consideration)
   when the VALUE-TYPE is ENUM
   It defines the Enumeration List Translation of the Signal -->
<sb:ENUM INDEX="0" LABEL="No Error"/>
   <!-- INDEX is the Enum Value (corresponds to the Signal Value in decimal),
    LABEL is the matching Translated Signal Value -->
<sb:ENUM INDEX="1" LABEL="Channel 1 out of range high"/>
</sb:ENUM-VALUES>
  <!-- End of Signal Enumeration List Definition -->
</sb:SIGNAL>
  <!-- End of a Signal Definition -->
  <!-- More Signals can be defined here! -->
</sb:SIGNALS>
  <!-- End of list of Signals Definition -->
</sb:FRAME>
  <!-- End of Frame Definition -->
```

For an example to label list translation, see Chapter 12.12.4.1, "SENT Label List Translation Example", on page 683.



SENT Label List

Type	ID / Addr [hex]	Symbolic Label
4 bit	0	Air Temperature
---	---	Simu-Dual Throttle Position: - TPS1 - TPS2
4 bit	A	SENT Standard Revision: - Revision
8 bit	01	Diagnostic Error Codes: - Diagnostic Code
8 bit	03	Sensor Type: - Sensor Class

Load from file

SENT_Labels_DemoBoard.xml

☑ Apply label list

Figure 12-64: SENT label list

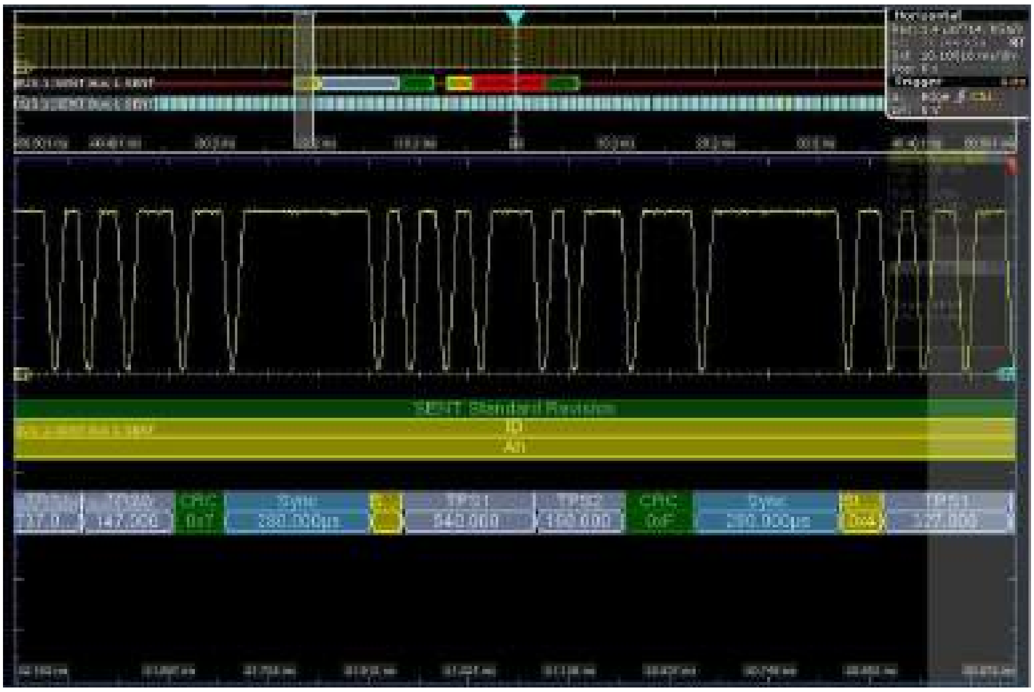


Figure 12-65: SENT decode results with label list translation

Remote command:

`BUS<m>:SENT:FRAMe<n>:SYMBol?` on page 1757

12.12.4.1 SENT Label List Translation Example

The example shows the `xml` sequence for a label list translation in the SENT protocol:

Figure 12-66: SENT label list translation

```
<?xml version="1.0" encoding="UTF-8"?>
<sb:LABEL-LIST-FILE>
 <sb:PROJECT ID="SENT-TRANSLATION SYSTEM">
  <sb:SHORT-NAME>SENT</sb:SHORT-NAME>
  <sb:LONG-NAME>SENT-Translation System Demo</sb:LONG-NAME>
  <sb:DESCRIPTION>This is the database for Translation demo for SENT.</sb:DESCRIPTION>
 </sb:PROJECT>
 <sb:FRAMES>
  <sb:FRAME NAME="Air Temperature" STATE="ON">
   <sb:DESCRIPTION></sb:DESCRIPTION>
   <sb:ID-VALUE>0</sb:ID-VALUE>
   <sb:ID-LENGTH>4</sb:ID-LENGTH>
   <sb:DATA-SIZE>16</sb:DATA-SIZE>
  </sb:FRAME>
  <sb:FRAME NAME="Humidity" STATE="OFF">
   <sb:DESCRIPTION></sb:DESCRIPTION>
   <sb:ID-VALUE>2</sb:ID-VALUE>
   <sb:ID-LENGTH>4</sb:ID-LENGTH>
   <sb:DATA-SIZE>16</sb:DATA-SIZE>
  </sb:FRAME>
  <sb:FRAME NAME="Barometric Pressure" STATE="OFF">
```

```
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>4</sb:ID-VALUE>
 <sb:ID-LENGTH>4</sb:ID-LENGTH>
 <sb:DATA-SIZE>16</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Configuration Code" STATE="OFF">
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>04</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Manufacturer Code" STATE="OFF">
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>05</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Sensor Type" STATE="ON">
 <sb:DESCRIPTION>specifies the SENT Sensor Type</sb:DESCRIPTION>
 <sb:ID-VALUE>03</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Sensor Class">
   <sb:SHORT-NAME>Sensor Class</sb:SHORT-NAME>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>32.0</sb:MAX>
   <sb:ENUM-VALUES>
    <sb:ENUM INDEX="0" LABEL="Not Specified"/>
    <sb:ENUM INDEX="1" LABEL="P"/>
    <sb:ENUM INDEX="2" LABEL="P/-"/>
    <sb:ENUM INDEX="3" LABEL="P/S"/>
    <sb:ENUM INDEX="4" LABEL="P/S/Default T"/>
    <sb:ENUM INDEX="5" LABEL="P/S/Sensor-Specific T"/>
    <sb:ENUM INDEX="6" LABEL="P1/P2"/>
    <sb:ENUM INDEX="7" LABEL="P/Default T"/>
    <sb:ENUM INDEX="8" LABEL="P/Sensor-Specific T"/>
    <sb:ENUM INDEX="9" LABEL="P1/P2/Default T"/>
    <sb:ENUM INDEX="10" LABEL="P1/P2/Sensor-Specific T"/>
    <sb:ENUM INDEX="16" LABEL="Not Defined"/>
    <sb:ENUM INDEX="17" LABEL="MAF (hi-res,lin)"/>
    <sb:ENUM INDEX="18" LABEL="MAF (hi-res,non-lin)"/>
    <sb:ENUM INDEX="19" LABEL="MAF (hi-res,lin) / Pressure"/>
    <sb:ENUM INDEX="20" LABEL="MAF (hi-res,non-lin) / Pressure"/>
```

```
    <sb:ENUM INDEX="21" LABEL="MAF (lin) / Pressure (hi-res)"/>
    <sb:ENUM INDEX="22" LABEL="MAF (non-lin) / Pressure (hi-res)"/>
   </sb:ENUM-VALUES>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="SENT Standard Revision" STATE="ON">
 <sb:SHORT-NAME>SENT Standard</sb:SHORT-NAME>
 <sb:DESCRIPTION>specifies the SENT Standard Revision Number</sb:DESCRIPTION>
 <sb:ID-VALUE>10</sb:ID-VALUE>
 <sb:ID-LENGTH>4</sb:ID-LENGTH>
 <sb:DATA-SIZE>8</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Revision">
   <sb:SHORT-NAME>Revision</sb:SHORT-NAME>
   <sb:DESCRIPTION>SENT-Standard Revision Number</sb:DESCRIPTION>
   <sb:BIT-POSITION>7</sb:BIT-POSITION>
   <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>4.0</sb:MAX>
   <sb:ENUM-VALUES>
    <sb:ENUM INDEX="0" LABEL="Not defined"/>
    <sb:ENUM INDEX="1" LABEL="J2716 Rev 1"/>
    <sb:ENUM INDEX="2" LABEL="J2716 Rev 2"/>
    <sb:ENUM INDEX="3" LABEL="J2716 Rev 3"/>
   </sb:ENUM-VALUES>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Diagnostic Error Codes" STATE="ON">
 <sb:DESCRIPTION>used to diagnose the current SENT System</sb:DESCRIPTION>
 <sb:ID-VALUE>01</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Diagnostic">
   <sb:SHORT-NAME>Diagnostic Code</sb:SHORT-NAME>
   <sb:DESCRIPTION></sb:DESCRIPTION>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>4096</sb:MAX>
```

```
   <sb:ENUM-VALUES>
    <sb:ENUM INDEX="0" LABEL="No Error"/>
    <sb:ENUM INDEX="1" LABEL="Channel 1 out of range high"/>
    <sb:ENUM INDEX="2" LABEL="Channel 1 out of range low"/>
    <sb:ENUM INDEX="3" LABEL="Initialization Error (Channel 1)"/>
    <sb:ENUM INDEX="4" LABEL="Channel 2 out of range high"/>
    <sb:ENUM INDEX="5" LABEL="Channel 2 out of range low"/>
    <sb:ENUM INDEX="6" LABEL="Initialization Error (Channel 2)"/>
    <sb:ENUM INDEX="7" LABEL="Channel 1 and 2 Rationality Error"/>
    <sb:ENUM INDEX="1025" LABEL="Slow Channel Temperature out of range high"/>
    <sb:ENUM INDEX="1026" LABEL="Slow Channel Temperature out of range low"/>
    <sb:ENUM INDEX="1027" LABEL="Slow Channel Temperature initialization error"/>
    <sb:ENUM INDEX="1028" LABEL="Slow Channel Humidity out of range high"/>
    <sb:ENUM INDEX="1029" LABEL="Slow Channel Humidity out of range low"/>
    <sb:ENUM INDEX="1030" LABEL="Slow Channel Humidity initialization error"/>
    <sb:ENUM INDEX="1031" LABEL="Slow Channel Barometric Pressure out of range high"/>
    <sb:ENUM INDEX="1032" LABEL="Slow Channel Barometric Pressure out of range low"/>
    <sb:ENUM INDEX="1033" LABEL="Slow Channel Barometric Pressure initialization error"/>
   </sb:ENUM-VALUES>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Simu-Dual Throttle Position" STATE="ON">
 <sb:SHORT-NAME>DTP</sb:SHORT-NAME>
 <sb:DATA-SIZE>20</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>TPS1</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>19</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>UNSIGNED_INT</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>TPS2</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>7</sb:BIT-POSITION>
   <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
```

```
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Dual Throttle Position" STATE="OFF">
 <sb:SHORT-NAME>DTP</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>TPS1</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>UNSIGNED_INT</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>TPS2</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (16)" STATE="OFF">
 <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>16</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
```

```
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (16/8)" STATE="OFF">
 <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>16</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>7</sb:BIT-POSITION>
   <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (14/10)" STATE="OFF">
 <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>14</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
```

```
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>9</sb:BIT-POSITION>
   <sb:BIT-LENGTH>10</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Single Secure Sensor" STATE="OFF">
 <sb:SHORT-NAME>SSS</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>Ch1</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>Counter</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>256.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Pressure Sensor" STATE="OFF">
 <sb:SHORT-NAME>P</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>Pressure1</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
```

```
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>Pressure2</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
 </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Pressure and Temperature Sensor" STATE="OFF">
 <sb:SHORT-NAME>P/T</sb:SHORT-NAME>
 <sb:DATA-SIZE>24</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Channel_1">
   <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>23</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
  <sb:SIGNAL ID="Channel_2">
   <sb:SHORT-NAME>Temperature</sb:SHORT-NAME>
   <sb:DESCRIPTION>""</sb:DESCRIPTION>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>10000.0</sb:MAX>
   <sb:UNIT></sb:UNIT>
  </sb:SIGNAL>
```

```
    </sb:SIGNALS>
   </sb:FRAME>
   <sb:FRAME NAME="Pressure and Secure Sensor" STATE="OFF">
    <sb:SHORT-NAME>P/S</sb:SHORT-NAME>
    <sb:DATA-SIZE>24</sb:DATA-SIZE>
    <sb:SIGNALS>
     <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
     <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>Counter</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>11</sb:BIT-POSITION>
      <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
    </sb:SIGNALS>
   </sb:FRAME>
  </sb:FRAMES>
 </sb:LABEL-LIST-FILE>
```

12.12.5 SENT Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Data is decoded and displayed in the order of its reception. The "Decode results" box shows the detailed decoded data for each frame as it is received.

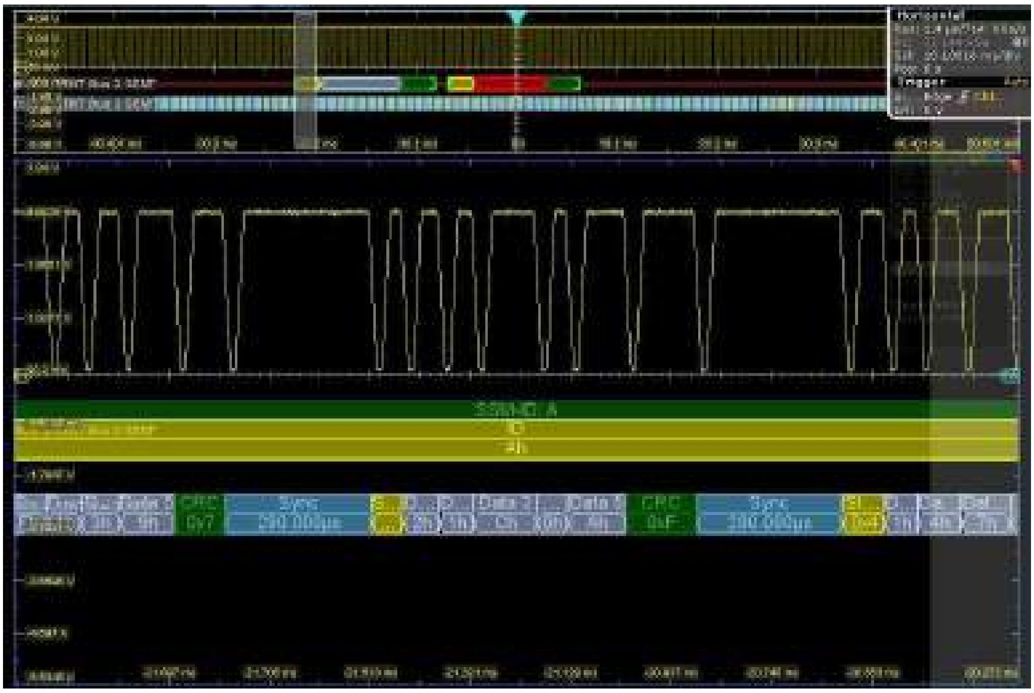


Figure 12-67: SENT decode results display

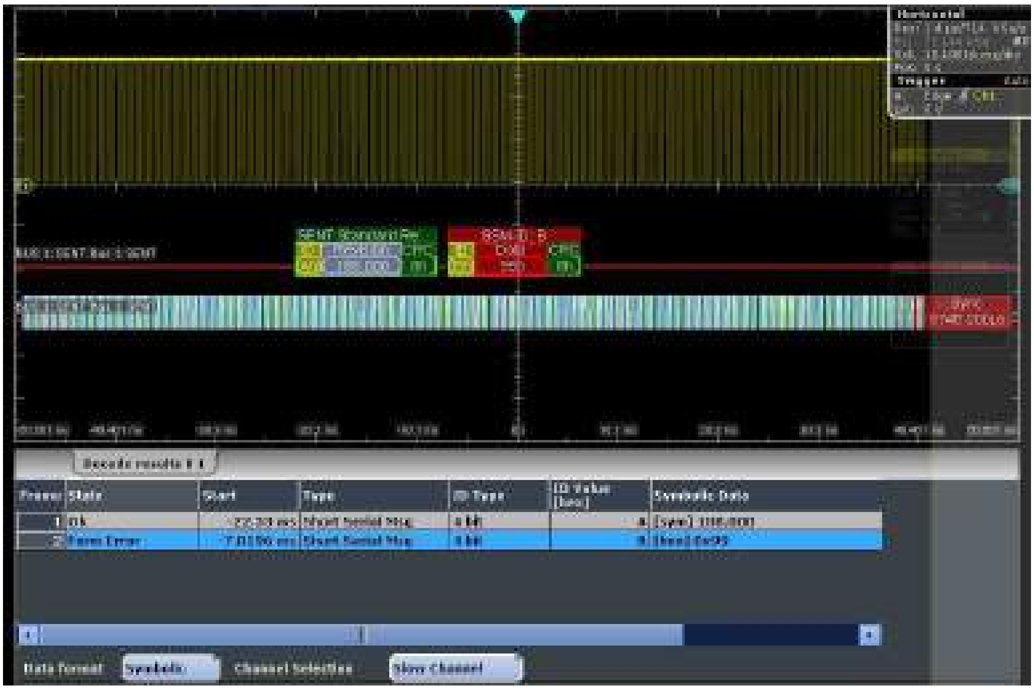


Figure 12-68: SENT decode results of a short serial message

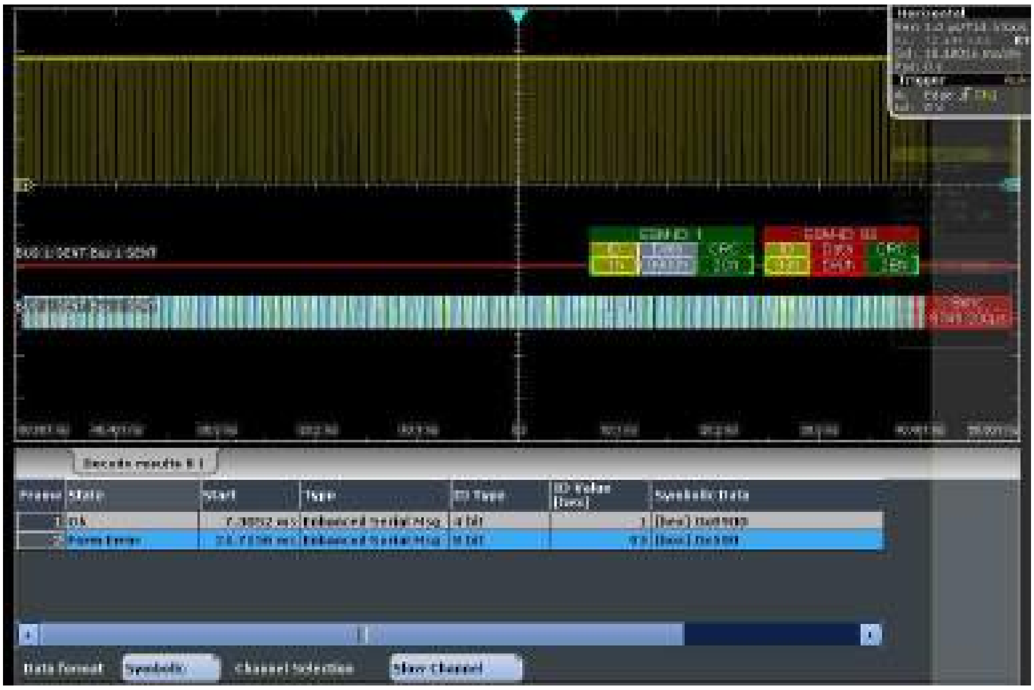


Figure 12-69: SENT decode results of an enhanced serial message

Table 12-15: Content of the decode result table

Column	Description
State	Overall state of the frame
Start	Time of frame start in relation to the trigger point
Type	Frame type
Sync Duration	Time of the synchronization pulse
Status [bin]	Status value
ID Type	Identifier type
ID Value [hex]	Identifier value
Data Nibbles	Value of the data nibble
Symbolic Data	Symbolic data value
Label	Symbolic label name defined in the label list
CRC [hex]	CRC sequence value
Pause Pulse [Ticks]	Number of the pulse pause clock

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.

3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.13.3, "Decode Results", on page 1751.

12.12.6 Search on Decoded SENT Data

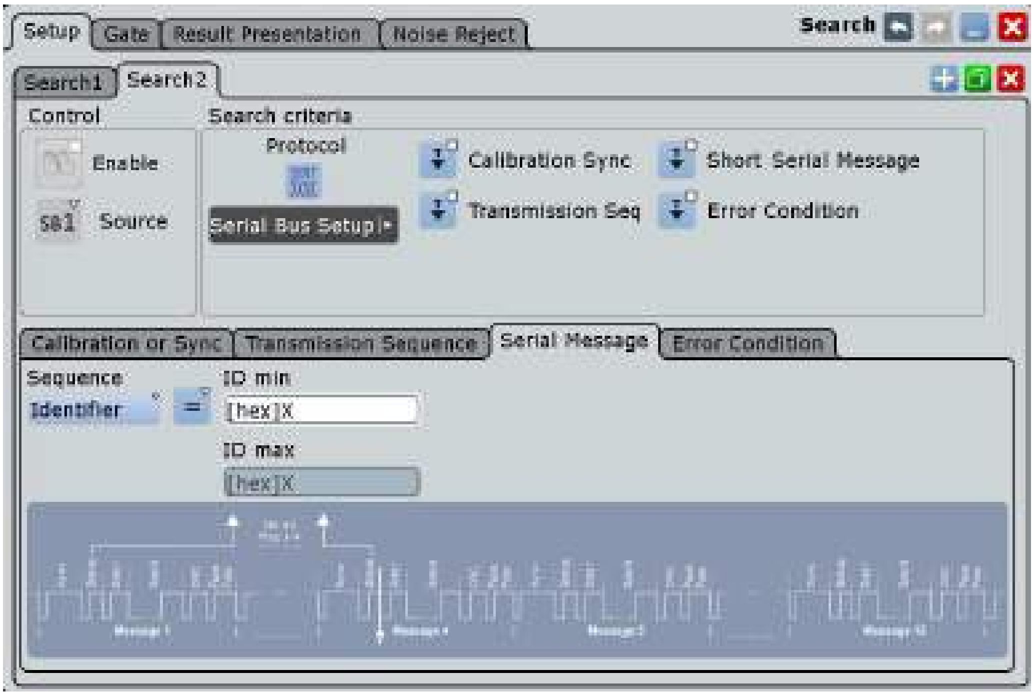
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.12.6.1 SENT Search Setup

Access: SEARCH > "Setup" tab



Source: SB1

Sequence: Identifier =

ID min: [hex]X

ID max: [hex]X

Search criteria
Enable the events to be searched for.

Unlike triggering, where you can trigger only on one defined event, you can search for various different events in one search.

"Calibration Sync"
Searches for the end of the "Calibration/Synchronization" sequence, i.e. the falling edge.
This setting does not require any input parameters.

"Transmission Seq"
Searches for the end of the status nibble in a single transmission sequence, or the end of the combination of the status and data nibble(s).
Description of the specific settings: "Transmission Sequence setup" on page 695

"Serial Message"
Searching on a serial message depends on the serial protocol selected with Serial Protocol > Short | Enhanced and the associated setting parameters:

- "Sequence > Identifier": searches for the end of the identifier nibble.
- "Sequence > ID+Data": searches for the end of the "ID and Data" nibble.

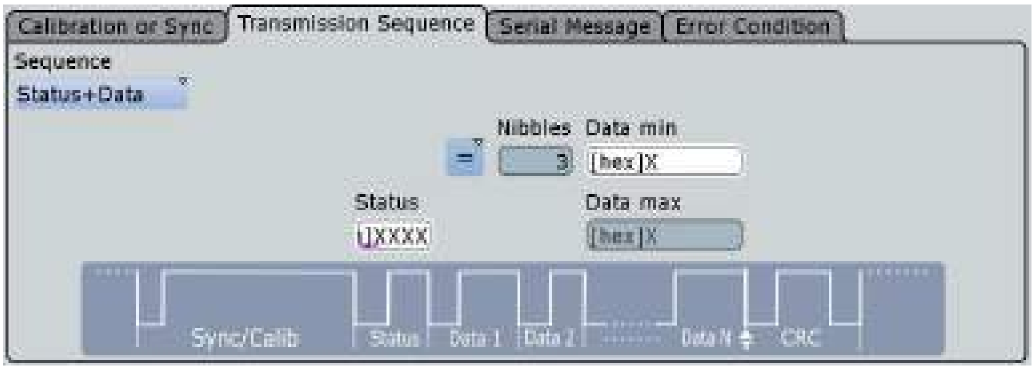
Description of the serial messages specific settings: "Serial Message setup" on page 697

"Error Condition"
Searches for the end of certain error events.
Description of trigger type specific settings: "Error conditions setup" on page 698

Remote command:
`SEARch:TRIGger:SENT:TYPE` on page 1759
`SEARch:TRIGger:SENT:CALibration` on page 1759
`SEARch:TRIGger:SENT:TRANsmission` on page 1760
`SEARch:TRIGger:SENT:SMSG` on page 1760
`SEARch:TRIGger:SENT:ERRor` on page 1760

Transmission Sequence setup
Configures the search conditions for the transmission sequence.

Note: The displayed parameters depend on the selected "Sequence". The instrument displays the data setting parameters when you select "Status+Data", see "Sequence" on page 696.
The search type specific conditions are the same as for the trigger type, see "Transmission Sequence setup" on page 676.



Sequence: Status+Data

Condition: =

Nibbles: 3

Data min: [hex]X

Status: []XXXX

Data max: [hex]X

Figure 12-70: Search setting parameters of a transmission sequence

Sequence ← Transmission Sequence setup
Selects the condition for searching in a single transmission sequence.

You can search for the end of the status nibble or the combination of the status and data nibble(s).

Remote command:
`SEARch:TRIGger:SENT:TTYPe` on page 1760

Status ← Transmission Sequence setup
Defines the data bits for the status nibble.

Remote command:
`SEARch:TRIGger:SENT:STATus` on page 1761

Condition ← Transmission Sequence setup
Selects the operator to define a specific data pattern or a data range.

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`SEARch:TRIGger:SENT:TDCN` on page 1761

Data Nibbles ← Transmission Sequence setup
Sets the number of data units in a single transmission sequence.

The maximum number of data nibbles is 6.

Remote command:
`BUS<m>:SENT:DNIBbles` on page 1743

Data min ← Transmission Sequence setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`SEARch:TRIGger:SENT:TDMN` on page 1762

Data max ← Transmission Sequence setup

The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`SEARch:TRIGger:SENT:TDMX` on page 1762

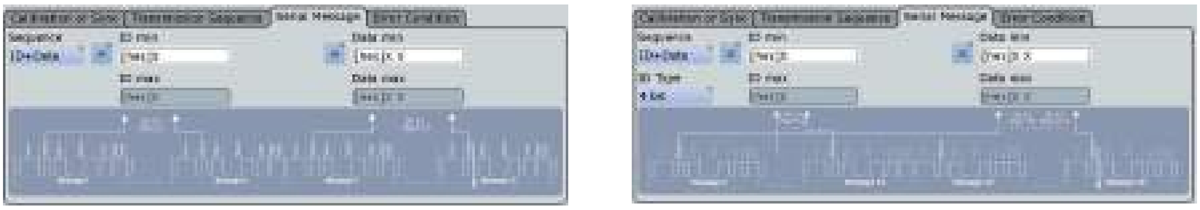
Serial Message setup

Configures the search conditions for a serial message.

Note: The displayed parameters depend on the selected "Sequence". The instrument indicates the data setting parameters when you select "ID+Data", see "Sequence" on page 697.

The description of the search type specific settings are the same as for the trigger type, see "Serial Message setup" on page 677.

Search setting parameters of the serial message types



Short Serial Message

Enhanced Serial Message

Sequence ← Serial Message setup

Selects the condition for searching in a serial message.

You can search for the end of an identifier nibble or the combination of the identifier and data nibble(s).

Remote command:

`SEARch:TRIGger:SENT:STYPe` on page 1762

ID Type ← Serial Message setup

Selects the message ID format for the enhanced serial message type.

You can select either 4 bit or 8 bit message ID.

Remote command:

`SEARch:TRIGger:SENT:SIDType` on page 1763

Identifier Condition ← Serial Message setup

Selects the operator to set a specific identifier or an identifier range.

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:

`SEARch:TRIGger:SENT:SICN` on page 1763

Identifier min ← Serial Message setup

Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit).

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:

`SEARch:TRIGger:SENT:SIMN` on page 1763

Identifier max ← Serial Message setup

The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`SEARch:TRIGger:SENT:SIMX` on page 1764

SSM Data Condition ← Serial Message setup

Selects the operator to set a specific data pattern or a data range.

The available operators:

- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:

`SEARch:TRIGger:SENT:SDCN` on page 1764

Data min ← Serial Message setup

Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:

`SEARch:TRIGger:SENT:SDMN` on page 1764

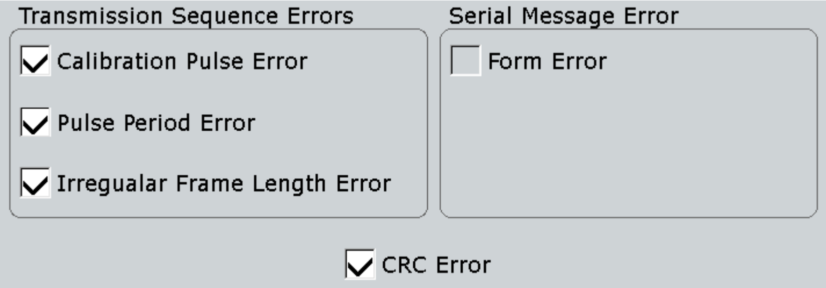
Data max ← Serial Message setup

The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`SEARch:TRIGger:SENT:SDMX` on page 1765

Error conditions setup



Transmission Sequence Errors

☑ Calibration Pulse Error

☑ Pulse Period Error

☑ Irregualar Frame Length Error

Serial Message Error

☐ Form Error

☑ CRC Error

Performs the search on one or more of the following error events:

- "Transmission sequence errors"
  - "Calibration Pulse Error"
    Searches for calibration pulse errors.
  - "Pulse Period Error"
    Searches for pulse period errors in a transmission sequence.
  - "Irregular Frame Length Error"
    Searches for irregular frame length errors in a transmission sequence.
- Serial message error
  - "Form Error"
    Searches for format errors in serial messages.
- "CRC Error"
  Searches for errors in the complete data transmission.

Remote command:
`SEARch:TRIGger:SENT:PULSeerror` on page 1765
`SEARch:TRIGger:SENT:PPERioderror` on page 1765
`SEARch:TRIGger:SENT:FORMerror` on page 1766
`SEARch:TRIGger:SENT:CRCerror` on page 1766
`SEARch:TRIGger:SENT:IRFLength` on page 1765

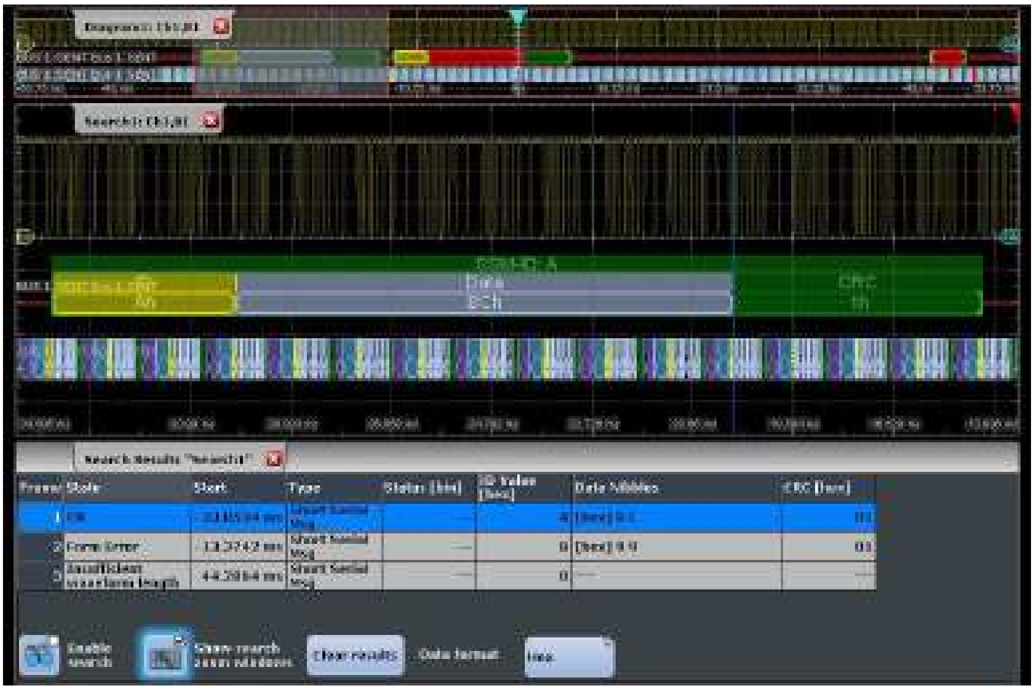
12.12.6.2 SENT Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437



Frame	State	Start	Type	Status [bin]	ID Value [hex]	Data Nibbles	CRC [hex]
1	OK	[illegible] ms	Short Serial Msg	—	4	[hex] [illegible]	0[illegible]
2	Form Error	13.2742 ms	Short Serial Msg	—	0	[hex] 9 9	0[illegible]
3	Insufficient waveform length	44.2864 ms	Short Serial Msg	—	0	—	—

Figure 12-71: Search on the Status nibble in a SENT transmission signal

The columns in the search result table are the same as in the decoding table, see Chapter 12.12.5, "SENT Decode Results", on page 691.

Remote commands:

- `SEARch:RESult:SENT:FCOunt?` on page 1767
- `SEARch:RESult:SENT:FRAMe<m>:STATus?` on page 1770
- `SEARch:RESult:SENT:FRAMe<m>:STARt?` on page 1770
- `SEARch:RESult:SENT:FRAMe<m>:STOP?` on page 1770
- `SEARch:RESult:SENT:FRAMe<m>:DATA?` on page 1767
- `SEARch:RESult:SENT:FRAMe<m>:CSValue?` on page 1767
- `SEARch:RESult:SENT:FRAMe<m>:IDTYpe?` on page 1768
- `SEARch:RESult:SENT:FRAMe<m>:IDValue?` on page 1768
- `SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:STATe?` on page 1768
- `SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:VALue?` on page 1769
- `SEARch:RESult:SENT:FRAMe<m>:PAPTicks?` on page 1769
- `SEARch:RESult:SENT:FRAMe<m>:SCOM?` on page 1769
- `SEARch:RESult:SENT:FRAMe<m>:SDATa?` on page 1769
- `SEARch:RESult:SENT:FRAMe<m>:SYMBol?` on page 1771
- `SEARch:RESult:SENT:FRAMe<m>:SYNCduration?` on page 1771
- `SEARch:RESult:SENT:FRAMe<m>:TYPE?` on page 1771

12.13 RFFE (Option R&S RTO-K40)

Radio Frequency Front-End (RFFE) control interface is a serial interface specified by the Mobile Industry Processor Interface (MIPI) alliance. The RFFE interface is designed to control RF front-end components in mobile terminals.

12.13.1 The RFFE Protocol

The RFFE interface is specified in the "MIPI® Alliance Specification for RF Front-End Control Interface". The RFFE interface is used by the radio frequency front-end interface chips in most LTE-Advanced platforms and in smart phones in general. RFFE is a replacement for existing standards like SPI and I²C that do no meet performance requirements.

Bus structure

RFFE is a two-wire, serial interface that connects up to 4 master devices (Radio Frequency IC, RFIC) to up to 15 slaves (front-end modules, FEM) on a single RFFE bus. A slave device has read-write capability, or it is write-only. Only one of the masters is the active master (bus owner master, BOM), which can initiate command sequences on the bus.

The interface has two lines: one clock signal (SCLK) controlled by the master, and a serial bidirectional data signal (SDATA). Furthermore, a VIO supply/reference voltage from a common source is applied to all components on the bus.

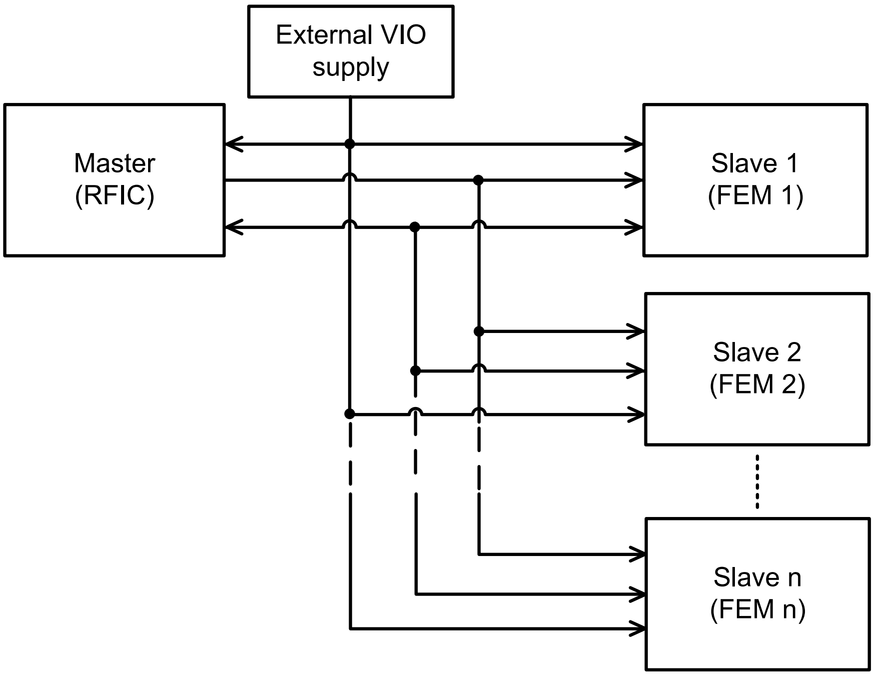


Figure 12-72: RFFE bus structure with external VIO supply

Command sequences

Protocol messages are called command sequences in RFFE. The standard defines a variety of command sequences to accomplish read and write access to slaves and to non-active masters. Command sequences are initiated by the BOM master on the SDATA line.

In general, a command sequence consists of:

- Sequence start condition (SSC)
  Two bits: 1 followed by 0 on SDATA while SCLK is at logic level zero.
- Command frame
  Consist of a 4-bit slave address field (SA), followed by 8 command payload bits and a single parity bit.
- Address and/or data frames, depending on the command sequence
  A frame consists of 8 data bits or 8 register address bits, followed by a single parity bit. The number of address and data frames varies depending on the command sequence type.
- Bus park cycle (BP)
  A BP cycle is sent at the end of a command sequence, and when the device transfers control of SDATA to another device.

Between the end of a command sequence and the beginning of a new command sequence, the bus is in idle condition at least for 10 ns.

The bits are sent MSB first.

<table>
<tr><td rowspan="3">SSC</td><td colspan="2">Command frame</td><td colspan="2">Address and data frames</td><td rowspan="3">BP</td></tr>
<tr><td>SA</td><td>Command payload</td><td>[Address frames]</td><td>[Data frames]</td></tr>
<tr><td>4 bits</td><td>8 bits + P</td><td>8 bits + P</td><td>8 bits + P</td></tr>
</table>

Figure 12-73: General structure of a RFFE Write command sequence

<table>
<tr><td rowspan="3">SSC</td><td colspan="2">Command frame</td><td colspan="3">Address and data frames</td><td rowspan="3">BP</td></tr>
<tr><td>SA</td><td>Command payload</td><td>[Address frames]</td><td rowspan="2">BP</td><td>[Data frames]</td></tr>
<tr><td>4 bits</td><td>8 bits + P</td><td>8 bits + P</td><td>8 bits + P</td></tr>
</table>

Figure 12-74: General structure of a RFFE Read command sequence

Trigger

The R&S RTO uses a hardware-based trigger to trigger on various parts of slave device messages, to trigger at maximum bus speed and on frame gaps. The data and clock lines must be connected to the input channels. Triggering on math and reference waveforms is not possible.

You can trigger on:

- Start of command sequence (SSC). In addition, you can specify a slave address.
- End of command sequence). In addition, you can specify a slave address.
- Various errors, for example, parity and bus park error
- Read and write command sequences between the BOM and the slaves.

Within a command sequence, you can trigger on specific parts of the message:

- Slave address
- Byte count
- Register address
- Data word

Search

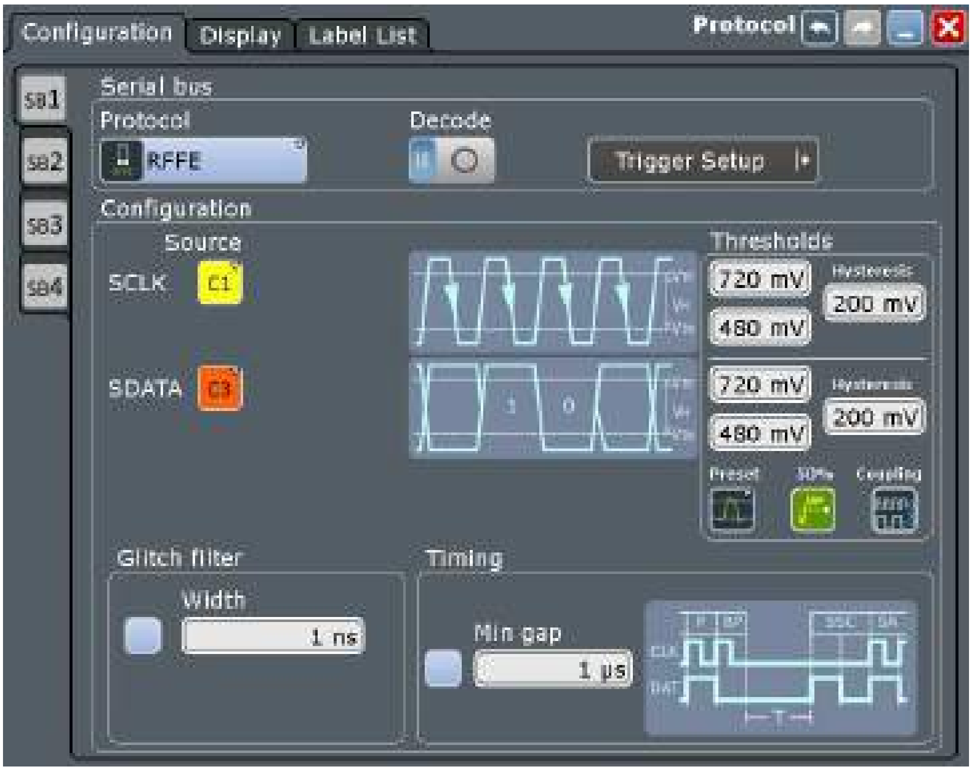
Using the search functionality, you can find various events in the acquired and decoded data. You can find the same events which you also can trigger on. In addition, you can find command sequences of master-to master communication and "interrupt summary and identification" command sequences.

12.13.2 RFFE Configuration

12.13.2.1 RFFE Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *RFFE*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

SCLK Source

Sets the source of the clock line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:RFFE:CLOCk:SOURce` on page 1772

SDATA Source

Sets the source of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:RFFE:DATA:SOURce` on page 1772

Thresholds

Set the threshold values for digitization of signals for each line: the positive going threshold (V_{TP}, upper value), the negative going threshold (V_{TN}, lower value), and the hysteresis. The hysteresis is the difference of V_{TP} and V_{TN}.

If the signal value on the line is higher than the positive going threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the negative going threshold.

There are several ways to set the thresholds:

- "Preset"
  Sets default threshold voltages for 1.2 V or 1.8 V bus. The value is set to "Manual" if at least one threshold was entered manually.
- Manual setup
  Enter the values directly in the fields. Note that the three values are dependent, so it is sufficient to enter two values for each line.
- "50%"
  Automatic setup: The instrument measures the signal voltages and calculates the thresholds.
- "Coupling"
  If enabled, the SDATA thresholds are set to the SCLK threshold values.

Remote command:
`BUS<m>:RFFE:PRESet` on page 1772
`BUS<m>:RFFE:CLOCk:THReshold:HIGH` on page 1774

`BUS<m>:RFFE:CLOCk:THReshold:LOW` on page 1774
`BUS<m>:RFFE:CLOCk:THReshold:HYSTeresis` on page 1774
`BUS<m>:RFFE:DATA:THReshold:HIGH` on page 1773
`BUS<m>:RFFE:DATA:THReshold:LOW` on page 1773
`BUS<m>:RFFE:DATA:THReshold:HYSTeresis` on page 1774
`BUS<m>:RFFE:COUPling` on page 1773
`BUS<m>:SETReflevels` on page 1495

Glitch filter
Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

The "Width" field sets the maximum glitch width to be ignored.

Remote command:
`BUS<m>:RFFE:GFILter` on page 1775
`BUS<m>:RFFE:GFWidth` on page 1775

Timing
Defines the idle time between the Bus Park Cycle (BP) and Sequence Start Condition (SSC).

You can define a minimum time "Min gap". The standard defines a minimum of 10 ns to separate two subsequent command sequences.

Remote command:
`BUS<m>:RFFE:MINGap:SELect` on page 1775
`BUS<m>:RFFE:MINGap:TIME` on page 1776

12.13.2.2 Configuring RFFE Signals

For details on configuration settings, see Chapter 12.13.2.1, "RFFE Configuration Settings", on page 703.

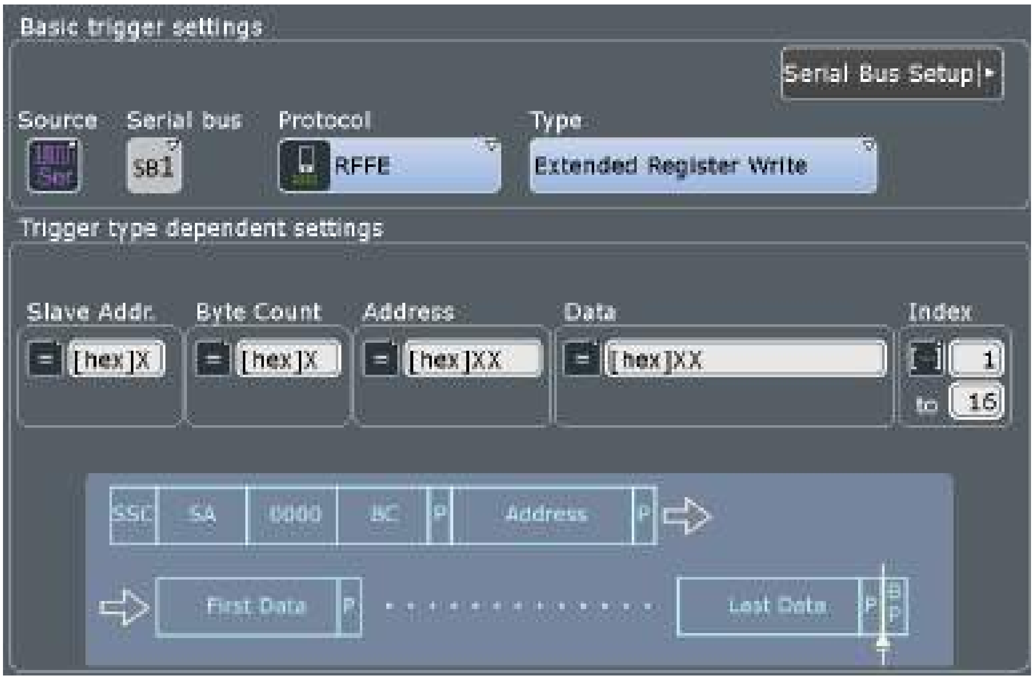
1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "RFFE".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "SCLK" button, and select the waveform of the clock line.
7. Tap the "SDATA" button, and select the waveform of the data line.
8. Set the logical thresholds using one of these ways:
    - Tap "Preset" and select the reference voltage of the bus.
    - Tap "50%" to setup thresholds by means of automatic measurements.
    - To couple the SDATA thresholds to the clock settings, tap "Coupling".
    - If the default settings and the automatic setup do not fit, enter the threshold and values into the corresponding fields. Hysteresis is adjusted by the instrument.

9. If the signal has glitches which can distort the decoding, enable the glitch filter and set the glitch width.
10. Enable "Decode".

12.13.3 RFFE Trigger

12.13.3.1 RFFE Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = RFFE"



Basic trigger settings

Source: Serial
Serial bus: SB1
Protocol: RFFE
Type: Extended Register Write

Trigger type dependent settings

Slave Addr.: = [hex]X
Byte Count: = [hex]X
Address: = [hex]XX
Data: = [hex]XX
Index: 1 to 16

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

Selects the trigger type for RFFE analysis.

The instrument triggers always at the end of the met trigger criteria.

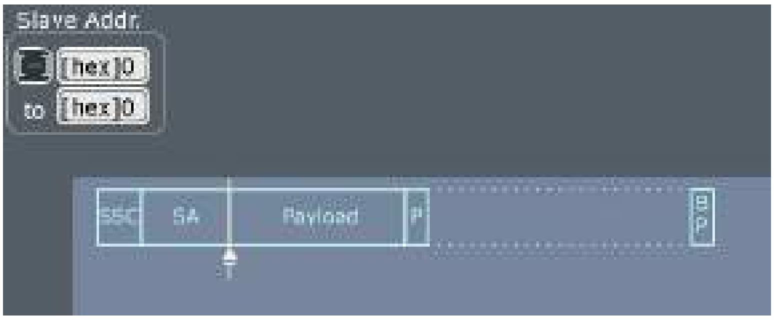
Remote command:

`TRIGger<m>:RFFE:TYPE` on page 1777

Sequence Start ← Type
Triggers on the beginning of a command sequence, after the slave address. The SSC is a 1 followed by 0 on SDATA line while SCLK is at logic level zero.

Optionally, you can specify a slave address pattern or a slave address range to trigger only on command sequences that are sent to these slaves.

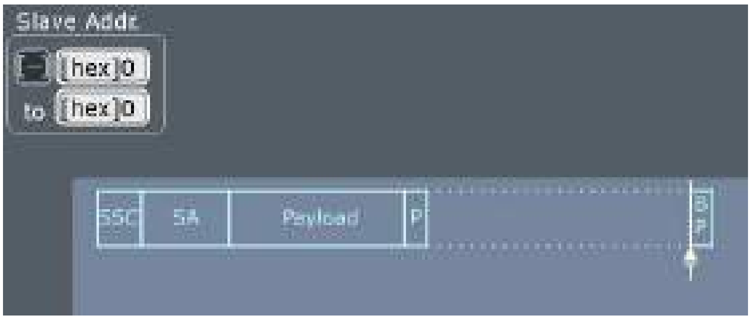
See: "Slave Addr." on page 711.



Sequence Stop ← Type
Triggers on the end of a command sequence, on the bus park cycle.

Optionally, you can specify a slave address pattern or a slave address range to trigger only on command sequences that are sent to these slaves.

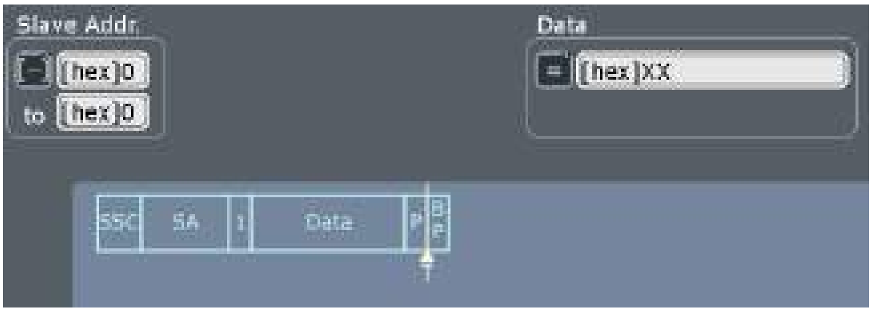
See: "Slave Addr." on page 711.



Register 0 Write ← Type
Triggers on "Register 0 Write" command sequences. This sequence sends 7 data bits in the command payload.

You can refine the trigger condition:

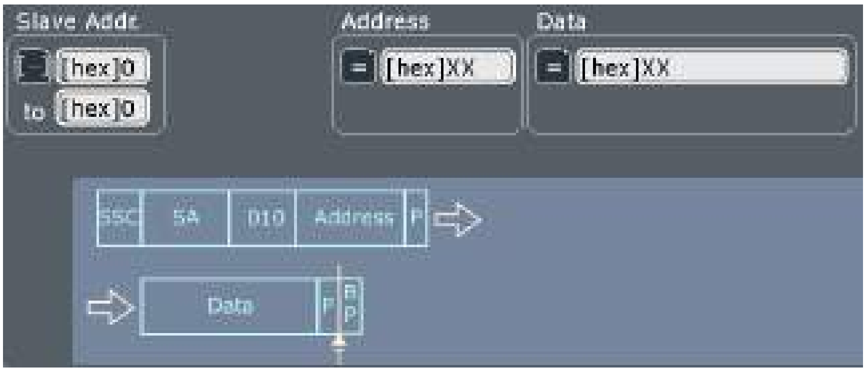
- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 711.
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 713.



Register Write ← Type
Triggers on "Register Write" command sequences. This sequence sends the register address in the command payload, and sends one data frame.

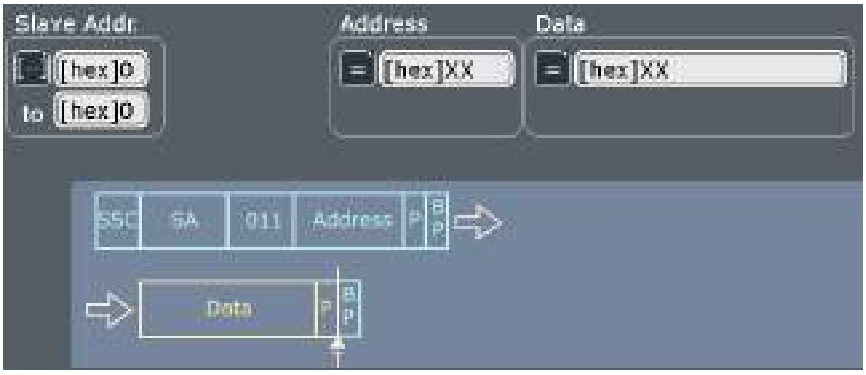
You can refine the trigger condition:

- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 711.
- Set a register address condition to trigger only on command sequences that write data to the specified register.
  See: "Address" on page 712.
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 713.



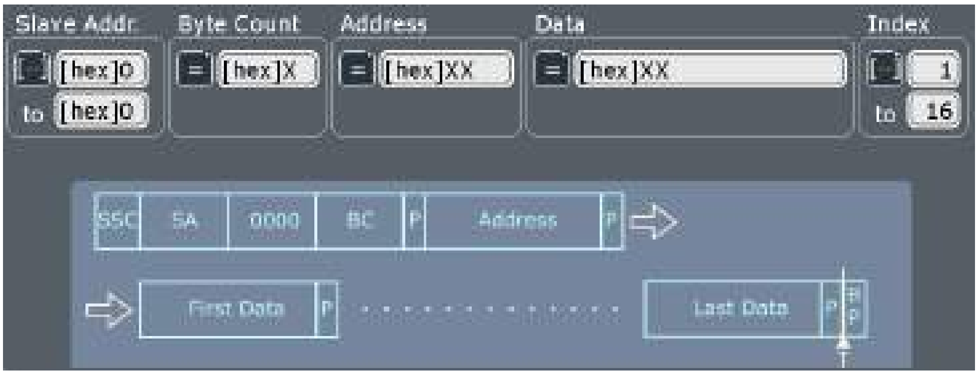
Register Read ← Type
Triggers on "Register Read" command sequences. This sequence sends the register address in the command payload, and reads back one data frame.

You can refine the trigger condition using the same settings as for the "Register Write" command sequence, see "Register Write" on page 708.



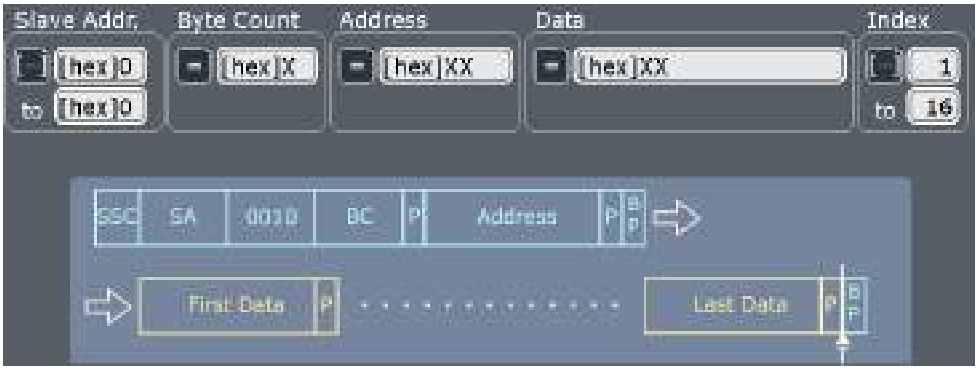
Extended Register Write ← Type
Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by one address frame with the address of the first extended register, and up to 16 data frames.

You can refine the trigger condition:
- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 711
- Set a byte count condition to trigger only on command sequences that send the specified number of data frames.
  See: "Byte count" on page 712
- Set a register address condition to trigger only on command sequences that write data to the specified register.
  See: "Address" on page 712
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 713 and "Index" on page 713



Extended Register Read ← Type
Triggers on "Extended Register Read" command sequences. This sequence sends the byte count of data frames in the command payload, followed by one address frame with the address of the first extended register, and reads back up to 16 data frames.

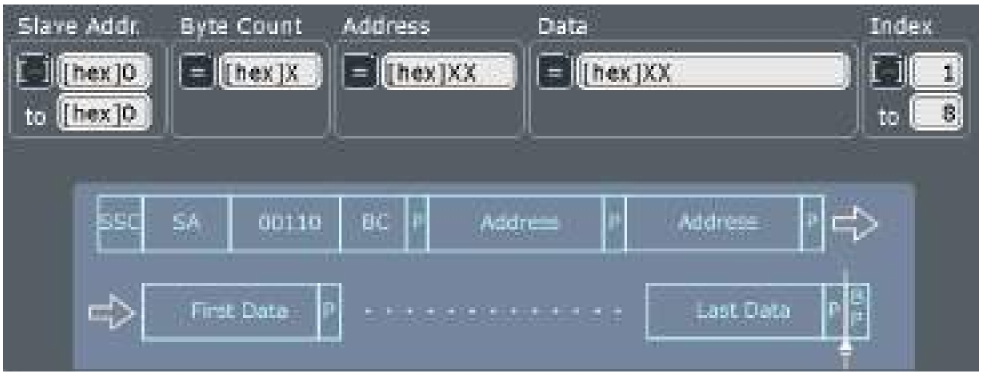
You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 709.



Extended Register Write Long ← Type

Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by 2 address frames with the address of the first extended register, and up to 8 data frames.

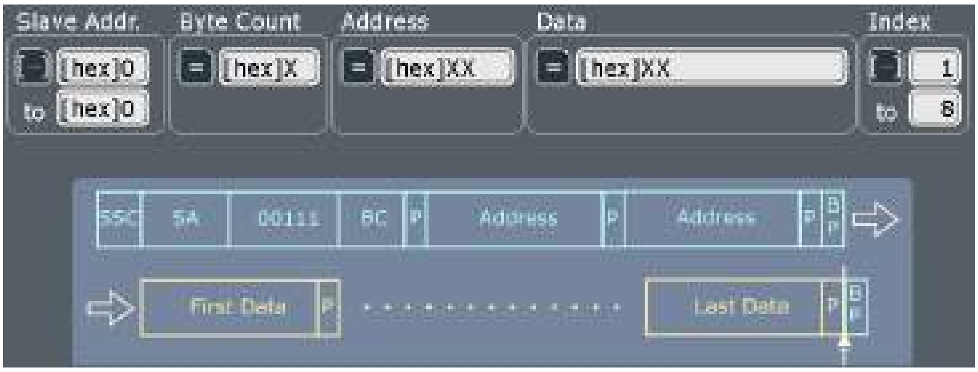
You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 709.



Extended Register Read Long ← Type

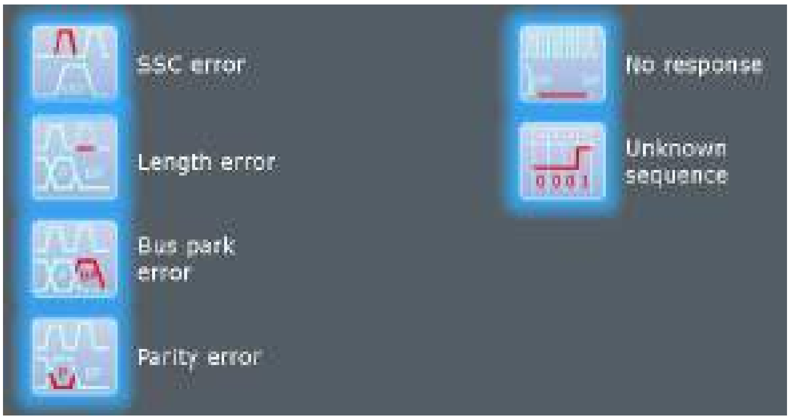
Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by 2 address frames with the address of the first extended register, and reads back up to 8 data frames.

You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 709.



Error conditions ← Type

Triggers if at least one of the selected errors occurs in a frame. The instrument triggers on the first detected error.



"SSC error"	Triggers when no valid SSC sequence has been found after the idle time. The instrument triggers at the invalid sequence.
"Length error"	Triggers on an incorrect length of the command sequence - when additional or missing bits are detected and the sequence of bits is not as expected.
"Bus park error"	Triggers on an incorrect bus park cycle - when the instrument expects a low bit in bus park but detects high bit.
"Parity error"	Triggers on incorrect parity bits.
"No response"	Triggers on any No Response Frame. All 9 bits of a No Response Frame, including the parity bit, are zero.
"Unknown sequence"	Triggers when the instrument cannot detect any supported command sequence.

Remote command:
`TRIGger<m>:RFFE:ERRor:SSC` on page 1781
`TRIGger<m>:RFFE:ERRor:LENGth` on page 1781
`TRIGger<m>:RFFE:ERRor:BP` on page 1780
`TRIGger<m>:RFFE:ERRor:PARity` on page 1781
`TRIGger<m>:RFFE:ERRor:NOResponse` on page 1781
`TRIGger<m>:RFFE:ERRor:USEQuence` on page 1781

Slave Addr.

Defines the addess of the slave. The slave address setup consists of the condition and one or two address patterns.

Slave Addr.: [hex]0 to [hex]0
Byte Count: [hex]0 to [hex]0
Address: [hex]00 to [hex]00
Data: [hex]00 to [hex]00
Index: 1 to 16

"Condition"	Sets the operator to trigger on a specific address pattern ("Equal" or "Not equal") or an address range.

"Slave Address (Min)"	Defines the slave address pattern for all operators that require one pattern.
"Slave Adress (Max)"	Defines the second address pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:RFFE:SADD:CONDition` on page 1779
`TRIGger<m>:RFFE:SADD:MIN` on page 1780
`TRIGger<m>:RFFE:SADD:MAX` on page 1780

Address

Defines the register address. The register address setup consists of the condition and one or two address patterns.

"Condition"	Sets the operator to trigger on a specific address pattern ("Equal" or "Not equal") or an address range.
"Address (Min)"	Defines the register address pattern for all operators that require one pattern.
"Adress (Max)"	Defines the second address pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:RFFE:ADDRess:CONDition` on page 1779
`TRIGger<m>:RFFE:ADDRess:MIN` on page 1780
`TRIGger<m>:RFFE:ADDRess:MAX` on page 1780

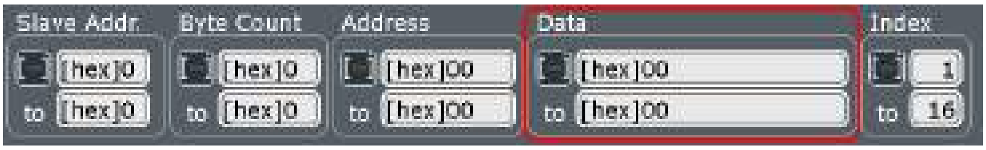
Byte count

Sets the number of data frames to be read or written in the command sequence. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame.

"Condition"	Sets the operator to trigger on a specific byte count ("Equal" or "Not equal") or an byte count range range.
"Byte count (Min)"	Defines the byte count for all operators that require one count setting.
"Byte count (Max)"	Defines the second byte count value that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:RFFE:BCOunt:CONDition` on page 1779
`TRIGger<m>:RFFE:BCOunt:MIN` on page 1780
`TRIGger<m>:RFFE:BCOunt:MAX` on page 1780

Data
Defines the data trigger condition. The data setup consists of the condition and one or two data patterns.



To define on which data frames of the sequence you want to trigger, use the Index settings.

"Condition"	Sets the operator to trigger on a specific data pattern ("Equal" or "Not equal") or an data range.
"Data (Min)"	Defines the data pattern for all operators that require one pattern.
"Data (Max)"	Defines the second data pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:RFFE:DATA:DCON` on page 1779
`TRIGger<m>:RFFE:DATA:DMIN` on page 1780
`TRIGger<m>:RFFE:DATA:DMAX` on page 1780

Index
Defines which data frames are relevant for the trigger. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame.

The index allows you to check for a certain bit pattern at a certain position in the byte sequence. Futhermore, you can trigger on the occurence of a certain bit pattern within a data range.

To trigger on any data byte that fulfills the data pattern settings, set the index to XX.

"Condition"	Sets the operator to trigger on a specific data frame ("Equal") or an data frame range.
"Data (Min)"	Defines the frame index of the data pattern for all operators that require one index.
"Data (Max)"	Defines the frame index of the last data pattern that is required to specify a range with condition "In range". The instrument adjusts this value If you enter a data pattern that is longer than the index range.

Remote command:
`TRIGger<m>:RFFE:DATA:ICON` on page 1779
`TRIGger<m>:RFFE:DATA:IMIN` on page 1780
`TRIGger<m>:RFFE:DATA:IMAX` on page 1780

12.13.3.2 Triggering on RFFE Signals

Prerequesites: An RFFE bus is configured, see Chapter 12.13.2, "RFFE Configuration", on page 703, and "Decode" is enabled.

1. Press the TRIGGER key.
   If the "Protocol Configuration" dialog box is open, you can tap the "Trigger Setup" button.
2. Tap the "Source" button and select the "Serial bus" trigger source.
3. Select the serial bus that is set to RFFE.
4. Select the "Trigger type".
5. To refine the trigger settings, configure additional settings, which are available for many trigger types.
   For details, see Chapter 12.13.3.1, "RFFE Trigger Settings", on page 706.

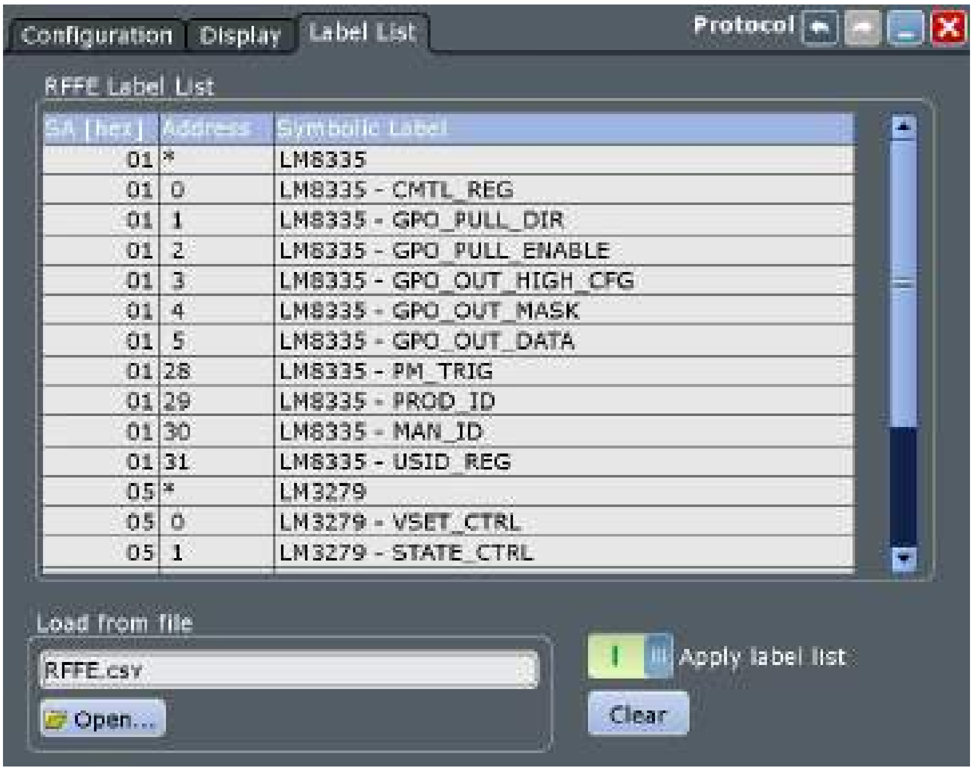
12.13.4 RFFE Label List

Label lists are protocol-specific. A label list file for RFFE contains slave addresses and/or register addresses and their symbolic names:

- "SA": slave address (SID in the labal list file)
- Address: register address.
- "Symbolic label": symbolic name as combination of the slave name (SID text) and the address name (Address text), specifying the device function

Example: RFFE label list file

```
# Labels for RFFE protocol
#   Column order: SID, SID text, Address, Address text
# ---------------------------------------------------------------------------
@PROTOCOL_NAME = rffe
0x01,LM8335
0x01,LM8335,0x00,CMTL_REG
0x01,LM8335,0x01,GPO_PULL_DIR
0x01,LM8335,0x02,GPO_PULL_ENABLE
0x01,LM8335,0x03,GPO_OUT_HIGH_CFG
0x01,LM8335,0x04,GPO_OUT_MASK
0x01,LM8335,0x05,GPO_OUT_DATA
0x01,LM8335,0x1C,PM_TRIG
0x01,LM8335,0x1D,PROD_ID
0x01,LM8335,0x1E,MAN_ID
0x01,LM8335,0x1F,USID_REG
0x05,LM3279
0x05,LM3279,0x00,VSET_CTRL
0x05,LM3279,0x01,STATE_CTRL
0x05,LM3279,0x02,GPO_CTRL
0x05,LM3279,0x1C,PM_TRIG
0x05,LM3279,0x1D,PROD_ID
0x05,LM3279,0x1E,MAN_ID
0x05,LM3279,0x1F,USID_REG
0x0A,Test
```



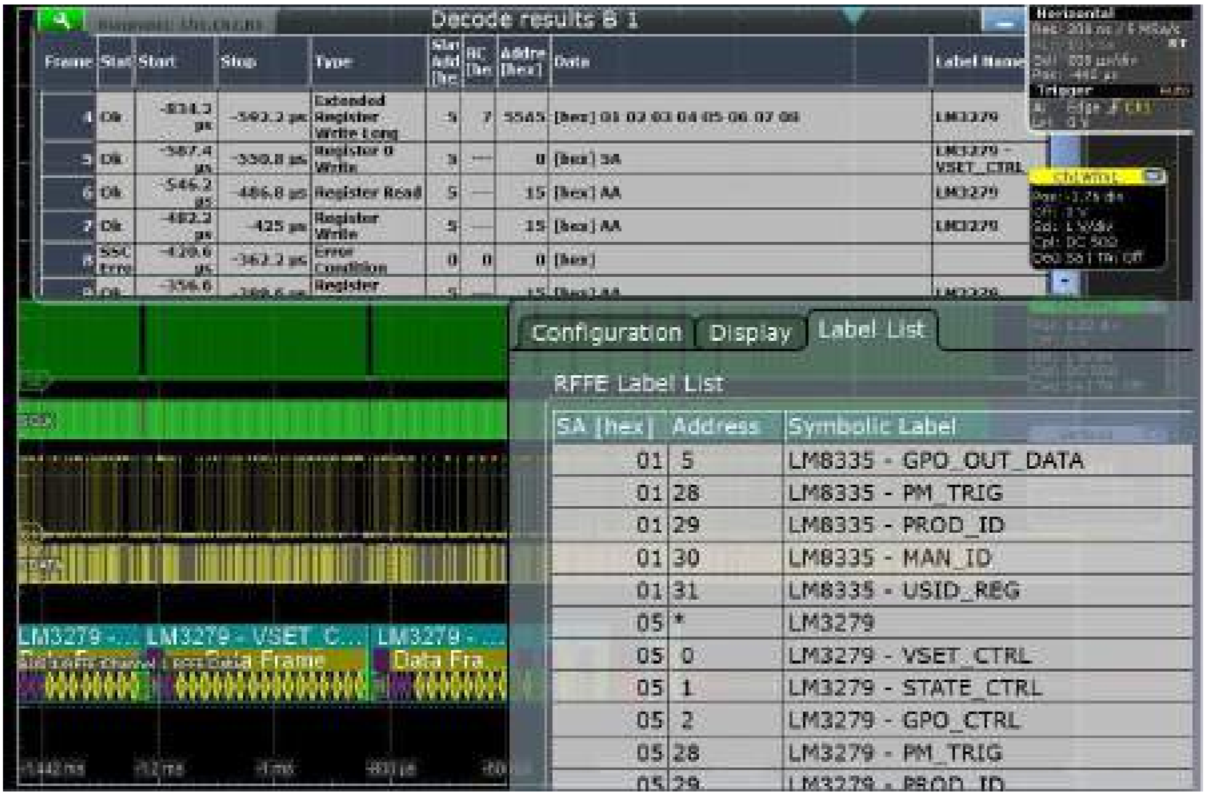
RFFE Label List

SA [hex]	Address	Symbolic Label
01	*	LM8335
01	0	LM8335 - CMTL_REG
01	1	LM8335 - GPO_PULL_DIR
01	2	LM8335 - GPO_PULL_ENABLE
01	3	LM8335 - GPO_OUT_HIGH_CFG
01	4	LM8335 - GPO_OUT_MASK
01	5	LM8335 - GPO_OUT_DATA
01	28	LM8335 - PM_TRIG
01	29	LM8335 - PROD_ID
01	30	LM8335 - MAN_ID
01	31	LM8335 - USID_REG
05	*	LM3279
05	0	LM3279 - VSET_CTRL
05	1	LM3279 - STATE_CTRL

Load from file: RFFE.csv

Apply label list: I

Figure 12-75: RFFE label list in R&S RTO



Decode results B 1

Frame	Stat	Start	Stop	Type	Slav Add [he	BC [he	Addre [hex]	Data	Label Name
4	Ok	-834.3 µs	-593.2 µs	Extended Register Write Long	5	7	5565	[hex] 01 02 03 04 05 06 07 08	LM3279
5	Ok	-587.4 µs	-330.8 µs	Register 0 Write	5	---	0	[hex] 3A	LM3279 - VSET_CTRL
6	Ok	-546.2 µs	-486.8 µs	Register Read	5	---	15	[hex] AA	LM3279
7	Ok	-482.2 µs	-425 µs	Register Write	5	---	15	[hex] AA	LM3279
8	SSC Erro	-420.6 µs	-362.2 µs	Error Condition	0	0	0	[hex]	

RFFE Label List

SA [hex]	Address	Symbolic Label
01	5	LM8335 - GPO_OUT_DATA
01	28	LM8335 - PM_TRIG
01	29	LM8335 - PROD_ID
01	30	LM8335 - MAN_ID
01	31	LM8335 - USID_REG
05	*	LM3279
05	0	LM3279 - VSET_CTRL
05	1	LM3279 - STATE_CTRL
05	2	LM3279 - GPO_CTRL
05	28	LM3279 - PM_TRIG
05	29	LM3279 - PROD_ID

Figure 12-76: Decoded RFFE signal with applied label list and results table

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:RFFE:SEQuence<n>:SYMBol?` on page 1785

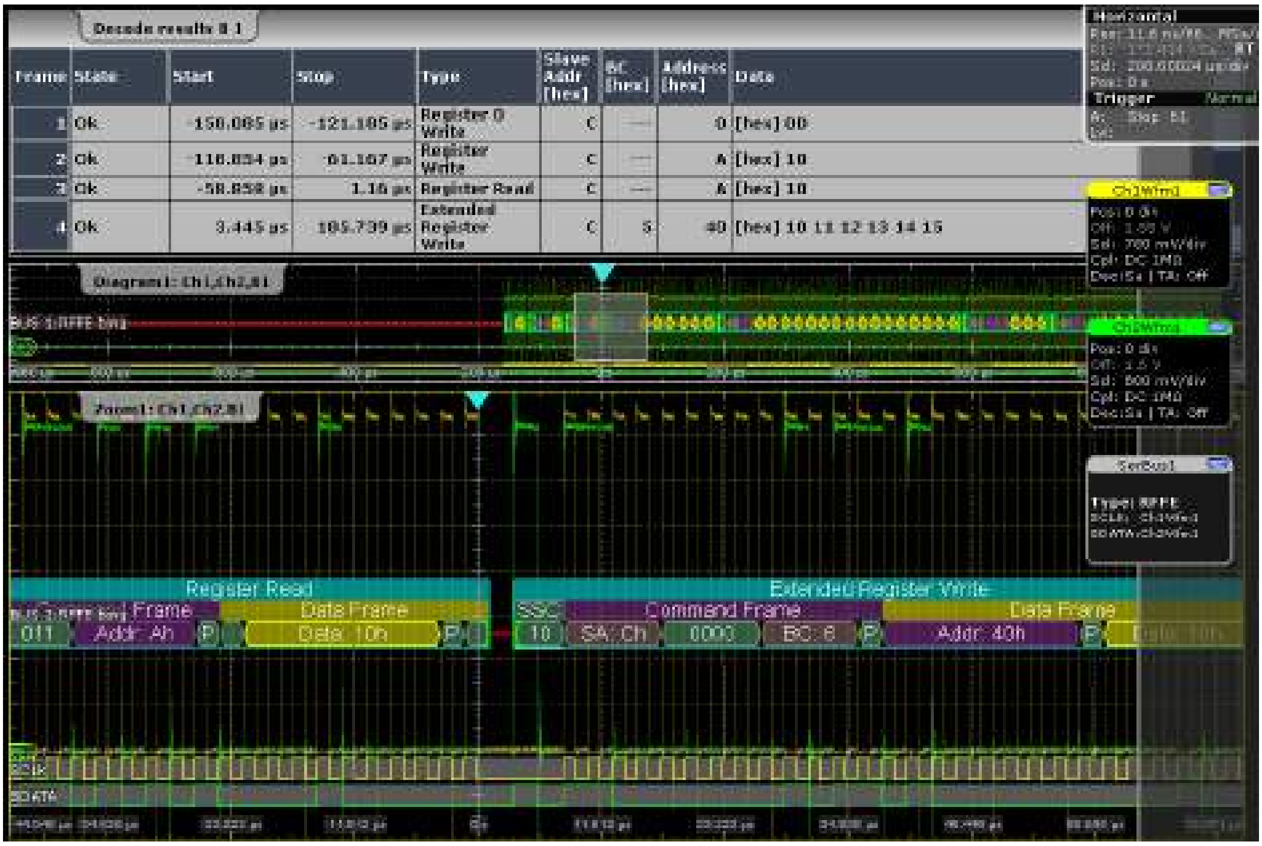
12.13.5 RFFE Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.



Decode results B 1

Frame	State	Start	Stop	Type	Slave Addr [hex]	BC [hex]	Address [hex]	Data
1	Ok	-150.085 µs	-121.105 µs	Register 0 Write	C	—	0	[hex] 00
2	Ok	-118.834 µs	-61.167 µs	Register Write	C	—	A	[hex] 10
3	Ok	-58.858 µs	1.16 µs	Register Read	C	—	A	[hex] 10
4	Ok	3.445 µs	105.739 µs	Extended Register Write	C	5	40	[hex] 10 11 12 13 14 15

Figure 12-77: Decoded RFFE signal and results table. The signal is triggered on sequence stop. A part of the decoded data is shown in a zoom diagram.

Table 12-16: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of command sequence start (SSC)
Stop	Time of command sequence end
Type	Type of the command sequence
Slave address	Address of the slave (hex value)
BC	Byte count (decimal value)
Address	Register address (hex value)
Data	Values of the data bytes. The data format is selected below the table.
Label name	Symbolic name of the address if a label list is applied.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.14.3, "Decode Results", on page 1782.

12.13.6 Search on Decoded RFFE Data

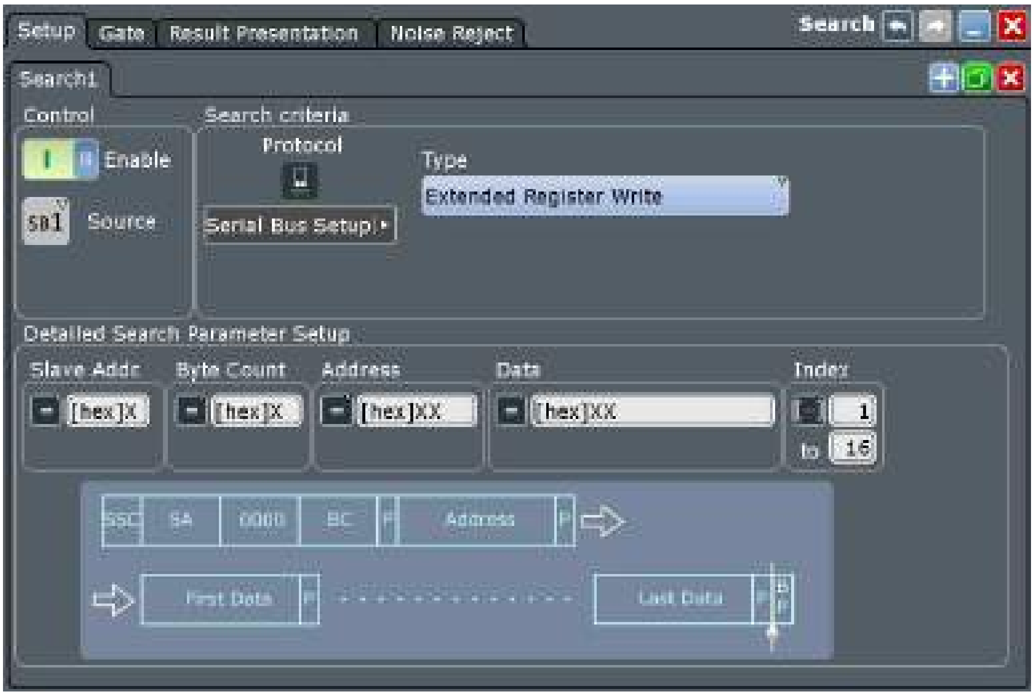
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.13.6.1 RFFE Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for RFFE



Enable: I
Source: SB1
Type: Extended Register Write
Slave Addr: [hex]X
Byte Count: [hex]X
Address: [hex]XX
Data: [hex]XX
Index: 1 to 16

Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".

For details, see also "Type" on page 706.

"Sequence Start"

Searches for SSC.
Additional search parameter: "Slave Addr." on page 721

"Sequence Stop"

Searches for bus park at the end of a command sequence.
Additional search parameter: "Slave Addr." on page 721

"Register 0 Write"

Searches for "Register 0 Write" command sequences. Additional search parameters:

- Slave address, see "Slave Addr." on page 721.
- Data pattern, see "Data" on page 722

"Register Write"

Searches for "Register Write" command sequences. Additional search parameters:

- Slave address, see "Slave Addr." on page 721
- Register address, see "Address" on page 722
- Data pattern, see "Data" on page 722

"Register Read"

Searches for "Register Read" command sequences.
This search uses the same additional parameters as the "Register Write" search.

"Extended Register Write"

Searches for "Extended Register Write" command sequences. Additional search parameters:

- Slave address, see "Slave Addr." on page 721
- Byte count, see "Byte count" on page 722
- Register address, see "Address" on page 722
- Data pattern, see "Data" on page 722 and "Index" on page 723

"Extended Register Read"

Searches for "Extended Register Read" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Extended Register Write Long"

Searches for "Extended Register Write Long" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Extended Register Read Long"

Searches for "Extended Register Read Long" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Master Read" Searches for "Master Read" command sequences. Additional search parameters:

- Address of the non-BOM master, see "Slave Addr." on page 721.
- Register address, see "Address" on page 722.
- Data pattern that is returned by the non-BOM master, see "Data" on page 722.

"Master Write" Searches for "Master Write" command sequences. Additional search parameters:

- Address of the non-BOM master, see "Slave Addr." on page 721
- Register address, see "Address" on page 722
- Data pattern to be written into the non-BOM, see "Data" on page 722.

"Master Ownership Handover"

Searches for "Master Ownership Handover" command sequences. Additional search parameters:

- Address of the BOM-to-be, see "Slave Addr." on page 721
- Data pattern of the confirmation sequence of the new BOM, see "Data" on page 722.

"Interrupt Summary and Notification"

Searches for interrupts. Additional search parameters:

- Slave address, see "Slave Addr." on page 721
- Byte count, see "Byte count" on page 722
- Data of the interrupt indentification sequence, see

"Error Condition"

Searches for the selected errors, see "Error conditions" on page 723.

Remote command:
`SEARch:TRIGger:RFFE:TYPE` on page 1787

Slave Addr.

Searches for a slave address or a slave address range.

In command sequences transfered between masters, this is the non-BOM address.

The slave address settings are the same as in the RFFE trigger setup, see "Slave Addr." on page 711.

Remote command:
`SEARch:TRIGger:RFFE:SADD:CONDition` on page 1789
`SEARch:TRIGger:RFFE:SADD:MIN` on page 1790
`SEARch:TRIGger:RFFE:SADD:MAX` on page 1791

Byte count

Searches for a byte count or a byte count range.

The byte count settings are the same as in the RFFE trigger setup, see "Byte count" on page 712

Remote command:

`SEARch:TRIGger:RFFE:BCOunt:CONDition` on page 1789

`SEARch:TRIGger:RFFE:BCOunt:MIN` on page 1790

`SEARch:TRIGger:RFFE:BCOunt:MAX` on page 1791

Address

Searches for a register address or an address range.

The register address settings are the same as in the RFFE trigger setup, see "Address" on page 712.

Remote command:

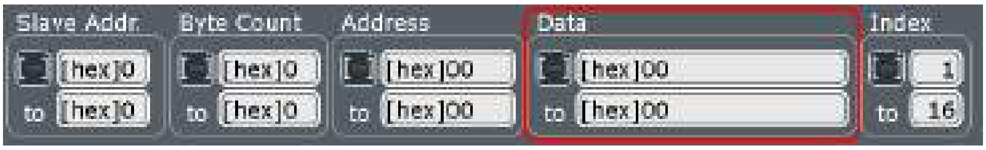
`SEARch:TRIGger:RFFE:ADDRess:CONDition` on page 1789

`SEARch:TRIGger:RFFE:ADDRess:MIN` on page 1790

`SEARch:TRIGger:RFFE:ADDRess:MAX` on page 1791

Data

Searches for a data pattern or an data word range. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame, and for



The data settings are the same as in the RFFE trigger setup, see "Data" on page 713.

Remote command:

`SEARch:TRIGger:RFFE:DATA:DCON` on page 1789

`SEARch:TRIGger:RFFE:DATA:DMIN` on page 1791

`SEARch:TRIGger:RFFE:DATA:DMAX` on page 1791

Index

Defines which data frames are relevant for the search. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame. To search for any data byte that fulfills the data pattern settings, set the index to XX.

Slave Addr. [hex]0 to [hex]0
Byte Count [hex]0 to [hex]0
Address [hex]00 to [hex]00
Data [hex]00 to [hex]00
Index 1 to 16

Remote command:

`SEARch:TRIGger:RFFE:DATA:ICON` on page 1790
`SEARch:TRIGger:RFFE:DATA:IMIN` on page 1791
`SEARch:TRIGger:RFFE:DATA:IMAX` on page 1791

Data

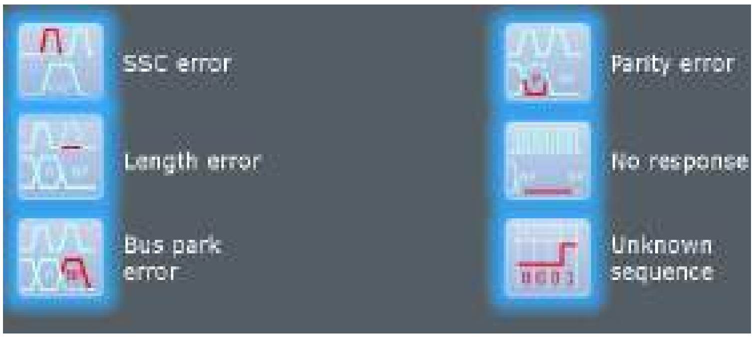
Defines the pattern of the interrrupt identification sequence, which consists of interrupt slots 15 to 0. The setting is only available for "Interrupt Summary and Notification" command sequence.

Remote command:

`SEARch:TRIGger:RFFE:INTerrupt` on page 1791

Error conditions

Unlike trigger, search for timing conditions (idle time) is not available.



Remote command:

`SEARch:TRIGger:RFFE:ERRor:BP` on page 1792
`SEARch:TRIGger:RFFE:ERRor:LENGth` on page 1792
`SEARch:TRIGger:RFFE:ERRor:NOResponse` on page 1792
`SEARch:TRIGger:RFFE:ERRor:PARity` on page 1792
`SEARch:TRIGger:RFFE:ERRor:SSC` on page 1793
`SEARch:TRIGger:RFFE:ERRor:USEQuence` on page 1793

12.13.6.2 RFFE Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Search Results "RFFESearchCh1"

	State	Start	Stop	Type	Slave Addr [hex]	BC [hex]	Address [hex]	Data	Label Name
1	Ok	-1.4742 ms	-1.2296 ms	Extended Register Read Long	5	7	55A5	[hex] 11 22 33 44 55 66 77 88	LM3279
2	Ok	-1.2252 ms	-838.8 µs	Extended Register Write	5	F	55	[hex] 10 01 23 32 45 54 67 76 89 98 AB BA CD DC EF FE	LM3279
				Extended					

Figure 12-78: Results of a search for sequence start. All command sequences of the acquisition are found.

Remote commands:

- `SEARch:RESult:RFFE:FCOunt` on page 1794
- `SEARch:RESult:RFFE:SEQuence<m>:TYPE?` on page 1794
- `SEARch:RESult:RFFE:SEQuence<m>:STATe?` on page 1794
- `SEARch:RESult:RFFE:SEQuence<m>:STARt?` on page 1794
- `SEARch:RESult:RFFE:SEQuence<m>:STOP?` on page 1795
- `SEARch:RESult:RFFE:SEQuence<m>:SADD?` on page 1795
- `SEARch:RESult:RFFE:SEQuence<m>:ADDRess?` on page 1795
- `SEARch:RESult:RFFE:SEQuence<m>:BCOunt?` on page 1796
- `SEARch:RESult:RFFE:SEQuence<m>:DATA?` on page 1796
- `SEARch:RESult:RFFE:SEQuence<m>:SYMBol?` on page 1796
- `SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:STATe?` on page 1796

- `SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:VALue?` on page 1797

12.13.6.3 Searching RFFE Data

Prerequisites: An RFFE bus is configured, see Chapter 12.13.2, "RFFE Configuration", on page 703, and "Decode" is enabled.

1. Press the SEARCH key on the front panel.
2. Tap the "Source" button and select the serial bus that is set to RFFE.

   "Protocol" shows the RFFE icon.
3. Tap "Type" and select the search type.
   All trigger types are also available for search.
4. To refine the search settings, configure additional settings, which are available for many search types.
   For details, see Chapter 12.13.6.1, "RFFE Search Setup", on page 719.
5. Under "Control", "Enable" the search.

   The "Search Results" box opens.
6. Close the "Search" dialog box.
7. Press RUN STOP to start acquisition.
8. Stop acquisition, or tap "Show search zoom window".

   Now you can navigate the search results and analyze the signal.>

12.14 D-PHY (Option R&S RTO-K42)

The D-PHY is a specification developed by the Mobile Industry Processor Interface (MIPI) alliance as a standard for the communication of high-speed components, like cameras and displays, within mobile devices.

12.14.1 D-PHY Basic

A D-PHY interface consists of one clock lane and up to four data lanes. The D-PHY data lanes have two operational modes:

- A high speed mode (HS): differential signal with a data rate of 80 Mbps to 1.5GHz.This mode is used for the transmission of large volumes of information.

- A low power mode (LP): single-ended signal with a data rate < 10 Mbps. This mode is used for conserving power .

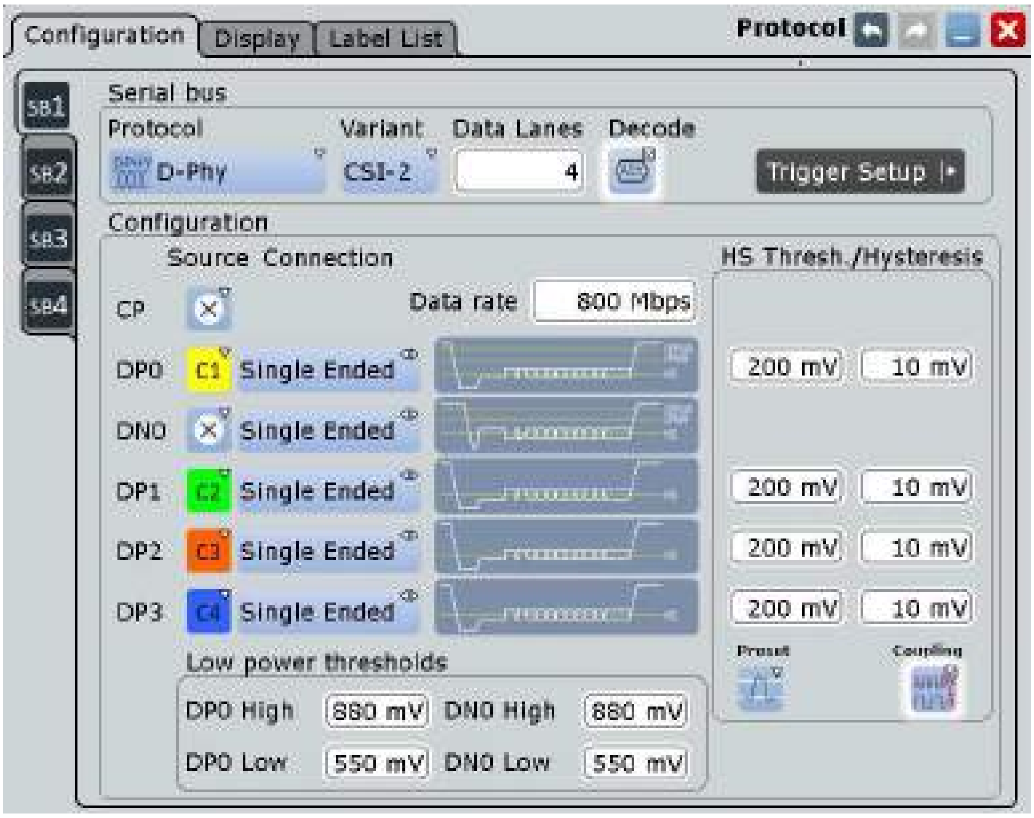
D-PHY provides a framework for other protocols such as the Display Serial Interface (DSI) and Camera Serial Interface (CSI-2).

12.14.2 D-PHY Configuration

12.14.2.1 D-PHY Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = D-PHY"

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: D-Phy
Variant: CSI-2
Data Lanes: 4
Decode

CP
Data rate: 800 Mbps

	Source	Connection	HS Thresh.	Hysteresis
DP0	C1	Single Ended	200 mV	10 mV
DN0		Single Ended		
DP1	C2	Single Ended	200 mV	10 mV
DP2	C3	Single Ended	200 mV	10 mV
DP3	C4	Single Ended	200 mV	10 mV

DP0 High: 880 mV
DN0 High: 880 mV
DP0 Low: 550 mV
DN0 Low: 550 mV

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Variant
Selects the protocol running on the interface. You can select between the Display Serial Interface (DSI) and Camera Serial Interface (CSI-2).

Remote command:
`BUS<m>:DPHY:VARiant` on page 1800

Data Lanes
Sets the number of data lanes. You can select up to four lanes.

Remote command:
`BUS<m>:DPHY:DLANes` on page 1798

Source Connection
Defines the source and the tpye of probe used for the respective lane.

Permitted source selections are none, the analog, mathematical, and reference channels.

CP ← Source Connection
Sets the source of the clock lane.

Remote command:
`BUS<m>:DPHY:CP:SOURce` on page 1798

DP0/DN0 ← Source Connection
Selects the source of the low power data lanes.

The "DP0" lane has to be present all the time, hence "Source DP0">"None" is not allowed.

Remote command:
`BUS<m>:DPHY:DPZero:SOURce` on page 1801
`BUS<m>:DPHY:DNZero:SOURce` on page 1801

DP1/DP2/DP3 ← Source Connection
Selects the source of the high speed data lanes.

Remote command:
`BUS<m>:DPHY:DPONe:SOURce` on page 1801
`BUS<m>:DPHY:DPTWo:SOURce` on page 1801
`BUS<m>:DPHY:DPTHree:SOURce` on page 1801

Probe ← Source Connection
Selects the type of probe used for the respective lane. The D-PHY low power mode uses a single-ended signals, while the high speed mode signaling is differential.

Remote command:
`BUS<m>:DPHY:CP:PROBe` on page 1798
`BUS<m>:DPHY:DNZero:PROBe` on page 1801
`BUS<m>:DPHY:DPZero:PROBe` on page 1801
`BUS<m>:DPHY:DPONe:PROBe` on page 1801
`BUS<m>:DPHY:DPTWo:PROBe` on page 1801
`BUS<m>:DPHY:DPTHree:PROBe` on page 1801

Data Rate
Sets a data rate.

Remote command:
`BUS<m>:DPHY:DRATe` on page 1799
`BUS<m>:DPHY:DSPData` on page 1799

HS Threshold
Sets the threshold value for the digitization of high speed data line.

Remote command:
`BUS<m>:DPHY:DPZero:HSPeed:THReshold` on page 1802
`BUS<m>:DPHY:DPONe:HSPeed:THReshold` on page 1802
`BUS<m>:DPHY:DPTWo:HSPeed:THReshold` on page 1802
`BUS<m>:DPHY:DPTHree:HSPeed:THReshold` on page 1802

Hysteresis
Sets a value for the hysteresis of the respective lane.

Remote command:
`BUS<m>:DPHY:CP:HSPeed:HYSTeresis` on page 1801
`BUS<m>:DPHY:DPZero:HSPeed:HYSTeresis` on page 1801
`BUS<m>:DPHY:DPONe:HSPeed:HYSTeresis` on page 1801
`BUS<m>:DPHY:DPTWo:HSPeed:HYSTeresis` on page 1801
`BUS<m>:DPHY:DPTHree:HSPeed:HYSTeresis` on page 1801

Preset
Presets the threshold and hysteresis values of the high speed data lanes. A preset sets the low power threshold to 1.20V and high speed threshold to 200 mV.

Remote command:
`BUS<m>:DPHY:THPReset` on page 1799

Coupling
Enables coupling, i.e. the same threshold and hysteresis value is used for all lanes.

Remote command:
`BUS<m>:DPHY:THCoupling` on page 1799

Low power thresholds
Sets the thresholds for the low power mode.

DP0 High / DN0 High ← Low power thresholds
Sets the high power threshold value for the respective lane.

Remote command:
`BUS<m>:DPHY:DNZero:LPOWer:THUPper` on page 1800
`BUS<m>:DPHY:DPZero:LPOWer:THUPper` on page 1800

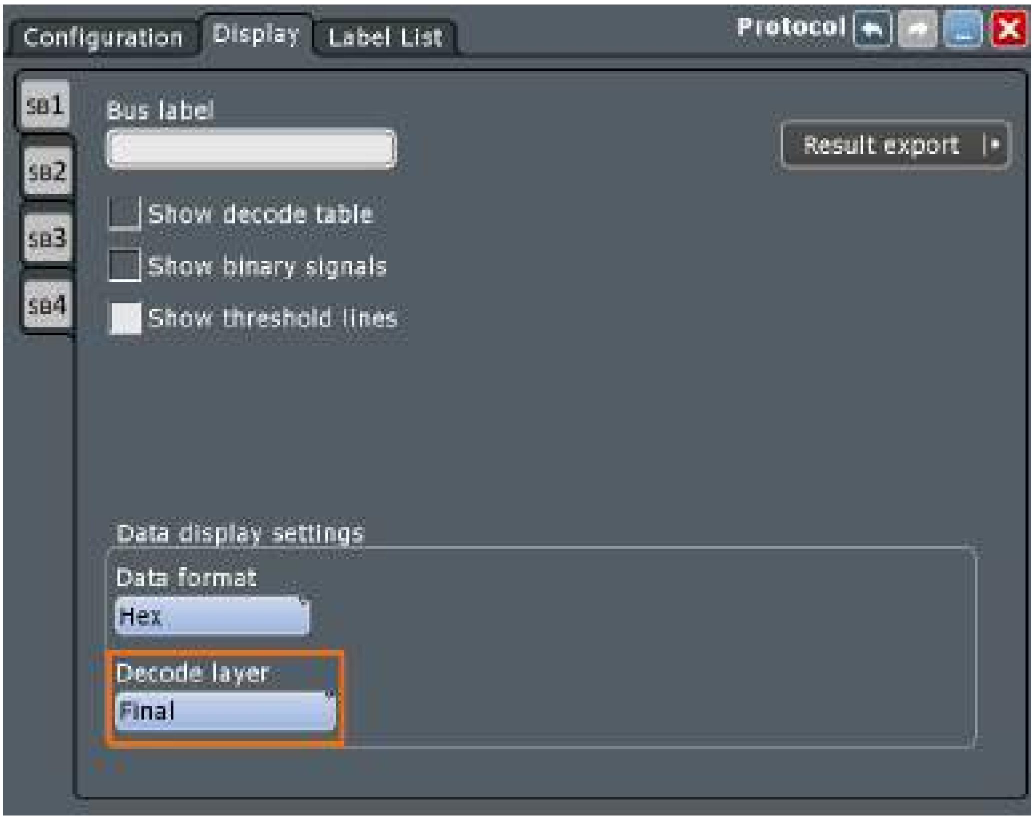
DP0 Low / DN0 Low ← Low power thresholds
Sets the low power threshold value for the respective lane.

Remote command:
`BUS<m>:DPHY:DNZero:LPOWer:THLower` on page 1800
`BUS<m>:DPHY:DPZero:LPOWer:THLower` on page 1800

12.14.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = D-PHY" > "Display" tab

To enhance the decode possibilities of the D-PHY protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"HS Edges"	The high speed edges of each lane, showing the transitions in high speed mode.
"HS Binary"	All high speed bits of each lane, whether they are part of a burst or not.
"HS Burst Bits"	The filtered high speed bits of each lane , including only bits that are part of a burst.
"HS Burst Words"	8 bits per word in a high speed burst of eache lane.
"HS Merged Bytes"	The words from the previous layer after they have been merged into one honeycomb.
"HS Merged Words"	The bytes that are combined/split into words.
"LP Edges"	The combined edge display of DP0 and DN0.

"LP States"	The low power states LP00, LP01, LP10, LP11 of DP0 and DN0.

12.14.2.3 Configuring the D-PHY Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "D-PHY".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Variant" button, and select the protocol.
7. Enter the number of "Data Lanes".
8. Select the source and type of "Probe", for each lane.
9. Enter the "HS threshold" and the "Hysteresis" for each data lane.
10. Enter the low power thresholds.
11. Enable "Decode", if available.

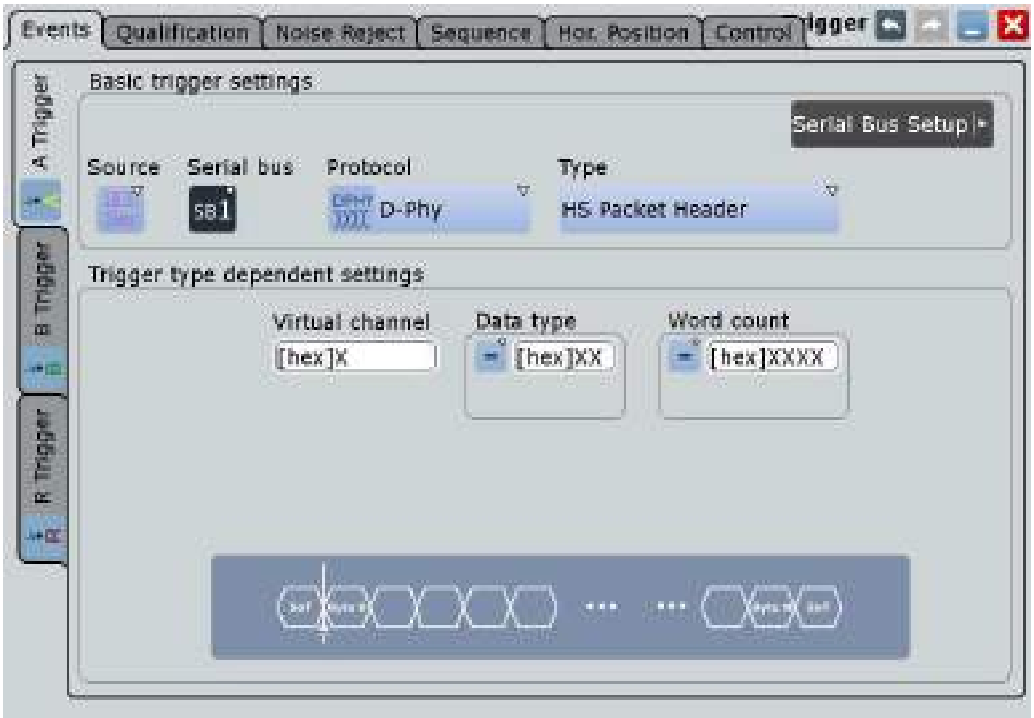
12.14.3 D-PHY Trigger

12.14.3.1 D-PHY Trigger Settings

Access: TRIGGER > "Source" = *Serial Bus* and "Protocol" = *D-PHY*

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.



Basic trigger settings

Source

Serial bus: SB1

Protocol: D-Phy

Type: HS Packet Header

Trigger type dependent settings

Virtual channel: [hex]X

Data type: [hex]XX

Word count: [hex]XXXX

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

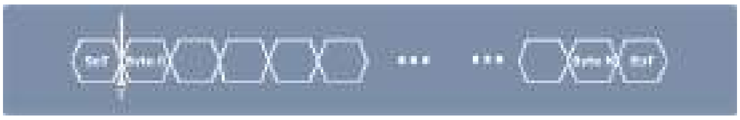
Selects the trigger type for the D-PHY analysis.

Remote command:

`TRIGger<m>:DPHY:TYPE` on page 1803

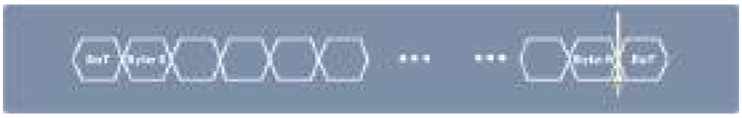
HS Start of Packet ← Type

Sets the trigger to the transmission start of a high speed packet.



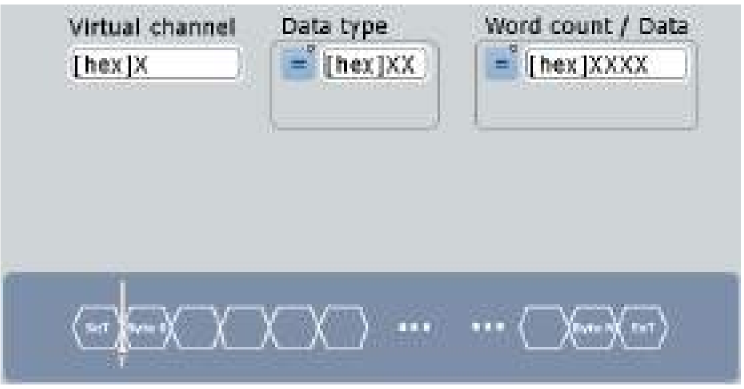
HS End of Packet ← Type

Sets the trigger to the transmission end of a high speed packet.



HS Packet Header ← Type

Sets the trigger to a packet header of a high speed package. The header consists of a data indentefier (containing the Virtual Channel and the Data Type) and a Word Count. You can specify the values each part of the packet header.



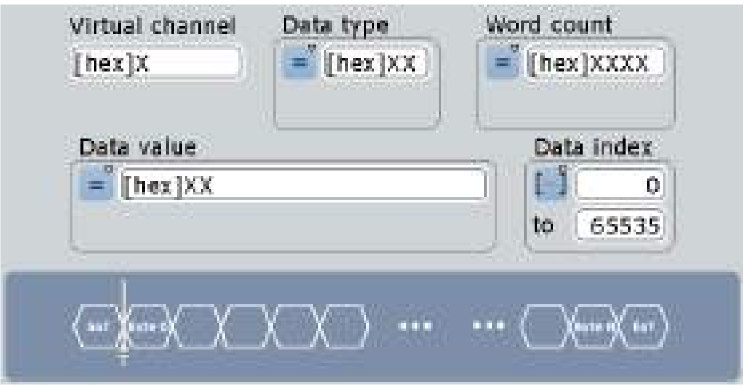
Virtual channel [hex]X

Data type = [hex]XX

Word count / Data = [hex]XXXX

HS Data ← Type

Sets the trigger to a specified high speed data.



Virtual channel [hex]X

Data type = [hex]XX

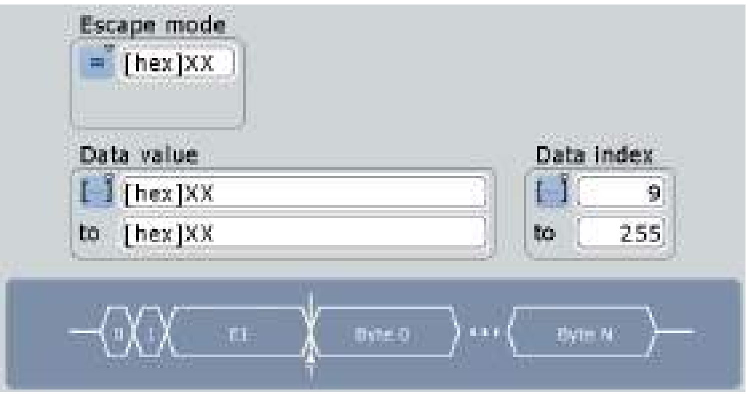
Word count = [hex]XXXX

Data value = [hex]XX

Data index [ ] 0 to 65535

LP Escape Mode ← Type

Sets the trigger to a escape mode event.



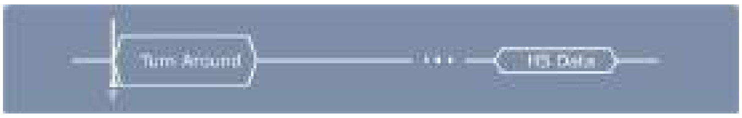
Escape mode = [hex]XX

Data value [ ] [hex]XX to [hex]XX

Data index [ ] 9 to 255

LP Lane Turnaround ← Type

Sets the trigger to a low power turnaround, a reversion of the transmission direction.



LP HS Request ← Type

Sets the trigger to a high speed request.

Virtual Channel

Triggers on a specific virtual channel, an indepedent data stream for up to four peripherals.

Remote command:
`TRIGger<m>:DPHY:HSVC` on page 1809

Data Type

Sets the specified data type to be triggered on. The data type setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:DPHY:DTYPe:CONDition` on page 1805
`TRIGger<m>:DPHY:DTYPe:MAX` on page 1806
`TRIGger<m>:DPHY:DTYPe:MIN` on page 1806

Word Count

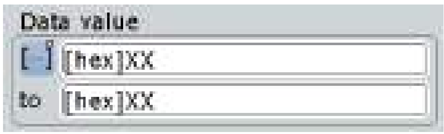
Sets the specified specific word count to be triggered on. The word count setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.
"Data Min/ Data"	Defines the bit pattern of the word pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:DPHY:WCOunt:CONDition` on page 1809
`TRIGger<m>:DPHY:WCOunt:MAX` on page 1810
`TRIGger<m>:DPHY:WCOunt:MIN` on page 1810

Data Value

Set the specified data value to be triggered on.The data value setup consists of the condition and one or two data value patterns.


Data value
[-] [hex]XX
to [hex]XX

"Condition"	Defines the operator to set a specific data value ("Equal" or "Not equal") or a data value range.
"Data Min/ Data"	Defines the bit pattern of the data value pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data value pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "Type">"HS Data":
`TRIGger<m>:DPHY:DATA:CONDition` on page 1803
`TRIGger<m>:DPHY:DATA:MAX` on page 1804
`TRIGger<m>:DPHY:DATA:MIN` on page 1804
For "Type">"LP Escape Mode":
`TRIGger<m>:DPHY:ESDTa:CONDition` on page 1807
`TRIGger<m>:DPHY:ESDTa:MAX` on page 1808
`TRIGger<m>:DPHY:ESDTa:MIN` on page 1808

Data Index

Data index sets the range within this series of the data value that is considered for the analysis. The data index setup consists of the condition and one or two data index values.


Data index
[-] 0
to 65535

"Condition"	Defines the operator to set a specific data ("Equal") or a data range.
"Index Min/Index"	Defines the minimum index.
"Index Max"	The second index pattern is required to specify a range with conditions "In range".

Remote command:
For "Type">"HS Data":
`TRIGger<m>:DPHY:DIDX:CONDition` on page 1804
`TRIGger<m>:DPHY:DIDX:MAX` on page 1805
`TRIGger<m>:DPHY:DIDX:MIN` on page 1805
For "Type">"LP Escape Mode":
`TRIGger<m>:DPHY:ESINdex:CONDition` on page 1808
`TRIGger<m>:DPHY:ESINdex:MAX` on page 1809
`TRIGger<m>:DPHY:ESINdex:MIN` on page 1809

Escape mode
The escape mode setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:DPHY:ESCMode:CONDition` on page 1806
`TRIGger<m>:DPHY:ESCMode:MAX` on page 1807
`TRIGger<m>:DPHY:ESCMode:MIN` on page 1807

12.14.3.2 Triggering on D-PHY

Prerequisite: A bus is configured for the D-PHY signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog, tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

Ser

3. Tap "Serial bus" and select the serial bus that is set to D-PHY, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "D-PHY".

4. Select the "Trigger Type" to be used for D-PHY protocol analysis.
5. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.14.3.1, "D-PHY Trigger Settings", on page 730.

12.14.4 D-PHY Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Decoded D-PHY short packet, single-ended probes shows a decoded short packet with a two lane measurement. Single-ended probes are used on the "CP" , "DP0", "DN0" and "DP1" lanes. You can see the low power HS Request which is only possible when "DP0" and "DN0" are running with single ended probes.

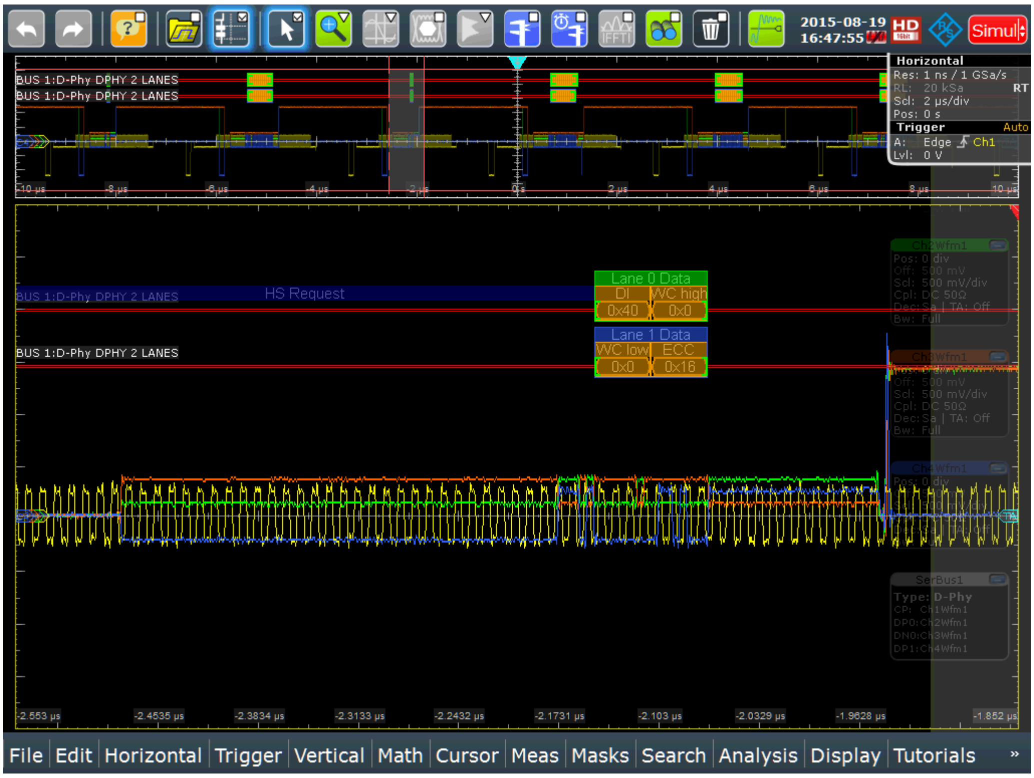
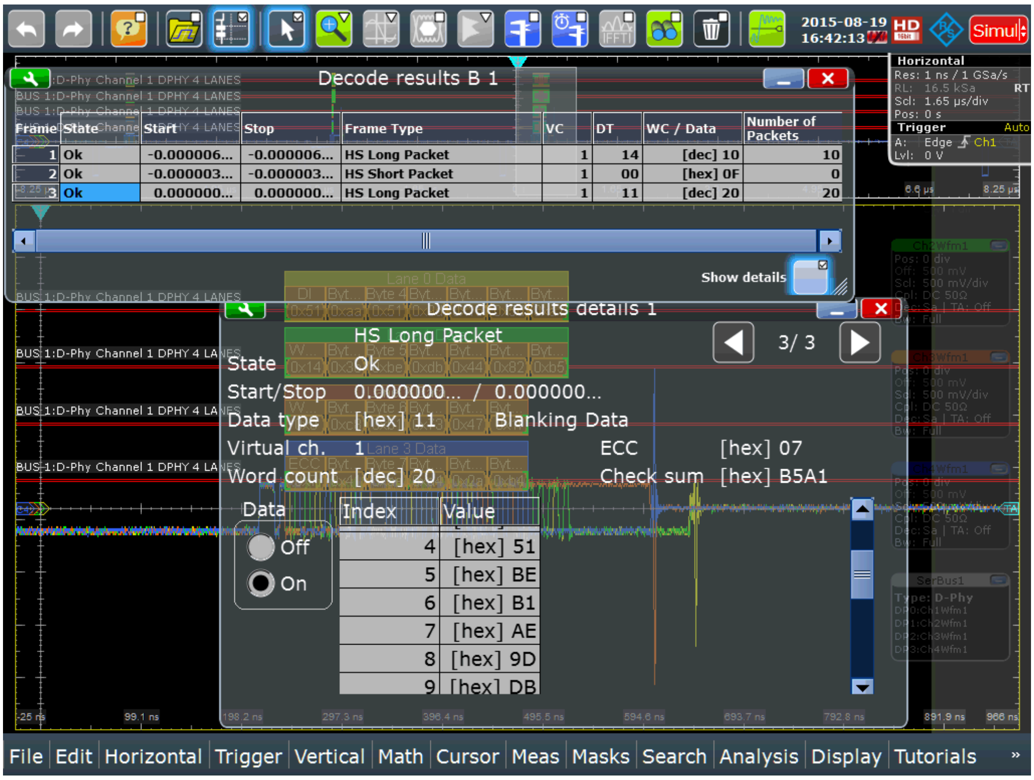


Figure 12-79: Decoded D-PHY short packet, single-ended probes

The example in Figure 12-80 shows a decoded D-PHY signal and the result tables. Differential probes are used for the four data lanes "DP0", "DP1", "DP2" and "DP3".



Decode results B 1

Frame	State	Start	Stop	Frame Type	VC	DT	WC / Data	Number of Packets
1	Ok	-0.000006...	-0.000006...	HS Long Packet	1	14	[dec] 10	10
2	Ok	-0.000003...	-0.000003...	HS Short Packet	1	00	[hex] 0F	0
3	Ok	0.000000...	0.000000...	HS Long Packet	1	11	[dec] 20	20

Show details ☑

Decode results details 1

HS Long Packet 3/ 3

State Ok
Start/Stop 0.000000... / 0.000000...
Data type [hex] 11 Blanking Data
Virtual ch. 1 ECC [hex] 07
Word count [dec] 20 Check sum [hex] B5A1

Data
○ Off
● On

Index	Value
4	[hex] 51
5	[hex] BE
6	[hex] B1
7	[hex] AE
8	[hex] 9D
9	[hex] DB

Figure 12-80: Decoded D-PHY signal with result tables, differential probes

Table 12-17: Content of the decode result table

Column	Description
State	Overall state of the frame
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point
Frame Type	Frame type
VC	Number of virtual channels
DT	Data type
WC/ Data	Word count or data value
Number of Packets	Number of packets in the frame

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.

3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.15.3, "D-PHY Decode Results", on page 1810.

12.14.5 Search on Decoded D-PHY Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

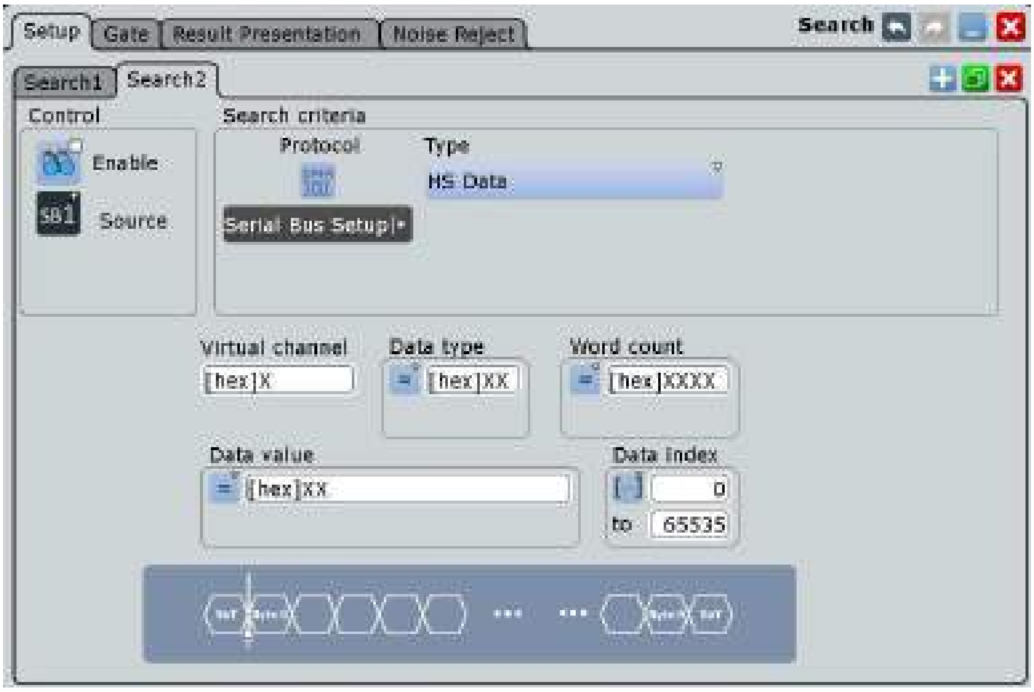
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

12.14.5.1 D-PHY Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for D-PHY



Type: HS Data

Virtual channel: [hex]X

Data type: = [hex]XX

Word count: = [hex]XXXX

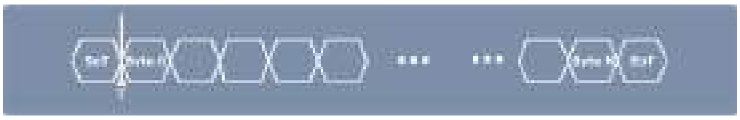
Data value: = [hex]XX

Data index: 0 to 65535

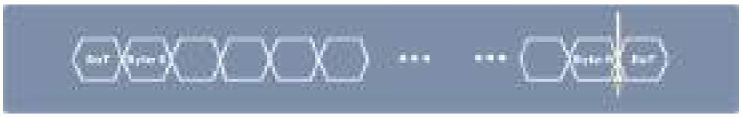
Type
Searches for the selected D-PHY type.

Remote command:
`SEARch:TRIGger:DPHY:TYPE` on page 1817

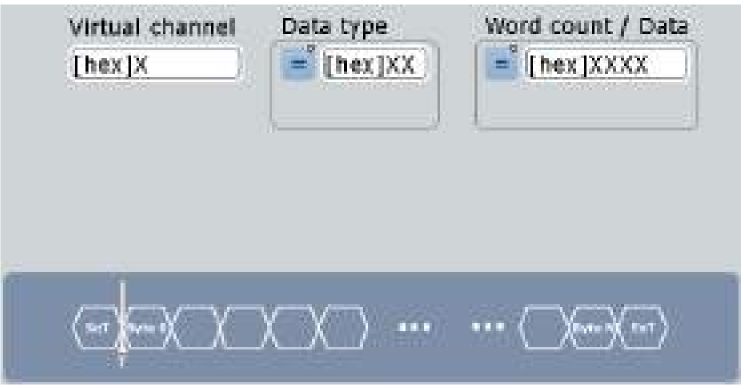
HS Start of Packet ← Type
Searches for a transmission start of a high speed packet.



HS End of Packet ← Type
Searches for a transmission end of a high speed packet.

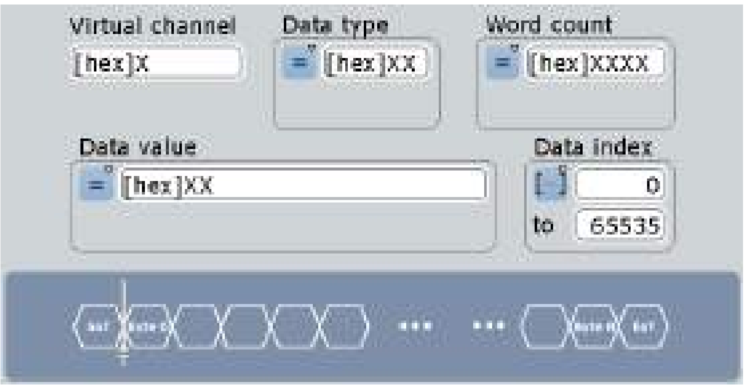


HS Packet Header ← Type
Searches for a packet header of a high speed package. The header consists of a data indentefier (containing the Virtual Channel and the Data Type) and a Word Count/ Data. You can specify the values each part of the packet header.



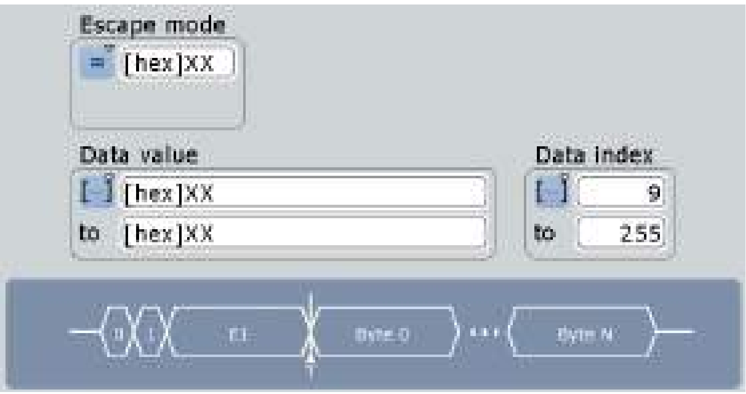
Virtual channel [hex]X
Data type = [hex]XX
Word count / Data = [hex]XXXX

HS Data ← Type
Searches for a a specified high speed data.



Virtual channel [hex]X
Data type = [hex]XX
Word count = [hex]XXXX
Data value = [hex]XX
Data index [ ] 0 to 65535

LP Escape Mode ← Type
Searches for an escape mode event.

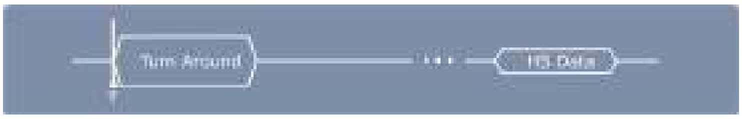


Escape mode
= [hex]XX

Data value
[–] [hex]XX
to [hex]XX

Data index
[–] 9
to 255

LP Lane Turnaround ← Type
Searches for a low power turnaround, a reversion of the transmission direction.



LP HS Request ← Type
Searches for a high speed request.

Virtual Channel
Searches for a specific virtual channel, an indepedent data stream for up to four peripherals.

Remote command:
`SEARch:TRIGger:DPHY:HSVC` on page 1824

Data Type
Searches for a specific data type. The data type setup consists of the condition and one or two data patterns.

Data type
[–] [hex]XX
to [hex]XX

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:DTYPe:CONDition` on page 1819
`SEARch:TRIGger:DPHY:DTYPe:MAX` on page 1820
`SEARch:TRIGger:DPHY:DTYPe:MIN` on page 1820

Word Count/ Data

Searches for a specific word count /data. The word count setup consists of the condition and one or two data patterns.

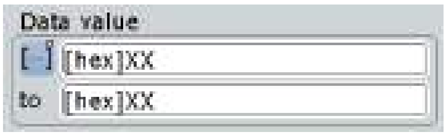
Word count
[hex]XXXX
to [hex]XXXX

"Condition"	Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.
"Data Min/Data"	Defines the bit pattern of the word pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:WCOunt:CONDition` on page 1824
`SEARch:TRIGger:DPHY:WCOunt:MAX` on page 1825
`SEARch:TRIGger:DPHY:WCOunt:MIN` on page 1825

Data Value

Searches for a specific data value. The data value setup consists of the condition and one or two data value patterns.



Data value
[hex]XX
to [hex]XX

"Condition"	Defines the operator to set a specific data value ("Equal" or "Not equal") or a data value range.

"Data Min/Data"	Defines the bit pattern of the data value pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data value pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "Type">"HS Data":
`SEARch:TRIGger:DPHY:DATA:CONDition` on page 1817
`SEARch:TRIGger:DPHY:DATA:MAX` on page 1818
`SEARch:TRIGger:DPHY:DATA:MIN` on page 1818
For "Type">"LP Escape Mode":
`SEARch:TRIGger:DPHY:ESDTa:CONDition` on page 1822
`SEARch:TRIGger:DPHY:ESDTa:MAX` on page 1823
`SEARch:TRIGger:DPHY:ESDTa:MIN` on page 1823

Data Index

Data index sets the range within this series of the data value to be searched for. The data index setup consists of the condition and one or two data index values.

"Condition"	Defines the operator to set a specific data ("Equal") or a data range.
"Index Min/Index"	Defines the minimum index.
"Index Max"	The second index pattern is required to specify a range with conditions "In range".

Remote command:
For "Type">"HS Data":
`SEARch:TRIGger:DPHY:DIDX:CONDition` on page 1818
`SEARch:TRIGger:DPHY:DIDX:MAX` on page 1819
`SEARch:TRIGger:DPHY:DIDX:MIN` on page 1819
For "Type">"LP Escape Mode":
`SEARch:TRIGger:DPHY:ESINdex:CONDition` on page 1823
`SEARch:TRIGger:DPHY:ESINdex:MAX` on page 1824
`SEARch:TRIGger:DPHY:ESINdex:MIN` on page 1824

Escape mode

Searches for an escape mode event. The escape mode setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.
"Data Min/Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:ESCMode:CONDition` on page 1821
`SEARch:TRIGger:DPHY:ESCMode:MAX` on page 1821
`SEARch:TRIGger:DPHY:ESCMode:MIN` on page 1822

12.14.5.2 D-PHY Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

- `SEARch:RESult:DPHY:FCOunt?` on page 1826
- `SEARch:RESult:DPHY:FRAMe<m>:CS?` on page 1826
- `SEARch:RESult:DPHY:FRAMe<m>:DATA?` on page 1826
- `SEARch:RESult:DPHY:FRAMe<m>:DTName?` on page 1827
- `SEARch:RESult:DPHY:FRAMe<m>:DTYPe?` on page 1827
- `SEARch:RESult:DPHY:FRAMe<m>:ECC?` on page 1827
- `SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:IDX?` on page 1828
- `SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:VALue?` on page 1828
- `SEARch:RESult:DPHY:FRAMe<m>:STARt?` on page 1828
- `SEARch:RESult:DPHY:FRAMe<m>:STATe?` on page 1829
- `SEARch:RESult:DPHY:FRAMe<m>:STOP?` on page 1829
- `SEARch:RESult:DPHY:FRAMe<m>:TYPE?` on page 1830
- `SEARch:RESult:DPHY:FRAMe<m>:VCHannel?` on page 1830

12.14.5.3 Searching D-PHY

Prerequisite: A serial bus is configured for the D-PHY signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to D-PHY (e.g. "SerBus1", unless already selected).
4. Specify search criteria according to Chapter 12.14.5.1, "D-PHY Search Setup", on page 739.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a D-PHY decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.15 M-PHY (Option R&S RTO-K44)

The M-PHY® is a serial communication protocol. Its specifications were developed by the Mobile Industry Processor Interface (MIPI) alliance as standards for the communication of high-speed components, like smartphones and tablets, within mobile devices. For more details on the specifications, refer to http://mipi.org/specifications/physical-layer#M-PHY Specification.

This protocol is the foundation for several upper layer protocols, such as UniPro^{SM} (Unified Protocol), which manage complex data transfer functions. Each of these protocols is optimized for its particular purpose, such as data storage, data transfer, display, camera, memory sharing and radio interface.

When implemented together with the MIPI UniPro, defined as UniPort-M, they deliver high speed, low power, scalable and flexible data transport solutions.

12.15.1 M-PHY Basic

This chapter provides an overview of the characteristics of the M-PHY and UniPro protocols.

12.15.1.1 Data Transfer

M-PHY words are always ten bits long (both data and control words). For UniPro, they have variable lengths that depends on the frame type. For example, control words have 8 bits, data words have 16 bits and reserved words have 3 bits.

To achieve power efficiency and high performance transmissions, multiple power-saving states and recovery times are utilized. Scalability and flexibility are achieved through the various transmission speed ranges and rates.

Different modes of operations:

- Disable mode: lowest power mode entered into once the power supply is turned on
- Hibernate (Hibern8): ultra low power state, which can be used without configuration loss
- High-speed mode (HS): supports three gears with predefined data rates. This mode is used during high-speed transmission for transporting large volume of data. This mode utilizes the power-saving Stall state to reduce power consumption while offering a fast state transition in the range of nanoseconds
- Low-power mode (PWM): supports seven gears with predefined frequency ranges. This mode is used during low-speed transmission for power conservation. This mode utilizes the power-saving Sleep state with a state transition time typically in the range of microseconds

The R&S RTO supports all operating speed modes: high-speed and low-power mode. The gear settings of these modes are auto detected by the instrument.

12.15.1.2 Data Analysis

The M-PHY and UniPro decoding process involves several stages, similar to D-PHY.

The stages are as the following:

- Stage 1: involves two substages:
  - Stage 1a: converts the three stage cross points into bit and attempts a HS-Sync. This stage involves the Hibern8-Detection/Filter, NRZ Unclocked Decoder and Burst Detection.

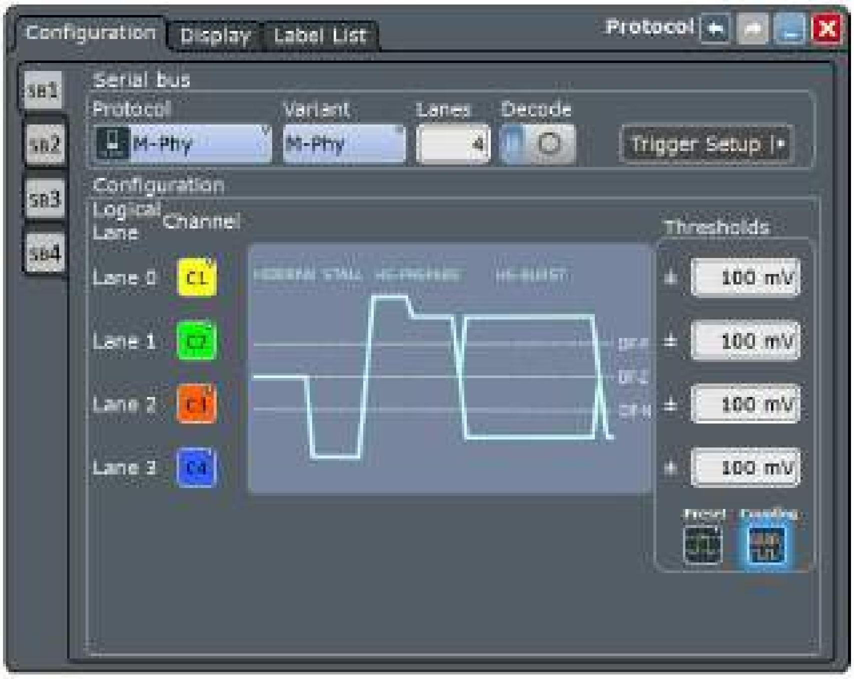
  - Stage 1b is only involved if Stage 1a burst detection fails, assuming using PWM. Input is from the bits from stage 1a. This stage involves the PWM Decoder, Line CFG Decoder and Burst Detection.
- Stage 2: performs the 8b/10b decoding of bits from stage 1 into Bytes and identifies the 8b/10b control words. This stage involves the 8b/10b Decoder and Shift-decoder to Bytes.
- Stage 3: starts decoding the Bytes from stage 2. This stage involves the Descrambler and 17-bit Shift Decoder.
- Stage 4: merges the data lanes and finalizes the decoding to the UniPro data frames. This stage involves the Lane Merger, PDU Sync Detector, Shift Decode and Dynamic Dataunit Decoder.

12.15.2 M-PHY Configuration

12.15.2.1 M-PHY Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "M-Phy"

Make sure that the tab of the correct serial bus is selected on the left side.



Serial bus

Protocol: M-Phy

Variant: M-Phy

Lanes: 4

Lane 0: C1

Lane 1: C2

Lane 2: C3

Lane 3: C4

Thresholds: ± 100 mV, ± 100 mV, ± 100 mV, ± 100 mV

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Variant

Selects the protocol running on the interface. You can select between the M-PHY and UniPro.

Remote command:

`BUS<m>:MPHY:VARiant` on page 1831

Lanes

Sets the number of logical lanes that are mapped to the physical lines. You can select up to four lanes.

Remote command:

`BUS<m>:MPHY:DLANes` on page 1831

Lane 0 / Lane 1 / Lane 2 / Lane 3: Channel

Select the signal sources for the logical lanes.

Remote command:

`BUS<m>:MPHY:DZERo:SOURce` on page 1832
`BUS<m>:MPHY:DONE:SOURce` on page 1832
`BUS<m>:MPHY:DTWO:SOURce` on page 1832
`BUS<m>:MPHY:DTHRee:SOURce` on page 1832

Thresholds

Sets the threshold value to properly condition the signal for decode.

Remote command:

`BUS<m>:MPHY:DZERo:THReshold` on page 1832
`BUS<m>:MPHY:DONE:THReshold` on page 1832
`BUS<m>:MPHY:DTWO:THReshold` on page 1832
`BUS<m>:MPHY:DTHRee:THReshold` on page 1832

Preset

Selects the predefined value to preset the threshold value of the data lanes.

Remote command:

`BUS<m>:MPHY:THPReset` on page 1833

Coupling

Enables the same threshold value for all lanes.

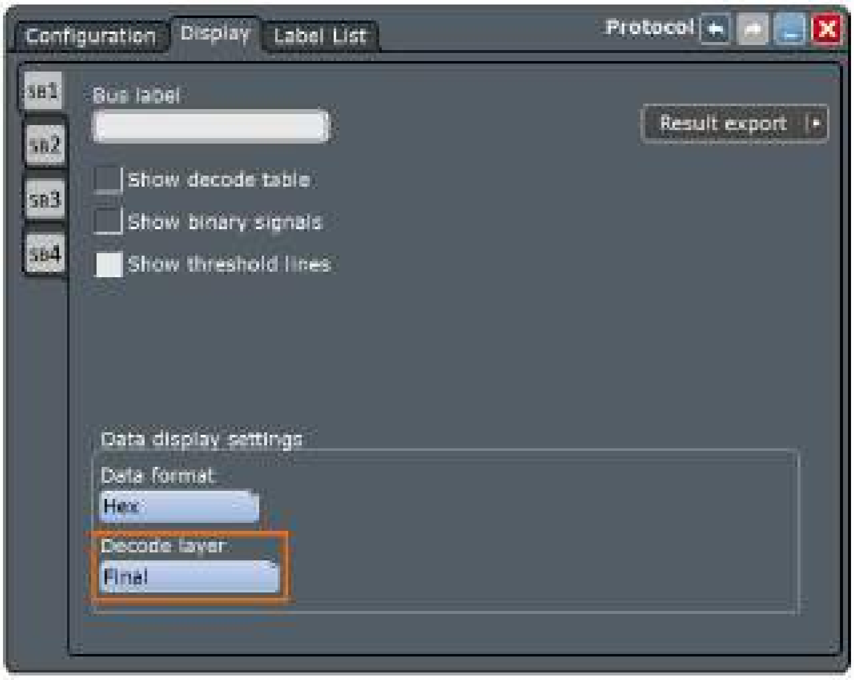
Remote command:

`BUS<m>:MPHY:THCoupling` on page 1832

12.15.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = M-Phy" > "Display" tab

To enhance the decode possibilities of the M-PHY or UniPro protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Bus label:

Data format: Hex

Decode layer: Final

Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	Final decoded frames of each lane.
"Edges"	All edges of each lane in stage 1 decoding.
"Bits"	All bits of each lane in stage 1 decoding.
"8b/10b Symbols"	8b/10b symbols in stage 2 decoding.
"LCC bits"	LCC bits in stage 3 decoding.
"UniPro filter/descrambler"	UniPro filter/descrambler in stage 3 decoding.
"UniPro lane merge"	UniPro lane merge in stage 4 decoding.
"UniPro bytes"	UniPro bytes in stage 2 decoding.

12.15.2.3 Configuring the M-PHY Signals

Assign the lanes to the channels and define the thresholds:

1. Press PROTOCOL on the front panel.
2. On the left, select the bus you want to configure.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select "M-Phy".
5. Tap "Variant" and select the protocol.
6. Enter the number of "Lanes".
7. Select the source "Channel" for each lane.
8. Enter the "Thresholds" for each lane.
9. Enable "Decode".
10. Optionally, you can:
    a) Enter a "Bus label" on the "Display" tab.
    b) Select a "Decode layer" on the "Display" tab.

12.15.3 M-PHY Trigger

12.15.3.1 M-PHY Trigger Settings

Access: TRIGGER > "Source" = "Serial Bus" and "Protocol" = "M-Phy"

Sequence: A only

Source | Serial bus: SB1 | Protocol: M-Phy | Type: Start of frame

Make sure that:

- The data sources of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Setup" tab.
- The trigger source is "Serial bus": TRIGGER > "Setup" tab.
- The correct serial bus is selected: TRIGGER > "Setup" tab.
- The correct protocol is selected: TRIGGER > "Setup" tab.

Type

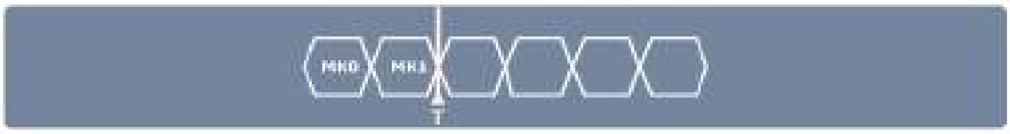
Selects the trigger type for the analysis of the selected protocol.

Remote command:

`TRIGger<m>:MPHY:TYPE` on page 1834

Start of frame ← Type

Triggers on the start of an M-PHY or a UniPro frame.

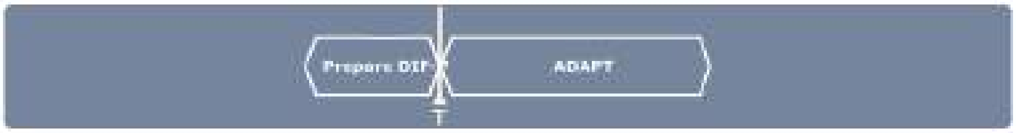


Burst ← Type

Triggers on an M-PHY burst frame.

Adapt ← Type

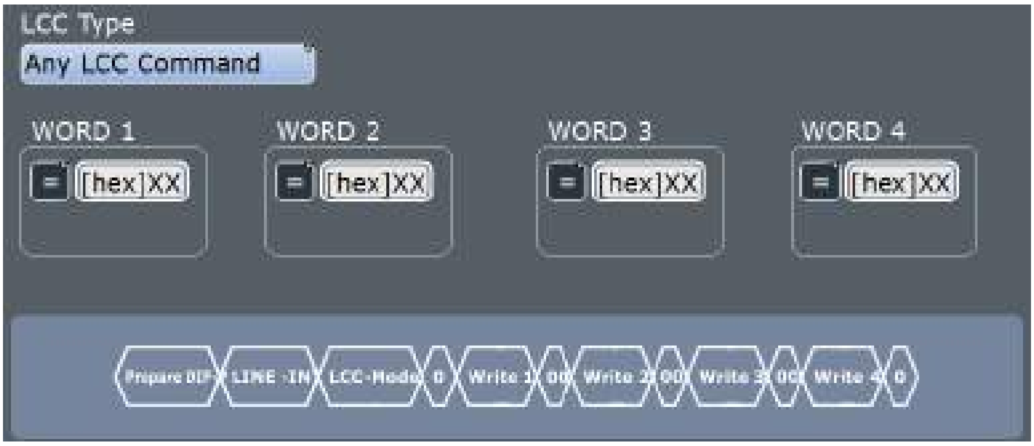
Triggers on an M-PHY Adapt frame. This control frame is used for clock/bit synchronization.



LCC ← Type

Triggers on an M-PHY Line Control Command (LCC) frame that matches the specified LCC Type or any WORD condition.

This control frame is used for configuring the line to a different state or mode depending on the LCC type.



LCC Type: Any LCC Command

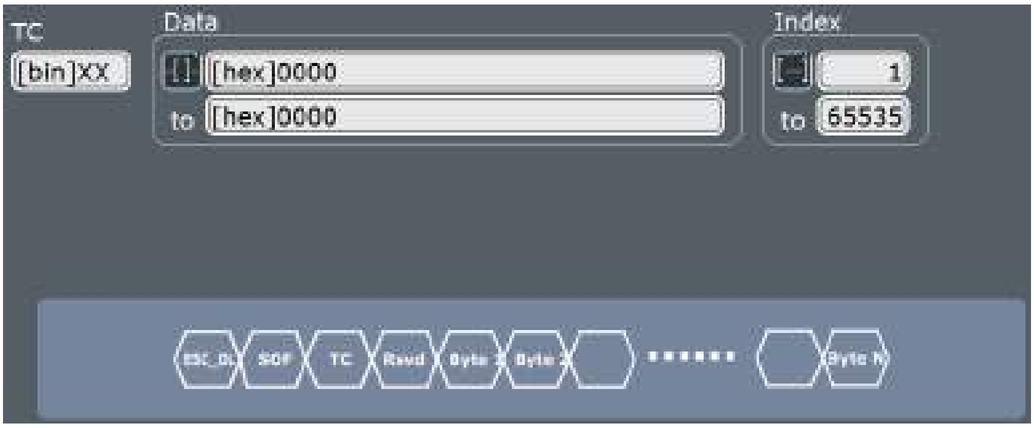
WORD 1: = [hex]XX

WORD 2: = [hex]XX

WORD 3: = [hex]XX

WORD 4: = [hex]XX

DL PDU SOF ← Type
Triggers on a UniPro Downlink Protocol Data Unit (DL PDU) Start Of Frame (SOF) that matches the specified TC, Data or Index condition.

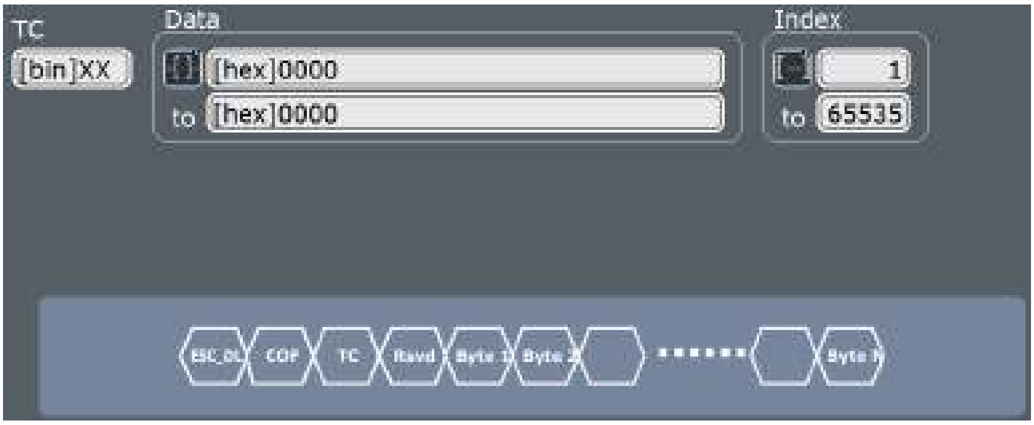


TC: [bin]XX

Data: [hex]0000 to [hex]0000

Index: 1 to 65535

DL PDU COF ← Type
Triggers on a UniPro DL PDU Continuation Of Pre-empted Frame (COF) that matches the specified TC, Data or Index condition.



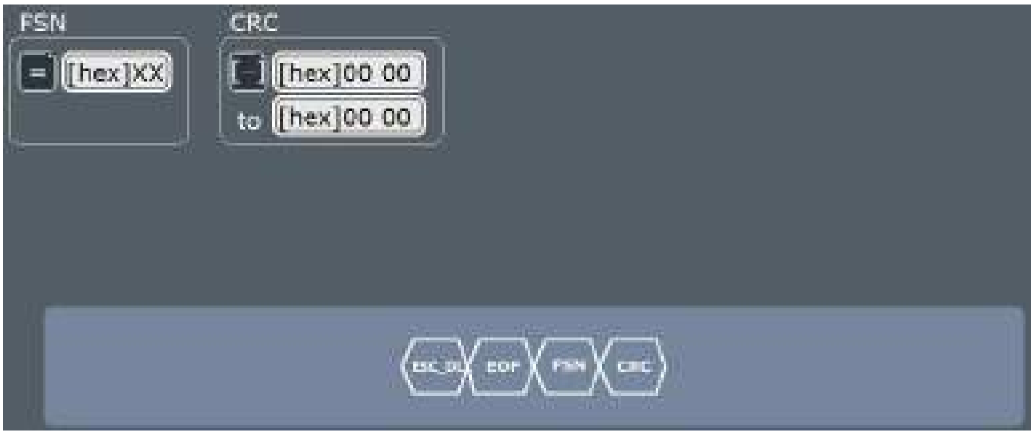
TC: [bin]XX

Data: [hex]0000 to [hex]0000

Index: 1 to 65535

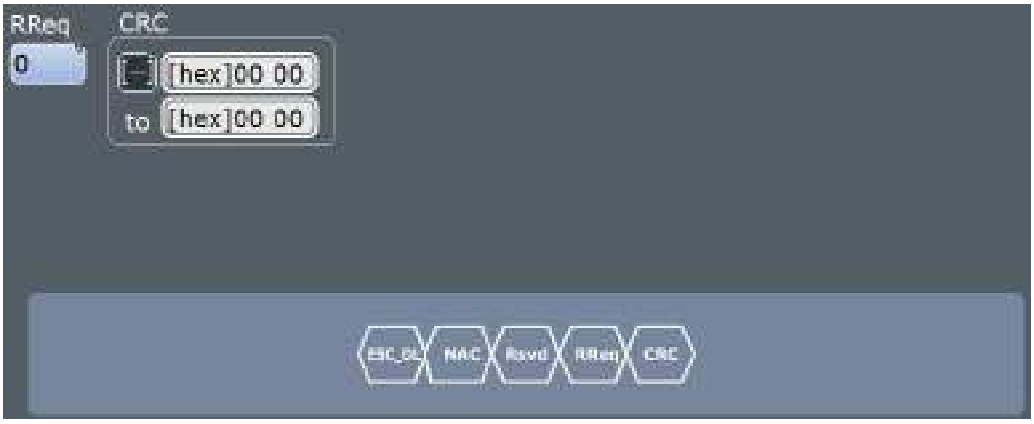
DL PDU EOF ← Type

Triggers on a UniPro DL PDU End Of Frame (EOF) frame that matches the specified FSN or CRC condition.



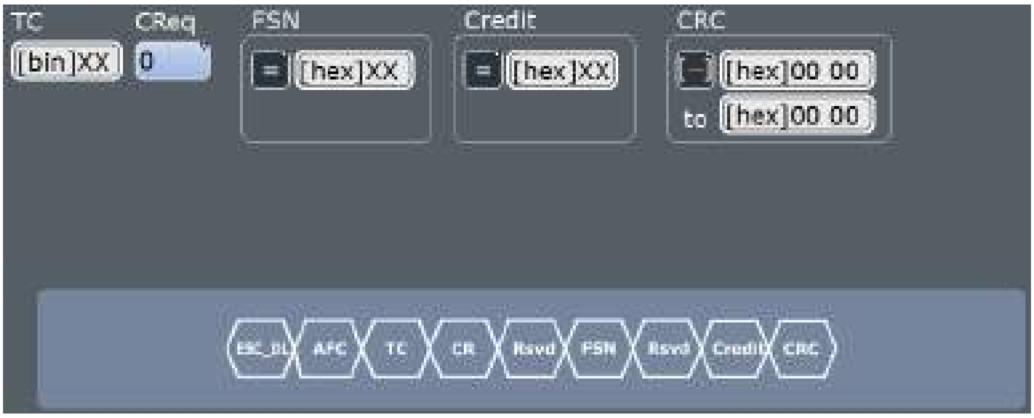
DL PDU NAC ← Type

Triggers on a UniPro DL PDU Negative Acknowledgment Control (NAC) frame that matches the specified RReq or CRC condition.



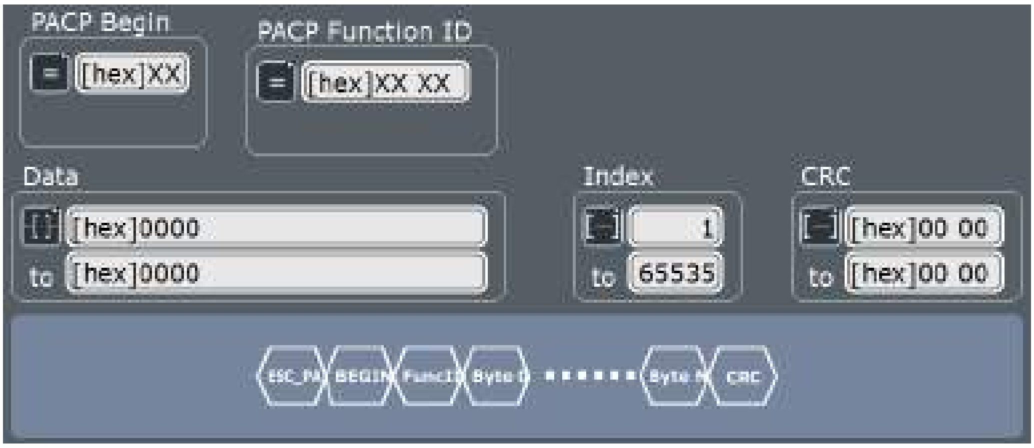
DL PDU AFC ← Type

Triggers on a UniPro DL PDU Acknowledgement and L2 Flow Control (AFC) frame that matches the specified TC, CReq, FSN, Credit or CRC condition.



PACP ← Type
Triggers on a UniPro PHY Adapter Control Protocol (PACP) frame that matches the specified PACP Begin, PACP Function ID, Data, Index or CRC condition.

This control frame is used mainly for power mode change and L1.5 link management. It is also used in scrambling request.



PACP Begin
= [hex]XX

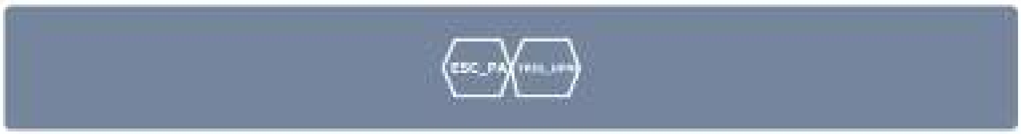
PACP Function ID
= [hex]XX XX

Data
[hex]0000
to [hex]0000

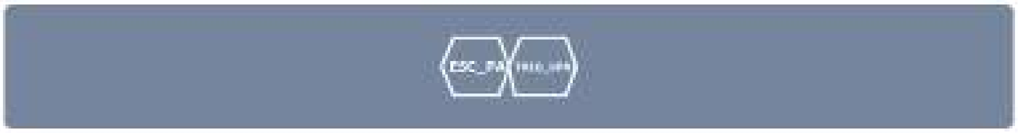
Index
1
to 65535

CRC
[hex]00 00
to [hex]00 00

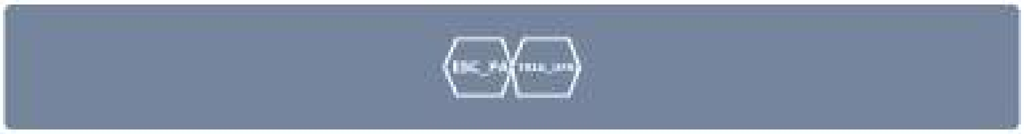
Trigger Upper0 ← Type
Triggers on a UniPro Trigger Upper0 frame. This control frame is used for link startup sequence.



Trigger Upper1 ← Type
Triggers on a UniPro Trigger Upper1 frame. This control frame is used for link startup sequence.



Trigger Upper2 ← Type
Triggers on a UniPro Trigger Upper2 frame. This control frame is used for link startup sequence.



Errors ← Type
Triggers on the specified M-PHY or UniPro error frame.

LCC Type

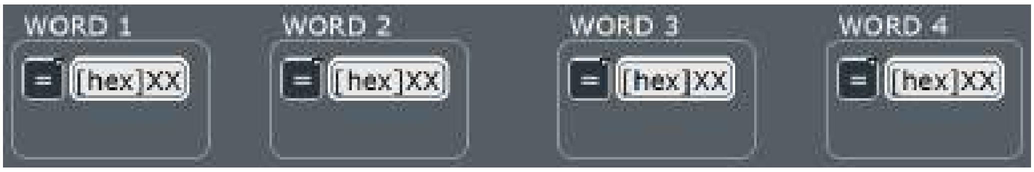
Selects the type of LCC command to be triggered on.

"Any LCC Command"	All the available LCC commands
"HIBERN8-SLEEP"	Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 90% power and is used with PWM burst
"HIBERN8-STALL"	Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 75% power and is used with HS burst
"READ-CAPABILITY"	Recovers data about the Optical Media Converter (OMC) capabilities
"READ-MFG-INFO"	Retrieves manufacturing ID and vendor-specific information
"READ-VEND-INFO"	Retrieves the additional four delimited bytes containing vendor-specific information
"WRITE-ATTRIBUTE"	Sets the configuration parameters required for lane operation
"PWM-G0/PWM-G1/PWM-G2/PWM-G3/PWM-G4/PWM-G5/PWM-G6/PWM-G7"	Switches the transmission mode to the selected low-power gear
"HS-G1A/HS-G2A/HS-G3A/HS-G4A/HS-G1B/HS-G2B/HS-G3B/HS-G4B"	Switches the transmission mode to the selected high-speed gear
"Reserved"	Reserved bit command. These bits are reserved for future use

Remote command:
`TRIGger<m>:MPHY:LCCType` on page 1835

WORD 1/WORD 2/WORD 3/WORD 4

Sets the specified words to be triggered on. The setup for a word consists of the condition and one or two word patterns.



"Condition"	Defines the operator to set a specific word, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the word pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "WORD 1":
`TRIGger<m>:MPHY:LWONe:CONDition` on page 1836
`TRIGger<m>:MPHY:LWONe:MIN` on page 1837
`TRIGger<m>:MPHY:LWONe:MAX` on page 1837
For "WORD 2":
`TRIGger<m>:MPHY:LWTWo:CONDition` on page 1837
`TRIGger<m>:MPHY:LWTWo:MIN` on page 1838
`TRIGger<m>:MPHY:LWTWo:MAX` on page 1838
For "WORD 3":
`TRIGger<m>:MPHY:LWTHree:CONDition` on page 1838
`TRIGger<m>:MPHY:LWTHree:MIN` on page 1839
`TRIGger<m>:MPHY:LWTHree:MAX` on page 1839
For "WORD 4":
`TRIGger<m>:MPHY:LWFour:CONDition` on page 1839
`TRIGger<m>:MPHY:LWFour:MIN` on page 1840
`TRIGger<m>:MPHY:LWFour:MAX` on page 1840

TC

Sets the specified Traffic Class (TC) to be triggered on.

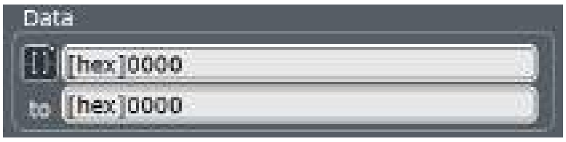
TC is used for classifying the traffic flow based on protocol and port number, e.g. TC0 and TC1 are two priority classes with guaranteed link reliability defined and used in L2.

"Data"	Defines the bit pattern of the TC pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`TRIGger<m>:MPHY:TC` on page 1840

Data

Sets the specified data to be triggered on. The data setup consists of the condition and one or two data patterns.



"Condition"	Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.
"Data Min/Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:DATA:DCON` on page 1841
`TRIGger<m>:MPHY:DATA:DMIN` on page 1841
`TRIGger<m>:MPHY:DATA:DMAX` on page 1841

Index

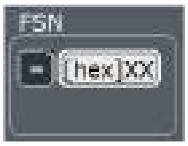
Sets the specified value or range within this series of data that is considered for the analysis. The index setup consists of the condition and one or two index values.

"Condition"	Defines the operator to set a specific index, e.g. "Equal" or a range.
"Index Min/Index"	Defines the bit pattern of the index pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Index Max"	The second index pattern is required to specify a range with conditions "In range".

Remote command:
`TRIGger<m>:MPHY:DATA:ICON` on page 1841
`TRIGger<m>:MPHY:DATA:IMIN` on page 1842
`TRIGger<m>:MPHY:DATA:IMAX` on page 1842

FSN

Sets the specified Frame Sequence Number (FSN) to be triggered on. The FSN setup consists of the condition and one or two FSN patterns.



"Condition"	Defines the operator to set a specific FSN, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the FSN pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second FSN pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:FSNumber:CONDition` on page 1842
`TRIGger<m>:MPHY:FSNumber:MIN` on page 1843
`TRIGger<m>:MPHY:FSNumber:MAX` on page 1843

CRC
Sets the specified Cyclic Redundancy Check (CRC) to be triggered on. The CRC setup consists of the condition and one or two CRC patterns.

CRC is an error detecting code to detect accidental changes to raw data.

"Condition"	Defines the operator to set a specific CRC, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the CRC pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second CRC pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:CRC:CONDition` on page 1843
`TRIGger<m>:MPHY:CRC:MIN` on page 1844
`TRIGger<m>:MPHY:CRC:MAX` on page 1844

Req
Sets the specified Reset Link Request (RReq) or Credit Transmit Request (CReq) to be triggered on.

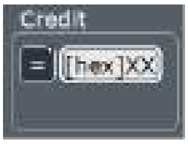
RReq is used for requesting the remote end to re-initialize its Transmit (TX) Physical Layer (PHY) while CReq is used for requesting flow control information for the corresponding TC from the remote end.

"Data"	Defines the bit pattern of the RReq pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
For "RReq":
`TRIGger<m>:MPHY:RREQ` on page 1845
For "CReq"
`TRIGger<m>:MPHY:CREQ` on page 1844

Credit
Sets the specified credit to be triggered on. The credit setup consists of the condition and one or two credit patterns.

Credit represents the total number of credits available since boot time.



"Condition"	Defines the operator to set a specific credit, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the credit pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second credit pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:CREDit:CONDition` on page 1845
`TRIGger<m>:MPHY:CREDit:MIN` on page 1846
`TRIGger<m>:MPHY:CREDit:MAX` on page 1846

PACP Begin
Sets the specified PACP Begin to be triggered on. The PACP Begin setup consists of the condition and one or two PACP Begin patterns.

"Condition"	Defines the operator to set a specific PACP Begin, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the data value pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second PACP Begin pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:MPHY:PBEGin:CONDition` on page 1846

`TRIGger<m>:MPHY:PBEGin:MIN` on page 1846

`TRIGger<m>:MPHY:PBEGin:MAX` on page 1847

PACP Function ID

Sets the specified PACP Function ID to be triggered on. The PACP Function ID setup consists of the condition and one or two PACP Function ID patterns.

"Condition"	Defines the operator to set a specific PACP Function ID, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the PACP Function ID pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second PACP Function ID pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:MPHY:PFID:CONDition` on page 1847

`TRIGger<m>:MPHY:PFID:MIN` on page 1847

`TRIGger<m>:MPHY:PFID:MAX` on page 1848

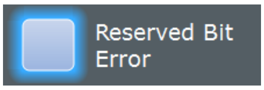
Errors

Sets the type of error events to be triggered on.

Reserved Bit Error ← Errors

Triggers on reserved bit error.

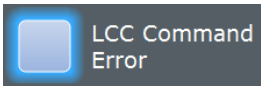
This error means that the waveform violates the reserved field according to the specification. For example, a DL_PDU_AFC frame requires that the two bits before and three bits after the FSN field to be reserved and set as 0. If the waveform carries 1 in these positions instead, it is marked as this error.



Remote command:
`TRIGger<m>:MPHY:ERRor:REServed` on page 1849

LCC Command Error ← Errors
Triggers on LCC command error.

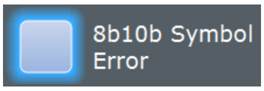
This error is marked when the Command field in the LCC packet is not a known command defined in the specification.



Remote command:
`TRIGger<m>:MPHY:ERRor:LCMD` on page 1848

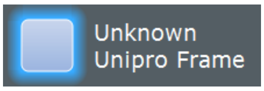
8b10b Symbol Error ← Errors
Triggers on 8b10b symbol error.

For example, some of the 10-bit combinations that do not map to 8-bit according to the specification are invalid 10-bit and therefore marked as this error.



Remote command:
`TRIGger<m>:MPHY:ERRor:SYMBol` on page 1849

Unknown Unipro Frame ← Errors
Triggers on unidentified UniPro frame error. This error is marked when the end mark on Unipro packets is undetected.



Remote command:
`TRIGger<m>:MPHY:ERRor:UNKNown` on page 1849

Length Error ← Errors
Triggers on frames that violate the length according to the specification.

Remote command:
`TRIGger<m>:MPHY:ERRor:LENGth` on page 1848

12.15.3.2 Triggering on M-PHY

Prerequisite: A bus is configured for the M-PHY signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog, tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus":
3. Tap "Serial bus" and select the serial bus that is set to M-PHY, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "M-Phy".
4. Select the "Type" to use in the M-PHY protocol analysis.
5. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.15.3.1, "M-PHY Trigger Settings", on page 750.

12.15.4 M-PHY Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Figure 12-81 shows a decoded M-PHY signal and the result tables.

Figure 12-81: Decoded M-PHY signal with result tables

green brackets [...] = start and end of frame
yellow frame header = burst
red frame header = frame containing error (also reported in the results table)
dark blue = data before synchronization (M-PHY frame) / line init (LCC frame)
orange = data after synchronization (M-PHY frame) / data (LCC frame)
light blue = marker 0
marine blue = marker 1 to 6
yellow = command type (LCC frame)
grey = fillers (M-PHY frame) / reserved word (LCC frame)

The example in Figure 12-82 shows a decoded UniPro signal and the result tables.

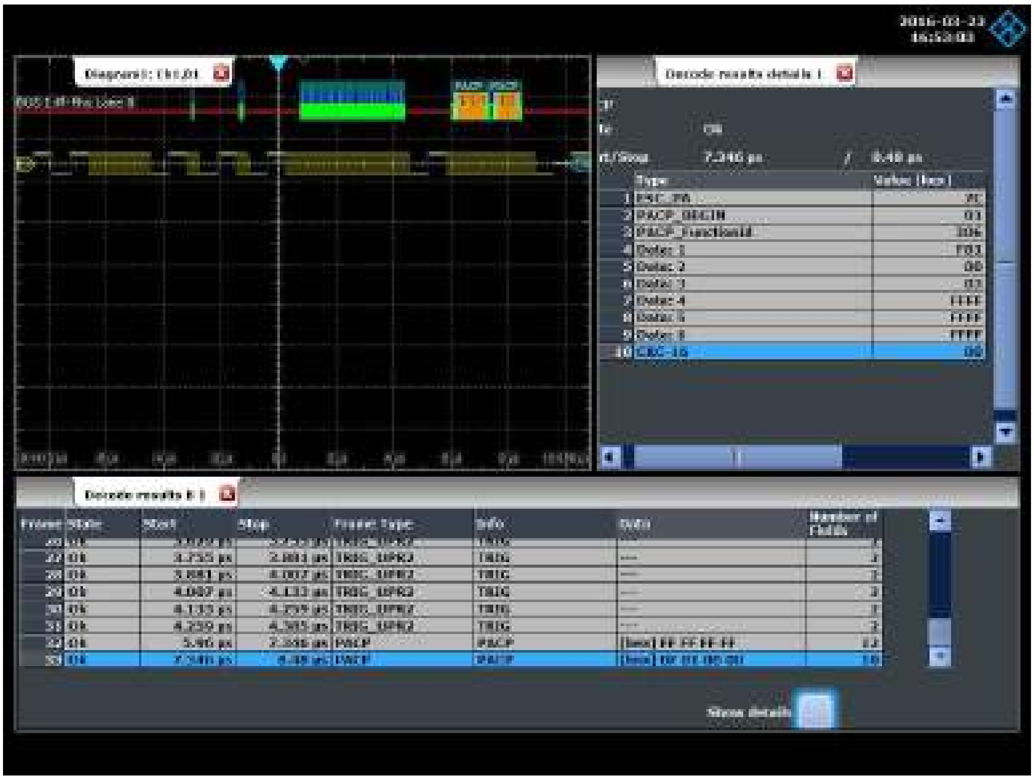


Figure 12-82: Decoded UniPro signal with result tables

green brackets [...] = start and end of frame
turqoise frame header = PDU
red frame header = frame containing error (also reported in the results table)
marine blue = ESC_DL word
dark blue = identifier (ID) word such as SOF, COF, EOF, NAC or AFC
yellow = TC word
orange = data
light blue = CRC
grey = filler, spacer or reserved word

Table 12-18: Content of the decode result table

Column	Description
Frame	Frame count
State	Overall state of the frame indicating, for example, if the frame is valid or invalid
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point
Frame Type	Frame identifier specifying the data or control frame name
Info	Label on top of the frame
Data	Payload information
Number of Fields	Total number of fields in the frame

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.16.3, "Decode Results", on page 1849.

12.15.5 Search on Decoded M-PHY Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

12.15.5.1 M-PHY Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for M-PHY

Type

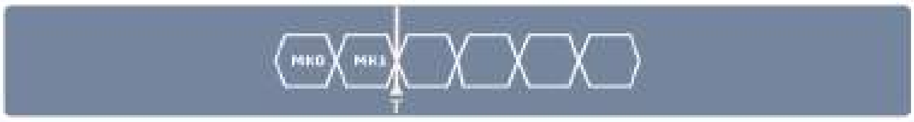
Selects the search type for the selected protocol.

Remote command:

`SEARch:TRIGger:MPHY:TYPE` on page 1855

Start of frame ← Type

Searches for the start of an M-PHY or a UniPro frame.

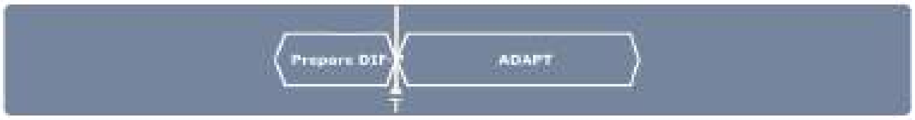


Burst ← Type

Searches for an M-PHY burst.

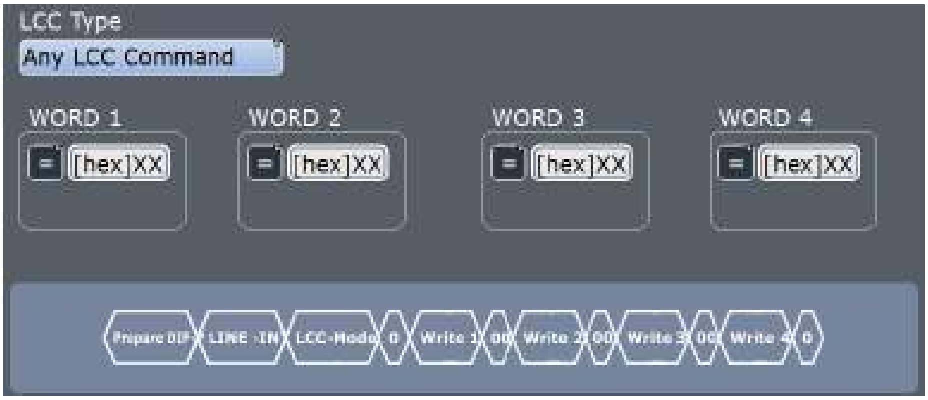
Adapt ← Type

Searches for an M-PHY Adapt frame. This control frame is used for clock/bit synchronization.



LCC ← Type
Searches for an M-PHY Line Control Command (LCC) frame that matches the specified LCC Type or any WORD condition.

This control frame is used for configuring the line to a different state or mode depending on the LCC type.


LCC Type
Any LCC Command

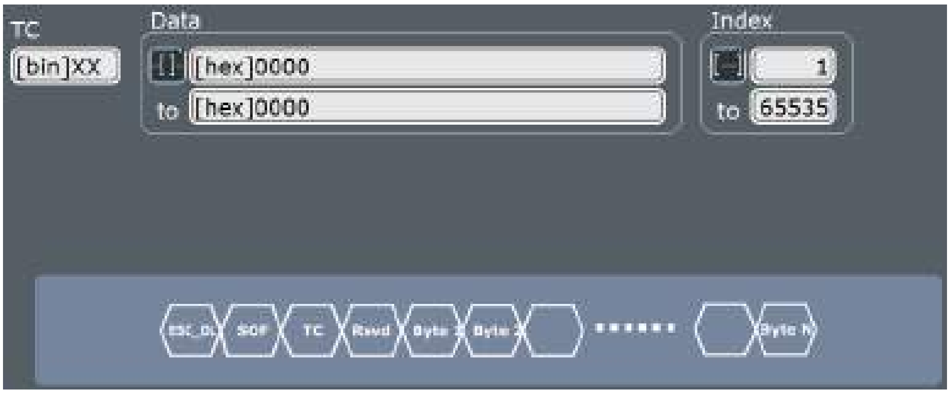
WORD 1
= [hex]XX

WORD 2
= [hex]XX

WORD 3
= [hex]XX

WORD 4
= [hex]XX

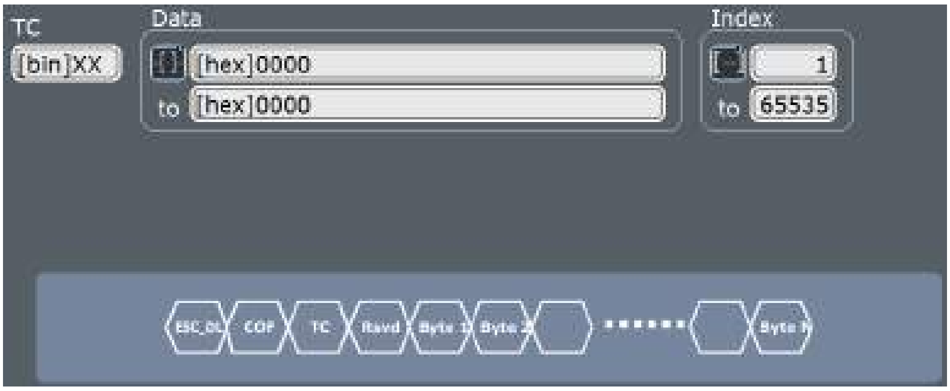
DL PDU SOF ← Type
Searches for a UniPro Downlink Protocol Data Unit (DL PDU) Start Of Frame (SOF) that matches the specified TC, Data or Index condition.


TC
[bin]XX

Data
[hex]0000
to [hex]0000

Index
1
to 65535

DL PDU COF ← Type
Searches for a UniPro DL PDU Continuation Of Pre-empted Frame (COF) that matches the specified TC, Data or Index condition.



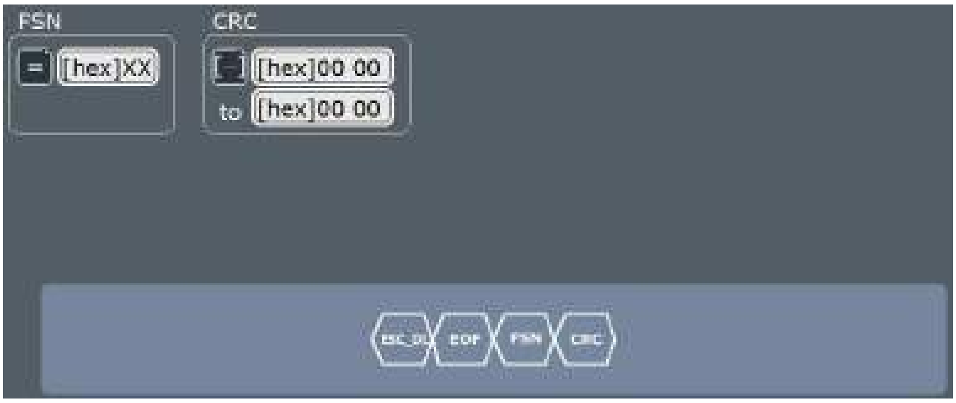
TC [bin]XX

Data [hex]0000 to [hex]0000

Index 1 to 65535

DL PDU EOF ← Type

Searches for a UniPro DL PDU End Of Frame (EOF) that matches the specified FSN or CRC condition.

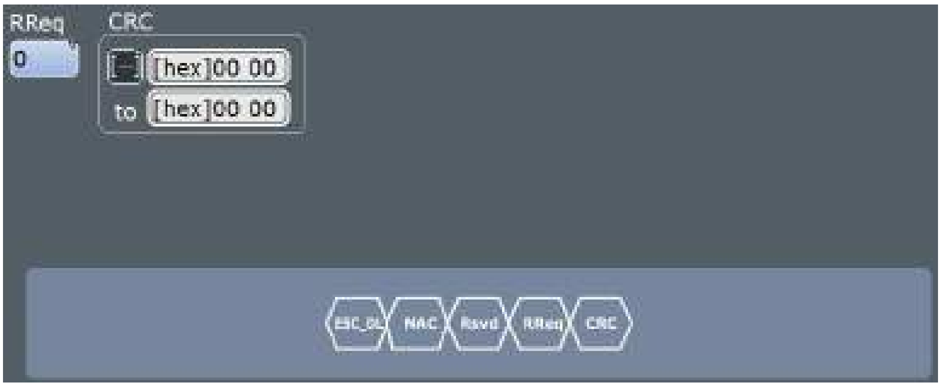


FSN = [hex]XX

CRC [hex]00 00 to [hex]00 00

DL PDU NAC ← Type

Searches for a UniPro DL PDU Negative Acknowledgment Control (NAC) frame that matches the specified RReq or CRC condition.

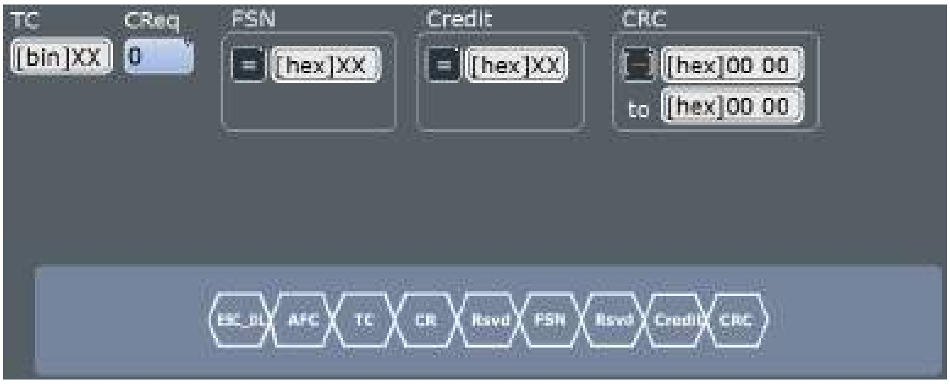


RReq 0

CRC [hex]00 00 to [hex]00 00

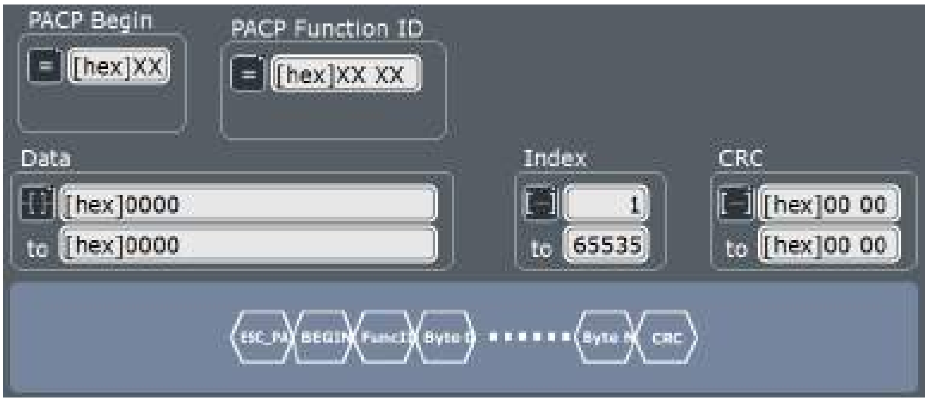
DL PDU AFC ← Type

Searches for a UniPro DL PDU Acknowledgement and L2 Flow Control (AFC) frame that matches the specified TC, CReq, FSN, Credit or CRC condition.

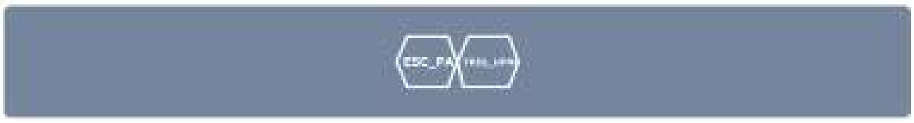

TC [bin]XX
CReq 0
FSN = [hex]XX
Credit = [hex]XX
CRC [hex]00 00 to [hex]00 00

PACP ← Type
Searches for a UniPro PHY Adapter Control Protocol (PACP) frame that matches the specified PACP Begin, PACP Function ID, Data, Index or CRC condition.

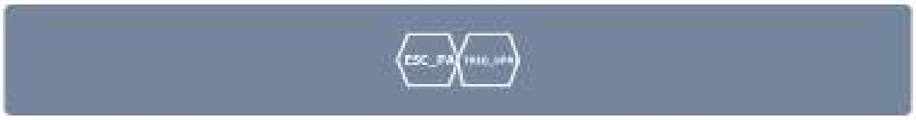
This control frame is used mainly for power mode change and L1.5 link management. It is also used in scrambling request.


PACP Begin = [hex]XX
PACP Function ID = [hex]XX XX
Data [hex]0000 to [hex]0000
Index 1 to 65535
CRC [hex]00 00 to [hex]00 00

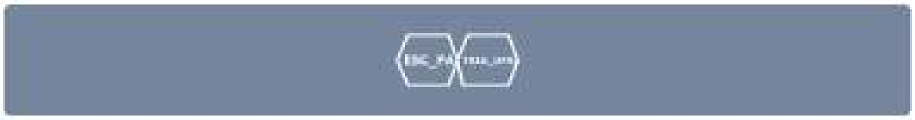
Trigger Upper0 ← Type
Searches for a Trigger Upper0 frame. This control frame is used for link startup sequence.



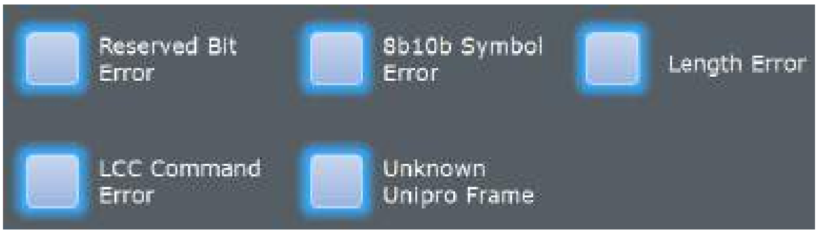
Trigger Upper1 ← Type
Searches for a Trigger Upper1 frame. This control frame is used for link startup sequence.



Trigger Upper2 ← Type
Searches for a Trigger Upper2 frame. This control frame is used for link startup sequence.



Errors ← Type
Searches for the specified error frame.



LCC Type
Selects the type of LCC command to be searched for.

LCC Type
Any LCC Command

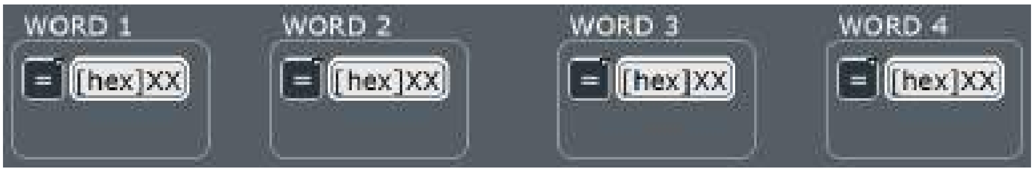
"Any LCC Command"	All the available LCC commands
"HIBERN8-SLEEP"	Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 90% power and is used with PWM burst
"HIBERN8-STALL"	Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 75% power and is used with HS burst
"READ-CAPABILITY"	Recovers data about the Optical Media Converter (OMC) capabilities
"READ-MFG-INFO"	Retrieves manufacturing ID and vendor-specific information
"READ-VEND-INFO"	Retrieves the additional four delimited bytes containing vendor-specific information
"WRITE-ATTRIBUTE"	Sets the configuration parameters required for lane operation
"PWM-G0/PWM-G1/PWM-G2/PWM-G3/PWM-G4/PWM-G5/PWM-G6/PWM-G7"	Switches the transmission mode to the selected low-power gear
"HS-G1A/HS-G2A/HS-G3A/HS-G4A/HS-G1B/HS-G2B/HS-G3B/HS-G4B"	Switches the transmission mode to the selected high-speed gear

"Reserved"	Reserved bit command. These bits are reserved for future use

Remote command:
`SEARch:TRIGger:MPHY:LCCType` on page 1856

WORD 1/WORD 2/WORD 3/WORD 4

Sets the specified words to be searched for. The setup for a word consists of the condition and one or two word patterns.



"Condition"	Defines the operator to set a specific word, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the word pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "WORD 1":
`SEARch:TRIGger:MPHY:LWONe:CONDition` on page 1857
`SEARch:TRIGger:MPHY:LWONe:MIN` on page 1858
`SEARch:TRIGger:MPHY:LWONe:MAX` on page 1858
For "WORD 2":
`SEARch:TRIGger:MPHY:LWTWo:CONDition` on page 1858
`SEARch:TRIGger:MPHY:LWTWo:MIN` on page 1859
`SEARch:TRIGger:MPHY:LWTWo:MAX` on page 1859
For "WORD 3":
`SEARch:TRIGger:MPHY:LWTHree:CONDition` on page 1859
`SEARch:TRIGger:MPHY:LWTHree:MIN` on page 1860
`SEARch:TRIGger:MPHY:LWTHree:MAX` on page 1860
For "WORD 4":
`SEARch:TRIGger:MPHY:LWFour:CONDition` on page 1860
`SEARch:TRIGger:MPHY:LWFour:MIN` on page 1861
`SEARch:TRIGger:MPHY:LWFour:MAX` on page 1861

TC

Sets the specified Traffic Class (TC) to be searched for.

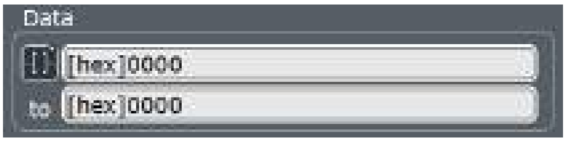
TC is used for classifying the traffic flow based on protocol and port number, e.g. TC0 and TC1 are two priority classes with guaranteed link reliability defined and used in L2.

"Data"	Defines the bit pattern of the TC pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
`SEARch:TRIGger:MPHY:TC` on page 1861

Data

Sets the specified data to be searched for. The data setup consists of the condition and one or two data patterns.



[hex]0000
[hex]0000

"Condition"	Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.
"Data Min/Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:DATA:DCONdition` on page 1862
`SEARch:TRIGger:MPHY:DATA:DMIN` on page 1862
`SEARch:TRIGger:MPHY:DATA:DMAX` on page 1862

Index

Index sets the range within this series of data that is considered for the search. The index setup consists of the condition and one or two data index values.

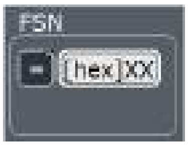
1
65535

"Condition"	Defines the operator to set a specific index, e.g. "Equal" or a range.
"Index Min/Index"	Defines the bit pattern of the index pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Index Max"	The second index pattern is required to specify a range with conditions "In range".

Remote command:
`SEARch:TRIGger:MPHY:DATA:ICONdition` on page 1863
`SEARch:TRIGger:MPHY:DATA:IMIN` on page 1863
`SEARch:TRIGger:MPHY:DATA:IMAX` on page 1863

FSN

Sets the specified Frame Sequence Number (FSN) to be searched for. The FSN setup consists of the condition and one or two FSN patterns.



"Condition"	Defines the operator to set a specific FSN, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the FSN pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second FSN pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:FSNumber:CONDition` on page 1864
`SEARch:TRIGger:MPHY:FSNumber:MIN` on page 1864
`SEARch:TRIGger:MPHY:FSNumber:MAX` on page 1864

CRC

Sets the specified Cyclic Redundancy Check (CRC) to be searched for. The CRC setup consists of the condition and one or two CRC patterns.

CRC is an error detecting code to detect accidental changes to raw data.

"Condition"	Defines the operator to set a specific CRC, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the CRC pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second CRC pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:CRC:CONDition` on page 1865
`SEARch:TRIGger:MPHY:CRC:MIN` on page 1865
`SEARch:TRIGger:MPHY:CRC:MAX` on page 1865

Req

Sets the specified Reset Link Request (RReq) or Credit Transmit Request (CReq) to be searched for.

RReq is used for requesting the remote end to re-initialize its Transmit (TX) Physical Layer (PHY) while CReq is used for requesting flow control information for the corresponding TC from the remote end.

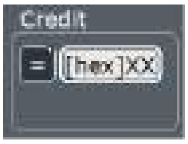
"Data"	Defines the bit pattern of the RReq pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

Remote command:
For "RReq":
`SEARch:TRIGger:MPHY:RREQ` on page 1866
For "CReq"
`SEARch:TRIGger:MPHY:CREQ` on page 1866

Credit

Sets the specified credit to be searched for. The credit setup consists of the condition and one or two credit patterns.

Credit represents the total number of credits available since boot time.



"Condition"	Defines the operator to set a specific credit, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the credit pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second credit pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:CREDit:CONDition` on page 1866
`SEARch:TRIGger:MPHY:CREDit:MIN` on page 1867
`SEARch:TRIGger:MPHY:CREDit:MAX` on page 1867

PACP Begin

Sets the specified PACP Begin to be searched for. The PACP Begin setup consists of the condition and one or two PACP Begin patterns.

"Condition"	Defines the operator to set a specific PACP Begin, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the data value pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second PACP Begin pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:PBEGin:CONDition` on page 1867
`SEARch:TRIGger:MPHY:PBEGin:MIN` on page 1868
`SEARch:TRIGger:MPHY:PBEGin:MAX` on page 1868

PACP Function ID

Sets the specified PACP Function ID to be searched for. The PACP Function ID setup consists of the condition and one or two PACP Function ID patterns.

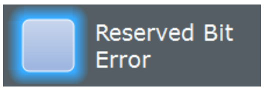
"Condition"	Defines the operator to set a specific PACP Function ID, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the PACP Function ID pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second PACP Function ID pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:PFID:CONDition` on page 1868
`SEARch:TRIGger:MPHY:PFID:MIN` on page 1869
`SEARch:TRIGger:MPHY:PFID:MAX` on page 1869

Errors
Sets the type of error events to be searched for.

Reserved Bit Error ← Errors
Searches for reserved bit error.

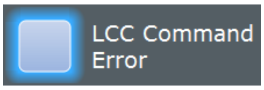
This error means that the waveform violates the reserved field according to the specification. For example, a DL_PDU_AFC frame requires that the two bits before and three bits after the FSN field to be reserved and set as 0. If the waveform carries 1 in these positions instead, it is marked as this error.



Remote command:
`SEARch:TRIGger:MPHY:ERRor:REServed` on page 1869

LCC Command Error ← Errors
Searches for LCC command error.

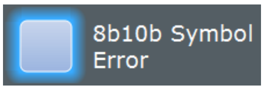
This error is marked when the Command field in the LCC packet is not a known command defined in the specification.



Remote command:
`SEARch:TRIGger:MPHY:ERRor:LCMD` on page 1870

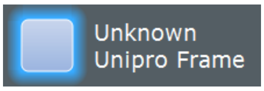
8b10b Symbol Error ← Errors
Searches for 8b10b symbol error.

For example, some of the 10-bit combinations that do not map to 8-bit according to the specification are invalid 10-bit and therefore marked as this error.



Remote command:
`SEARch:TRIGger:MPHY:ERRor:SYMBol` on page 1870

Unknown Unipro Frame ← Errors
Searches for unidentified UniPro frame error. This error is marked when the end mark on Unipro packets is undetected.

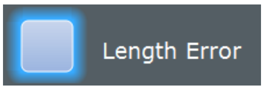


Remote command:

`SEARch:TRIGger:MPHY:ERRor:UNKNown` on page 1870

Length Error ← Errors

Searches for frames that violate the length according to the specification.



Remote command:

`SEARch:TRIGger:MPHY:ERRor:LENGth` on page 1870

12.15.5.2 M-PHY Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

The columns in the search result table are the same as in the decoding table, see M-PHY Decode Results.

Remote commands:

- `SEARch:RESult:MPHY:FCOunt?` on page 1871
- `SEARch:RESult:MPHY:FRAMe<m>:CCOunt?` on page 1871
- `SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:DATA?` on page 1871
- `SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:TYPE?` on page 1872
- `SEARch:RESult:MPHY:FRAMe<m>:DATA?` on page 1872
- `SEARch:RESult:MPHY:FRAMe<m>:FTYPe?` on page 1872
- `SEARch:RESult:MPHY:FRAMe<m>:STARt?` on page 1874
- `SEARch:RESult:MPHY:FRAMe<m>:STATe?` on page 1873
- `SEARch:RESult:MPHY:FRAMe<m>:STOP?` on page 1874

12.15.5.3 Searching M-PHY

Prerequisite: A serial bus is configured for the M-PHY signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.

2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to M-PHY (e.g. "SerBus1").
4. Specify the search criteria according to Chapter 12.15.5.1, "M-PHY Search Setup", on page 765.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs an M-PHY decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.16 Custom: Manchester / NRZ (Option R&S RTO-K50)

R&S RTO-K50 is a firmware option that enables the R&S RTO to analyze customizable serial bus signals encoded by the following coding standards:

- Manchester
- Manchester II
- NRZ Clocked
- NRZ Unclocked

For analysis, signals encoded in any of these protocols can be triggered and decoded.

Due to the free format description, no search within the decoded events is available.

This chapter describes:

12.16.1 Custom: Manchester / NRZ Protocols

"Manchester" coding is a self-clocked coding scheme also known as phase-shift keying (or phase encoding, PE). It is used in protocols such as ProfiBus (IEC 61158), DALI (Digital Addressable Lighting Interface, IEC 60929 and IEC 62386), MVB (Multifunction Vehicle Bus, part of IEC 61375 for Train Communication Networks, TCN), and Ethernet 10BASE-T (10 Mbit/s, IEEE 802.3i). In terms of a logical Boolean operation, the

Manchester value of each bit (as per G. E. Thomas) is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.

"Manchester II" coding (as per IEEE 802.3) is represented by inverted Manchester values: a "0" is expressed by a low-to-high transition, a "1" by a high-to-low transition.

NRZ stands for "non-return-to-zero" coding: Typically a "1" is represented by a positive voltage and a "0" is represented by a negative voltage, with no "zero" voltage state. NRZ code requires only half the bandwidth of Manchester code, and it can either be clocked or unclocked. NRZ unclocked signals require a user-defined bit rate and gap time setting for triggering and decoding.

12.16.1.1 Special Features of Manchester Coding

In practical protocols, Manchester coding appears in many variations, often employing deliberate coding violations to encode special waveform features, such as unambiguous synchronization and termination patterns. To adapt to these specific Manchester implementations and handle ambiguous signals, the option R&S RTO-K50 for Custom Serial Bus uses a combination of automatic algorithms and user configurable parameters.

Quaternary Symbols

The software supports not just traditional binary symbols "0" and "1", but also arbitrary violation waveforms that use two additional symbols, yielding a total of four valid "quaternary bit" values. The two additional violation symbols are "H" (high) and "L" (low). Values of "H" correspond to a waveform lacking a transition in the center of the bit, with a physical high voltage state. Similarly, "L" violations also lack a center transition, but have a physical low voltage state. Most Manchester synchronization and termination conventions, even those containing violations, may be expressed as sequences of these four symbols. R&S RTO-K50 uses the quaternary notation to support Manchester patterns in the honeycomb display and to describe synchronization and termination patterns in the frame description table.

Idle Conditions

The state of the signal line in between messages is the idle condition. Manchester appears in practical standards with varying idle conditions: it can idle at the high, low, or middle voltage state. High and low idle states correspond to "biphase" Manchester, while the middle voltage (often ground) adds a third state to become "ternary" Manchester. Using ternary Manchester, option R&S RTO-K50 can usually establish the gaps between messages automatically. Using binary Manchester, the software has no way to automatically discriminate an idling bus from monotonic sequences of "H" or "L" violations. For these biphase situations, R&S RTO-K50 offers a "Gap Time" detection feature, which allows to distinguish long intervals of non-transitions between bus idling and sequences of violations. Other differences between biphase and ternary Manchester are managed automatically by the software, with no user input required.

Edge Conventions

Most Manchester encodings establish the beginning of the first bit by a first transition, hence an "overhead" edge. The center of the bit is then marked by a second transition, which is a "sampling" edge. Some Manchester implementations, however, sample the first bit on the first edge. The option R&S RTO-K50 attempts to automatically detect this situation. Unfortunately, it is possible to trick the algorithm with waveforms that contain many (legitimate) violations. In these situations, the user can force a "First Edge" or "Second Edge" convention for handling edges. Edge sampling according to the "First Edge" convention is more likely to appear in biphase Manchester, but the software also supports this setting for ternary Manchester situations.

Bit Rate

Typically, a single bit rate is clearly specified in Manchester protocols; however, some implementations use a variable bit rate. By default, R&S RTO-K50 automatically determines the bit rate with no user input required. However, there are fundamental ambiguities possible in Manchester, if the bitrate is unknown. In particular, sequences like "0000", "1111", "0101", "1010", and many situations involving "H" and "L" violations, cannot be decoded without a known bit rate. The situation becomes even less defined with eventual Manchester coding violations. In these situations, a fixed "Bit Rate" setting has to be provided by the user to bypass the software's estimation algorithm.

12.16.2 Custom: Manchester / NRZ Configuration

If you need information on how to get started with configuring the custom serial bus setup, see Chapter 12.16.2.5, "Configuring Custom Manchester / NRZ Signals", on page 800. Otherwise proceed with the configuration settings.

12.16.2.1 Custom: Manchester / NRZ Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *Custom*

Make sure that the tab of the correct serial bus is selected on the left side.

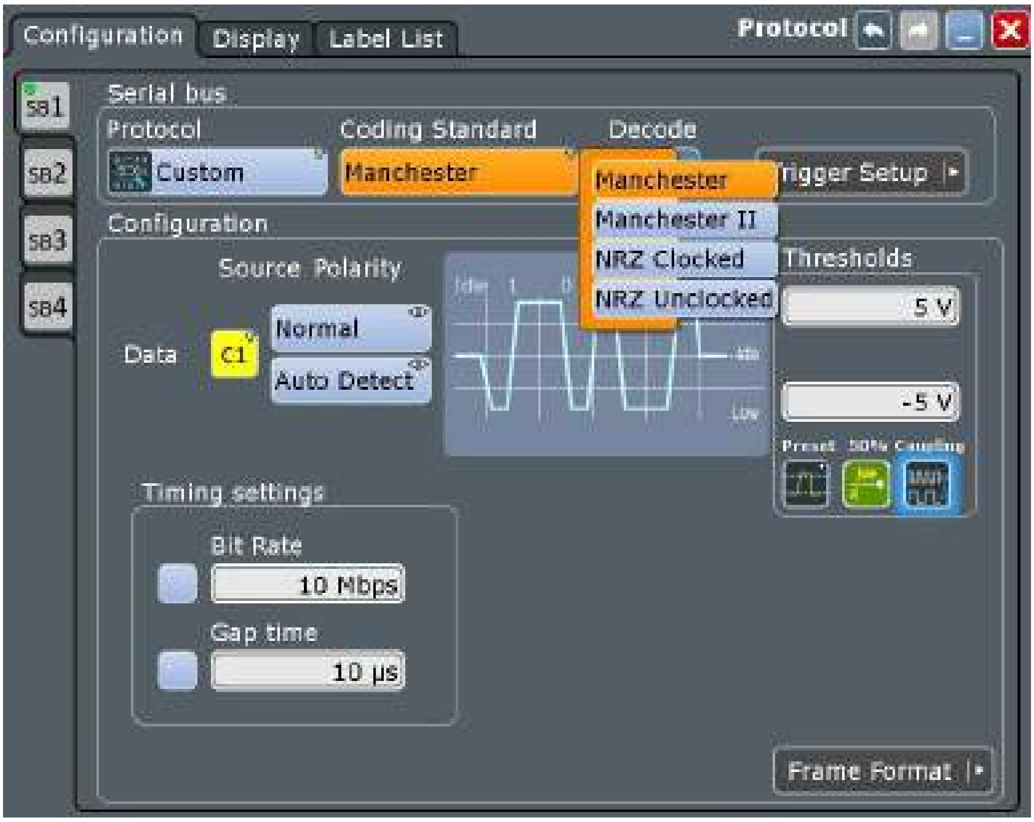


Figure 12-83: Coding standard selection in the serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Coding Standard

To define the coding of the custom serial bus to be analyzed, select one of the following standards:

"Manchester"	Selects the coding standard Manchester. Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 µs), as shown in Figure 12-83.

Figure 12-84: Custom serial bus coding configuration Manchester

"Manchester II" Selects the coding standard Manchester II, which is the inverted signal of the coding standard Manchester.
Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 µs), as shown in Figure 12-83.


Protocol: Custom
Coding Standard: Manchester II
Data: C1, Normal, Auto Detect
Thresholds: 5 V, -5 V

Figure 12-85: Custom serial bus coding configuration Manchester II

"NRZ Clocked" Selects the coding standard NRZ Clocked.
Optional "Timing settings" is "Gap time" (default: disabled, 10 µs), as shown in Figure 12-86.

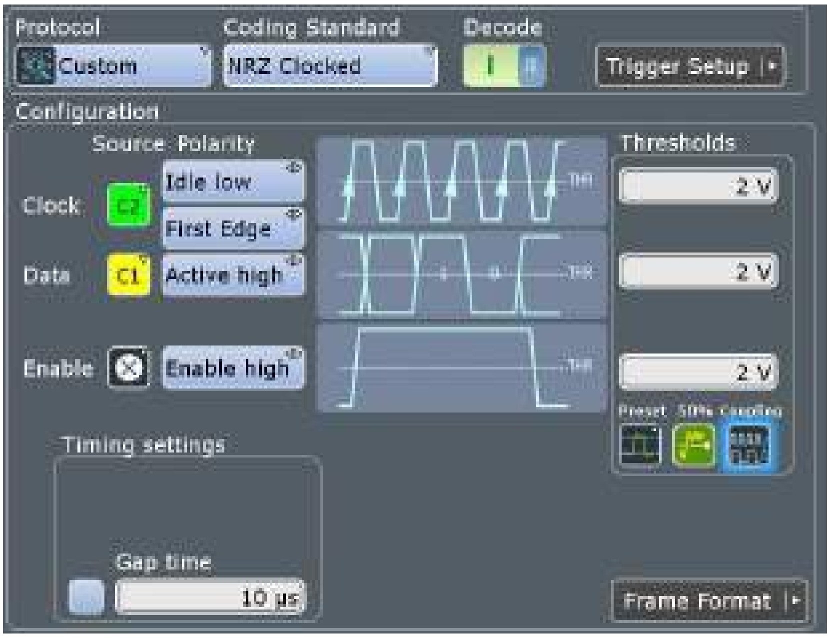
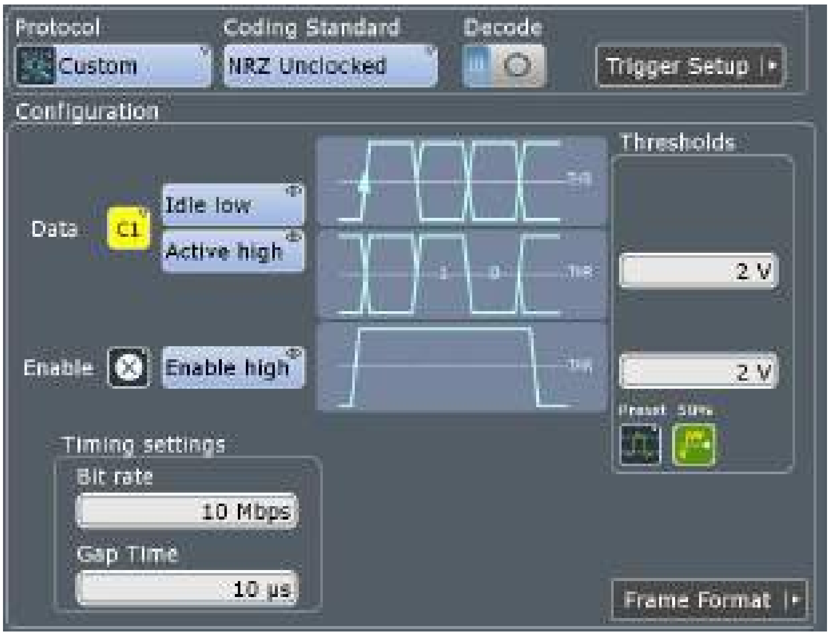

Protocol: Custom
Coding Standard: NRZ Clocked
Clock: C2, Idle low, First Edge
Data: C1, Active high
Enable: Enable high
Thresholds: 2 V, 2 V, 2 V
Gap time: 10 µs

Figure 12-86: Custom serial bus coding configuration NRZ clocked

"NRZ Unclocked"

Selects the coding standard NRZ unclocked.
Obligatory "Timing settings" are "Bit Rate" (default 10 Mbit/s) and "Gap time" (default 10 µs), as shown in Figure 12-87.



Protocol: Custom
Coding Standard: NRZ Unclocked
Data: C1, Idle low, Active high
Enable: Enable high
Timing settings
Bit rate: 10 Mbps
Gap Time: 10 µs
Thresholds: 2 V, 2 V

Figure 12-87: Custom serial bus coding configuration NRZ Unclocked

Remote command:
`BUS<m>:CMSB:CODing` on page 1876

Data Source
Defines the input source for the custom serial bus data signal.

The data source for Manchester and NRZ coding standards is selected separately, independent of each other. The data source is set to default upon switching the coding standard.

Permitted source selections are:
- For "Manchester"/ "Manchester II":
  - Decoding: the analog, mathematical, and reference channels
  - Triggering: the analog channels
- For "NRZ Clocked":
  - Decoding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.
  - Triggering: the analog and digital channels
- For "NRZ Unclocked":
  - Decoding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.
  - Triggering: the analog channels

Remote command:
`BUS<m>:CMSB:MANChester:DATA` on page 1876
`BUS<m>:CMSB:NRZ:DATA` on page 1879

Clock Source
Defines the source for the custom serial bus clock signal (only available for the coding standard "NRZ Clocked").

Permitted source selections are the analog, mathematical, reference and digital channels.

Digital channels can be only used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Remote command:
`BUS<m>:CMSB:NRZ:CLCK` on page 1879

Data Polarity (Manchester)
Defines the polarity of the custom serial bus data signal in Manchester coding standards. The available settings are "Normal" or "Inverted".

Remote command:
`BUS<m>:CMSB:MANChester:POLarity` on page 1877

Data Polarity (NRZ)
Defines the polarity of the custom serial bus data signal in NRZ coding standards. The available settings are:

"Active high"	The value "1" is represented by a voltage above the threshold.
"Active low"	The value "1" is represented by a voltage below the threshold.

Remote command:
`BUS<m>:CMSB:NRZ:POLarity` on page 1882

Data Idle Polarity (NRZ Unclocked)
Defines the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked"). The available settings are:

"Idle low"	The base value of the clock is "0"; after an idle period, the data signal starts with a low-to-high transition.
"Idle high"	The base value of the clock is "1"; after an idle period, the data signal starts with a high-to-low transition.

Remote command:
`BUS<m>:CMSB:NRZ:IDLPolarity` on page 1880

Clock Polarity (NRZ Clocked)
Defines the polarity of the custom serial bus clock signal (only available for the coding standard "NRZ Clocked"). The available settings are:

"Idle low"	The base value of the clock is "0".
"Idle high"	The base value of the clock is "1".

Remote command:
`BUS<m>:CMSB:NRZ:CPOLarity` on page 1880

Clock Phase (Manchester)
Defines the phase of the custom serial bus clock signal for the Manchester coding standards. The available settings are:

"Auto Detect"	Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the clock phase.
"First Edge"	• At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge. • At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge.
"Second Edge"	• At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge. • At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge. **Note:** The requirement to specify "First Edge" or "Second Edge" (or let the decoder decide) has the following background: In Manchester coding, an edge is always a transition from high to low (0) or from low to high (1). However, if the signal comes from the idle state, this implies that right before the first valid edge, there is always an overhead transition from idle to high or from idle to low. Some standards may regard this as a valid transition. To avoid a potentially ambiguous situation, a decision has to be made if the first edge is indeed only some overhead transition - or a transition that needs to be sampled. For more details on edge conditions, see Chapter 12.16.1.1, "Special Features of Manchester Coding", on page 779.

Remote command:
`BUS<m>:CMSB:MANChester:CPHase` on page 1878

Clock Phase (NRZ Clocked)
Defines the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on "Clock Polarity". The available settings are:

"First Edge"	• At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge • At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge
"Second Edge"	• At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge • At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge

Remote command:
`BUS<m>:CMSB:NRZ:CPHase` on page 1880

Enable Source (NRZ)
Defines the input source for the custom serial bus enable signal.

If an input is chosen, signals are only decoded when this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

Permitted source selections are the analog, mathematical, and reference channels.

When the serial bus trigger has been selected, the only permitted source selections are the analog channels "C1" – "C4", which are required for triggering.

Math and Ref channels can only be selected, if no serial bus trigger is selected.

Remote command:
`BUS<m>:CMSB:NRZ:ENBLe` on page 1881

Enable Polarity (NRZ)
Selects whether the transmitted enable signal is active when the voltage is below the Thresholds ("Enable low") or higher than it ("Enable high").

Remote command:
`BUS<m>:CMSB:NRZ:ENAPolarity` on page 1881

Thresholds
Sets the threshold value for the digitization of each signal line. If the signal voltage on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal voltage is below the lower threshold, the signal state is considered low.

- Manchester coding standards use 3-state signals with an upper and a lower voltage threshold in the range of -25 V to +25 V. A low-to-high transition requires the signal to exceed the upper threshold; a high-to-low transition requires the signal to fall below the lower threshold.
- NRZ coding standards use a single voltage threshold for the data line. The value in the range of -25 V to +25 V is entered into the middle of three available threshold input fields, or into the upper available threshold input field in case of NRZ Unclocked.
- In the NRZ Clocked coding standard, there is an additional clock voltage threshold available. This value in the range of -25 V to +25 V is entered into the upper threshold input field.

There are four ways to set the threshold:

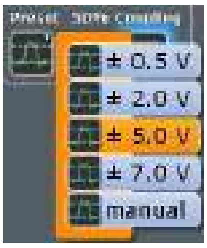
"Threshold" Directly sets the threshold values.

- For Manchester: upper threshold in the upper field, lower threshold in the lower field.
- For NRZ Clocked: clock threshold in the upper field, data threshold in the middle field and enable threshold in the lower field.
- For NRZ Unclocked: data threshold in the upper field and enable threshold in the lower field.

Remote command:
`BUS<m>:CMSB:MANChester:THReshold:HIGH` on page 1877
`BUS<m>:CMSB:MANChester:THReshold:LOW` on page 1877
`BUS<m>:CMSB:NRZ:THReshold:CLCK` on page 1882
`BUS<m>:CMSB:NRZ:THReshold:DATA` on page 1882
`BUS<m>:CMSB:NRZ:THReshold:ENBLe` on page 1882

"Preset"

- Either sets individual voltages by selecting "manual",
- or sets the voltages to one out of various pre-defined levels.



When any non-predefined threshold is set, the "Preset" status automatically changes to "manual" (without affecting anything else).

Remote command:
`BUS<m>:CMSB:MANChester:THReshold:PRESet` on page 1877
`BUS<m>:CMSB:NRZ:THReshold:PRESet` on page 1883

"50%" Executes a measurement of reference levels and sets the thresholds to the middle reference voltage level of the measured amplitude.

Remote command:
`BUS<m>:SETReflevels` on page 1495

"Coupling"

- For Manchester and Manchester II coding, the upper and lower threshold are coupled to voltage values with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.
- For NRZ Clocked coding, the clock and data threshold values are coupled to the same voltage.

Remote command:
`BUS<m>:CMSB:MANChester:THReshold:COUPling` on page 1878
`BUS<m>:CMSB:NRZ:THReshold:COUPling` on page 1883

Enable Bit Rate
Enables the bit rate settings for the coding standards "Manchester" and "Manchester II". This setting is not available for "NRZ Clocked", but always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard.

Remote command:
`BUS<m>:CMSB:BITRate:ENABle` on page 1884

Bit Rate
Defines the transmission speed setting for the data signal. A bit rate definition is optional for the coding standards "Manchester" and "Manchester II", not available for "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 50 Mbps.

For more details on the bit rate, see Chapter 12.16.1.1, "Special Features of Manchester Coding", on page 779.

Remote command:
`BUS<m>:CMSB:BITRate:VALue` on page 1884

Enable Gap Time
Enables the gap time settings (always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Remote command:
`BUS<m>:CMSB:GAPTime:ENABle` on page 1884

Gap time
Specifies a minimum gap time (idle time or timeout) between two frames. A gap time definition is optional for the coding standards "Manchester", "Manchester II" and "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.

For more details on gap time and idle conditions, see Chapter 12.16.1.1, "Special Features of Manchester Coding", on page 779.

Remote command:
`BUS<m>:CMSB:GAPTime:VALue` on page 1884

Trigger Setup
The navigation button "Trigger Setup" in the upper right corner of the protocol configuration menu (Figure 12-83) opens the trigger setup dialog, which is described in Chapter 12.16.3, "Custom: Manchester / NRZ Trigger", on page 800.

Frame Format
The navigation button "Frame Format" in the lower right corner of the protocol configuration menu (Figure 12-83) opens the frame format dialog, which is described in Chapter 12.16.2.2, "Frame Format Configuration", on page 788.

12.16.2.2 Frame Format Configuration

This dialog enables you to describe the generic format and logical structure of typical protocols by creating customized frame descriptions of various structures and lengths.

Frame type: FORWARD-group-address

Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
start	1		Binary	MSB First	⬛	-
Y	3	=100	Binary	MSB First	🟩	-
ADDR	4		Hex	MSB First	🟦	1
S	1		Hex	MSB First	🟩	2
DATA	8		Hex	MSB First	🟨	3
stop	2	=HH	Binary	MSB First	⬛	-

dali.xml

Figure 12-88: Example of a custom "DALI" frame format description (frame 2 of 4)

Frame type: Master

Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
MSD	9	=1LH0LH000	Hex	MSB First	🟨	-
F	4		Hex	MSB First	🟨	1
ADDR	12		Hex	MSB First	🟩	2
CRC	8		Hex	MSB First	🟩	3

MVB.xml

Figure 12-89: Example of a custom "MVB" frame format description (frame 1 of 2)

Frame type: 00

Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
Start Delim	16	=101010101HL	Binary	MSB First	🟨	-
OP-00	8	=00000000	Binary	MSB First	🟦	1
data	8	[]	Hex	MSB First	🟩	2
End Delim	8	=1HLHL101	Binary	MSB First	🟨	-

ProfiBus Voltage.xml

Figure 12-90: Example of a custom "ProfiBus Voltage" frame format description (frame 1 of 3)

2016-09-15 11:12:33

Horizontal
83.2 ns / 12.019231 MSa/s
7.212 kSa RT
60.00384 µs/div
0 s

Trigger Auto
A: Edge Ch1
Level: 0 V

Ch1Wfm1
500 mV/div
0 div 500 mV
DC 50Ω BW: 4 GHz
Sample

Ch2Wfm1
500 mV/div
0 div 500 mV
DC 50Ω BW: 4 GHz
Sample

SerBus1
Type: Custom
NRZ CLK: C2W1
NRZ DATA: C1W1
NRZ ENABLE: None

Frame type: Condition Example

	Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
1	PRE	32	=0xFFFFFFFF	Hex	MSB First	⬛	-
2	Id	4	=0010	Binary	MSB First	🟪	-
3	Src	4	{Address}	Hex	LSB First	🟦	1
4	Dest	4	{Address}	Hex	LSB First	🟩	2
5	Data	3	[]	Hex	MSB First	🟨	-
6	P	1	[]odd(5)	Decimal	MSB First	🟧	3
7	CRC	5	crc5usb(2-6)	Hex	MSB First	🟦	-

FileName_2016-09-15_0_090049.xml

Figure 12-91: Example of a crc, parity and block frame conditions

Frames

A frame format description (or *frame description*, for short) is represented by one "page" in this dialog. It can be created by clicking on "Add". If one or several frame descriptions already exist, the new frame description is then created at the end of the frame format description list (or *frame list*, for short). Describing a frame format requires assigning it a name as well as creating Cells and specifying cell descriptions. The number of frame descriptions is limited to 50. The frame description that is currently on display can be deleted from the frame list by clicking on "Remove".

The "Frame type" string is intended for the user to label the frame description (typically according to the specifications of the applicable protocol standard). For example, MDIO (Management Data Input/Output) specifies the frames "READ", "WRITE", "ADDRESS", etc. The example for the DALI protocol in Figure 12-88 has been created with the frame type "*FORWARD-group-address*".

The frame format dialog also provides the features "Open", "Save", "Save As...", and "Explore...", to store created sets of frame descriptions into files (in ".xml" format), or load existing files of this kind.

The frame identification is executed top down, in the order in which the frame formats are described in the frame list. This provides a hierarchy of criteria for identifying frames.

In case it is required to change the order of previously created frame descriptions, it is recommended to save the set of frame descriptions, and then edit the XML file with any suitable editor. (This also allows - with due care - additional editing features, if required.)

If no user-defined frame description should be suitable to identify an incoming frame, per default such a "missed" frame is reproduced as "Undescribed Bits" in the honeycomb display, as in the example in Figure 12-98. These bits are not shown in the results table.

Note: There may be frame descriptions that will positively identify each kind of frame, e.g. if no **equal** operator (see Condition) is defined for any of the cells. This will "catch" every single frame, even if there are other frame descriptions to follow in the frame list. Therefore, if a "catch all" frame description is used, it should be placed at the end of the frame list, or it will overwrite any subsequent frame description. However, instead of using a "catch all" frame description, the built-in "undescribed bits" display as mentioned above may be the better approach to create frame descriptions.

It is in the responsibility of the user to define unambiguous settings for each frame type. For a description of these conditions in `XML` file format and the required `XML` grammar and syntax, see Chapter 12.16.2.3, "XML Syntax", on page 797.

Remote command:

`BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1885

`BUS<m>:CMSB:ADDFrame` on page 1885

`BUS<m>:CMSB:CLR` on page 1885

`BUS<m>:CMSB:FCOunt?` on page 1885

Cells

A cell description (which is represented by one row in one frame description) can be created at any position of a frame description (see Frames) by clicking on "Insert". This brings up a new cell description in the active frame description, on top of the selected position. The "Append" button adds a cell description at the end of a frame description, below the lowest existing cell description. The number of cell descriptions is not limited. The "Remove" button deletes a selected cell description from the active frame description.

The cell result can be selected to be displayed in a specified result column of the decode table (see "Result Column" on page 796).

Note: The cell descriptions must be sequential and complete. No gaps are allowed, since the Bit Count is used to calculate the start position of the next cell.

A frame type is identified as soon as all user-defined cell conditions are met, which can be regarded as related by the Boolean AND operator.

This can also locate a synchronization pattern, specified by the equal operator in the Condition cell. For example, if the user defines a "Preamble" cell with the condition *=FFFFFFFF*, the decoder will scan the data for this pattern, and then synchronize to it.

The cells in a frame are described by:

- Cell Name
- Bit Count
- Condition
- Numeric Format
- Bit Order
- Color
- Result Column

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CCOunt?` on page 1886
`BUS<m>:CMSB:FRAMe<n>:APPend` on page 1886

Cell Name

The strings in the column title describe cell names. They do not have to be unique; cell names are just for user support.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME` on page 1886

Bit Count

This crucial information defines the length of the cell and - based upon the previous cells - also the cell end position and the next cell start position within a frame.

If, for a given bit count, the Condition value is longer, it will be truncated. If the condition value is shorter, it will be padded with 0. Both truncation and padding occur at the left side of the condition value.

Examples:

- if "Condition" is "=111000" and the Bit Order is "MSB", then
  - if "Bit Count" is 4, the truncated condition is "=1000"
  - if "Bit Count" is 8, the padded condition is "=00111000"
- if "Condition" is "=111000" and the bit order is "LSB" (accordingly, the condition in "MSB" format would be "=000111"), then

  - if "Bit Count" is 4, the truncated condition is "=1000" for LSB and "=0001" for MSB
  - if "Bit Count" is 8, the padded condition is "=00111000" for LSB and "=00011100" for MSB

These examples are true for the Numeric Format specified as "binary".

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount` on page 1886

Condition
This text field is used to apply various conditions and functionalities for a cell. Among others, it can be used to identify mandatory values (such as CRC checksum or ID) that help to identify a frame. The numeric format and bit order of the condition value has to match up with what is defined in the fields Numeric Format and Bit Order.

The following conditions are implemented:

"= (equal)" The **equal** operator (represented by the "=" sign) defines a pattern for the cell to match. Valid condition entries are characters that match the cell's defined Numeric Format, Bit Order, and Bit Count. In binary format, for example, valid characters are "1", "0", "H" (high), and "L" (low).

Three cases have to be distinguished (cases A, B1, and B2), depending on the presence of a Variable Length Array: [] in the same frame description:

- **Case A**: If there is **no** "Variable Length Array" cell, then each cell marked with the equal operator acts as a key to identify a frame type. Only if all these cells match up with the expected value, the frame type will be identified.
- **Cases B1 and B2**: If there **is** a "Variable Length Array" cell, then the equal operator has two different functionalities, depending on the position of the equal-operator cell within the frame description:
  - **B1**: If the cell is located *anywhere before* the "Variable Length Array" cell, the condition acts as a key to identify a frame type (as in case A).
  - **B2**: If the cell is located *immediately after* the "Variable Length Array" cell, the condition acts as an array delimiter. (Note: If the cell, which is marked with the equal operator, is located after the "Variable Length Array" cell, but *not* immediately after it, the decode result is unpredictable.)

Typically, Manchester protocols use code violations for synchronization. The states "H" and "L", supported by the equal operator in binary Numeric Format, mark that a transition is expected at this bit, but only a high or low signal is found.
Examples for the MVB protocol:
Master - Delimiter: "*=1LH0LH000*" (also shown in Figure 12-89)
Slave - Delimiter: "*=0000LH0LH*"
For more details on the violation symbols "H" and "L", see Chapter 12.16.1.1, "Special Features of Manchester Coding", on page 779.
Also, the length of the pattern must correspond to the bit field length (or the results are unpredictable).

"[ ] (array)"

The **array** operator (represented by the "[" and "]" bracket signs) defines the number of permissible repetitions of the cell.

Example: Fixed Length Array: [n]

The length parameter "n" is a decimal number > 0, which determines that the cell will be repeated n times within the frame. If, for example, the Bit Count is 8, then the array operator will identify n cells of 8 bit length, and present them in the results table and honeycomb display with the specified name and color.

A fixed length array is treated the same as other cells, except the real length of such an array is n · bit count.

Example: Variable Length Array: []

This array operator with empty "[" and "]" bracket signs does not determine a fixed size array. The cell could be repeated any number of times, including 0 times. As a result, the cell and the frame are of unspecified length (a situation that covers typical use cases). For an example, see Figure 12-90.

The length of the frame is then determined by the end of frame condition, which can be an operator or a gap.

For processing reasons, only one (1) variable length array is supported in a frame, and a delimiter must follow immediately in the next cell after it. This is required to enable the software to correctly terminate the array. Otherwise the bits could not be assigned correctly, and it would not be possible to determine where a repletion starts and where it ends. With an end of frame condition, the software can calculate the length of one single array within a frame. But if there were more arrays, it would be impossible to know which array was how long.

The variable length array can also be the last cell of a frame. In this case, no delimiter is required. If decoded successfully, the detailed view in the results table shows the elements of the array. If the cell name of the array is "Data", then the detail view of result table displays the elements with an array index as "Data: 1", "Data: 2" ... etc.

If the variable length array cell is selected in the Result Column, it is shown as array [n], where n is the actual size detected in the waveform.

As an exception to the rule, it is permissible to assign the variable length array to consecutive fields. In this case the fields are treated as a structure which will be repeated. For example, if two consecutive fields are defined as A[] and B[], the decoder will create a sequence of ABABAB until the end condition has been detected.

Note: It is possible to combine check functions in a dynamic array. In the example above, if B[] is extended by odd(1), with "1" being the index of A[], then B will check the parity for each index of A.

"crc5usb(n-m)"	The **crc 5 bit** operator performs a check for a 5\-bit CRC function using the polynomial as defined by the USB standard. n and m define the index range for the CRC check. For example, if the CRC shall check fields 1 to 4, the function shall be written "crc5usb(1-5)". If the range of the CRC check includes an array, all elements in the array will be included in the CRC check. If the check fails, the CRC field is marked as "CRC error" in the result details and displayed in the color red in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.
"odd(n-m), even(n-m)"	The "**parity**" operators perform checks on odd or even parity in the given index range n to m. Odd parity is fulfilled if the count of "1" bits in the range including the parity bit is odd. Even parity is fulfilled if the count of "1" bits in the range including the parity bit is even. If the parity check fails, the parity field is marked as "CRC error" in the result details and displayed in red color in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.
"{Block}"	The **block** operator is represented by the "{" and "}" bracket signs. Consecutive fields marked with "{Block}" and using the same name are displayed in the honeycomb display as a consecutive packet of name "Block" with the first field's color. This feature is a visual effect in the honeycomb only.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1887

Numeric Format
Selects from the following numeric data formats for the Condition value:

- Decimal
- Hexadecimal
- Octal
- Binary

The following rules apply:

- If the condition value contains at least one "H", "h", "L", "l", "X", "x", and the remaining characters only contain "1" and/or "0", the numeric format is automatically interpreted as binary, regardless of its definition.
- The wild-card characters "x" and "X" are only supported in binary format.
  Examples: if the numeric format is set to be "HEX", then
  - "=1HL111000" is valid (read as binary)
  - "=0x10101" is valid (read as binary, the "x" is interpreted here as a wild card)
  - "=1010" is valid (read as HEX, with a total of 16 bits)
  - "=0x5A" is valid (read as HEX "5A", since "0x" is a valid HEX prefix; nevertheless, it is recommended to enter "5A" instead)
  - "=5X12" is invalid
  - "=1H33" is invalid

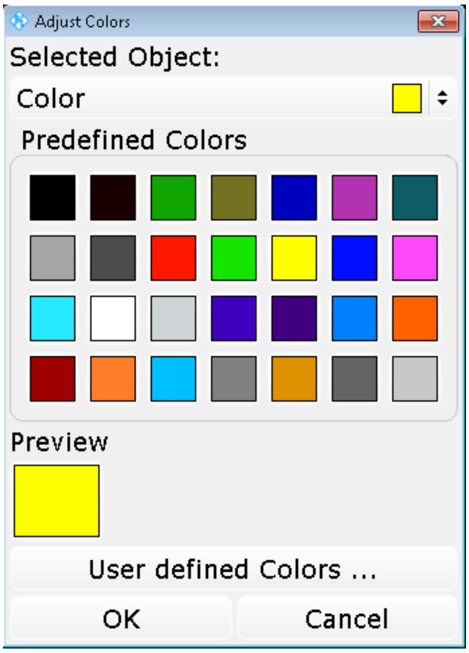
Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat` on page 1887

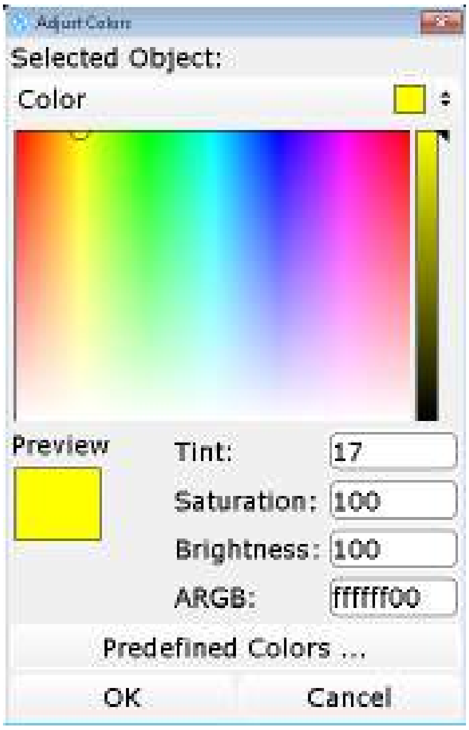
Bit Order
This defines, in which order the bits of a cell's Condition value are evaluated: either the most significant bit (MSB) or the least significant bit (LSB) first. Since the bit order is taken into consideration for the interpretation of the condition, the user should specify MSB or LSB correctly.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder` on page 1888

Color
Opens a dialog to select the color representation of different cells in the honeycomb display. Assigning user-selected colors helps to interpret the decode results more easily.

In the "Adjust Colors" dialog, you can either select one of the predefined colors or define a new one.





Tint: 17
Saturation: 100
Brightness: 100
ARGB: ffffff00

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB` on page 1888

Result Column
This determines which cells shall be displayed in which result columns of the decode table. No index means that the result is not displayed. The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, the user can define different result columns, to display unrelated information.

Note: To see more than the three selected results, bring up a full list of the states and values of all cells by activating "Show details" in the decode table dialog. For an example, see Figure 12-97.

Remote command:

`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN` on page 1888

Open or Save XML File

For efficient working and for convenient exchange of frame descriptions, they can both be loaded ("Open") or saved ("Save" / "Save As...") in `XML` file format. "Explore..." opens the `SaveXML` folder, which is the "Default Path" for saving frame descriptions.

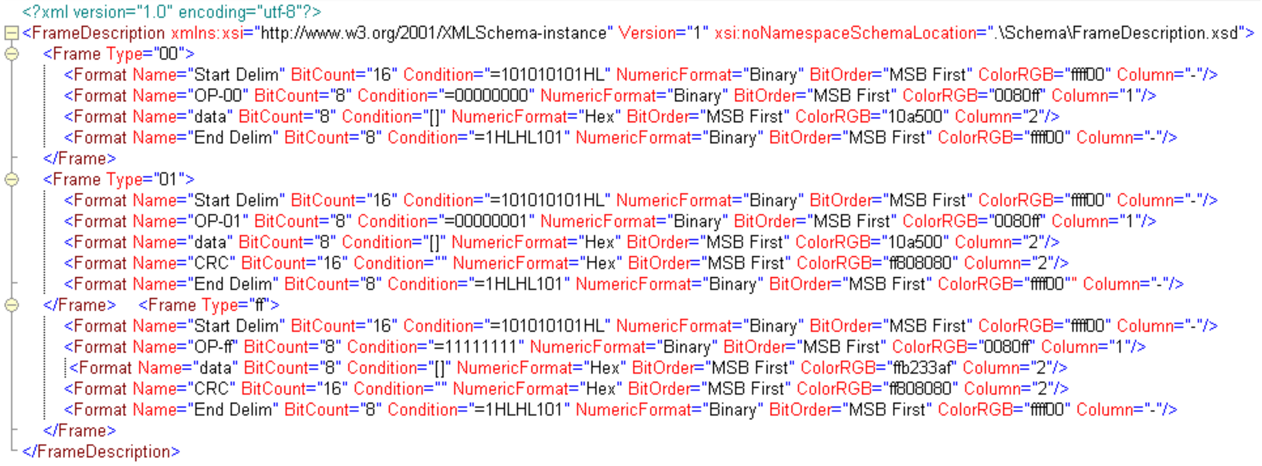
Remote command:

`BUS<m>:CMSB:LOAD` on page 1889

`BUS<m>:CMSB:SAVE` on page 1889

12.16.2.3 XML Syntax

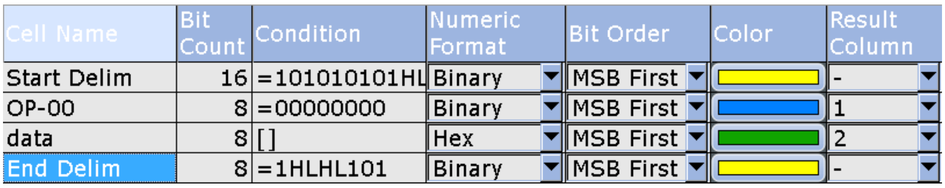
This chapter explains the required grammar and syntax of `XML` files, which contain frame descriptions and can be loaded or saved. Below is a typical example of such an `XML` file:



```
<?xml version="1.0" encoding="utf-8"?>
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
  <Frame Type="00">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-00" BitCount="8" Condition="=00000000" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
  <Frame Type="01">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-01" BitCount="8" Condition="=00000001" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00"" Column="-"/>
  </Frame>    <Frame Type="ff">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-ff" BitCount="8" Condition="=11111111" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
     <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ffb233af" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
</FrameDescription>
```

Figure 12-92: Example of XML file syntax with three custom frame format descriptions

The first out of three `XML` frames in Figure 12-92 is interpreted by the software in the following way:



Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
Start Delim	16	=101010101HL	Binary	MSB First	🟨	-
OP-00	8	=00000000	Binary	MSB First	🟦	1
data	8	[]	Hex	MSB First	🟩	2
End Delim	8	=1HLHL101	Binary	MSB First	🟨	-

Figure 12-93: Example of one custom frame format description for the MVB protocol

For the context of this figure, see Chapter 12.16.2.2, "Frame Format Configuration", on page 788.

A suitable `XML` file as shown in Figure 12-92 is composed as follows:

Header:

```
<?xml version="1.0" encoding="utf-8"?>
```

Root Element:

```
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
```

The root element contains the "Frame Description" attributes, including a link for the file`FrameDescription.xsd`. This schema file, which is installed in the system, enables the software to validate an `XML` file before opening it.

Frame:

A frame description must include between *0* and *n* tags of the following kind:

```
<Frame> </Frame>
```

Frame Type:

Each "<Frame>" tag requires a "Type" attribute in string format:

```
<Frame Type = "string">
```

This tells the software the name of each frame, as described in section Frame Type.

Format:

Each frame must include between *1* and *n* tags of the following kind:

```
<Format> </Format>
```

Together with the attributes, this is written in short form, as in Figure 12-92:

```
<Format attribute... attribute... attribute... />
```

The format describes the fields (or Cells) in each frame. It can have the following attributes:

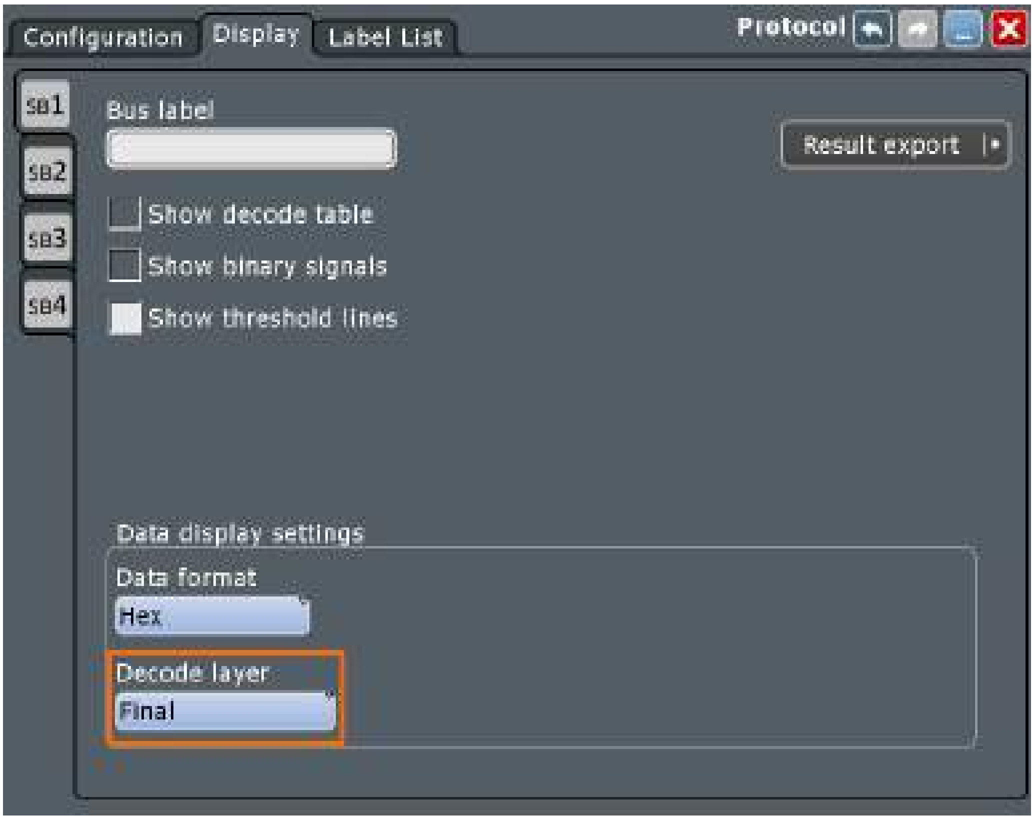
- Name (optional) is the "Cell Name", in string format.
- BitCount specifies the length of bits, in numerical format.
- Condition (optional) identifies the bit pattern to match, in string format.
- NumericFormat allows the following choices:
  - "Decimal"
  - "Hex"
  - "Octal"
  - "Binary"
- BitOrder allows two alternatives:
  - "MSB First" (most significant bit first)
  - "LSB First" (least significant bit first)
- Color allows to set a user defined ARGB hexadecimal color value.
- Column is the "Result Column" with four options:
  - "-" (none, which is the default

  - "1"
  - "2"
  - "3"

12.16.2.4 Custom: Manchester / NRZ Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = Custom" > "Display" tab

To enhance the decode possibilities of the custom serial protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...
"Synchronization"	...

12.16.2.5 Configuring Custom Manchester / NRZ Signals

For configuration, assign the lines to the input channels, define the active states and the logical thresholds, and specify frame format descriptions.

Serial bus setup

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "Custom".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   This prevents using digital waveforms (Math and Ref) as channel signals.

   Note: For triggering on a custom serial bus, analog input channels are required.
7. Switch back to the "Serial Bus Setup" dialog.
8. Tap "Coding Standard" and select the coding ("Manchester", "Manchester II", "NRZ Clocked", or "NRZ Unclocked") you want to set up.
9. Select the polarity and phase of the data signal (and potentially of the clock signal).
10. Set the logical thresholds, see "Thresholds" on page 786.
11. Still in the protocol "Configuration" tab, select "Decode" to activate the decode functionality.
12. Switch to the "Frame Format" dialog and open or create frame format descriptions.

For details on configuration settings, see Chapter 12.16.2.1, "Custom: Manchester / NRZ Configuration Settings", on page 780.

12.16.3 Custom: Manchester / NRZ Trigger

If you need information on how to get started with triggering on Custom serial bus signals, see Chapter 12.16.3.2, "Triggering on Custom Manchester / NRZ Serial Bus", on page 803. Otherwise proceed with the Custom serial bus trigger settings.

12.16.3.1 Custom: Manchester / NRZ Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = Custom"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected coding standard and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to the data sheet.

Figure 12-94: Custom serial bus trigger event settings dialog (here with "Manchester" and "Frame Start" selected)

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

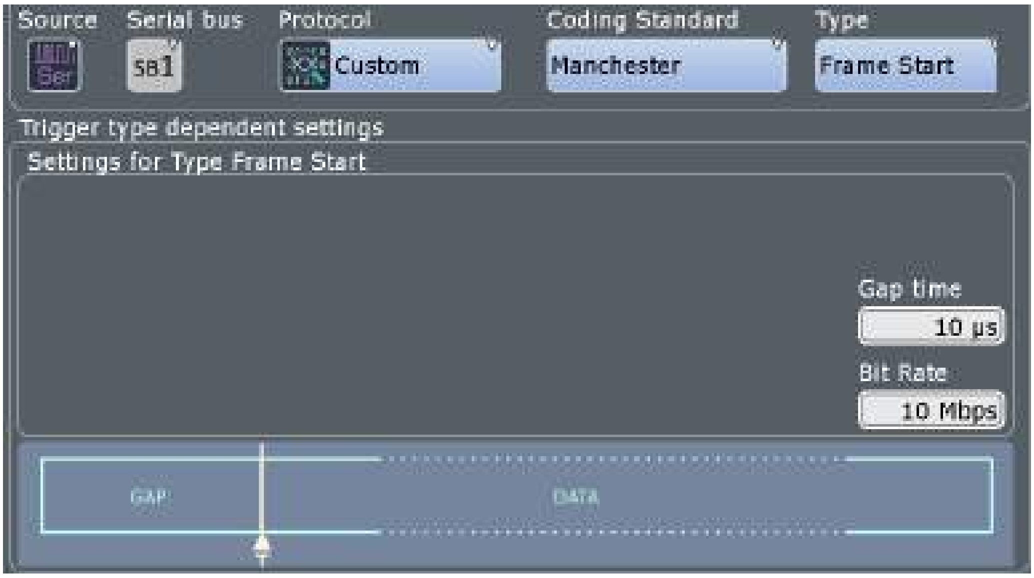
Defines the trigger type for custom serial bus analysis. The available trigger types are "Frame Start" and "Pattern".

Remote command:
`TRIGger<m>:CMSB:TYPE` on page 1890

Frame Start ← Type

For Manchester and NRZ Clocked coding standards, the frame start trigger is set to the end of the gap time. The start of frame (SOF) condition is the first bit after the gap (timeout).

For the NRZ Unclocked coding standard, the trigger requires that the signal contains a start bit. The frame start trigger follows the gap time and is set to the end of the start bit.

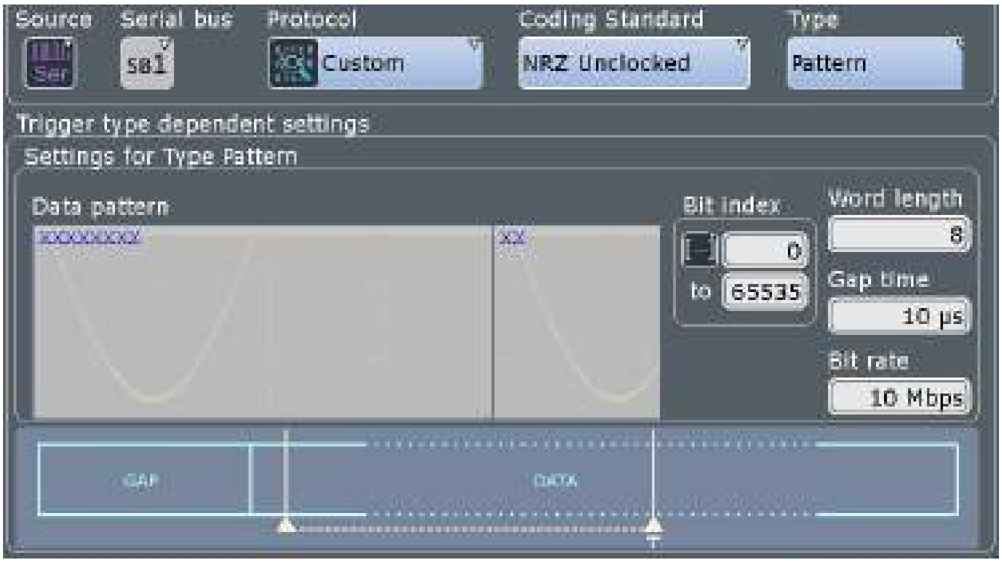


Source: Ser
Serial bus: SB1
Protocol: Custom
Coding Standard: Manchester
Type: Frame Start
Trigger type dependent settings
Settings for Type Frame Start
Gap time: 10 µs
Bit Rate: 10 Mbps

Figure 12-95: Custom serial bus dialog for setting the frame start trigger

Pattern ← Type

Specifies the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time, and after the detected start of the data frame. The trigger instant is after the last bit of the specified data pattern.



Source: Ser
Serial bus: SB1
Protocol: Custom
Coding Standard: NRZ Unclocked
Type: Pattern
Trigger type dependent settings
Settings for Type Pattern
Data pattern: XXXXXXXX XX
Bit index: 0 to 65535
Word length: 8
Gap time: 10 µs
Bit rate: 10 Mbps

Figure 12-96: Custom serial bus pattern trigger settings dialog (here for coding standard "NRZ Unclocked")

"Data Pattern"	Specifies the data pattern that is to be found and triggered. The pattern can be entered in binary or hexadecimal format, maximum pattern length is 256 binary characters or 64 hexadecimal characters.
"Bit index operator"	Sets the operator ("Equal", "Greater or equal", or "In range") to set a specific bit index (data position).

"Bit index"	Sets the bit index (data position), or the start value of a bit index range. Default bit index value is 0, permitted values range from 0 to 65535.
"Bit index to"	Sets the end value of a bit index range (data position range). Available only, if the "Bit index operator" is set to "In range". Default bit index end value is 65535, permitted values range from 0 to 65535.
"Word Length"	Sets the number of bits in an NRZ Unclocked word (hence, the size of the data frame). Default word length is 8 bits, permitted lengths range from 0 to 31 bits. **Note:** The NRZ Unclocked coding standard requires a signal that contains both a start bit and a stop bit: ● The start bit should be opposite in polarity to the idle state of the signal, and it is the first transition detected following the gap time. ● The stop bit should be the same polarity of the idle state, and it is the last bit in a data frame. The end of the stop bit and the detection of the next frame's start bit constitutes the maximum gap time. In order for the trigger to operate correctly, the **user has to specify** the correct word length in the trigger menu. The trigger then counts the number of bits it decodes, and when the count matches the word length, the next bit is treated as the stop bit.
"Gap Time"	Sets the minimum gap time for synchronization. The trigger is set to a position after the gap time, as soon as the other trigger conditions are met. Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.
"Bit Rate"	Sets the transmission speed for the data signal. Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 50 Mbps.

Remote command:
`TRIGger<m>:CMSB:PATTern` on page 1890
`TRIGger<m>:CMSB:ICONdition` on page 1890
`TRIGger<m>:CMSB:IMIN` on page 1891
`TRIGger<m>:CMSB:IMAX` on page 1891
`BUS<m>:CMSB:GAPTime:VALue` on page 1884
`TRIGger<m>:CMSB:NRZ:WRDLength` on page 1891

12.16.3.2 Triggering on Custom Manchester / NRZ Serial Bus

Prerequisite: A bus is configured for the custom serial bus signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.16.2.1, "Custom: Manchester / NRZ Configuration Settings", on page 780), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

Ser

3. Tap "Serial bus" and select the serial bus that is set to Custom serial bus, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "Custom".
4. Tap "Type" and select the trigger type to be used for custom serial bus protocol analysis.
   Available trigger types are "Frame Start" and "Pattern".
5. Depending on the selected custom serial bus coding standard, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.16.3.1, "Custom: Manchester / NRZ Trigger Settings", on page 800.

12.16.4 Custom: Manchester / NRZ Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" (and optionally "Show threshold lines"). For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the Frame Format Configuration settings.

The color-coding of the various Cells simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The Frame Format Configuration defines the cells and their Color scheme. The honeycomb display applies these settings according to the following rules:

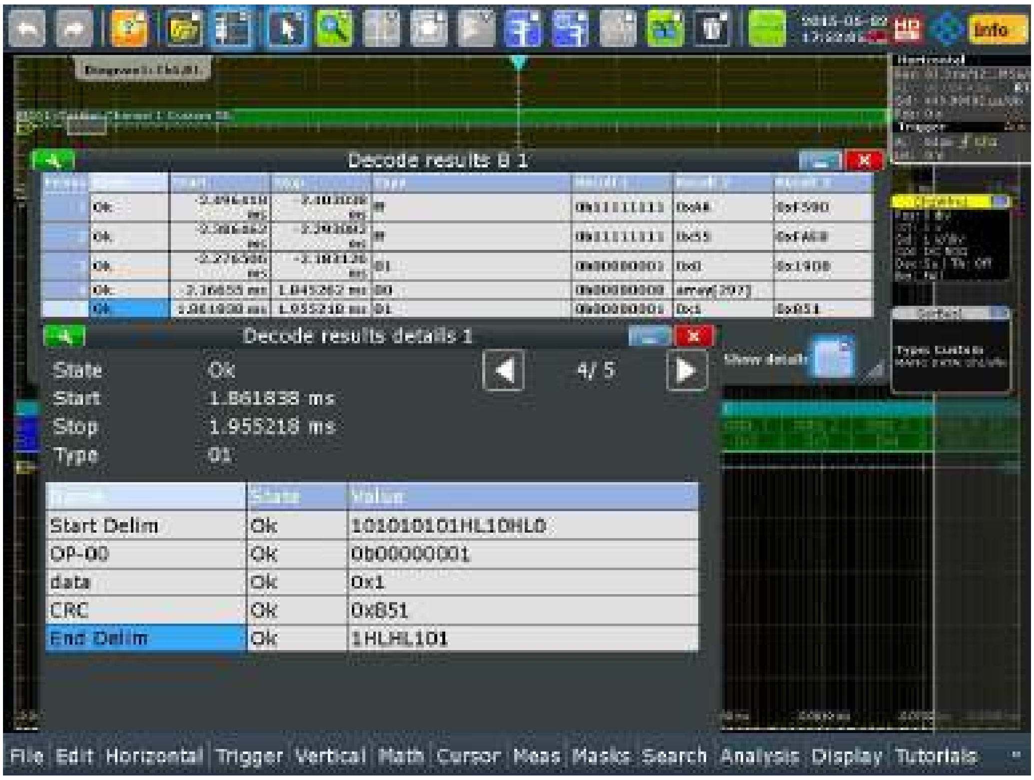
- Each frame is displayed as a honeycomb frame with the frame type being displayed (in the 1st line of the honeycomb).
- Each cell (row) is displayed as a honeycomb cell with the name in the header line (2nd line in the honeycomb) and the formatted content in the value line (3rd line in the honeycomb).

Since the frame description is customizable, the result table has to be mostly generic. Due to the limited width of the result table, the user has to select a limited amount of results (i.e., the three results defined in the Result Column) to be displayed by specifying this in the frame description. This leads to a detailed view that shows all information on a per-frame base.

Examples

The example in Figure 12-97 shows decoded and binary signals of a custom serial bus. The format information of DALI is being used to display as a result.

Note that activating "Show details" in the decode table provides a more detailed analysis of decode results for one selected frame. This brings up a list of the states and values of all cells of the selected frame (in binary format). With this details dialog open, the user can still click on the basic decode table, to change the selection of the frame to be displayed in detail.



Decode results details 1

4/ 5

State Ok
Start 1.861838 ms
Stop 1.955218 ms
Type 01

Name	State	Value
Start Delim	Ok	101010101HL10HL0
OP-00	Ok	0b00000001
data	Ok	0x1
CRC	Ok	0xB51
End Delim	Ok	1HLHL101

Figure 12-97: Decode results table and details of a "ProfiBus Voltage" protocol sample waveform

In the honeycomb display, Cells are shown in the Color that have been set by the user in the Frame Format Configuration.

For example, the result "array[297]" in "Frame 4", "Result 2" of the decoding table in Figure 12-97, is the short name for an array field display, and the number in the brackets indicates the length of the array, as described in Variable Length Array: [].

The tables "Decode results" and "Decode results details" in Figure 12-97 are described in Table 12-19 and Table 12-20:

Table 12-19: Content of the "Decode results" table

Column	Description
State	Overall state of the frame: either OK or the relevant error condition (e.g. preamble, length)
Start	Start time of the frame

Column	Description
Stop	Stop time of the frame
Type	Frame type as specified in the "Frame type" field of the "Frame Format" description dialog (see "Frames" on page 791)
Result 1	1st cell content as specified in the Result Column of the "Frame Format" description dialog (see "Frames" on page 791)
Result 2	2nd cell content (as above)
Result 3	3rd cell content (as above)

Table 12-20: Content of the "Decode results details" table

Column	Description
Name	Name of the cell (e.g. Start, Data) as specified in the Cell Name column of the "Frame Format" description dialog (see "Frames" on page 791)
State	Overall state of the cell: either OK or the relevant error condition (e.g. length error)
Value	Data content of the cell (e.g. 0x1, 1000LL00L)

Figure 12-98: The function "Undescribed Bits" catches frames missed by the frame format descriptions

In the result presentation, frames labeled "Undescribed Bits" (as in Figure 12-98) show the bit patterns that are not matched by any user defined frame format description. Showing these raw bits is a functionality to help the user develop suitable frame format descriptions.

The following commands are used to retrieve decode results in remote control. For an example on how to query the status of a frame, see Chapter 20.17.17.3, "Decode Results", on page 1891.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.17.3, "Decode Results", on page 1891.

12.17 8b/10b (Option R&S RTO-K52)

The 8b/10b coding scheme is used for high-speed serial data transmission, used by different standards, like fibre channel, PCIe, DVI and USB 3.0. Also the MIPI UniPro M-PHY interface in smartphones as well as display interfaces such as HDMI use 8b/10b encoding, as do base stations based on the Common Public Radio Interface (CPRI).

The R&S RTO can decode differential and single-ended 8b/10b signals. Furthermore, you can search the decoded data to isolate data contents as well as error states such as disparity violations.

You can also trigger on defined data contents as well as error states.

12.17.1 The 8b/10b Code

The 8b10b is a code where a 8-bit parallel data input is mapped into a 10-bit output. This code achieves a DC-balance and bounded disparity and simultaneously allows a reasonable clock recovery.

In the coding scheme, the original 8 bits are split into two blocks, three most significant bits and five least significant bits, see Figure 12-99. After that the 3-bit block is encoded into 4 bits and the 5-bit block into 6 bits. The 4-bit and the 6-bit blocks are then combined into a 10-bit.

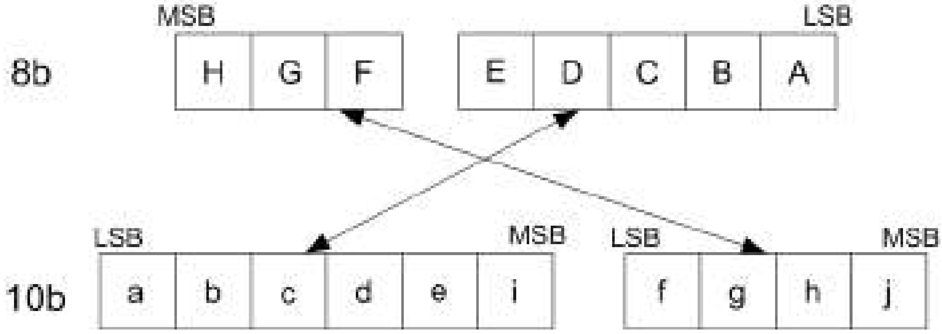


Figure 12-99: Coding scheme of the 8b/10b

The additional two bits I and j that join the stream are variable and ensure the running disparity.

There are two type of characters used in the 8b/10b coding, special characters Kx.y and data characters Dx.y. Hereby x denotes the decimal value of EDCBA and is within the range from 0-31 and y denotes the decimal value of HGF and is within the range 0-7.

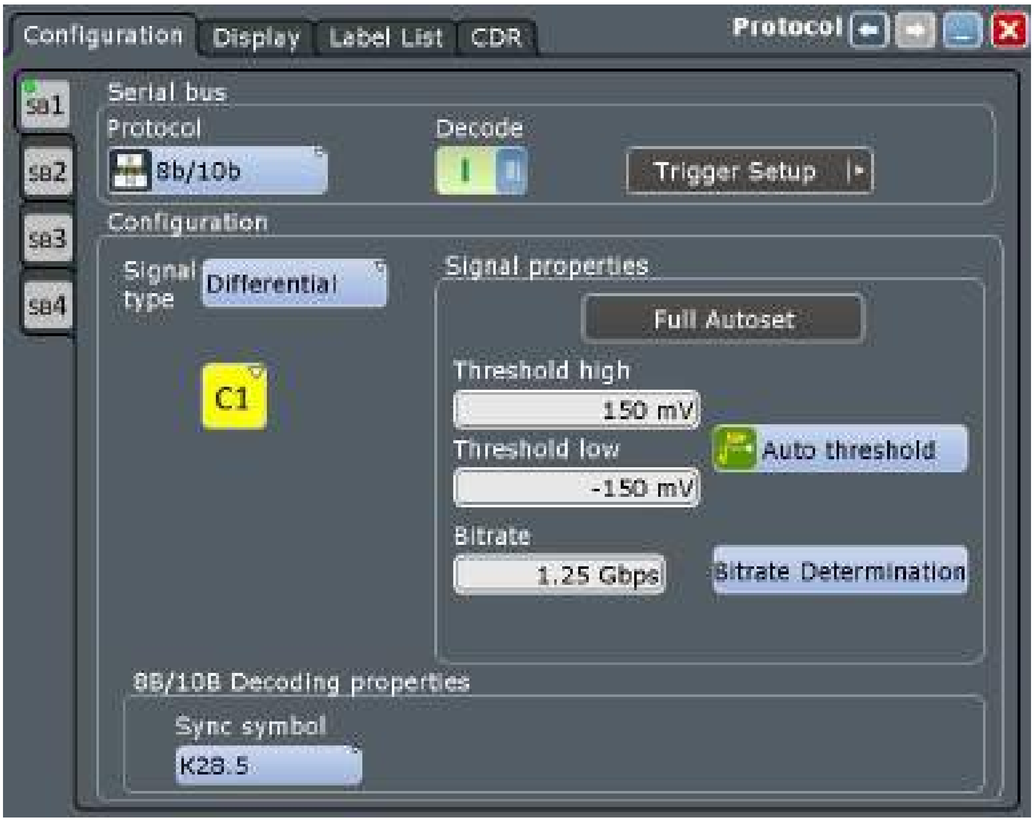
12.17.2 8b/10b Configuration

12.17.2.1 8b/10b Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "8b/10b"

The full autoset function configures all settings at the tap of a button. You can readjust all settings manually.

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Signal type
Selects the signal type that is used for the decoding. You can choose between a differential and single-ended signal.

Remote command:
`BUS<m>:EBTB:TYPE` on page 1901

Source
Selects the source of the provided differential signal , if "Signal type" > "Differential".

Remote command:
`BUS<m>:EBTB:DIFFerential:SOURce` on page 1898

Source D+
Selects the source of the provided single ended signal, if "Signal type" > "Single ended".

Remote command:
`BUS<m>:EBTB:DPLus:SOURce` on page 1899

Source D-
Selects the source of the provided single ended signal , if "Signal type" > "Single ended".

Remote command:
`BUS<m>:EBTB:DMINus:SOURce` on page 1899

Full Autoset
Starts software algorithms for determining the signal threshold levels and bitrate.

Remote command:
`BUS<m>:EBTBFAUToscale` on page 1901

Threshold High
Sets the threshold high of the signal, if "Signal type" > "Differential".

Remote command:
`BUS<m>:EBTB:DIFFerential:THRHigh` on page 1898

Threshold Low
Sets the threshold low of the signal, if "Signal type" > "Differential".

Remote command:
`BUS<m>:EBTB:DIFFerential:THRLow` on page 1898

Threshold D+
Sets the high threshold (D+) of the signal, if "Signal type" > "Single ended".

Remote command:
`BUS<m>:EBTB:DPLus:THReshold` on page 1900

Threshold D-
Sets the high threshold (D-) of the signal, if "Signal type" > "Single ended".

Remote command:
`BUS<m>:EBTB:DMINus:THReshold` on page 1899

Auto Threshold
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Bitrate
Sets the number of transmitted bits per second.

Remote command:
`BUS<m>:EBTB:BITRate` on page 1898

Bitrate Determination
Starts a software algorithm for the automatic determination of the bitrate.

Remote command:
`BUS<m>:EBTBBITDetermi` on page 1901

SW CDR Bitrate
Disables the automatic software birtate determination.

Remote command:
`BUS<m>:EBTB:ACTestimate` on page 1897

Sync Symbol
Selects the sync symbol, a control symbol used for low level control functions. You can select one of the comma control symbols (K28.1, K28.5, K28.7) used for synchronisation or you can enter a pattern.

Remote command:
`BUS<m>:EBTB:SYNC` on page 1901

Pattern
Selects a pattern that serves as a sync symbol.

Remote command:
`BUS<m>:EBTB:FCSY` on page 1900

Second pattern
Enables a second pattern that serves as a sync symbol and sets its value.

Remote command:
`BUS<m>:EBTB:SCSY` on page 1900
`BUS<m>:EBTB:USCS` on page 1901

12.17.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "8b/10b" > "Display" tab

Display format: K/D Codes

Display Format
Selects the display format for the results of the display table.

Remote command:
`BUS<m>:EBTB:DISF` on page 1899

12.17.2.3 Configuring 8b/10b

For configuration, you assign the line to the input channel, set the threshold, the bitrate, and the sync symbol.

For details on configuration settings, see Chapter 12.17.2.1, "8b/10b Configuration Settings", on page 808.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.

4. Tap the "Protocol" button and select the protocol: "8b/10b".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Signal type" button, and select the used signal type for the measurement.
7. Select the source for the signal type.
8. Tap "Full Autoset".
   Alternatively, you can determine the signal threshold using "Auto threshold" and the bitrate using "Bitrate Determination".
9. Check the threshold and bitrate settings and adjust the values if necessary.
10. Select the "Sync symbol" to be used for decoding.

12.17.3 8b/10b Trigger

If you need information on how to get started with triggering on 8b/10b signals, see Chapter 12.17.3.2, "Triggering 8b/10b Data", on page 814. Otherwise proceed with the 8b/10b trigger settings.

12.17.3.1 8b/10b Trigger Setup

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = 8b1/0b"

Sequence: A only
Source: SBus
Serial bus: SB1
Protocol: 8b/10b
Trigger Type 8b/10b: Symbol
Symbol
Format: 8-Bit
8b Pattern: [hex]BC

Trigger Type 8b/10b
Selects the type of condition to be triggered on.

"Symbol"	Triggers on a specified symbol or expression.

"Error Condition"	Triggers on the selected error conditions.

Remote command:
`TRIGger<m>:EBTB:TYPE` on page 1904

Disparity error
Triggers on disparity errors.

Remote command:
`TRIGger<m>:EBTB:DISParityerr` on page 1902

Glitching error
Triggers on glitching errors.

Remote command:
`TRIGger<m>:EBTB:GLITcherror` on page 1903

Unknown symbol error
Triggers on a symbol that is not defined by the the 8b/10b.

Remote command:
`TRIGger<m>:EBTB:UNK` on page 1904

Symbol Type
Selects the symbol type to be triggered on.

"Symbol"	Sets a sepcific symbol.
"Expression"	Sets a series of symbols.

Remote command:
`TRIGger<m>:EBTB:SSTYpe` on page 1903

Format
Selects the format of the symbol to be triggered on, if "Symbol Type" > "Symbol".

Remote command:
`TRIGger<m>:EBTB:SYMFormat` on page 1903

K/D Codes Symbol
Selects the data character (Dx.y) or control character to be triggered on. You can specify the value of the data character to be searched for with "Dx Value" and "Dy Value".

Remote command:
`TRIGger<m>:EBTB:SYMType` on page 1904

Dx Value ← K/D Codes Symbol
Sets the x value of the data character Dx.y to be triggered on, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`TRIGger<m>:EBTB:DX` on page 1902

Dy Value ← K/D Codes Symbol
Sets the y value of the data character Dx.y to be triggered on, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`TRIGger<m>:EBTB:DY` on page 1903

8b Pattern
Sets the 8-bit pattern to be triggered on, if "Format" > "8-bit".

Remote command:
`TRIGger<m>:EBTB:EBPA` on page 1903

10b Pattern
Sets the 10-bit pattern to be searched for, if "Format" > "10-bit".

Remote command:
`TRIGger<m>:EBTB:TBPA` on page 1904

Expression
Defines the expression to be triggered on, if "Symbol Type" > "Expression".

Remote command:
`TRIGger<m>:EBTB:SYME` on page 1903

12.17.3.2 Triggering 8b/10b Data

Prerequisite: A bus is configured for the 8b/10b signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.17.2, "8b/10b Configuration", on page 808), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to 8b/10b, e.g.:

   The "Protocol" selection is then automatically set to "8b/10b".
4. Tap "Trigger Type 8b/10b" and select the trigger type to be used for 8b/10b protocol analysis.
5. Depending on the selected trigger type, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.17.3.1, "8b/10b Trigger Setup", on page 812.

12.17.4 8b/10b Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Symbol	State	Start	Data
1	Ok	-15 µs	D21.0-
2	Ok	4.998 µs	D2.0+
3	Ok	5.002 µs	D0.0+
4	Ok	14.986 µs	D21.5+
5	Ok	25.002 µs	D21.5+
6	Ok	35 µs	D21.5+
7	Ok	44.978 µs	D21.5+
8	Ok	55.002 µs	D21.5+
9	Ok	65.002 µs	D21.5+
10	Ok	75.002 µs	D21.5+
11	Ok	85.002 µs	D21.5+
12	Ok	95.002 µs	D21.5+
13	Ok	105.002 µs	D21.5+
14	Ok	115.002 µs	K28.5+
15	Ok	125.002 µs	D10.2-
16	Disparity	135.004 µs	K28.5+
17	Ok	145.002 µs	D21.5+
18	Ok	155.002 µs	K28.5+
19	Ok	165.004 µs	K23.7-
20	Ok	175.004 µs	K23.7-
21	Ok	185.004 µs	D1.0-
22	Ok	195.028 µs	D2.0-
23	Ok	205.002 µs	D2.0-
24	Ok	215.002 µs	D26.5-
25	Ok	225.004 µs	D26.5-
26	Ok	234.992 µs	D26.5-
27	Ok	244.978 µs	D26.5-
28	Ok	254.992 µs	D26.5-
29	Ok	265.004 µs	D26.5-
30	Ok	275.004 µs	D26.5-

Display format: K/D Codes

Table 12-21: Content of the decode result table

Column	Description
Symbol	Shows the index number of the symbol
State	Overall state of the symbol
Start	Time of the symbol start in relation to the trigger point
Data	The value of the data

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.18.3, "Decode Results", on page 1904.

12.17.5 Search on Decoded 8b/10b Data

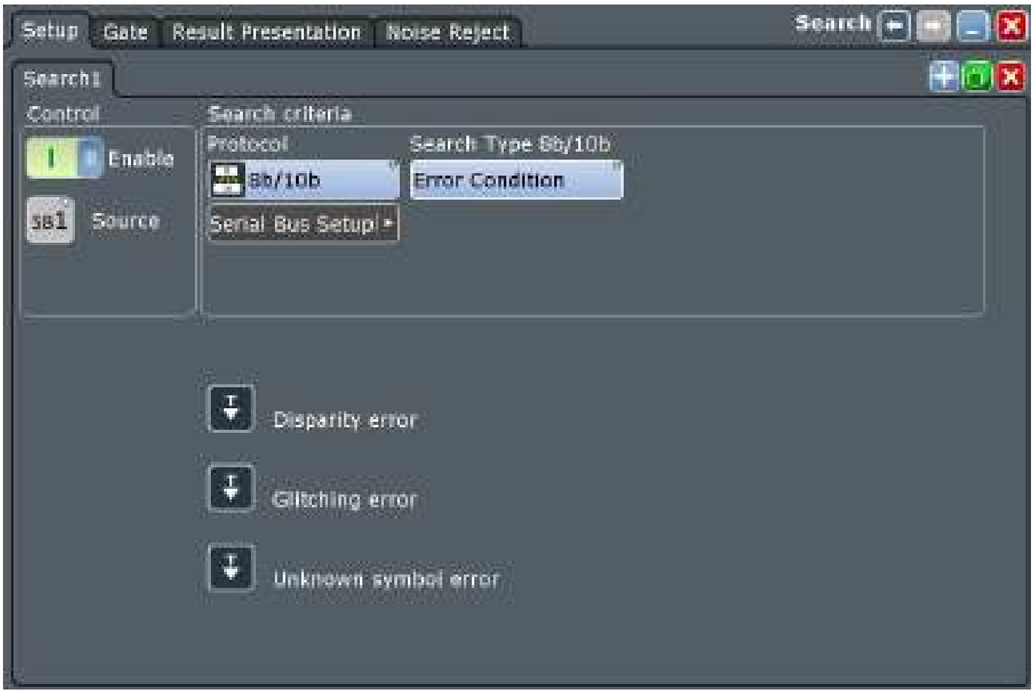
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.17.5.1 8b/10b Search Setup

Access: SEARCH > "Setup" tab.



Search Type 8b/10b

Selects the type of condition to be searched for.

"Symbol"	Searches for a specified symbol or expression.
"Error Condition"	Searches for the selected error conditions.

Remote command:
`SEARch:TRIGger:EBTB:TYPE` on page 1909

Disparity error

Searches for disparity errors.

Remote command:
`SEARch:TRIGger:EBTB:DISParityerr` on page 1906

Glitching error

Searches for glitching errors.

Remote command:
`SEARch:TRIGger:EBTB:GLITcherror` on page 1907

Unknown symbol error

Searches for a symbol that is not defined by the the 8b/10b.

Remote command:
`SEARch:TRIGger:EBTB:UNK` on page 1909

Symbol Type

Selects the symbol type to be searched for.

"Symbol"	Sets a sepcific symbol.

"Expression" Sets a series of symbols.

Remote command:
`SEARch:TRIGger:EBTB:SSTYpe` on page 1908

Format
Selects the format of the symbol to be searched for, if "Symbol Type" > "Symbol".

Remote command:
`SEARch:TRIGger:EBTB:SYMFormat` on page 1908

K/D Codes Symbol
Selects the data character (Dx.y) or control character to bea searched for. You can specify the value of the data character to be searched for with "Dx Value" and "Dy Value".

Remote command:
`SEARch:TRIGger:EBTB:SYMType` on page 1909

Dx Value ← K/D Codes Symbol
Sets the x value of the data character Dx.y to be searched for, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`SEARch:TRIGger:EBTB:DX` on page 1907

Dy Value ← K/D Codes Symbol
Sets the y value of the data character Dx.y to be searched for, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`SEARch:TRIGger:EBTB:DY` on page 1907

8b Pattern
Sets the 8-bit pattern to be searched for, if "Format" > "8-bit".

Remote command:
`SEARch:TRIGger:EBTB:EBPA` on page 1907

10b Pattern
Sets the 10-bit pattern to be searched for, if "Format" > "10-bit".

Remote command:
`SEARch:TRIGger:EBTB:TBPA` on page 1909

Expression
Defines the expression to be searched for, if "Symbol Type" > "Expression".

Remote command:
`SEARch:TRIGger:EBTB:SYME` on page 1908

12.17.5.2 8b/10b Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote Commands:

- `SEARch:RESult:EBTB:SCOunt<*>?` on page 1910
- `SEARch:RESult:EBTB:SYMBol<m>:DATA?` on page 1910
- `SEARch:RESult:EBTB:SYMBol<m>:STARt?` on page 1910
- `SEARch:RESult:EBTB:SYMBol<m>:STATus?` on page 1911
- `SEARch:RESult:EBTB:SYMBol<m>:STOP?` on page 1911

12.17.5.3 Searching 8b/10b Data

Prerequisite: A serial bus is configured for the 8b/10b signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to 8b/10b (e.g. "SerBus1", unless already selected).
4. Specify search criteria according to Chapter 12.17.5.1, "8b/10b Search Setup", on page 816.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a 8b/10b decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events.

For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.18 MDIO (Option R&S RTO-K55)

The R&S RTO-K55 option enables the R&S RTO to analyse Management Data Input/Output (MDIO) protocols. The option is compatible with the Ethernet standard IEEE 802.3 (http://standards.ieee.org/findstds/standard/802.3-2012.html) and supports simplified triggering and decoding for both variants of MDIO: Clause 22 with basic addressing, and Clause 45 with advanced addressing that meets the requirements of 10 Gigabit Ethernet devices.

12.18.1 The MDIO Protocol

MDIO is used for bidirectional transfer of control and status information between the physical layer entity (PHY) and the station management entities (STA).

A major application of MDIO is fault detection by interrogating registers of physical devices. Hence, MDIO serial bus visualization helps debugging new products by giving developers a quick insight into the native data on the bus without using a special decoder.

On physical level, MDIO is a clocked non-return-to-zero (NRZ) code similar to SPI. According to the Ethernet standard, the protocol defines two threshold levels, 2 V and 0.8 V, which establish a hysteresis.

On logical level, MDIO is a fairly simple protocol with a fixed word length of 64 bits. The structure of MDIO frames is shown in the following tables:

Table 12-22: MDIO frame structure according to Clause 22

	Management Frame Fields							
Frame	PRE	ST	OP	PHYAD	REGAD	TA	DATA	IDLE
WRITE	1...1	01	01	AAAAA	RRRRR	10	DDDDDDDDDDDDDDDD	Z
READ	1...1	01	10	AAAAA	RRRRR	Z0	DDDDDDDDDDDDDDDD	Z

Table 12-23: MDIO frame structure according to Clause 45

	Management Frame Fields							
Frame	PRE	ST	OP	PRTAD	DEVAD	TA	ADDRESS / DATA	IDLE

ADDRESS	1...1	00	00	PPPPP	EEEEE	10	AAAAAAAAAAAAAAAA	Z
WRITE	1...1	00	01	PPPPP	EEEEE	10	DDDDDDDDDDDDDDDD	Z
READ	1...1	00	11	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z
POST-READ increment address	1...1	00	10	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z

PRE = preamble, consisting of 32 logic "one" bits ("1...1")

ST = start of frame code (2 bits), "01" for Clause 22, "00" for Clause 45, "0X" for any, no other options permitted

OP = operation code or "OpCode" (2 bits). This is a frame type code specifying the type of transaction. For more details on the OpCode, see "OP" in Table 12-24, or `TRIGger<m>:MDIO:FRAMetype`.

PHYAD = address of a physical layer entity (in Clause 22)

PRTAD = address of a port (in Clause 45)

REGAD = register address within a PHY (in Clause 22)

DEVAD = device address within a port (in Clause 45)

TA = turnaround time, a 2-bit time spacing between REGAD/DEVAD and DATA. The turnaround provides the slave some time to answer upon a read command. TA is hard-wired even in write commands, although it is not required there.

ADDRESS / DATA = address or payload data, 16 bits

IDLE = A single value (high-impedance state) indicating to the Physical Medium Attachment (PMA) that there is no data to convey

Instead of a specific hardware trigger, the option R&S RTO-K55 uses a predefined generic serial bus pattern trigger. It simply triggers on a bit pattern in the data stream. This is very fast, but limited in the complexity of the conditions.

The MDIO trigger settings allow the user to define the MDIO fields individually. The firmware concatenates the settings to a single search pattern that is then used by the serial bus pattern.

While this design is simple, it doesn't allow triggering on a data range or even inequality. This explains the much simpler structure compared to other protocols.

12.18.2 MDIO Configuration

If you need information on how to get started with configuring the MDIO setup, see Chapter 12.18.2.3, "Configuring MDIO Signals", on page 824. Otherwise proceed with the configuration settings.

12.18.2.1 MDIO Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *MDIO*

Make sure that the tab of the correct serial bus is selected on the left side.

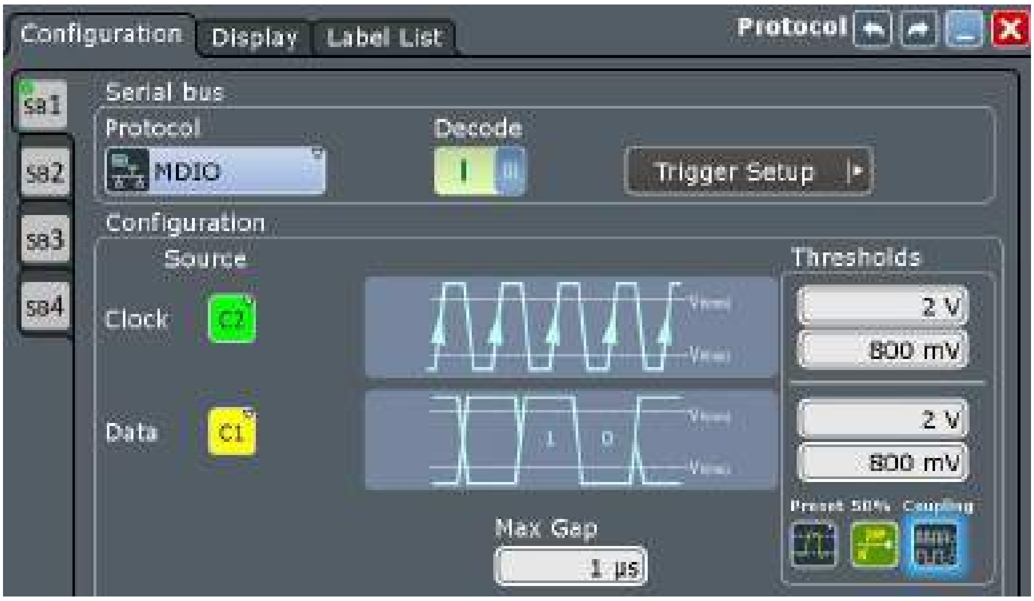


Figure 12-100: Serial bus MDIO protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Source

MDIO requires two source channels, one for clock and one for data.

"Clock"	Defines the source settings for the clock line (management data clock, MDC). Typically, select any of the the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on the test application. "Math" or "Ref" waveforms are also permitted.
"Data"	Defines the source settings for the data signal. Typically, select any of the the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on your application, but not the same as for "Clock". "Math" or "Ref" waveforms are also permitted.

Remote command:

`BUS<m>:MDIO:CLOCk:SOURce` on page 1912

`BUS<m>:MDIO:DATA:SOURce` on page 1912

Max Gap

Sets the maximum idle time between two frames.

Remote command:

`BUS<m>:MDIO:MAXGap` on page 1913

Thresholds

MDIO defines two thresholds for each source line:

- Vih(min) is being used for the rising edge evaluation. This "h" (high) threshold is the minimum value for the signal to be identified as "1". If the signal value comes from a low state (hence, rising edge), the state remains to be considered as low ("0"), until it has risen above Vih(min).
- Vil(max) is being used for the falling edge evaluation. This "l" (low) threshold is the maximum level for the signal to be identified as "0". If the signal value comes from a high state (hence, falling edge), the state remains to be considered as high ("1"), until it has fallen below Vil(max).

There are four ways to set the thresholds for the digitization of the signal lines:

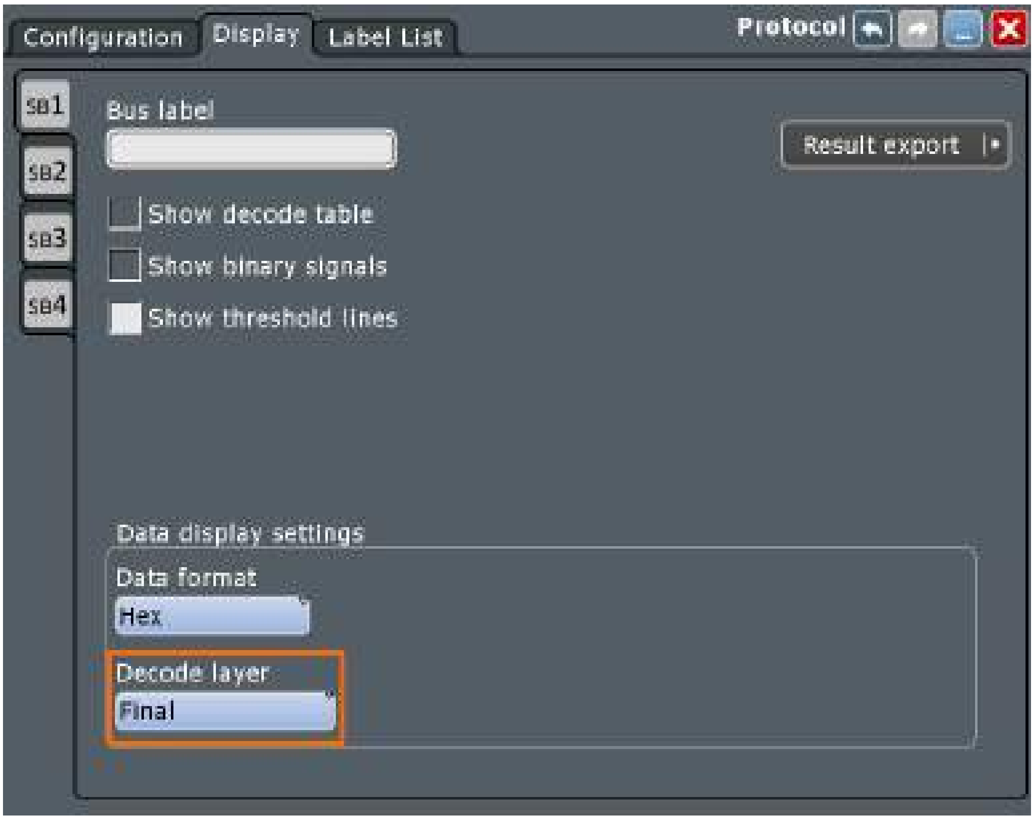
- "Threshold"
  Enter the values directly in the fields.
- "Preset"
  Allows to select the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
  Overwrites the data thresholds with the clock thresholds.

Remote command:
`BUS<m>:MDIO:CLOCk:THReshold:HIGH` on page 1913
`BUS<m>:MDIO:CLOCk:THReshold:LOW` on page 1913
`BUS<m>:MDIO:DATA:THReshold:HIGH` on page 1913
`BUS<m>:MDIO:DATA:THReshold:LOW` on page 1914
`BUS<m>:MDIO:PRESet` on page 1914
`BUS<m>:SETReflevels` on page 1495
`BUS<m>:MDIO:COUPling` on page 1914

12.18.2.2 MDIO Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = MDIO" > "Display" tab

To enhance the decode possibilities of the MDIO protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...

12.18.2.3 Configuring MDIO Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side of the "Configuration" tab, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Tap "Protocol" and select the protocol: "MDIO".

4. Optionally, you can enter a "Bus label" in the "Display" tab.
5. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   Note: For triggering on a serial bus, analog or digital input channels are required!
6. Switch back to the "Serial Bus Setup" dialog.
7. Select the waveform for the "Clock" and "Data" lines.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels by setting it to "50%", or enter a user-defined value directly in the "Threshold" fields. Optionally, use "Coupling" to couple the data thresholds to the clock thresholds.
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.18.2.1, "MDIO Configuration Settings", on page 821.

12.18.3 MDIO Trigger

If you need information on how to get started with triggering on MDIO signals, see Chapter 12.18.3.2, "Triggering on MDIO", on page 828. Otherwise proceed with the MDIO trigger settings.

12.18.3.1 MDIO Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = MDIO"

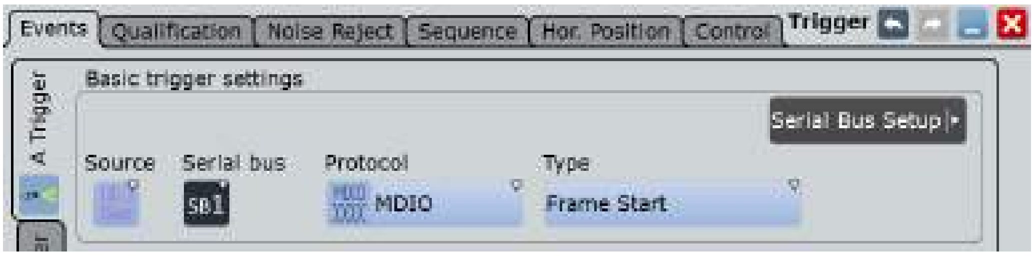
In this section, all trigger settings are described. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to the data sheet.

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

MDIO Trigger Type
Selects the trigger type for MDIO analysis.



Basic trigger settings

Source

Serial bus: SB1

Protocol: MDIO

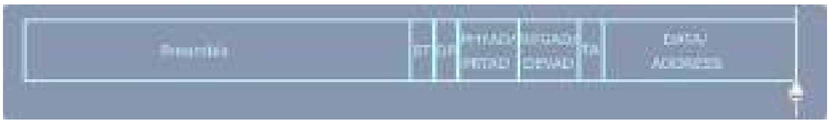
Type: Frame Start

Figure 12-101: MDIO trigger event settings dialog

"Frame Start" Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble.
Trigger pattern: preamble (32 bits "1")

There are no additional parameters to be specified.

"Frame Stop" Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit.
Trigger pattern: preamble (32 bits "1") + 32 bits "X"



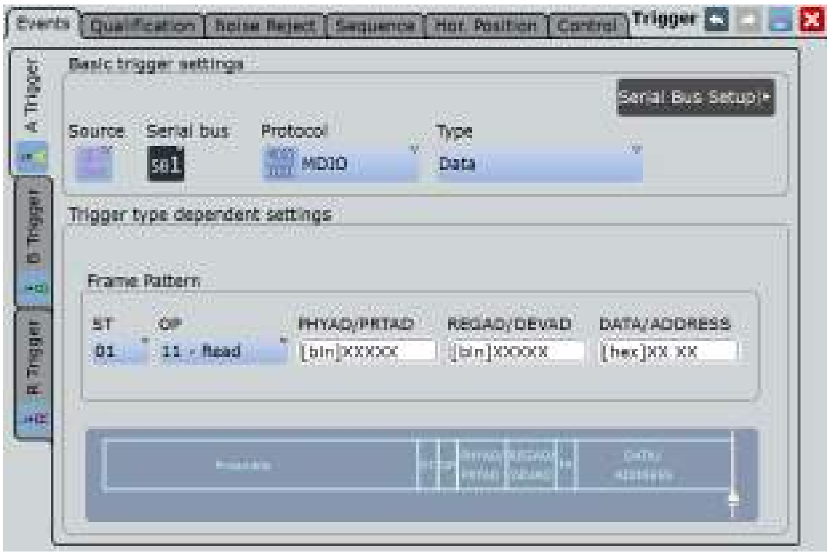
There are no additional parameters to be specified.

"Data"

Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI.

Note: All data triggers are always at the end of the frame, even if the specified pattern to trigger for is at a different position within the data word.

Trigger pattern: preamble (32 bits "1") + "ST" (2 bits, Start of Frame Code) + "OP" (2 bits, operation code or frame type code) + "PHYAD/PRTAD" (5 bits, Physical Layer Entity Address / Port Address) + "REGAD/DEVAD" (5 bits, Register Address / Device Address) + "TA" (2 "X" bits, turnaround time) + "DATA/ADDRESS" (16 bits)
For the parameters to be specified, see "ST" on page 827, "OP" on page 827, "PHYAD/PRTAD" on page 828, "REGAD/DEVAD" on page 828, and "DATA/ADDRESS" on page 828.



Basic trigger settings
Source
Serial bus: SB1
Protocol: MDIO
Type: Data

Trigger type dependent settings
Frame Pattern
ST: 01
OP: 11 - Read
PHYAD/PRTAD: [bin]XXXXX
REGAD/DEVAD: [bin]XXXXX
DATA/ADDRESS: [hex]XX XX

Remote command:
`TRIGger<m>:MDIO:TYPE` on page 1915

ST ← MDIO Trigger Type
Selects the start of frame code of the frame pattern; available only in trigger type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`TRIGger<m>:MDIO:ST` on page 1915

OP ← MDIO Trigger Type
Selects the type of frame code (or OP code, OpCode, operation code); available only in trigger type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`TRIGger<m>:MDIO:FRAMetype` on page 1916

PHYAD/PRTAD ← MDIO Trigger Type

Sets the physical address or port address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:

`TRIGger<m>:MDIO:PHYS` on page 1916

REGAD/DEVAD ← MDIO Trigger Type

Sets the register address or device address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:

`TRIGger<m>:MDIO:REGI` on page 1916

DATA/ADDRESS ← MDIO Trigger Type

Defines the payload data pattern or address pattern (16 bits); available only in trigger type "Data".

Remote command:

`TRIGger<m>:MDIO:DATA` on page 1917

12.18.3.2 Triggering on MDIO

Prerequisite: A serial bus is configured for the MDIO signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.18.2, "MDIO Configuration", on page 821), tap "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to MDIO, e.g.:

The "Protocol" selection is then automatically set to "MDIO".

4. Tap "Trigger Type MDIO" and select the trigger type to be used for MDIO protocol analysis.
5. If the trigger type "Data" is selected, the frame pattern has to be specified.

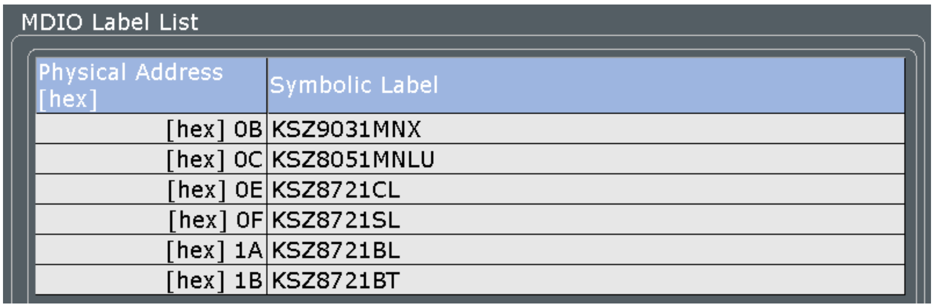
For information on how to proceed with the configuration settings, see Chapter 12.18.3.1, "MDIO Trigger Settings", on page 825.

12.18.4 MDIO Label List

Label lists are protocol-specific. A label list file for MDIO contains physical addresses and their symbolic names.

Example: MDIO label list CSV file

```
@PROTOCOL_NAME = mdio
0x0B, KSZ9031MNX
0x0C, KSZ8051MNLU
0x0E, KSZ8721CL
0x0F, KSZ8721SL
0x1A, KSZ8721BL
0x1B, KSZ8721BT
```



MDIO Label List

Physical Address [hex]	Symbolic Label
[hex] 0B	KSZ9031MNX
[hex] 0C	KSZ8051MNLU
[hex] 0E	KSZ8721CL
[hex] 0F	KSZ8721SL
[hex] 1A	KSZ8721BL
[hex] 1B	KSZ8721BT

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 484.

Remote command:

- `BUS<m>:MDIO:WORD<n>:SYMBol?` on page 1920

12.18.5 MDIO Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

An example test waveform consisting of six frames is shown in Figure 12-102. The corresponding "Decode results" table for these frames can be seen in the foreground. The upper part of the screen, behind the table, represents the waveform in a honeycomb display, along with the binary decode results. In the lower part of the screen is a zoom into frame #2, which is a "Write" frame, containing PRE, ST, OP, PRTAD, DEVAD, TA and DATA fields. The zoom shows both the honeycomb display and the binary decode results of that second frame.

Figure 12-102: Decoded and binary MDIO signal trace, and decode results table

green brackets [...] = start and end of frame
blue frame = frame ok
red frame = frame containing an error
grey = preamble (PRE), start pattern (ST), operation code (OP = frame type), or turnaround (TA) fields
dark green = PHY address or port address (depending on clause)
dark purple = register address or device address field (depending on clause)
yellow = data field or address field (depending on clause)

Table 12-24: Content of the "Decode results" table in the previous figure

Column	Description
Frame	Number of the acquired frame
State	State of frame, available messages are: ● OK ● OPcode error ● Length error ● Incomplete frame ● Unsynchronized bits
Start	Start time of the frame
Stop	Stop time of the frame

Column	Description
ST	Start of frame code, 2 bits ● "01" (Clause 22) ● "00" (Clause 45)
OP	Operation code (= Frame type), 2 bits ● "00" = Address frame (in Clause 45, only) ● "01" = Write frame (in Clause 22 or Clause 45) ● "10" = Read frame (in Clause 22) or Post Read frame (in Clause 45) ● "11" = Read frame (in Clause 45)
PHYAD/PRTAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● PHY address (in Clause 22) ● Port address (in Clause 45)
REGAD/DEVAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● Register address (in Clause 22) ● Device address (in Clause 45)
DATA/ADDRESS	Payload data field (in Clause 22 or Clause 45), or Address field (in Clause 45, only), shown as 4 hex characters or 16 binary bits (see Figure 12-103).
Register Name	Displays a translation of the PHYAD/PRTAD address label in textual form

In the decode results table, the contents of column "DATA/ADDRESS" can also be displayed in alternative numerical formats, e.g. in binary format, as shown in Figure 12-103.

Figure 12-103: The same signal trace and decode results table as in the previous figure, but only with "DATA" in binary format

To configure the numerical format of the content in column "DATA/ADDRESS", either use the button "Data format" in the "Decode results" table, as shown in Figure 12-103, or the same button in the "Display" tab of the "Protocol" dialog, as shown in Figure 12-104. Available data formats are "Hex", "Octal", "Binary", "Ascii", "Signed", and "Unsigned". If the binary format is selected, additional data format options are "Binary bit order", and "Binary bit group size". This defines if the data word is displayed most significant bit (MSB) or least significant bit (LSB) first, and in which size of groups the bits are displayed. This feature is also described in Chapter 12.1.2, "Display", on page 482.

Bus label

☑ Show decode table

☐ Show binary signals

☑ Show threshold lines

Data format: Binary

Binary bit order: LSB First

Binary bit group size: 4

Figure 12-104: The data display settings can be configured in the Display tab of the Protocol dialog

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.19.3, "Decode Results", on page 1917.

12.18.6 Search on Decoded MDIO Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

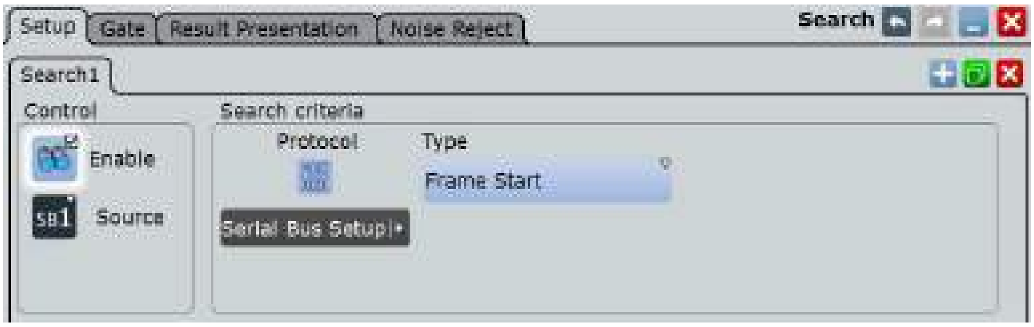
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

If you need information on how to get started with searching MDIO data, see Chapter 12.18.6.3, "Searching MDIO Data", on page 836. Otherwise proceed with the MDIO search setup.

12.18.6.1 MDIO Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for MDIO

Search criteria
Use the "Search criteria" dialog to define the event types to be searched.



Available event types are "Frame Start", "Frame Stop", and "Data".

Only if search criteria type "Data" is selected, individual search parameters can be specified in the tabs below the "Search criteria" dialog. For these parameters, see "ST" on page 834, "OP" on page 834, "PHYAD/PRTAD" on page 835, "REGAD/DEVAD" on page 835, and "DATA/ADDRESS" on page 835.

Remote command:
`SEARch:TRIGger:MDIO:TYPE` on page 1923

ST
Selects the start of frame code of the frame pattern; available only in search criteria type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`SEARch:TRIGger:MDIO:ST` on page 1923

OP
Selects the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`SEARch:TRIGger:MDIO:FRAMetype` on page 1921

PHYAD/PRTAD

Sets the physical address or port address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:PHYS` on page 1922

REGAD/DEVAD

Sets the register address or device address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:REGI` on page 1922

DATA/ADDRESS

Defines the payload data pattern or address pattern (16 bits); available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:DATA` on page 1921

12.18.6.2 MDIO Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

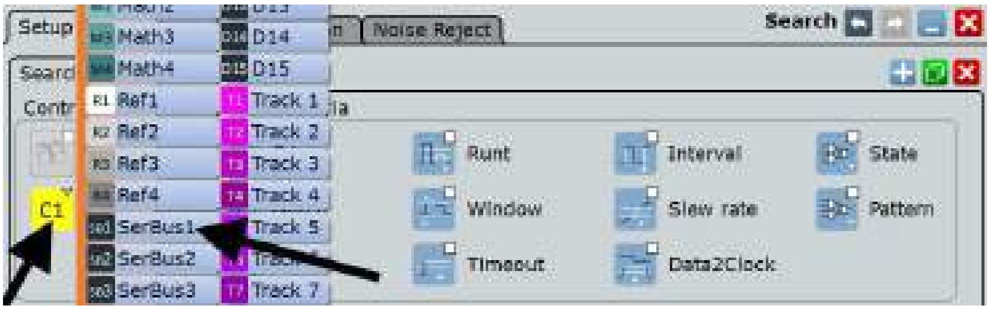
- `SEARch:RESult:MDIO:WCOunt` on page 1927
- `SEARch:RESult:MDIO:WORD<m>:STATe?` on page 1925
- `SEARch:RESult:MDIO:WORD<m>:STARt?` on page 1925
- `SEARch:RESult:MDIO:WORD<m>:STOP?` on page 1926
- `SEARch:RESult:MDIO:WORD<m>:ST?` on page 1925
- `SEARch:RESult:MDIO:WORD<m>:TYPE?` on page 1927
- `SEARch:RESult:MDIO:WORD<m>:PHYS?` on page 1924
- `SEARch:RESult:MDIO:WORD<m>:REGI?` on page 1924
- `SEARch:RESult:MDIO:WORD<m>:DATA?` on page 1924
- `SEARch:RESult:MDIO:WORD<m>:SYMBol?` on page 1926

12.18.6.3 Searching MDIO Data

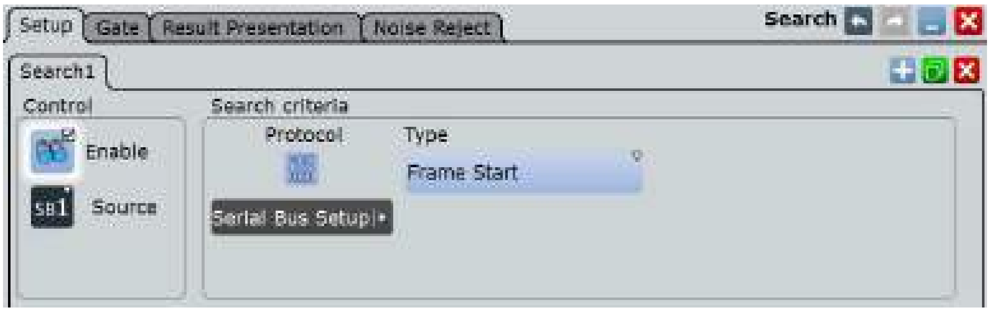
Prerequisite: A serial bus is configured for the MDIO signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to MDIO (e.g. "SerBus1", unless already selected).



The search dialog for MDIO protocol analysis is opened.



Source: SB1

Type: Frame Start

There are no additional search criteria to be specified.

4. To acquire a waveform, press SINGLE.

   The R&S RTO performs a MDIO decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
5. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

The R&S RTO displays the "Search Results" box that lists the detected events.

For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.19 USB (Option R&S RTO-K60)

R&S RTO-K60 is a firmware option that enables the R&S RTO to analyse Universal Serial Bus (USB) protocols, by triggering and decoding them. The option is compatible with the standards USB 1.0, USB 1.1, USB 2.0 and USB HSIC (High-Speed Inter-Chip). R&S RTO-K60 supports the data rates "Low Speed" (1.5 Mbit/s), "Full Speed" (12 Mbit/s) and "High Speed" (480 Mbit/s, available in USB 2.0 and HSIC).

12.19.1 The USB Protocol

The USB protocol was developed, starting in 1996, by the nonprofit organization USB Implementers Forum, Inc. (USB-IF), formed by Compaq, Hewlett-Packard, Intel, Lucent Technologies, Microsoft, NEC, and Philips. The purpose was to provide a common "plug-and-play" solution to replace a multitude of interfaces for the communication between computers and devices. It should allow even unskilled users to easily connect many devices to a PC. USB was originally used for devices that feature low signalling rates (up to 1.5 Mbit/s), especially human interface devices like mouse, joystick or keyboard. With the release of USB 2.0 in April 2000, devices such as printers, cameras and mass storage media were enabled to exchange data at faster rates (up to 480 Mbit/s). Additionally, the high speed protocol HSIC (High Speed Inter Chip) is used for the communication between on-board devices.

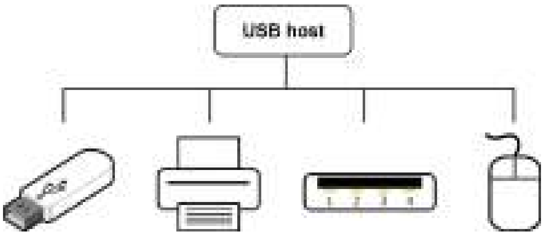


Figure 12-105: USB Topology: mass storage device, printer, USB hub, and mouse (human interface device) connected to a USB host

More information, including the USB specification, is available online within the web domain http://usb.org.

This chapter provides an overview of protocol characteristics, data transfer, packet structure, address and endpoint formats of USB as well as trigger possibilities of R&S®RTx-K60.

USB characteristics

Main characteristics of USB are:

- Four-wire design: USB requires a shielded cable containing four wires. Two of them, called D+ and D-, form a twisted pair (for low speed, they may not be twisted). These data lines transmit differential data signals and single-ended signal states, both referenced to a third wire: the GND or ground. The fourth wire, called VBUS (voltage bus), carries a nominal 5 V supply, which may be used to power a device.
- Host-to-device communication: in USB's "speak-when-spoken-to" protocol, communication is always initiated by the host. Consequently, there is no direct communication between USB devices, apart from very few exceptions.
- Addressing scheme: a maximum of 127 connected devices can be distinguished, because a packet's address field length is limited to 7 bits. USB devices have up to 16 OUT endpoints (from host to device) and up to 16 IN endpoints (from device to host).
- USB transactions consist of two or three packets: token, data, and typically handshake
- Packet type: a packet identifier (PID) is sent as a first byte within the packet and specifies the different packet types.
- NRZI (Non Return to Zero Inverted): a zero (0) is encoded as a transition of the physical level, whereas a one (1) has no transition, thus it is represented by a steady level.

Figure 12-106: Example of an NRZI sequence

- Bit stuffing: a zero (0) is inserted after every 6 consecutive ones (111111). This ensures sufficient transitions to keep the phase-locked loop (PLL) synchronized and locked onto the data stream.
- Little Endian scheme: both multiple bits and multiple bytes are transmitted with the least significant bit/byte (LSB) sent first, while the most significant bit/byte (MSB) is sent last.
- HSIC (High-Speed Inter-Chip): an industry standard for USB chip-to-chip interconnection with a 2-signal (strobe, data) source synchronous serial interface, using 240 MHz DDR signaling to provide only high-speed (480 Mbps) data rate.

Table 12-25: Simplified symbolic representation from the USB standard

Bus State	Protocol	Levels
Differential **"1"**		D+ High, D- Low
Differential **"0"**		D+ Low, D- High
Data **"J"** State	Low speed	D+ Low, D- High (differential **"0"**)
	Full speed	D+ High, D- Low (differential **"1"**)

Bus State	Protocol	Levels
Data **"K"** State	Low speed	D+ High, D- Low (differential **"1"**)
	Full speed	D+ Low, D- High (differential **"0"**)

In the example in Table 12-25, High speed can be assumed to be like Full speed. For a complete overview of bus states as well as for an electrical definition of High and Low speed, refer to chapter 7 of the USB specification.

Data transfer

In contrast to a conventional bus, USB is more like a network protocol, using target addresses and endpoints. However, USB features a bus master, called the host. It transmits packets of data to all devices or hubs connected to the host (or connected to a device or hub, which is in turn connected to the host). All connected devices receive each data packet, but disregard it unless it carries the correct address. In reply, only the addressed device (one at a time) can send data upstream, to the host.

The USB architecture supports four different kinds of data transfer: control, bulk, interrupt or isochronous transfer. For example, a "bulk OUT" transfer (from host to device) would look like this:

Figure 12-107: Example of a bulk OUT transfer. Blue: host speaks, white: device speaks

Packet structure

All packets must start with a **SYNC** field, also called **SOP** (start of packet), which indicates data transmission. It consists of "KJ" pairs, followed by one "KK". At low speed and full speed (USB 1.x), it is 8 bits long, encoded as "KJKJKJKK". At high speed (USB 2.0 and HSIC), it is up to 32 bits long, encoded as "KJKJKJKJKJKJ...KK".

The SYNC field is used to synchronize the clock of the receiver with that of the transmitter. The final 2 bits ("KK") indicate where the PID fields starts.

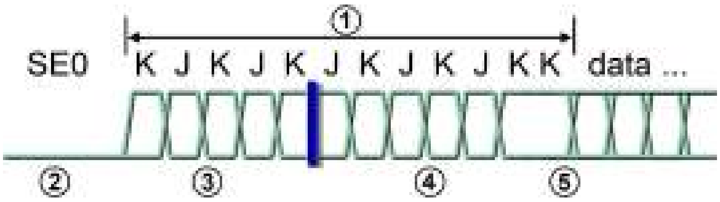


Figure 12-108: Start of a high speed packet: after an SE0, the packet starts with a SYNC field (or SOP), followed by the data packet

SE0 = Single-ended zero, both D+ and D- wire are on low level
1 = High-speed SYNC field (or SOP), length up to 32 bits
2 = Receiver-squelched differential envelope, below 100 mV

3 = Differential envelope exceeds 150 mV, reception enabled with 4 symbol times
4 = Clock recovery must lock in time to detect end of SYNC
5 = End of SYNC detected, receiver begins data recovery

After the SYNC (or SOP), USB data packets consist of (in this order):

- **PID** (packet identifier): specifies the type of packet. Examples are:
  - Token packets (IN, OUT, SETUP) are always the first packet in a USB transaction, containing the address of the device and its endpoint.
  - Token SOF packets (start of frame) are there to schedule a data transfer.
  - Handshake packets provide the status of the transaction.
  - Data packets are dedicated for the data transfer payload.
  - Various special packets provide special characteristics: for instance, SPLIT packets are used to communicate with low or full speed devices on a high speed link.

  The PID's length is 8 bit, beginning (LSB) with the fields PID0, PID1, PID2 and PID3. Those 4 bits are repeated in PID4, PID5, PID6 and PID7, but in complementary form (for integrity checking). The PID is the only part of a packet not to be covered by the CRC (see below). Packets with invalid or non-supported PID fields are rejected. For valid PIDs, see Table 12-26.
- **ADDR** (address): contains the USB address of the target device. The length of this field is 7 bits, resulting in addresses 0 through 127 (with 0 reserved as the default address after reset).
- **ENDP** (endpoint): number of the endpoint. The length of this field is 4 bits, resulting in a maximum of 16 different endpoints.
- **Frame number**: this field with a length of 11 bits specifies the current frame number from 0 through 2047. It is only sent in SOF packets.
- **Data field** (or "payload data"): the length of this field is not fixed, it can contain between 0 and 1024 bytes.
- **CRC** (cyclic redundancy check): Finally, the CRC field ensures that the received data is correct. If an error is detected in the CRC calculation, the packet is rejected. Packets (in this case: IN, OUT, SOF, SETUP, PING, SPLIT) are followed by a CRC5 (which is 5 bits long) over ADDR and ENDP (or the frame number field, in case of SOF); data packets (DATA0, DATA1, MDATA, DATA2) are followed by a CRC16 (which is 16 bits long) over the data field. No CRC is used for handshake packets.
- **EOP** (end of package): the devices determine the length of the data field by means of the EOP signal, which indicates the end of a packet. In low and full speed, it consists of two SE0 bits, followed by a J state. In case of high speed, the current state is inverted and kept for seven bit times, leading to a Bitstuff error that is used as an EOP indicator. This corresponds to the bit sequence 01111111 ahead of NRZI; in case of the SOF token, the bit sequence 0111111111111111111111111111111111111111 is transmitted (five NRZI bytes), which is used to recognize disconnects (since high-speed devices normally do not apply voltage to D+/D-). If no device is present, a higher voltage is measured. After that, the idle state (SE0) is occupied.

Table 12-26: Valid PIDs for different packet types

Packet type	Name	PID value	Meaning
Token	OUT	0xE1	Starts data transfer towards a device
	IN	0x69	Starts data transfer towards the host
	SOF	0xA5	Indicates start of frame
	SETUP	0x2D	Starts a setup transfer and sends information on this to the device
Data	DATA0	0xC3	Data packet with data-toggle bit 0
	DATA1	0x4B	Data packet with data-toggle bit 1
	DATA2	0x87	Data packet for high speed IN isochronous transfers that require high bandwidth
	MDATA	0x0F	Data packet for high speed OUT isochronous transfers that require high bandwidth
Handshake	ACK	0xD2	Acknowledgement of a packet received without error
	NAK	0x5A	Data not accepted, typically equivalent with some type of EAGAIN, meaning that the data should be re-sent at a later time
	STALL	0x1E	A severe error has occurred, the target endpoint can not be addressed until it is explicitly cleared again
	NYET	0x96	Only used in high speed transfers, meaning ACK, but in the next interval no data can be received, therefore the host should first apply a PING
Special	PRE	0x3C	Starts a low speed transfer via a full speed bus
	ERR	0x3C	Indicates an error in a SPLIT transaction (using the same PID as PRE, however, these can not be mistaken for each other)
	SPLIT	0x78	Starts a SPLIT transaction (thus: a low speed or full speed transfer via a high speed bus)
	PING	0xB4	Used for monitoring high speed data flow

- Token packets (IN, OUT, SETUP) and PING packets have the following format:

SYNC	PID	ADDR	ENDP	CRC5	EOP

- Start of frame packets (SOF) have the following format:

SYNC	PID	Frame number	CRC5	EOP

- Data packets have the following format:

SYNC	PID	Data	CRC16	EOP

- Handshake packets have the following format:

SYNC	PID	EOP

- SPLIT packets have the following format:

SYNC	PID	ADDR	SC	PORT	S	E	ET	CRC5	EOP

Trigger possibilities

Signals on the input channels CH1 - CH4 of the R&S RTO can be triggered by the option R&S®RTx-K60. The following trigger types are available:

- ANY Packet - Packet Sync: Triggering on the first rising slope after transmission of the packet Sync. Various lengths according to standard (in USB 2.0: 32 bit)
- Any token, OUT, IN, SOF, SETUP, AND-ing with user defined PID check, address, endpoint, CRC5: For OUT, IN, SETUP, the endpoint and CRC5 follow from the bit order, therefore such patterns can be recognized.
- Data Selection: DATA0, DATA1, DATA2, MDATA, (for USB 1.x only: AND-ing with user defined PID check, payload and CRC values)
- Handshake Packet Setup: Triggering on handshake packet, trigger with specific settings: ACK, NAK, NYET, STALL or ERR handshake packet
- Protocol Error: Triggering on PID/check error, CRC5 error, CRC16 (for USB 1.x only), frame length error (for USB 1.x only)
- Bus Event: Triggering on reset, resume, or suspend

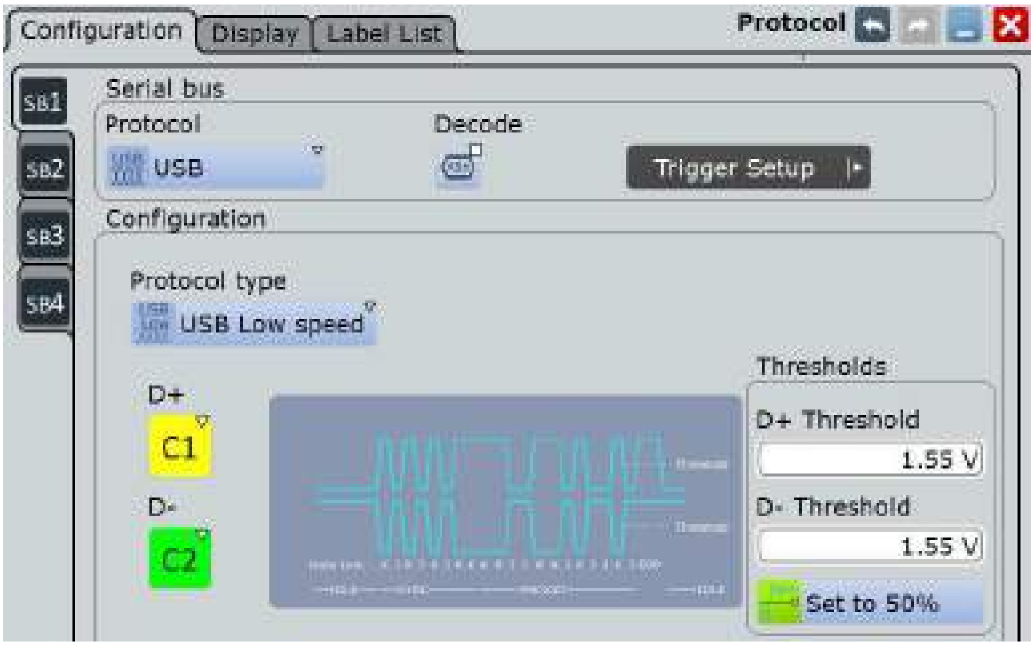
12.19.2 USB Configuration

If you need information on how to get started with configuring the USB setup, see Chapter 12.19.2.2, "Configuring USB Signals", on page 846. Otherwise proceed with the configuration settings.

12.19.2.1 USB Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *USB*

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: USB

Decode

Protocol type: USB Low speed

D+: C1

D-: C2

D+ Threshold: 1.55 V

D- Threshold: 1.55 V

Figure 12-109: Serial bus protocol configuration dialog

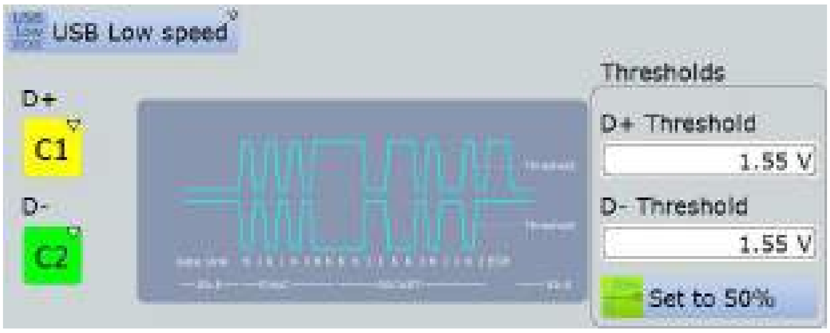
For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Protocol type

Defines the USB protocol technology and transmission speed.

"USB Low speed"

Selects USB low speed protocol (1.5 Mbit/s).



USB Low speed

D+: C1

D-: C2

D+ Threshold: 1.55 V

D- Threshold: 1.55 V

Figure 12-110: USB low speed protocol configuration

Remote command:

`BUS<m>:USB:DPLus:SOURce` on page 1928

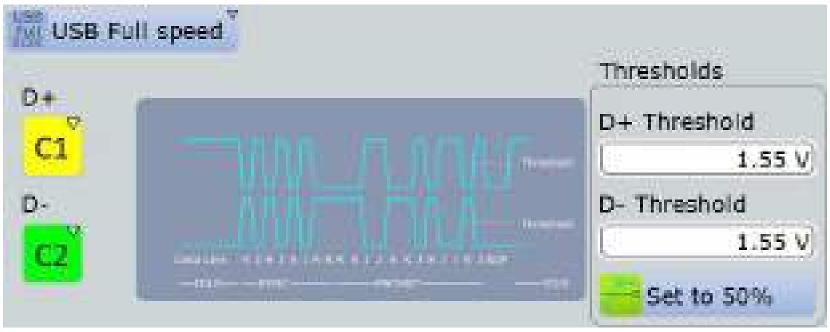
`BUS<m>:USB:DMINus:SOURce` on page 1929

`BUS<m>:USB:DPLus:THReshold` on page 1930

`BUS<m>:USB:DMINus:THReshold` on page 1930

"USB Full speed"

Selects USB full speed protocol (12 Mbit/s).



D+ Threshold: 1.55 V

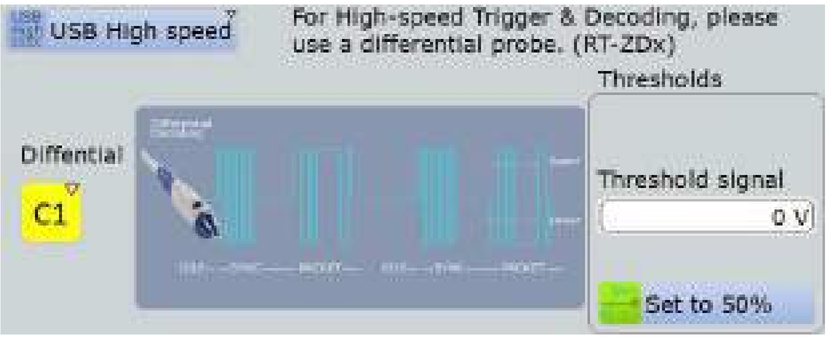
D- Threshold: 1.55 V

Figure 12-111: USB full speed protocol configuration

Remote command:
`BUS<m>:USB:DPLus:SOURce` on page 1928
`BUS<m>:USB:DMINus:SOURce` on page 1929
`BUS<m>:USB:DPLus:THReshold` on page 1930
`BUS<m>:USB:DMINus:THReshold` on page 1930

"USB High speed"

Selects USB high speed protocol (480 Mbit/s). As the signal is differential, there is only one source and one threshold to be defined.



For High-speed Trigger & Decoding, please use a differential probe. (RT-ZDx)

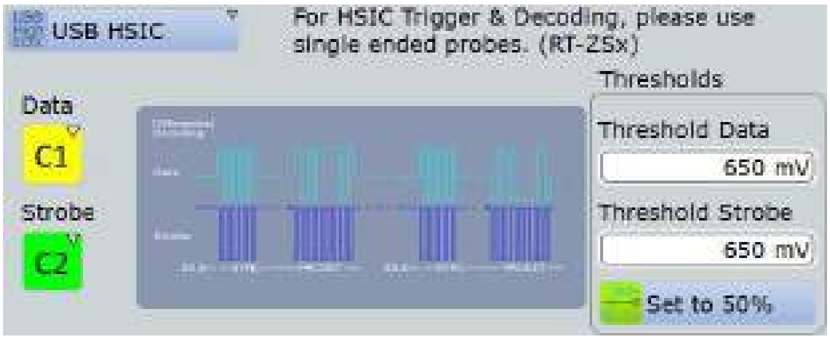
Threshold signal: 0 V

Figure 12-112: USB high speed protocol configuration

Remote command:
`BUS<m>:USB:DIFFerential:SOURce` on page 1929
`BUS<m>:USB:DIFFerential:THReshold` on page 1930

"USB HSIC"

Selects USB high speed inter-chip (HSIC) protocol.



For HSIC Trigger & Decoding, please use single ended probes. (RT-ZSx)

Threshold Data: 650 mV

Threshold Strobe: 650 mV

Figure 12-113: USB HSIC protocol configuration

Remote command:
`BUS<m>:USB:DATA:SOURce` on page 1929
`BUS<m>:USB:STRobe:SOURce` on page 1929
`BUS<m>:USB:DATA:THReshold` on page 1930
`BUS<m>:USB:STRobe:THReshold` on page 1931

Remote command:
`BUS<m>:USB:TECHnology` on page 1928

D+

Defines the source settings for the D+ data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:DPLus:SOURce` on page 1928

D-

Defines the source settings for the D- data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:DMINus:SOURce` on page 1929

Differential

Defines the source settings for the differential data signal (in USB high speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:DIFFerential:SOURce` on page 1929

Data

Defines the source settings for the data signal (in USB HSIC protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:DATA:SOURce` on page 1929

Strobe
Defines the source settings for the strobe signal (in USB HSIC protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:STRobe:SOURce` on page 1929

Thresholds
Sets the threshold value for the digitization of each signal line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, if the signal value is below the threshold, the signal state is considered low.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:USB:DPLus:THReshold` on page 1930
`BUS<m>:USB:DMINus:THReshold` on page 1930
`BUS<m>:USB:DIFFerential:THReshold` on page 1930
`BUS<m>:USB:DATA:THReshold` on page 1930
`BUS<m>:USB:STRobe:THReshold` on page 1931

12.19.2.2 Configuring USB Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "USB".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   This prevents to use Math waveforms, Ref waveforms and Tracks as channel signals.

   Note: For triggering on a serial bus, analog input channels are required!
7. Switch back to the "Serial Bus Setup" dialog.
8. Tap "Protocol type" and select the protocol type ("USB Low speed", "USB Full speed", "USB High speed", or "USB HSIC") you want to set up.

9. Depending on the protocol type, select the waveform for each of the available "D+", "D-", "Differential", "Data", and "Strobe" lines.
10. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
11. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.19.2.1, "USB Configuration Settings", on page 842.

12.19.3 USB Trigger

If you need information on how to get started with triggering on USB signals, see Chapter 12.19.3.2, "Triggering on USB", on page 856. Otherwise proceed with the USB trigger settings.

12.19.3.1 USB Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = USB"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.

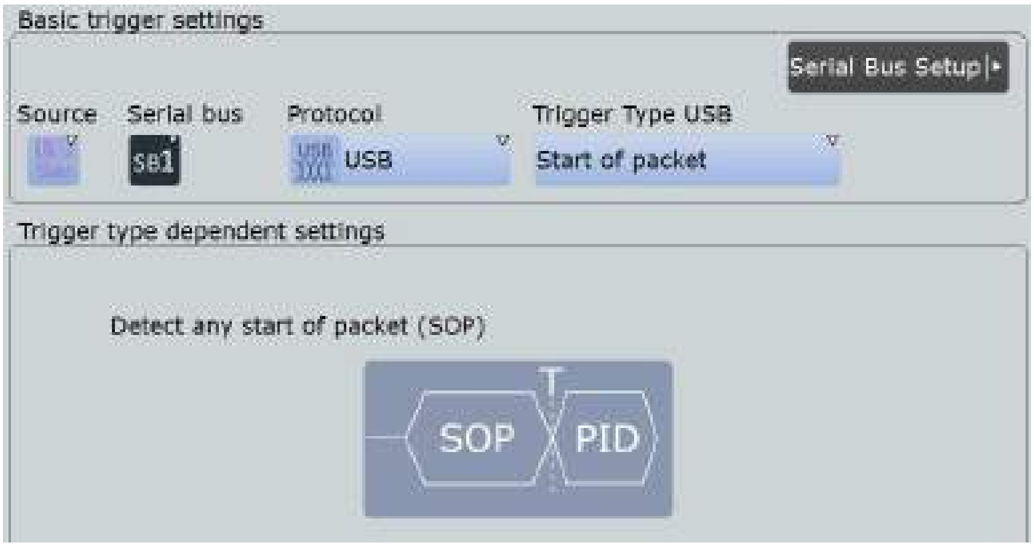


Figure 12-114: USB trigger event settings dialog

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type USB
Selects the trigger type for USB analysis. The available trigger types depend on the USB protocol type that is selected in the configuration setup, see "Protocol type" on page 843.

Remote command:
`TRIGger<m>:USB:TYPE` on page 1932

Start of packet ← Trigger type USB
Sets the trigger to the SOP (start of packet) field. The start of packet condition is the end of the SYNC field. The trigger instant is the end of the SOP field.

End of packet ← Trigger type USB
Sets the trigger to the EOP (end of packet) field. Not available for USB High Speed and USB HSIC protocol types. The trigger instant is the beginning of the EOP field.

Reset ← Trigger type USB
Sets the trigger to the Reset field. Not available for USB High Speed and USB HSIC protocol types. For more information on the reset condition, see the USB standard. The trigger instant is the end of the 10 ms period after the SE0 field.

Suspend ← Trigger type USB
Sets the trigger to the Suspend field. Not available for USB High Speed and USB HSIC protocol types. For more information on the suspend condition, see the USB standard. The trigger instant will be declared after the defined 3 ms timeout.

Resume ← Trigger type USB
Sets the trigger to the Resume field. Not available for USB High Speed and USB HSIC protocol types. For more information on the resume condition, see the USB standard. The trigger instant will be declared after the defined 20 ms timeout.

Token ← Trigger type USB
Sets the trigger to one out of four different token trigger types: OUT, IN, SOF, or SETUP.

See "Token" on page 850

Data ← Trigger type USB
Sets the trigger to one out of four different data trigger types: DATA0, DATA1, DATA2, or MDATA.

See "Data" on page 850

Handshake ← Trigger type USB
Sets the trigger to one out of four different handshake trigger types: ACK, NAK, STALL, or NYET.

See "Handshake" on page 851

Special PID ← Trigger type USB
Sets the trigger to one out of four different Special PID trigger types: PREamble, ERR, SPLIT, or PING.

See "Special PID" on page 851

Error condition ← Trigger type USB
Sets the trigger to one out of eight different error condition trigger types: Any error, PID error, CRC5 error, CRC16 error, Bitstuffing error, Unexpected PID error, SE1 error, or Glitching error.

See "Error condition" on page 853

Token

Sets the trigger to one out of four different token types:

- "OUT"
- "IN"
- "SOF"
- "SETUP"

If no additional conditions are set, the trigger instant is after the PID.

If the PID error check is selected, and

- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).

Remote command:
`TRIGger<m>:USB:TOKen` on page 1942

OUT, IN or SETUP ← Token

For the trigger token types "OUT", "IN" or "SETUP", the following conditions can be set:

You can refine the trigger condition:

- See "PID error check" on page 853
- See "End Point check" on page 853
- See "Address check" on page 853

SOF ← Token

For the trigger token type "SOF", the following conditions can be set:

You can refine the trigger condition:

- See "PID error check" on page 853
- See "Frame number check" on page 854

Data

Sets the trigger to one out of four different data types:

- "DATA0"
- "DATA1"
- "DATA2"

- "MDATA"

If no additional conditions are set, the trigger instant is after the PID.

If the PID error check is selected, and
- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).

Index position: 0

Payload pattern: [hex]XX

You can refine the trigger condition:
- See "PID error check" on page 853
- See "Payload check" on page 854

Remote command:
`TRIGger<m>:USB:DATA` on page 1934

Handshake

Sets the trigger to one out of four different handshake types:
- "ACK"
- "NAK"
- "STALL"
- "NYET"

If no handshake condition is set, the trigger instant is after the PID.

If the PID error check is selected, and
- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set.

See "PID error check" on page 853

Remote command:
`TRIGger<m>:USB:HAND` on page 1938

Special PID

Sets the trigger to one out of four different "Special PID" types:
- "PREamble"
- "ERR"
- "SPLIT"

- "PING"

If no additional conditions are set, the trigger instant is after the PID.

If the PID error check is selected, and
- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

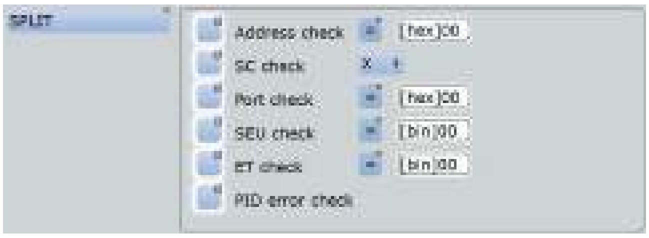
Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).

Remote command:
`TRIGger<m>:USB:SPEC` on page 1940

PREamble or ERR ← Special PID
For the Trigger Special Types "PREamble" and "ERR", the following condition can be set:

See "PID error check" on page 853

SPLIT ← Special PID
For the Trigger Special Type "SPLIT", the following conditions can be set:



You can refine the trigger condition:
- See "Address check" on page 853
- See "SC check" on page 855
- See "Port check" on page 855
- See "SEU check" on page 855
- See "ET check" on page 855
- See "PID error check" on page 853

PING ← Special PID
For the Trigger Special Type "PING", the following conditions can be set:

You can refine the trigger condition:
- See "Address check" on page 853
- See "End Point check" on page 853
- See "PID error check" on page 853

Error condition

Sets the trigger in case of one of the following eight different error condition types.
- Any error: triggers on any of the errors listed below.
- PID error: triggers on any packet identifier error.
- CRC5 error: triggers on any CRC5 error event
- CRC16 error: triggers on any CRC16 error event
- Bitstuffing error: triggers in the event of an erroneous or missing bit stuffing sequence (see USB standard).
- Unexpected PID error: triggers on any illegal PID. This is a PID that is not allowed in USB low speed and USB full speed protocols, especially PID's announcing packets such as SPLIT, DATA2, MDATA, or other noncompliant packets.
- SE1 error: triggers on the illegal bus state Single Ended 1 (SE1 = both lines high).
- Glitching error: triggers on an error in the bit period (see USB standard for the definition of glitching).

The trigger instant is the first occurrence of the specified error.

Remote command:

`TRIGger<m>:USB:ERRC` on page 1936

PID error check

Defines, whether a packet ID error check is executed or not.

Remote command:

`TRIGger<m>:USB:WPID` on page 1944

End Point check

Defines, whether an endpoint check that meets specific conditions is executed or not.

"Condition"	Defining a specific endpoint or an endpoint range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an endpoint, or sets the start value of an endpoint range.
"Max"	Sets the the end value of an endpoint range if "Condition" (`TRIGger<m>:USB:ECONdition`) is set to `INRange` or `OORange`.

Remote command:

`TRIGger<m>:USB:WEND` on page 1943

`TRIGger<m>:USB:ECONdition` on page 1936

`TRIGger<m>:USB:EMIN` on page 1936

`TRIGger<m>:USB:EMAX` on page 1936

Address check

Defines, whether an address check that meets specific conditions is executed or not.

"Condition"	Defining a specific address or an address range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min"	Specifies an address, or sets the start value of an address range.
"Max"	Sets the the end value of an address range if "Condition" (`TRIGger<m>:USB:ACONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WADD` on page 1943
`TRIGger<m>:USB:ACONdition` on page 1934
`TRIGger<m>:USB:AMAX` on page 1934
`TRIGger<m>:USB:AMIN` on page 1934

Payload check
Defines, whether a payload check that meets specific conditions is executed or not.

"Condition"	Sets the operator "any" or "equal" that allows to trigger for payload data at any position or at a specified position.
"Position"	Available only if "Condition" (`TRIGger<m>:USB:DPOPerator`) is set to *equal*. Specifies the position in which a special data pattern is to be triggered within the payload data packet.
"Data Condition"	Sets the operator ("equal" or "unequal", `TRIGger<m>:USB:DCONdition`) to set a specific payload data pattern.
"Payload pattern"	Specifies the payload data pattern that is to be triggered.

Remote command:
`TRIGger<m>:USB:WPAY` on page 1944
`TRIGger<m>:USB:DPOPerator` on page 1935
`TRIGger<m>:USB:DPOSition` on page 1935
`TRIGger<m>:USB:DCONdition` on page 1935
`TRIGger<m>:USB:PATT` on page 1938

Frame number check
Defines, whether a frame number check that meets specific conditions is executed or not.

"Condition"	Defining a specific frame number or a frame number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a frame number, or sets the start value of a frame number range.
"Max"	Sets the the end value of a frame number range if "Condition" (`TRIGger<m>:USB:FCONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WFRN` on page 1943
`TRIGger<m>:USB:FCONdition` on page 1937
`TRIGger<m>:USB:FMIN` on page 1938
`TRIGger<m>:USB:FMAX` on page 1938

SC check

Defines, whether a Start / Complete SPLIT transaction check is executed or not.

Remote command:

`TRIGger<m>:USB:WSTC` on page 1944

`TRIGger<m>:USB:STCO` on page 1941

Port check

Defines, whether a port check that meets specific conditions is executed or not.

"Condition"	Defining a specific port number or a port number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a port number, or sets the start value of a port number range.
"Max"	Sets the the end value of a port number range if "Condition" (`TRIGger<m>:USB:PCONdition`) is set to `INRange` or `OORange`.

Remote command:

`TRIGger<m>:USB:WPOR` on page 1944

`TRIGger<m>:USB:PCONdition` on page 1938

`TRIGger<m>:USB:PMIN` on page 1939

`TRIGger<m>:USB:PMAX` on page 1939

SEU check

Defines, whether an SEU check that meets specific conditions is executed or not. S and E represent the Start and End of a start-split transaction, U represents the reserved/Unused bit of a complete-split transaction. Permissible binary SEU values are 00, 01, 10, and 11.

"Condition"	Defining a specific SEU value or an SEU value range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an SEU value, or sets the start value of an SEU value range.
"Max"	Sets the the end value of an SEU value range if "Condition" (`TRIGger<m>:USB:SCONdition`) is set to `INRange` or `OORange`.

Remote command:

`TRIGger<m>:USB:WSEU` on page 1944

`TRIGger<m>:USB:SCONdition` on page 1939

`TRIGger<m>:USB:SMIN` on page 1940

`TRIGger<m>:USB:SMAX` on page 1940

ET check

Defines, whether an Endpoint Type (ET) check that meets specific conditions is executed or not.

"Condition"	Defining a specific endpoint type or an ET range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an ET, or sets the start value of an ET range.
"Max"	Sets the the end value of an ET range if "Condition" (`TRIGger<m>:USB:TCONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WETCheck` on page 1943
`TRIGger<m>:USB:TCONdition` on page 1941
`TRIGger<m>:USB:TMIN` on page 1942
`TRIGger<m>:USB:TMAX` on page 1942

12.19.3.2 Triggering on USB

Prerequisite: A bus is configured for the USB signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.19.2.1, "USB Configuration Settings", on page 842), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to USB, e.g.:

   The "Protocol" selection is then automatically set to "USB".
4. Tap "Trigger Type USB" and select the trigger type to be used for USB protocol analysis.
   Available trigger types depend on the USB protocol type that has been activated in "Protocol type" on page 843.
5. Depending on the selected USB protocol type and trigger type, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.19.3.1, "USB Trigger Settings", on page 847.

12.19.4 USB Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-115 shows a simulated USB full speed message. A Token OUT packet has been decoded, followed by an ACK packet with an erroneous complementary PID value (PID Error). The next event is a PRE packet, then a DATA1 packet with two bytes of data transmitted, and with a valid CRC16. The trigger instant is at the PID of the DATA1 packet.

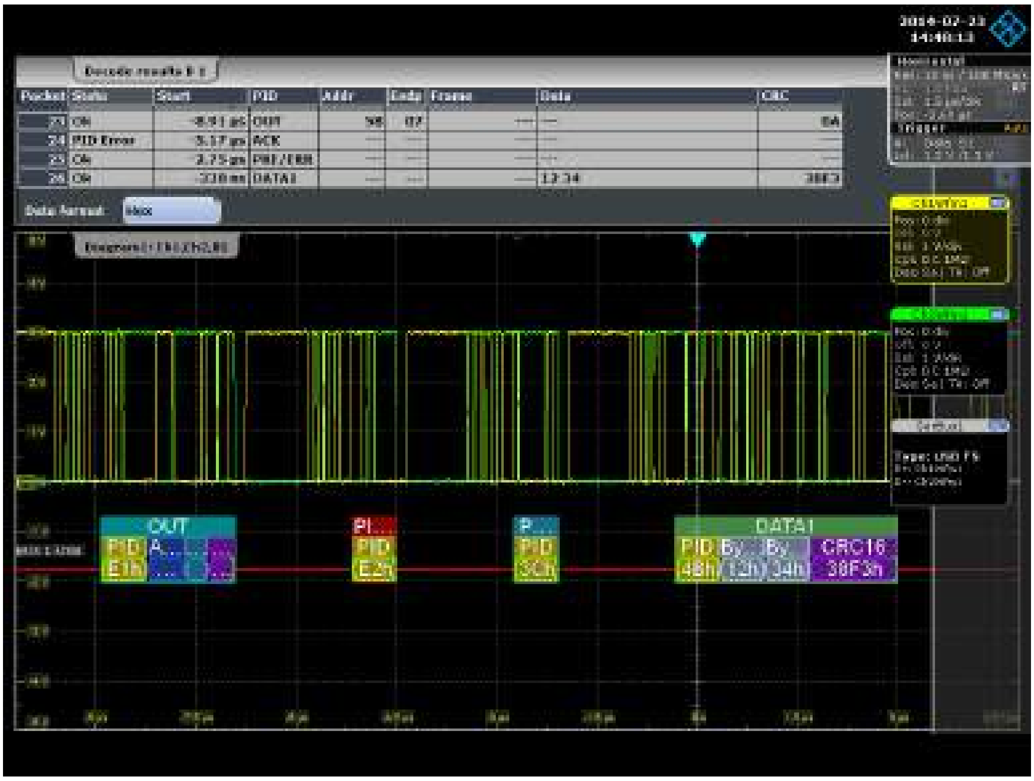


Figure 12-115: USB full speed protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address

blue = endpoint
purple = CRC5/16
grey = payload data bytes

The example in Figure 12-116 shows a simulated USB high speed message. A Token SETUP packet has been decoded, which contains a CRC5 error. The next event is a Token IN packet and an incomplete MDATA packet. Note that an incomplete packet is also decoded, as long as sample data are available. In such a case, no error will be shown, since the remaining CRC16 cannot be computed. The trigger instant is on the CRC5 error.

Figure 12-116: USB high speed protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address
blue = endpoint
purple = CRC5/16
grey = payload data bytes

The example in Figure 12-117 shows a simulated USB HSIC sequence, in which Data (ch1) and Strobe (ch2) are combined. A Token OUT packet, a DATA0 packet with an erroneous CRC16 value and a STALL packet have been decoded. The next events are a Token SETUP packet with erroneous CRC5 value, and a Token IN packet. In this scenario, the trigger instant is on the SOP (start of packet).

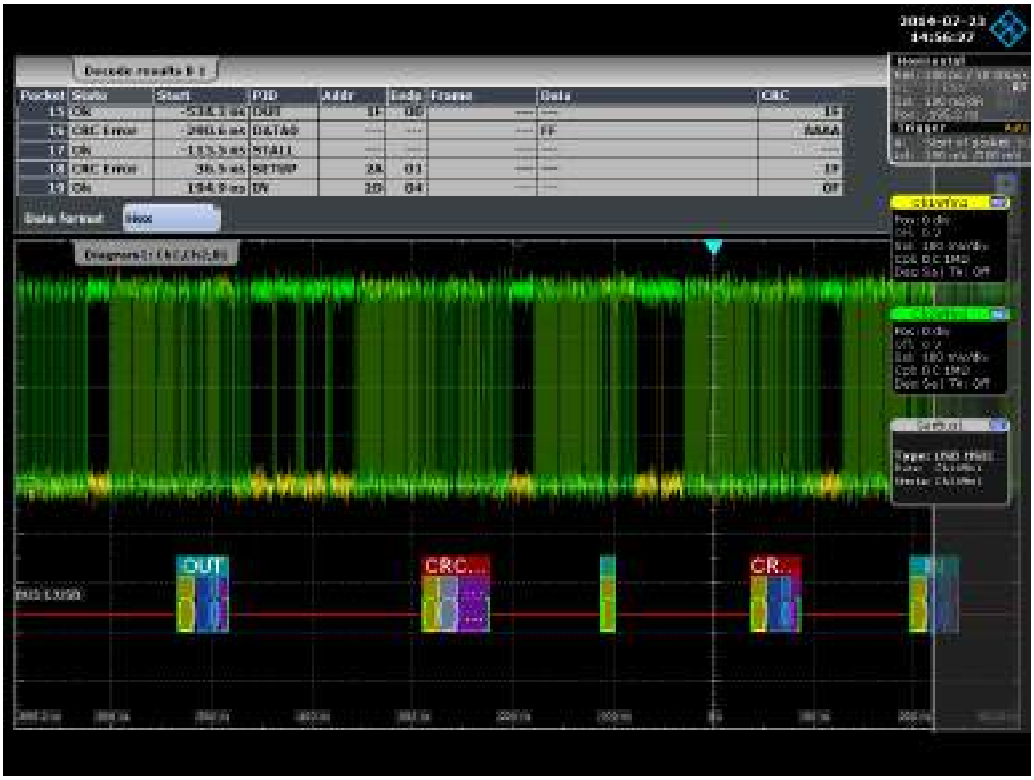


Figure 12-117: USB HSIC protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address
blue = endpoint
purple = CRC5/16
grey = payload data bytes

Table 12-27: Content of the "Decode results" table in the previous figures

Column	Description
State	Overall state of the packet: either OK or the relevant error condition (CRC, glitching, ...)
Start	Start time of the packet.
PID	PID type (OUT, IN, DATA0, ...)
Addr	Address of the recipient
Endp	Endpoint of the recipient
Frame	Frame number (in SOF packet)
Data	Values of the payload data bytes. The data format is selected below the table.
CRC	Either CRC5 or CRC16 (data packet PID)

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.20.3, "Decode Results", on page 1944.

12.19.5 Search on Decoded USB Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

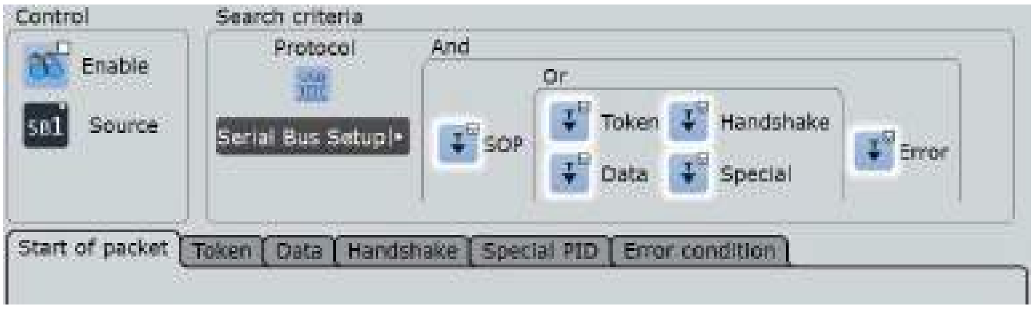
If you need information on how to get started with searching USB data, see Chapter 12.19.5.3, "Searching USB Data", on page 868. Otherwise proceed with the USB search setup.

12.19.5.1 USB Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for USB

Search criteria

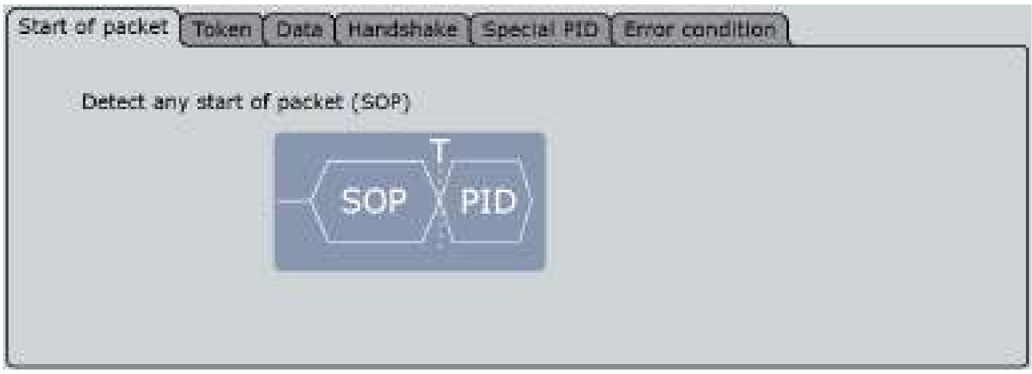
Use the "Search criteria" dialog to define the event types to be searched.



Individual search parameters (which do not depend on the USB protocol type and trigger settings), can be specified in the tabs below the "Search criteria" dialog.

Remote command:
`SEARch:TRIGger:USB:SSOP` on page 1959
`SEARch:TRIGger:USB:STOKen` on page 1961
`SEARch:TRIGger:USB:SDATa` on page 1959
`SEARch:TRIGger:USB:SHANdshake` on page 1959
`SEARch:TRIGger:USB:SSPE` on page 1960
`SEARch:TRIGger:USB:SERRor` on page 1959

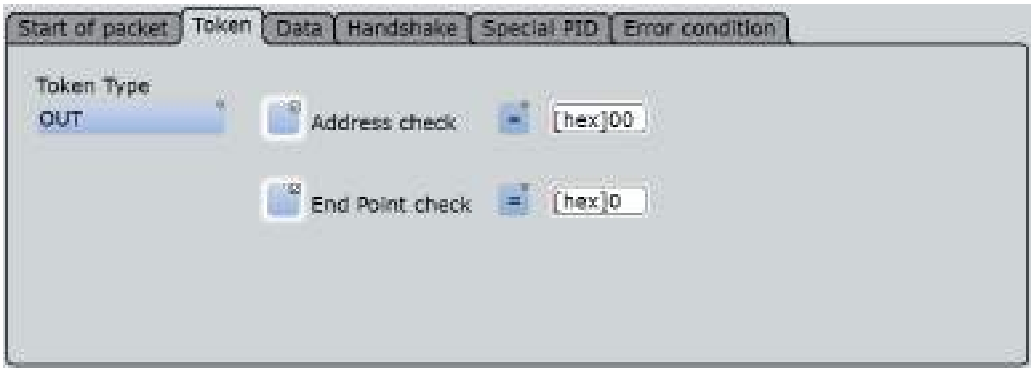
SOP
Searches for any start of packet. There are no additional parameters to be defined.



Token
Searches for four different token types: "OUT", "IN", "SOF", or "SETUP", as well as "Any" token.

For "Any" token, there are no additional parameters to be defined.

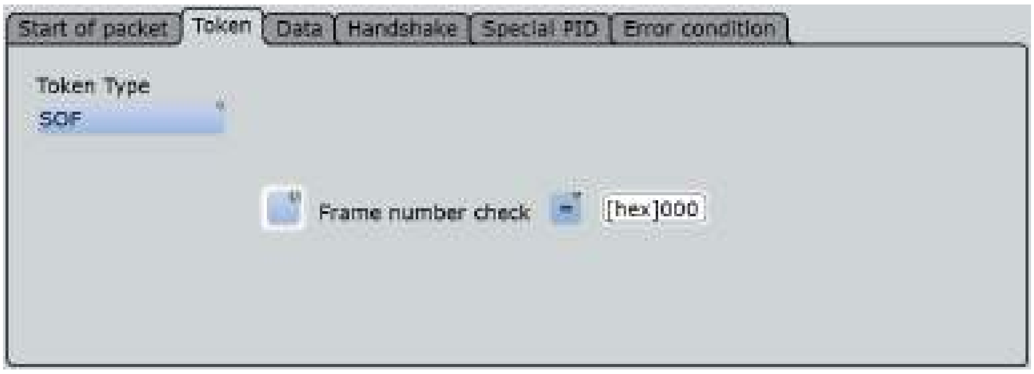
For "OUT", "IN", or "SETUP" tokens, additional search parameters are "Address check" and "End Point check".



Token Type
OUT
Address check = [hex]00
End Point check = [hex]0

You can refine the search condition:
- See "Address check" on page 864
- See "End Point check" on page 864

For "SOF" tokens, the additional search parameter is "Frame number check".



Token Type: SOF

☐ Frame number check = [hex]000

You can refine the search condition:

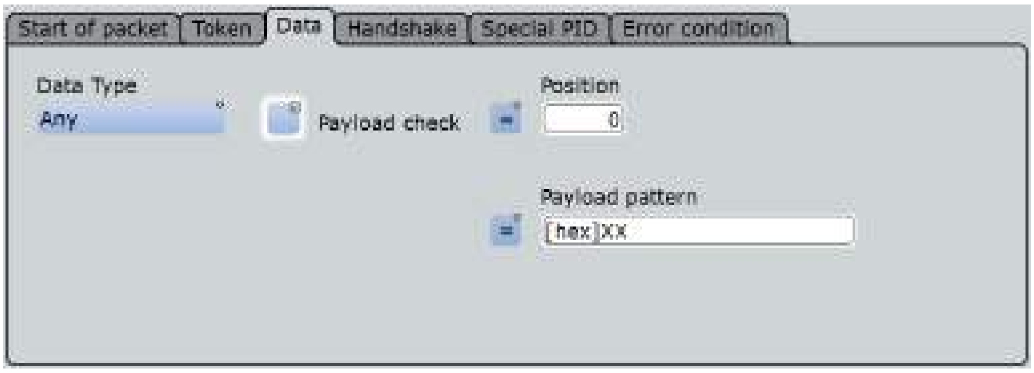
- See "Frame number check" on page 865

Remote command:

`SEARch:TRIGger:USB:TOKen` on page 1962

Data

Searches for data packets of the following types: DATA0, DATA1, DATA2, or MDATA, as well as "Any" data packet.



Data Type: Any

☐ Payload check

Position = 0

Payload pattern = [hex]XX

To search for payload in any data packet type, a data pattern and optionally a packet position have to be specified.

You can refine the search condition:

- See "Payload check" on page 865

Remote command:

`SEARch:TRIGger:USB:DATA` on page 1953

Handshake

Searches for four different handshake packet types: "ACK", "NAK", "STALL", or "NYET", as well as "Any" handshake packet. There are no additional parameters to be defined.

Handshake Type: Any

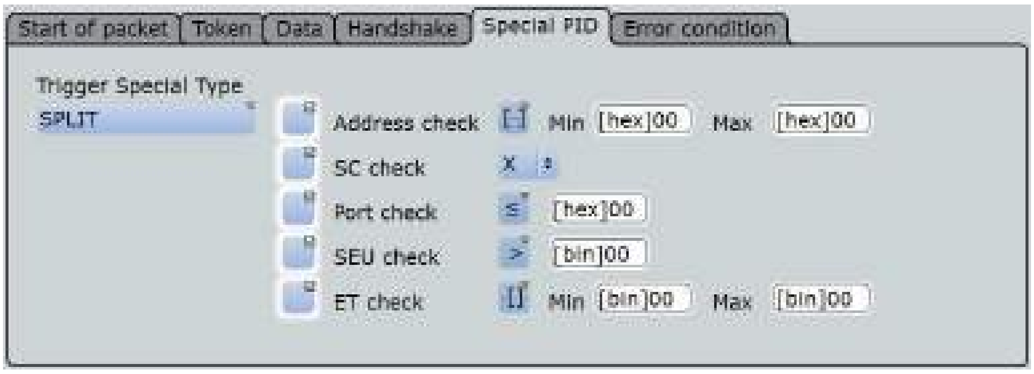
Remote command:
`SEARch:TRIGger:USB:HAND` on page 1956

Special PID
Searches for four different special packet identifier types: "PREamble", "ERR", "SPLIT", or "PING", as well as "Any" special PID.

For "Any", "PREamble", or "ERR", there are no additional parameters to be defined.

Trigger Special Type: Any

For "SPLIT", additional search parameters are "Address check", "SC check", "Port check", "SEU check", and "ET check".



Trigger Special Type: SPLIT
Address check: [ ] Min [hex]00 Max [hex]00
SC check: X
Port check: ≤ [hex]00
SEU check: > [bin]00
ET check: [ ] Min [bin]00 Max [bin]00

You can refine the search condition:

- See "Address check" on page 864
- See "SC check" on page 866
- See "Port check" on page 866
- See "SEU check" on page 866
- See "ET check" on page 867

For "PING", additional search parameters are "Address check" and "End Point check".

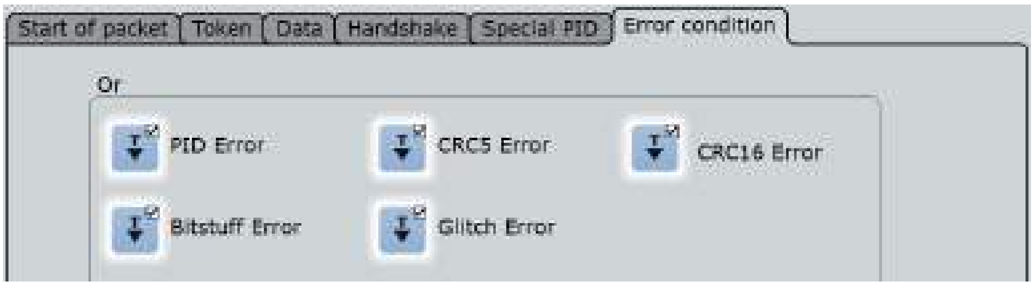
Trigger Special Type: PING
Address check: = [hex]00
End Point check: [ ] Min [hex]0 Max [hex]0

You can refine the search condition:

- See "Address check" on page 864
- See "End Point check" on page 864

Remote command:
`SEARch:TRIGger:USB:SPEC` on page 1960

Error condition
Searches for the following error conditions:



"PID Error"	Searches for packet identifier errors.

Remote command:
`SEARch:TRIGger:USB:PIDerror` on page 1957

"CRC5 Error"	Searches for any CRC5 error event.

Remote command:
`SEARch:TRIGger:USB:CRC5error` on page 1952

"CRC16 Error"	Searches for any CRC16 error event.

Remote command:
`SEARch:TRIGger:USB:CRC16error` on page 1952

"Bitstuff Error"	Searches for bitstuffing errors, thus an erroneous or missing bit stuffing sequence (see USB standard).

Remote command:
`SEARch:TRIGger:USB:BITSterror` on page 1952

"Glitch Error"	Searches for glitching errors (errors in the bit period, see USB standard for the definition of glitching).

Remote command:
`SEARch:TRIGger:USB:GLITcherror` on page 1956

Address check

Enables the search for an address that meets specific conditions.

"Condition"	Defining a specific address or an address range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an address, or sets the start value of an address range.
"Max"	Sets the the end value of an address range if "Condition" (`SEARch:TRIGger:USB:ACONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WADD` on page 1962
`SEARch:TRIGger:USB:ACONdition` on page 1951
`SEARch:TRIGger:USB:AMIN` on page 1951
`SEARch:TRIGger:USB:AMAX` on page 1952

End Point check

Enables the search for an endpoint that meets specific conditions.

"Condition"	Defining a specific endpoint or an endpoint range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an endpoint, or sets the start value of an endpoint range.
"Max"	Sets the the end value of an endpoint range if "Condition" (`SEARch:TRIGger:USB:ECONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WEND` on page 1963
`SEARch:TRIGger:USB:ECONdition` on page 1954
`SEARch:TRIGger:USB:EMIN` on page 1954
`SEARch:TRIGger:USB:EMAX` on page 1955

Frame number check
Enables the search for a frame number that meets specific conditions.

"Condition"	Defining a specific frame number or a frame number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a frame number, or sets the start value of a frame number range.
"Max"	Sets the the end value of a frame number range if "Condition" (`SEARch:TRIGger:USB:FCONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WFRN` on page 1963
`SEARch:TRIGger:USB:FCONdition` on page 1955
`SEARch:TRIGger:USB:FMIN` on page 1955
`SEARch:TRIGger:USB:FMAX` on page 1956

Payload check
Enables the search for a payload data pattern that meets specific conditions.

"Condition"	Sets the operator "any" or "equal" that allows to search for payload data at any position or at a specified position.
"Position"	Available only if "Condition" (`SEARch:TRIGger:USB:DPOPerator`) is set to *equal*. Specifies the position in which a special data pattern is to be searched within the payload data packet.
"Data Condition"	Sets the operator ("equal" or "unequal", `SEARch:TRIGger:USB:DCONdition`) to set a specific payload data pattern.
"Payload pattern"	Specifies the payload data pattern that is to be searched.

Remote command:
`SEARch:TRIGger:USB:WPAY` on page 1963
`SEARch:TRIGger:USB:DPOPerator` on page 1953
`SEARch:TRIGger:USB:DPOSition` on page 1954

`SEARch:TRIGger:USB:DCONdition` on page 1953
`SEARch:TRIGger:USB:PATT` on page 1956

SC check
Searches for the selected Start (0) or Complete (1) SPLIT transaction endpoint, or X (don't care).

Remote command:
`SEARch:TRIGger:USB:WSTC` on page 1964
`SEARch:TRIGger:USB:STCO` on page 1960

Port check
Enables the search for a port that meets specific conditions.

"Condition"	Defining a specific port number or a port number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a port number, or sets the start value of a port number range.
"Max"	Sets the the end value of a port number range if "Condition" (`SEARch:TRIGger:USB:PCONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WPOR` on page 1964
`SEARch:TRIGger:USB:PCONdition` on page 1957
`SEARch:TRIGger:USB:PMIN` on page 1957
`SEARch:TRIGger:USB:PMAX` on page 1957

SEU check
Enables the search for an SEU that meets specific conditions. (For SEU, see "SEU check" on page 855.)

"Condition"	Defining a specific SEU value or an SEU value range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an SEU value, or sets the start value of an SEU value range.
"Max"	Sets the the end value of an SEU value range if "Condition" (`SEARch:TRIGger:USB:SCONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WSEU` on page 1964
`SEARch:TRIGger:USB:SCONdition` on page 1958
`SEARch:TRIGger:USB:SMIN` on page 1958
`SEARch:TRIGger:USB:SMAX` on page 1958

ET check

Enables the search for an Endpoint Type (ET) that meets specific conditions.

"Condition"	Defining a specific endpoint type or an ET range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an ET, or sets the start value of an ET range.
"Max"	Sets the the end value of an ET range if "Condition" (`SEARch:TRIGger:USB:TCONdition`) is set to `INRange` or `OORange`.

Remote command:
`SEARch:TRIGger:USB:WETCheck` on page 1963
`SEARch:TRIGger:USB:TCONdition` on page 1961
`SEARch:TRIGger:USB:TMIN` on page 1962
`SEARch:TRIGger:USB:TMAX` on page 1962

12.19.5.2 USB Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

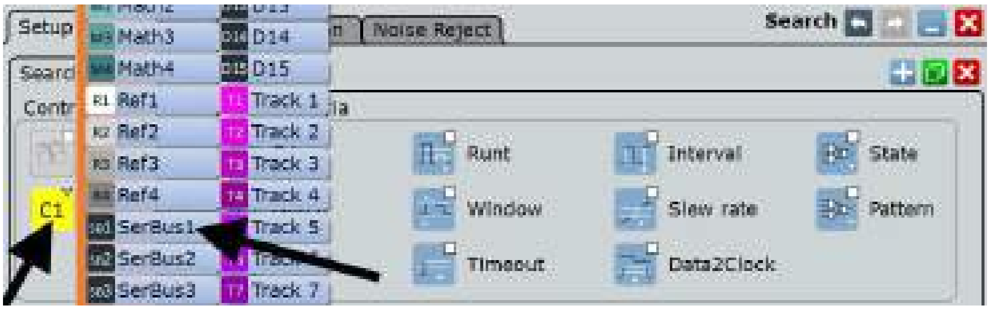
- `SEARch:RESult:USB:PCOunt?` on page 1969
- `SEARch:RESult:USB:PACKet<m>:STATus?` on page 1968
- `SEARch:RESult:USB:PACKet<m>:STARt?` on page 1968
- `SEARch:RESult:USB:PACKet<m>:STOP?` on page 1968
- `SEARch:RESult:USB:PACKet<m>:ADDRess?` on page 1965
- `SEARch:RESult:USB:PACKet<m>:DATA?` on page 1965
- `SEARch:RESult:USB:PACKet<m>:CRC?` on page 1965
- `SEARch:RESult:USB:PACKet<m>:ENDPoint?` on page 1966
- `SEARch:RESult:USB:PACKet<m>:ET?` on page 1966
- `SEARch:RESult:USB:PACKet<m>:FRAMe?` on page 1966
- `SEARch:RESult:USB:PACKet<m>:PID?` on page 1966
- `SEARch:RESult:USB:PACKet<m>:PORT?` on page 1967
- `SEARch:RESult:USB:PACKet<m>:SC?` on page 1967
- `SEARch:RESult:USB:PACKet<m>:SEU?` on page 1967

12.19.5.3 Searching USB Data

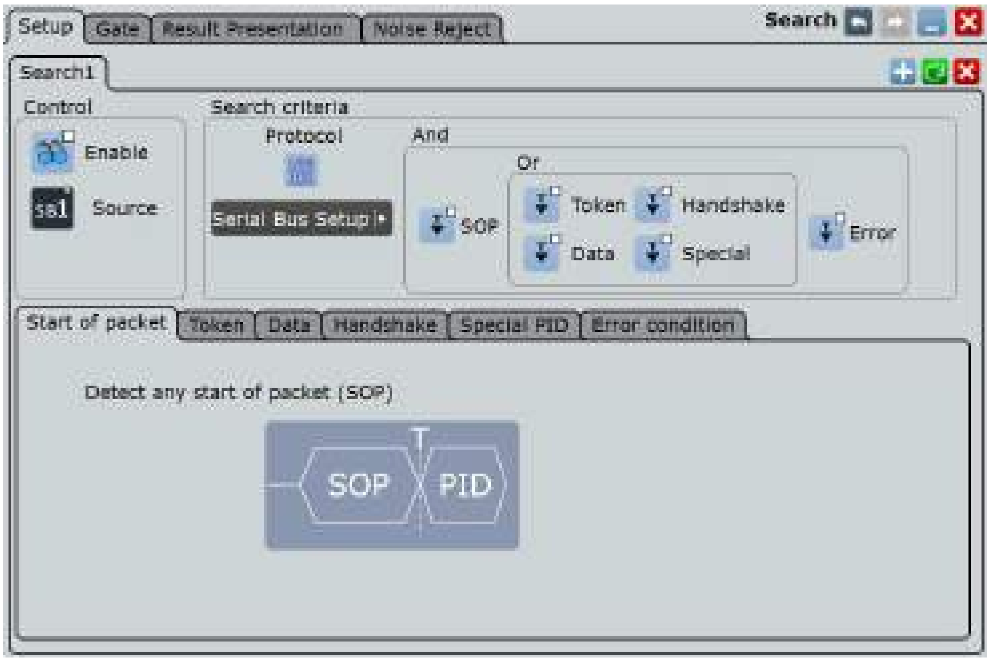
Prerequisite: A serial bus is configured for the USB signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to USB (e.g. "SerBus1", unless already selected).



The search dialog for USB protocol analysis is opened.



4. Specify search criteria according to Chapter 12.19.5.1, "USB Search Setup", on page 860.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a USB decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).

6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.20 USB 3.1 Generation 1 (Option R&S RTO-K61)

R&S RTO-K61 is a firmware option that enables the R&S RTO to analyze Universal Serial Bus (USB) signals encoded by the USB 3.1 coding standard, generation 1.

NOTICE

Oscilloscope must range up to 5 GHz, at least

As the USB 3.1 Gen 1 protocol (see The USB 3.1 Protocol) is defined for data rates up to 5 GHz, the full functionality of option R&S RTO-K61 requires an instrument that covers this frequency range up to 5 GHz.

For analysis, USB 3.1 encoded signals can be triggered, decoded and searched.

This chapter describes:

12.20.1 The USB 3.1 Protocol

The USB 3.1 protocol standard was published on July 26th, 2013, strongly enhancing the performance of the USB 2.0 protocol (see Chapter 12.19, "USB (Option R&S RTO-K60)", on page 837). Compared to USB 2.0, USB 3.1 defines a new physical layout, better power distribution and higher data rates.

The USB 3.1 standard features two speed levels (generations):

- **USB 3.1 Gen 1** for 5 Gbps (also labeled "SuperSpeed" or "SS"), encompassing and superseding USB 3.0 (published on November 12th, 2008)
- **USB 3.1 Gen 2** for 10 Gbps (also labeled "SuperSpeedPlus" or "SSP")

While USB 3.1 Gen 2 is not yet very common, you can use a fast oscilloscope (minimum 5 GHz) with option **R&S RTO-K61** to analyze signals encoded according to the **USB 3.1 Gen 1** protocol.

NOTICE

Oscilloscope must range up to 5 GHz, at least

As the USB 3.1 Gen 1 protocol is defined for data rates up to 5 GHz, option R&S RTO-K61 requires a fast oscilloscope that covers this frequency range.

USB 3.1 supersedes the USB 3.0 standard but uses, for example, the USB 3.0 Standard-A connector design with 9 pins. Hence, USB 3.1 cables and connectors contain 5 additional wires and pins compared to USB 2.0.

Figure 12-118: USB 3.1 cable cross-section and Standard-A plug - backward compatible with USB 2.0

A = Shield (braid) / connector shell
B = USB 2.0 unshielded twisted pair
C = USB 3.0 / USB 3.1 shielded twisted pair
D = USB 3.0 / USB 3.1 shielded twisted pair
1 = Voltage bus V_{CC} power supply pin, +5 V
2 = Differential data signal D-
3 = Differential data signal D+
4 = Ground pin for power return
5 = SuperSpeed receiver differential pair Rx-
6 = SuperSpeed receiver differential pair Rx+
7 = Ground drain for signal return
8 = SuperSpeed transmitter differential pair Tx-
9 = SuperSpeed transmitter differential pair Tx+
* = Connector images courtesy of Wikipedia authors smial and Unconventional2

Table 12-28: Backward compatibility of USB 3.1 connectors

Connector type	USB 3.1	Compatibility	USB 2.0
Standard-A	plug	... is backward compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug
Standard-B	plug	... is **not** compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug
Micro-USB	plug	... is **not** compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug

In order to achieve the data throughput of USB 3.1, all involved components (host, cable, device and optional hub) must comply with USB 3.1 specifications. If any component only complies, for example, with USB 2.0 Hi-Speed specifications, the setup will work, but limited to Hi-Speed USB data rates.

USB 3.1 also specifies a new connector format, called Type-C, with a reversible plug. This small and durable connector is, however, not mechanically compatible with USB 2.0 connectors.

USB 3.1 Type-C connector

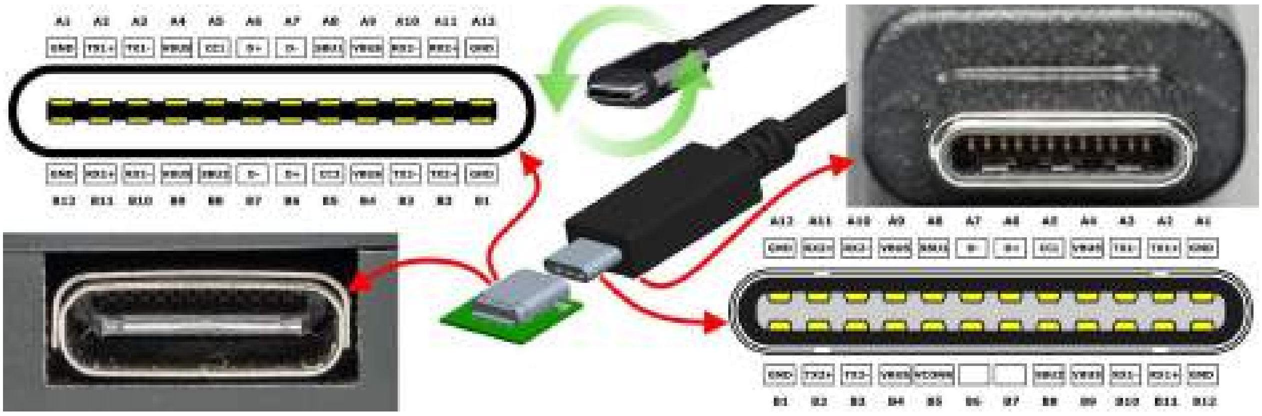


Figure 12-119: USB 3.1 Type-C receptacle and reversible plug

A1 to A12 = Twelve USB Type-C pins
B1 to B12 = The same USB Type-C pins as A1 to A 12, but in reverse order
* = Images courtesy of Heise Medien, Acon, phoneArena and Wikipedia author Chindi.ap

Specific protocol features

Key features of USB 3.1 Gen 1 that are addressed by option R&S RTO-K61 include:

- Since 5 Gbps is too fast for serial pattern triggering, the option uses a search-based software trigger
- The protocol uses a non-return-to-zero (NRZ) unclocked signal with **8b/10b encoding** (while USB 3.1 Gen 2 uses 128b/132b encoding)
- The siglal is scrambled with a 32 bit minimum correlation sequence
- COMMA (K28.5), which occurs only during the reset phase, is the only unique bit sequence
  - COMMA is used for reset of the scrambling sequence, which has 32 bit minimum correlation
  - COMMA and packet framing are used for bit alignment
- The protocol uses a set of different frame types that are all covered by individual trigger and search dialogues of option R&S RTO-K61

Frame types

All frame types are listed below. The frame types are sorted in an almost alphabetical order, as in the oscilloscope's graphical user interface (GUI).

Each item in this list contains:

- the SCPI name of the frame
(hence the name of the frame according to the related remote control command (SCPI))
- the GUI name of the frame, which is sometimes identical with the SCPI name
(the GUI names are highlighted in **bold** font and linked to one of Table 12-29 / Table 12-30 / Table 12-31)
- a brief description of the frame type

List of frame types

- ACK - **ACK** = Handshake packet indicating a positive acknowledgment.
- BCNT - **BCNT** = BERT count, with BERT = Bit Error Rate Test. BCNT is a K28.3 sequence followed by the error count symbol EC. See also BERC.
- BDAT - **BDAT** = BERT data, ordered set of a BERT command. This data sequence (output of the scrambler) is used for BER testing and is equivalent to the logical idle sequence, consisting of scrambled 0.
- BERC - **BERC** = BERT error count, ordered set of a BERT command that does not increment the error count register. BERC is not looped back to the receiver but replaced with BCNT.
- BRST - **BRST** = BERT reset, ordered set of a BERT command. Any time a BRST is received, the error count register EC is set to 0 and the linear feedback shift register (LFSR) for scrambling is set to 0FFFFh. Any number of consecutive BRST ordered sets may be received.
- BIAM - **Bus Interval Adjustment** = The bus interval is the period that establishes the integral boundary of service intervals. It is equivalent to the Microframe interval (THSFRAM) defined in the USB 2.0 specification.
- DPH - **DPH** = Data Packet Header, containing a type field, the data packet’s address, route string, length, and other information about the packet, including a a 2-byte checksum (CRC-16).
- DPP - **Data Packet Payload** = The packet’s payload data and a 32-bit CRC.
- DPPA - **Data Packet Payload Abort** = Frame ordered set used to abort a data packet payload.
- ERDY - **ERDY** = The Endpoint Ready notification is a handshake packet indicating a positive acknowledgment.
- FWAKe - **Function Wake** = The function wake device notification is sent from a device (that is enabled for remote wakeup) to the host, if it wants to exit from "device suspend" or "function suspend".
- HRR - **Host Role Request** = This notification type is reserved for being issued by a SuperSpeed On-the-Go (SS-OTG) device, if its Role Swap Protocol (RSP) capability has been enabled.
- IDLE - **IDLE** = Logical Idle is a period of one or more symbol periods when no information (packets or link commands) is transferred on the link. The Idle Symbol (IS) is transmitted by a port at any time in the active (U0) state meeting the logical idle definition.
- ITP - **ITP** = Isochronous Timestamp Packet, sent periodically by a host to inform devices on the USB of the current bus time. ITPs are multicast on all active links.

- LTM - **Latency Tolerance** = Latency Tolerance Messaging is an optional normative USB power management feature that utilizes reported BELT (Best Effort Latency Tolerance) values to enable more power efficient platform operation.
- LC - **Link Command** = An eight-symbol sequence used for link-level flow control, retries, power management and device removal.
- LDM - **Link Delay Measurement** = A protocol for determining propagation delays through the USB topology with a high degree of accuracy (sometimes called "Precision Time Measurement").
- NRDY - **NRDY** = The Not Ready response is a handshake packet indicating a negative acknowledgment.
- PING - **PING** = This transaction packet can only be sent by the host, to transition all links, which are in the path to a device, back to the active (U0) state prior to initiating an isochronous transfer.
- PNGR - **PING_RESPONSE** = This transaction packet is sent by a device in response for each PING received from the host.
- PCAP - **Port Capability** = This link management packet describes each port's link capabilities and is sent by both link partners after the successful completion of training and link initialization.
- PCNF - **Port Configuration** = All Enhanced SuperSpeed ports that support downstream port capability can send this link management packet (LMP), which is similar to Port Capability. If a port, which was to be configured in the upstream facing mode, does not receive this LMP within a defined time after link initialization, then the upstream port shall transition to "eSS.Disabled" and a peripheral device shall try to connect at the other speeds this device supports.
- PCNR - **Port Configuration Response** = This link management packet is sent by the upstream port in response to a Port Configuration and indicates its acceptance or rejection.
- SKIP - **SKIP** = SKP compensates for different bit rates between two communicating ports. SKPs may be dynamically inserted or removed from the data stream. SKPEND marks the boundary between SKP symbols and the remainder of the SKP ordered set. (For SuperSpeedPlus operation, unscrambled.)
- STALL - **STALL** = This transaction packet can only be sent by an endpoint on the device. It is used to inform the host that the endpoint is halted or that a control transfer is invalid.
- STATUS - **STATUS** = This transaction packet can only be sent by the host to a control endpoint. It is used to inform a control endpoint that the host has initiated the Status stage of a control transfer.
- SLF - **Set Link Function** = This link management packet is used to configure functionality that can be changed without leaving the active (U0) state.
- SSPD - **Sublink Speed** = Speed of a sublink, which is the collection of receive or transmit lanes between a downstream facing port (DFP) and an upstream facing port (UFP).
- TS1T - **TS1** = Training sequences are ordered sets for initializing bit and symbol alignment and receiver equalization. Examples are TS1, TS2 and TSEQ.
- TS2T - **TS2** = See TS1
- TSEQ - **TSEQ** = See TS1

- U2IT - **U2 Inactivity Timeout** = This link management packet is used to define the timeout from U1 to U2.
- VDT - **Vendor Device Test** = Use of this link management packet is intended for vendor-specific device testing and shall not be used during normal operation of the link.

Other types

- ERRor - **Error** = This is not a frame type, but it is included as an artificial entry in the search and navigate dialog to allow selecting and activating the error search. If the host error bit is set to "1", this state indicates that the host was unable to accept the data. The reason can be a CRC error, length error, value out of range, packet incomplete or unknown error.
- UDEF - **Unknown** = Undefined data cannot be identified as any specific USB 3.1 frame, because the measured signal does not match with the specifications of any defined frame. Therefore, in this case the field is represented by a "?". You cannot search for "Unknown" or trigger on it, but these types are returned, if an unexpected (sub)type has been found. If some rough type identification is possible, the unknown data may fit one of the following descriptions of unknown types.
- UDVN - **Unknown Device Notification** = A Device Notification transaction packet can only be sent by a device, to inform the host of an asynchronous change in a device or interface state (e.g., to identify the function within a device that caused the device to perform a remote wake operation).
- UHP - **Unknown Header Packet** = An undefined header packet that starts with HPSTART, but then the type is invalid.
- ULMP - **Unknown LMP** = A Link Management Packet is a type of header packet primarily used to manage links by communicating information between links partners. LMPs only travel between pairs of directly connected ports.
- UTP - **Unknown TP** = A Transaction Packet is a type of header packet used to communicate information between a device and the host. TPs traverse all the links, directly connecting the host to a device. They have no payload data, instead they are used, e.g., to control the flow of data packets or configure devices and hubs.

The frames listed above consist of individual sets of fields. Some frames only contain one field, others are much longer: up to 29 fields (in case of the "ACK" frame).

We try to represent the structure of these frames. However, one single table that contains all frames and all fields would be very large: 30 by 40 cells. We have therefore split up the full table into the following four smaller tables:

- Table 12-29 contains the **short** frames that end with the "Link Control Word". (This table uses abbreviation, see below.)
- Table 12-30 contains the **long** frames that end with the "Link Control Word". (This table uses abbreviation, see below.)
- Table 12-31 contains the frames that do not end with the "Link Control Word". These frames have no additional fields other than those in the table.
- Table 12-32 contains the types that are no specified USB 3.1 frames.

The frames in both Table 12-29 and Table 12-30 are abbreviated. For the full set of fields, you must add to each frame the 2 fields "HPSTART" and "Type" in the beginning of the frame. Also add a "CRC" field and the 6 fields of the "Link Control Word" at the end of each frame. In Table 12-32, only the "Link Control Word" is abbreviated.

The 2-byte **"Link Control Word"** is used for both link level and end-to-end flow control. The fields in the Link Control Word are detailled in Table 12-30.

Table 12-29: Short frames that start with fields HPSTART and Type and end with CRC and the Link Control Word

Frame	Field3	Field4	Field5	Field6	Field7	Field8	Fld.9	Field10	Fld.11
Bus Interval Adjustment	Rsvd	Device Address	SubType	NotType	Rsvd	BusIntAdj	Rsvd		
Function Wake	Rsvd	Device Address	SubType	NotType	Interface	Rsvd	Rsvd		
Host Role Request	Rsvd	Device Address	SubType	NotType	RSP	Rsvd	Rsvd		
ITP	Counter	Delta	Adj Ctrl	Corr	Rsvd	Rsvd			
Latency Tolerance	Rsvd	Device Address	SubType	NotType	BELT	Rsvd	Rsvd		
Link Delay Measurement	SubType	LDM Type	LDMS	Rsvd	Response Delay	Rsvd	Rsvd		
NRDY	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	StreamId	Rsvd
PING	Route String	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
PING_RESPONSE	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
Port Configuration	SubType	Link Speed	Rsvd	Rsvd	Rsvd				
Port Configuration Response	SubType	Response Code	Rsvd	Rsvd	Rsvd				
STALL	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
Set Link Function	SubType	SLF	Rsvd	Rsvd	Rsvd				
U2 Inactivity Timeout	SubType	U2 IT	Rsvd	Rsvd	Rsvd				
Vendor Device Test	SubType	VDT	Rsvd	Vendor Def	... for fields no. 1, 2 and n+x see Table 12-30				

Table 12-30: Long frames that start with fields HPSTART and Type and end with CRC and the Link Control Word

Frame	**Fld.3**	**Field4**	**Fld.5**	**Field6**	**Fld.7**	**Fld.8**	**Field9**	**F.10**	**Fld.11**	**Fld.12**	**Fld.13**	**F.14**	**F.15**	**Fld.16**	**F.17**	**F.18**	**F.19**	**F.20**	**F.21**	**F.22**
ACK	Route String	Device Address	Sub-Type	Rsvd	rty	D	EPT-Num	TT	HE	NumP	SeqNum	Rsvd	TPF	StreamId	Rsvd	SSI	WPA	DBI	PP	NBI
DPH	Route String	Device Address	Seq-Num	Rsvd	EOB	D	EPT-Num	TT	S	Length	StreamId	Rsvd	SSI	WPA	DBI	PP	NBI			
ERDY	Rsvd	Device Address	Sub-Type	Rsvd	D	EPT-Num	Rsvd	Num P	Rsvd	StreamId	Rsvd									
Port Capa-bility	Sub-Type	Link Speed	Rsvd	Num HP Buf	Rsvd	Dir	OTG	Rsvd	Tie-breaker	Rsvd	Rsvd									
STA-TUS	Route String	Device Address	Sub-Type	Rsvd	D	EPT-Num	Rsvd	Rsvd	PP	Rsvd										
Sublink Speed	Rsvd	Device Address	Sub-Type	Not-Type	Rsvd	TPF	Rsvd	LSE	ST	Rsvd	Lanes	LP	LSM							

	Field1	**Field2**	**Field3**	...
Ahead of **Field 3**, add these two fields (**Field1** + **Field2**):	HPSTART	Type	see above	...

	Field n+1	**Field n+2**	**Field n+3**	**Field n+4**	**Field n+5**	**Field n+6**	**Field n+7**
After the **last field (n)**, add CRC + the **"Link Control Word"**:	CRC	**Hdr#**	**Rsvd**	**Hub#**	**DLY**	**DFR**	**CRC**

Table 12-31: Frames without additional fields other than in this table

Frame	Field1	Field2	Field3	Field4	Field5	Field6	F.7	Fld.8	Field9
BCNT	BERC	EC							
BDAT	BDAT								
BERC	BERC								
BRST	COM	BRST							
Data Packet Payload	HPSTART	Data	CRC	DPPEND					
Data Packet Payload Abort	HPSTART	Data	CRC	DPPABORT					
IDLE	Idle								
Link Command	LCSTART	SubType	CRC	SubType	CRC				
SKIP	SKP								
TS1	COM	Rsvd	Train	Rsvd	Loop	Scramble	LL	Rsvd	TS1ID
TS2	COM	Rsvd	Train	Rsvd	Loop	Scramble	LL	Rsvd	TS2ID
TSEQ	COM	Symbol							

And finally the remaining types that are no specified USB 3.1 frames:

Table 12-32: Other types

Type	Field1	Field2	Field3	Field4	Field5	Field6	Field7	Field8	Field9
Error	CRC Error	Length Error	Unknown	Value out of range	Packet Incomplete				
Unknown	?								
Unknown Device Notification	HPSTART	Type	Rsvd	Device Address	SubType	NotType	?	CRC	**LCW**
Unknown Header Packet	HPSTART	Type	?	?	CRC	**LCW**			
Unknown LMP	HPSTART	Type	SubType	?	?	CRC	**LCW**		
Unknown TP	HPSTART	Type	Rsvd	Device Address	SubType	?	?	CRC	**LCW**
LCW = Link Control Word, see Table 12-30, occupies the last 6 fields.									

More information on the USB 3.1 protocol, including all specifications down to the field contents, is available in the "Universal Serial Bus 3.1 Specification" documentation. Refer to the online resources at www.usb.org.

12.20.2 USB 3.1 Configuration

If you need information on how to get started with configuring the USB setup, see Chapter 12.20.2.2, "Configuring USB 3.1 Signals", on page 879. Otherwise proceed with the configuration settings.

12.20.2.1 USB 3.1 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *USB3*

Make sure that the tab of the correct serial bus is selected on the left side.

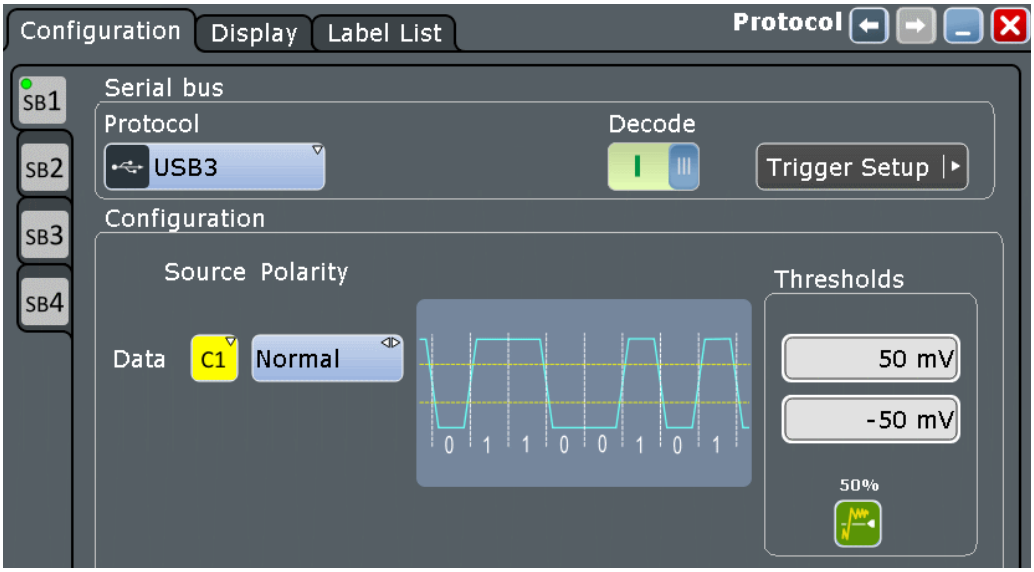


Figure 12-120: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data
Defines the source settings for the data signal. Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USBThree:SOURce` on page 1969

Polarity
Defines the signal polarity settings. Permitted selections are "Normal" and "Inverted".

Remote command:
`BUS<m>:USBThree:POLarity` on page 1969

Thresholds
Sets the threshold values for digitization of the analog signals.

The USB 3.1 standard uses 2-state signals with an upper and a lower voltage level. Permitted thresholds values are in the range of -2 V to +2 V, the default is -40 mV to +40 mV.

If the signal value on the line is higher than the upper threshold, the signal state is considered high. Otherwise, if the signal value is below the lower threshold, the signal state is considered low. The two threshold levels allow configuring a hysteresis setting.

There are two ways to set the threshold:
- "Threshold values"
  Enter the upper and lower values directly into the fields.
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude, adding a hysteresis offset for the high and low threshold.

Remote command:
`BUS<m>:USBThree:THRHigh` on page 1970
`BUS<m>:USBThree:THRLow` on page 1970
`BUS<m>:SETReflevels` on page 1495

Scramble Mode
Selects if the data pattern is scrambled or unscambled. Scrambling as specified in the standard minimizes EMI emissions, the unscrambled mode can simplify testing and debugging.

Remote command:
`BUS<m>:USBThree:SCRMode` on page 1970

12.20.2.2 Configuring USB 3.1 Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "USB3".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   This prevents to use Math and Ref waveforms as channel signals.

   Note: For triggering on a serial bus, analog input channels are required!
7. Switch back to the "Serial Bus Setup" dialog.
8. Set the logical thresholds: Either enter user-defined values directly in the "Threshold" fields, or set the thresholds to the middle reference levels with "50%".
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.20.2.1, "USB 3.1 Configuration Settings", on page 878.

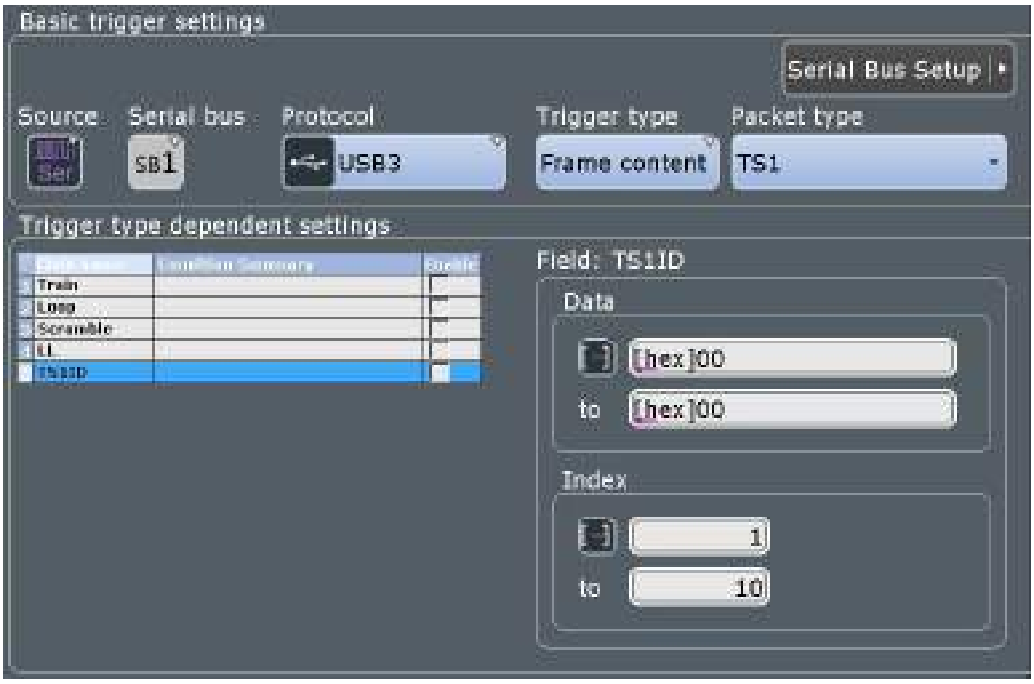
12.20.3 USB 3.1 Trigger

If you need information on how to get started with triggering on USB 3.1 Gen 1 signals, see Chapter 12.20.3.2, "Triggering on USB 3.1", on page 882. Otherwise proceed with the USB 3.1 trigger settings.

12.20.3.1 USB 3.1 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = USB3"

In this section, all trigger settings for USB 3.1 Gen 1 are described. The user interface of the instrument guides you through the trigger setup.



Basic trigger settings

Source: Ser
Serial bus: SB1
Protocol: USB3
Trigger type: Frame content
Packet type: TS1

Trigger type dependent settings

Field: TS1ID
Data: [hex]00 to [hex]00
Index: 1 to 10

Figure 12-121: USB 3.1 trigger event settings dialog

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type. You can trigger on:

"Frame start"	Start of a frame (packet). No additional settings are required.
"Frame content"	Trigger on various packet types, fields in the packets, and data patterns.
"Errors"	Trigger on various errors.

Remote command:
`TRIGger<m>:USBThree:TYPE` on page 1971

Error types: Item name, Enable

The table lists the error types you can trigger on. Select the required errors in the "Enable" column.

Remote command:
`TRIGger<m>:USBThree:ERRor:ENABle` on page 1972

Packet type

Selects the frame type for USB 3.1 Gen 1 analysis. For the available frame types, see "Frame types" on page 871.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

The trigger instant is the last criterion that is fulfilled.

Remote command:
`TRIGger<m>:USBThree:FRAMe:SELect` on page 1972
For frames that contain fields, the packet selection can also be done implicit by a parameter in the `TRIGger:USBThree:FRAMe:FIELd...` command.

Field name / Condition Summary / Enable

This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition Summary" is only shown in the table, if "Enable" is checked.

For an overview of frames and fields, see Frame types.

For an example of a table with displayed "Condition Summary" entries, see Figure 12-124.

Remote command:
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:ENABle` on page 1973

Data

Defines for the selected field, how a data check is executed.

"Condition"	Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies data or sets the start value of a data range.
"Max"	Sets the the end value of a data range, if "Condition" is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:DOPerator` on page 1973
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMIN` on page 1974
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMAX` on page 1974

BitState
Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (don't care).

Remote command:
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:BIT` on page 1975

Index
Defines for the selected field, how an index check is executed.

"Condition"	Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.
"Min"	Specifies the index or sets the start value of an index range.
"Max"	Sets the the end value of an index range, if "Condition" is set to `INRange`.

Remote command:
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:IOPerator` on page 1975
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMIN` on page 1976
`TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMAX` on page 1976

12.20.3.2 Triggering on USB 3.1

Prerequisite: A bus is configured for the USB 3.1 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.20.2, "USB 3.1 Configuration", on page 877), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to USB 3.1, e.g.:

SB1

The "Protocol" selection is then automatically set to "USB3".

4. Tap "Trigger type" and select whether you want to trigger on frame start, frame content or errors.
5. If you trigger on errors, select the error types you want to find.
6. If you trigger on frame content, tap "Packet type" and select the frame type to be used for USB 3.1 protocol analysis.
7. Depending on the selected frame type, more setup conditions have to be specified.

For information on the configuration settings, see Chapter 12.20.3.1, "USB 3.1 Trigger Settings", on page 880.

12.20.4 USB 3.1 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

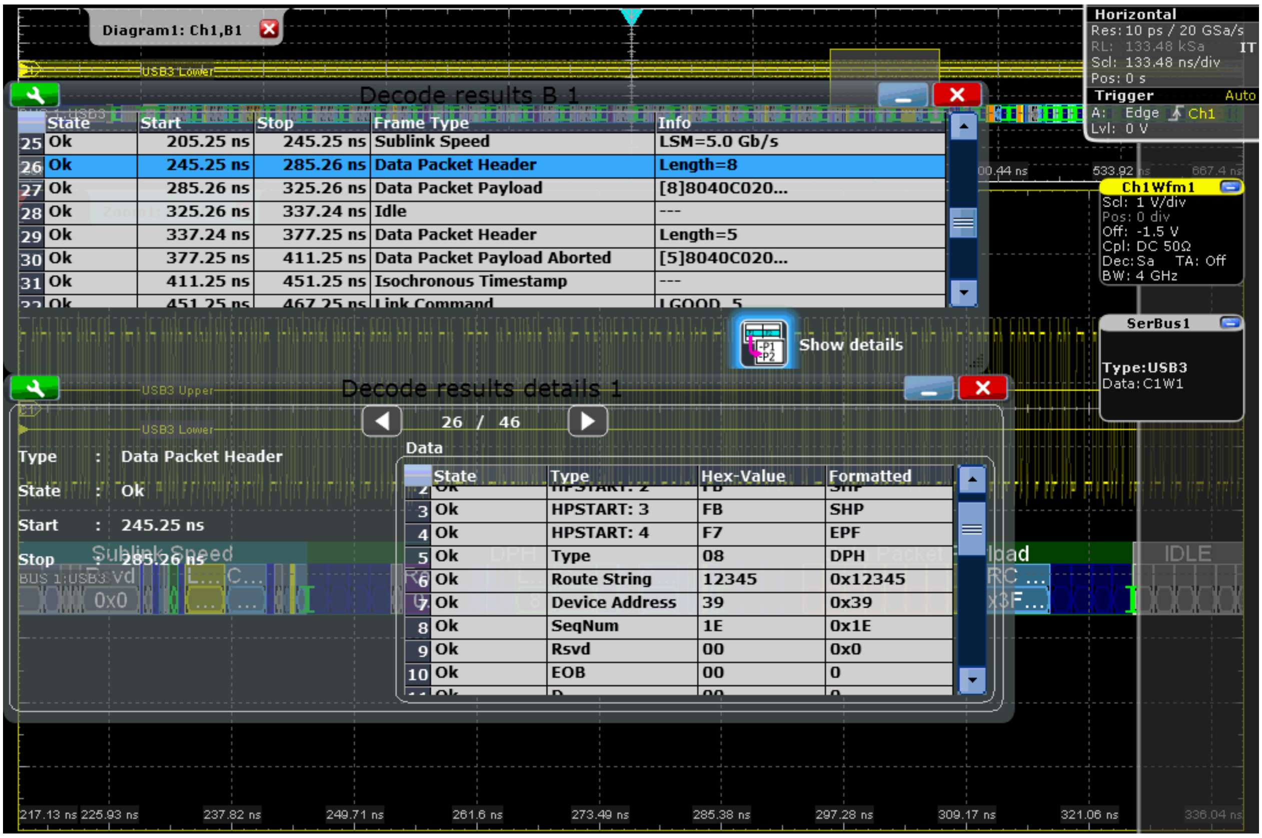
Examples

The example in Figure 12-122 shows a simulated USB 3.1 Gen 1 message. Among the long line of decoded frames, the zoom has selected a "Sublink Speed" frame, followed by a DPH ("Data Packet Header") frame and a "Data Packet Payload" frame.

Figure 12-122: USB 3.1 Gen 1 protocol: decoded and binary signal

1st frame = Sublink Speed
2nd frame = Data Packet Header (DPH)
3rd frame = Data Packet Payload
Green brackets [...] = Start and end of frame
Dark purple field = Route string
Green field = Length
Light blue fields = CRC checksum
Orange fields = Payload data bits
Grey fields = Idle bits

The example in Figure 12-123 shows the same simulated USB 3.1 Gen 1 message as in Figure 12-122, but with overlayed decode results (upper table, showing frames) and decode results details (table below, showing decoded fields of the selected frame).



	State	Start	Stop	Frame Type	Info
25	Ok	205.25 ns	245.25 ns	Sublink Speed	LSM=5.0 Gb/s
26	Ok	245.25 ns	285.26 ns	Data Packet Header	Length=8
27	Ok	285.26 ns	325.26 ns	Data Packet Payload	[8]8040C020...
28	Ok	325.26 ns	337.24 ns	Idle	---
29	Ok	337.24 ns	377.25 ns	Data Packet Header	Length=5
30	Ok	377.25 ns	411.25 ns	Data Packet Payload Aborted	[5]8040C020...
31	Ok	411.25 ns	451.25 ns	Isochronous Timestamp	---
32	Ok	451.25 ns	467.25 ns	Link Command	LGOOD_5

Type : Data Packet Header
State : Ok
Start : 245.25 ns
Stop : 285.26 ns

	State	Type	Hex-Value	Formatted
3	Ok	HPSTART: 3	FB	SHP
4	Ok	HPSTART: 4	F7	EPF
5	Ok	Type	08	DPH
6	Ok	Route String	12345	0x12345
7	Ok	Device Address	39	0x39
8	Ok	SeqNum	1E	0x1E
9	Ok	Rsvd	00	0x0
10	Ok	EOB	00	0

Horizontal
Res: 10 ps / 20 GSa/s
RL: 133.48 kSa
Scl: 133.48 ns/div
Pos: 0 s
Trigger Auto
A: Edge Ch1
Lvl: 0 V

Ch1Wfm1
Scl: 1 V/div
Pos: 0 div
Off: -1.5 V
Cpl: DC 50Ω
Dec: Sa TA: Off
BW: 4 GHz

SerBus1
Type:USB3
Data:C1W1

Figure 12-123: USB 3.1 Gen 1 protocol: decoded and binary signal, and decode results

Upper table = Decode Results table
Results, State = Frame state, for example "OK" or "Incomplete"
Results, Start = Start time of the frame
Results, Stop = Stop time of the frame
Results, Frame Type = Frame type as listed in "Frame types" on page 871
Results, Info = Specific frame information, for example result of the Link Speed Measurement = 5.0 Gb/s, or content of the Data Packet Payload
Lower table = Decode results details
Details, State = State of the field
Details, Type = Field type as listed in "Frame types" on page 871
Details, Hex-Value = Hexadecimal value of the field
Details, Formatted = Formatted content of the field, for example HPSTART "F7" = end packet framing (EPF)

If a frame is partially outside of the acquisition window, it cannot be completely decoded. However, as long as sufficient sample data are available, incomplete frames are partially decoded and do not appear as errors.

The trigger instant is the last criterion that is fulfilled.

For a description of the frames and for lists of their fields, see Chapter 12.20.1, "The USB 3.1 Protocol", on page 869, specifically Frame types.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote control commands for retrieving decode results are described in Chapter 20.17.21, "USB 3.1 (Option R&S RTO-K61)", on page 1969.

Remote command:

- `BUS<m>:USBThree:RESult:FCOunt?` on page 1977
- `BUS<m>:USBThree:RESult:FRAMe<n>:INFO?` on page 1977
- `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978
- `BUS<m>:USBThree:RESult:FRAMe<n>:STATe?` on page 1978
- `BUS<m>:USBThree:RESult:FRAMe<n>:STARt?` on page 1978
- `BUS<m>:USBThree:RESult:FRAMe<n>:STOP?` on page 1979
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:TYPE?` on page 1979
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STATus?` on page 1979
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:VAL?` on page 1980
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:FVAL?` on page 1980

12.20.5 Search on Decoded USB 3.1 Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

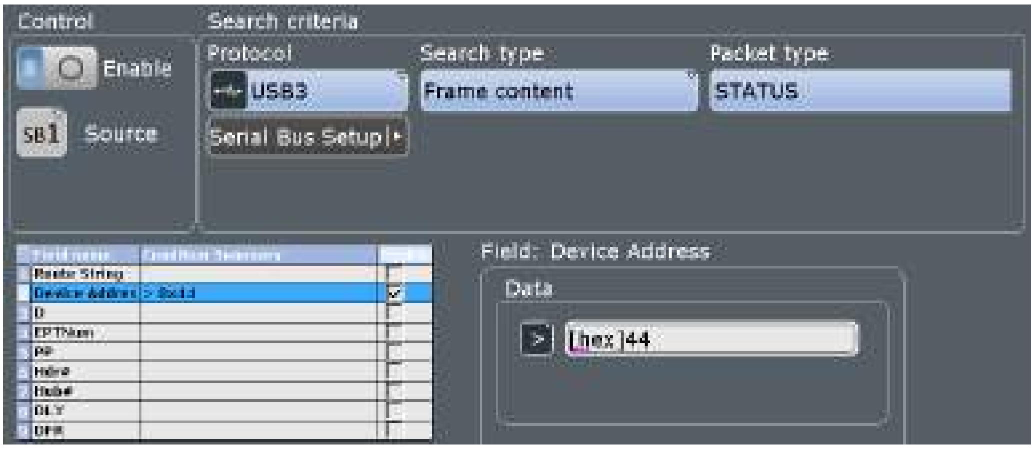
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

If you need information on how to get started with searching USB 3.1 data, see Chapter 12.20.5.3, "Searching USB 3.1 Data", on page 888. Otherwise proceed with the USB 3.1 search setup.

12.20.5.1 USB 3.1 Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for USB 3.1

Search criteria
Use the "Search criteria" dialog to define the search type. If you search for frame content, define the frame type in which data is to be searched.



Protocol: USB3

Search type: Frame content

Packet type: STATUS

Field: Device Address

Data: > hex 44

Figure 12-124: Example of search criteria for frame content in status frames

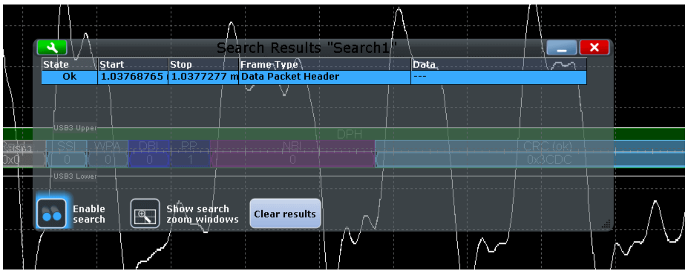
You can define individual search parameters for the fields of the selected frame in the table below the "Search criteria". To specify these parameters, select a field in the table and define the data and/or index operators and values, or the bit state.

For a description of how to set the search conditions, see Chapter 12.20.3.1, "USB 3.1 Trigger Settings", on page 880.

Remote command:
`SEARch:TRIGger:USBThree:TYPE` on page 1981
`SEARch:TRIGger:USBThree:ERRor:ENABle` on page 1981
`SEARch:TRIGger:USBThree:FRAMe:SELect` on page 1981
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:ENABle` on page 1982
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DOPerator` on page 1983
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMIN` on page 1983
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMAX` on page 1984
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:BIT` on page 1984
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IOPerator` on page 1985
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN` on page 1985
`SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMAX` on page 1986

12.20.5.2 USB 3.1 Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.



State	Start	Stop	Frame Type	Data
Ok	1.03768765	1.0377277 m	Data Packet Header	---

Figure 12-125: Search results table

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

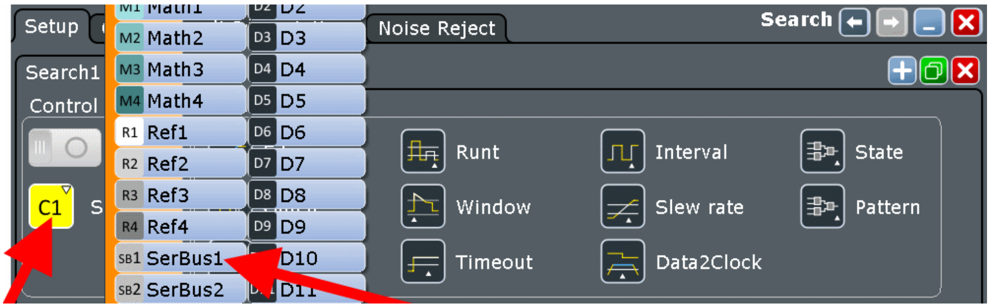
- `SEARch:RESult:USBThree:FCOunt?` on page 1987
- `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986
- `SEARch:RESult:USBThree:FRAMe<m>:INFO?` on page 1987
- `SEARch:RESult:USBThree:FRAMe<m>:STATe?` on page 1987
- `SEARch:RESult:USBThree:FRAMe<m>:STARt?` on page 1988
- `SEARch:RESult:USBThree:FRAMe<m>:STOP?` on page 1988
- `SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:TYPE?` on page 1988
- `SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STATus?` on page 1989
- `SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:VAL?` on page 1989
- `SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:FVAL?` on page 1990

12.20.5.3 Searching USB 3.1 Data

Prerequisite: A serial bus is configured for the USB 3.1 Gen 1 signal to be decoded and analyzed.

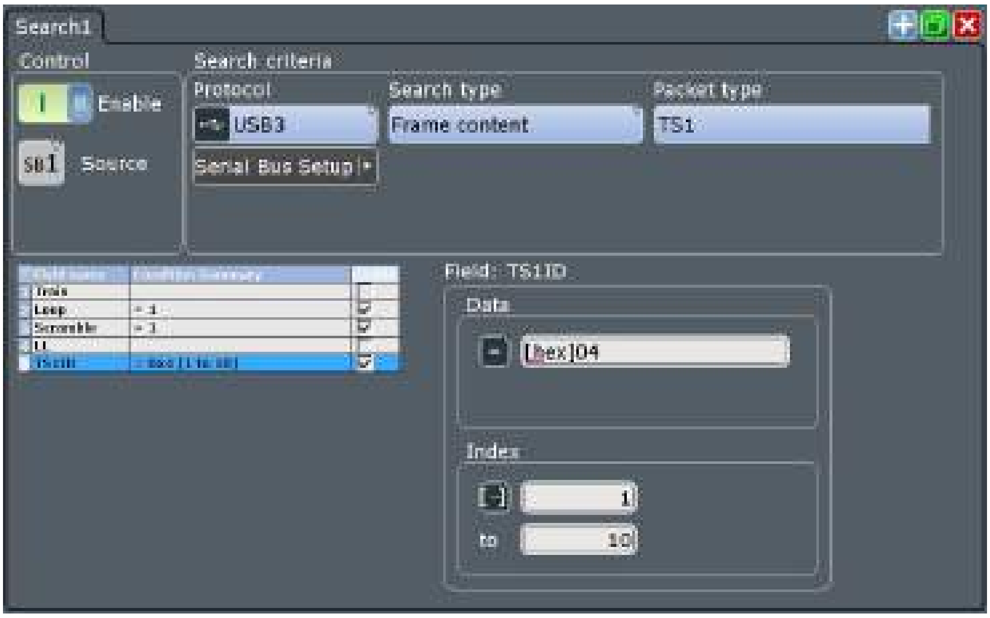
The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to USB 3.1 (e.g. "SerBus1", unless already selected).



The search dialog for USB3 protocol analysis is opened.

4. Specify search criteria according to Chapter 12.20.5.1, "USB 3.1 Search Setup", on page 887.



Protocol: USB3
Search type: Frame content
Packet type: TS1
Data: [hex]04
Index: 1 to 10

Figure 12-126: Example of search criteria for the frame "Training Sequence 1" (TS1)

5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a USB 3.1 decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).

6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.21 USBPD (Option R&S RTO-K63)

R&S RTO-K63 is a firmware option that enables the R&S RTO to analyze Universal Serial Bus Power Delivery (USBPD) signals.

For analysis, USBPD encoded signals can be triggered, decoded and searched.

This chapter describes:

12.21.1 The USB Power Delivery Protocol

The requirements on the USB have changed in the last years with the need of providing power through the USB port additionally to the data transfer. The USBPD specification aims to define standard for optimizing the power usage through the USB for the needs of the users.

USBPD characteristics

Main characteristics of USBPD are:

- Power direction is not fixed
- Negotiation of required power amount between devices
- Alternate modes can be defined through vendor defined messages, which allows for USB connector pins to be used for purposes other than USB

Message types

In the USBPD protocol, a power delivery connection can be made between a port that supplies power (source) and a port that consumes power (sink). They communicate with each other through messages. The USBPD specification defines three message types:

- Control messages: 16-bit messages used to control the messages between the port partners or transfer messages with no extra data. A control message consists of a message header and a CRC.
- Data messages: 48 to 240 bit messages used to transfer information between port partners. A data message consists of a message header and a number of data objects. The information that a data object carries is defined by the message type of the message header, see Table 12-33.
- Extended messages: can have a different length up to the defined maximum length of an extended message. It is used to transfer information between port partners. The information that the extended message carries is defined by the message type of the message header, see Table 12-33.

Frame packet types

All frame types are listed below. The frames listed above consist of individual sets of fields. Some frames only contain one field, others are much longer.

The frame types are sorted according to the message type.

Table 12-33: Frame packet types

SCPI	Description	Message type
ALRT	Alert message	Data
BATT	Battery status	Data
BIST	Built in self-test	Data
RQST	Request	Data
SINK	Sink capabilities message	Data
SRC	Source capabilities message	Data
VEND	Vendor defined message	Data
CTRL	Control	Control
DATA	Data	Data
LOWP	Low power	Low power
TEST	Test frame	Test
RESet	Reset frame	Reset
XBAC	Battery capabilities	Extended
XFRS	Firmware update response	Extended
XFRQ	Firmware update request	Extended
XGBC	Get battery cap	Extended
XGMI	Get manufacturer info	Extended
XGBS	Get battery status	Extended
XMFI	Manufacturer info	Extended
XMSG	Message	Extended
XSRC	Sources capabilities message	Extended
XSRS	Security response	Extended
XSRQ	Security request	Extended
XSTA	Status	Extended

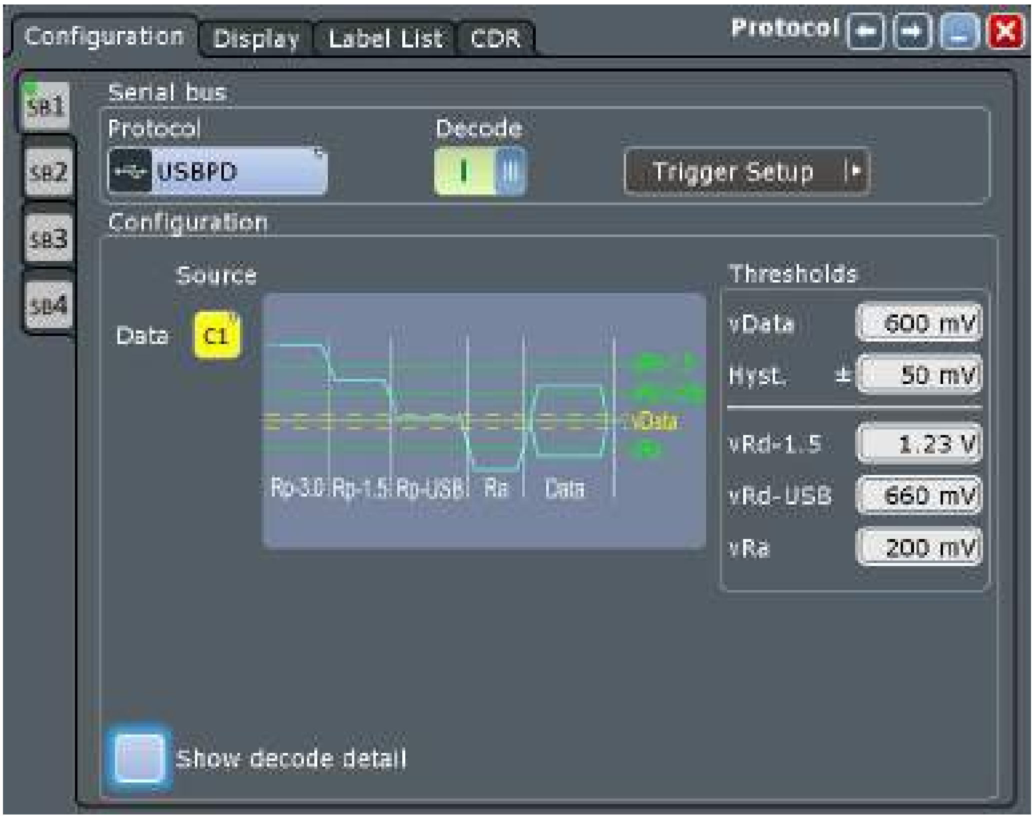
More information on the USBPD protocol, including all specifications down to the field contents, is available in the "Universal Serial Bus Power Delivery Specification" documentation. Refer to the online resources at www.usb.org.

12.21.2 USBPD Configuration

12.21.2.1 USBPD Configuration Settings

Access: PROTOCOL key > "Configuration" tab > "Protocol" = "USBPD"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Data

Defines the source settings for the data signal.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:USBPd:SOURce` on page 1991

vData
Sets the threshold value of the data.

Remote command:
`BUS<m>:USBPd:THReshold` on page 1991

Hyst
Sets a value for the hysteresis of the data.

Remote command:
`BUS<m>:USBPd:HYSTeresis` on page 1991

Current advertisment thresholds
The signal level provides information about the current advertisement between the bursts. These thresholds determine the levels at which the current advertisement modes are defined.

"vRd-1.5"	Sets the threshold at USB Type-C currnet of 1.5 A.
"vRd-USB"	Sets the threshold at default USB Type-C currnet.
"vRa"	Sets the threshold for the low current.

Remote command:
`BUS<m>:USBPd:THRBottom` on page 1991
`BUS<m>:USBPd:THRMid` on page 1992
`BUS<m>:USBPd:THRTop` on page 1992

Show decode detail
If enabled, the data word are broken down into sub-frames. If not enabled the data words are displayed as 32-bit data words.

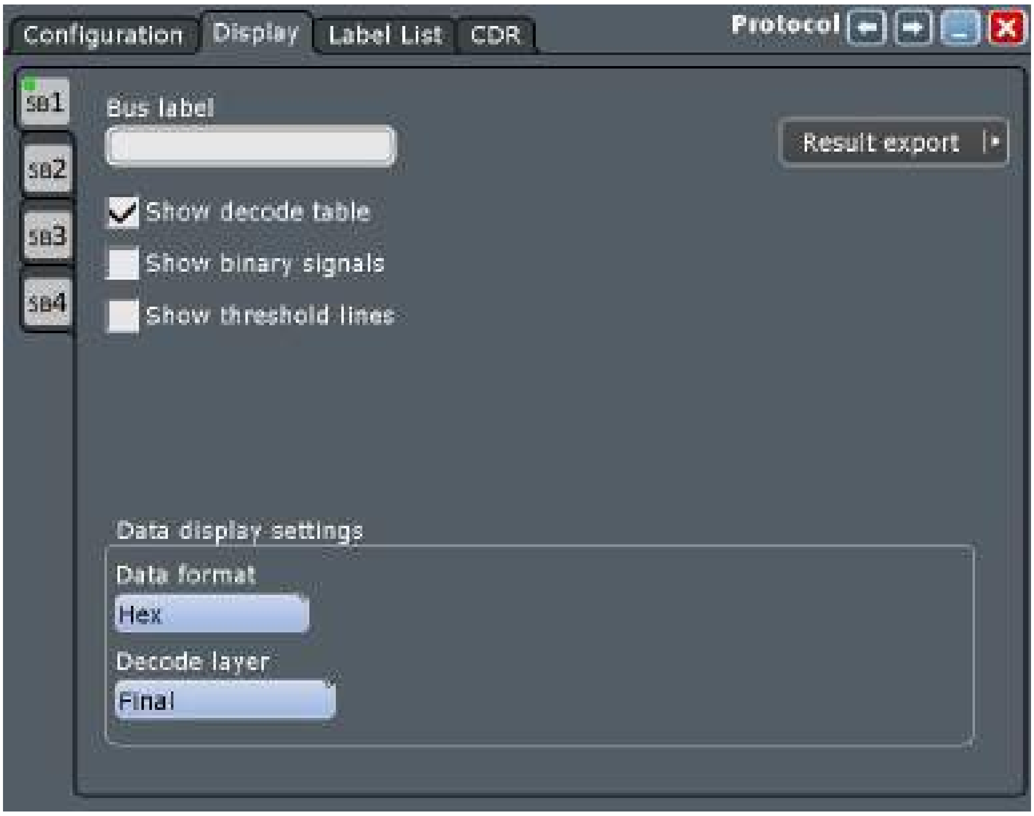
If the "Show decode detail" is enabled you cannot do a serach and trigger on USBPD frames.

Remote command:
`BUS<m>:USBPd:DETail` on page 1990

12.21.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = USBPD " > "Display" tab

To enhance the decode possibilities of the USBPD protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Bus label

☑ Show decode table

☐ Show binary signals

☐ Show threshold lines

Data format: Hex

Decode layer: Final

Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Bits"	...
"4b5b Symbols"	...

12.21.2.3 Configuring the USBPD Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.

4. Tap the "Protocol" button and select the protocol: "USBPD".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Select the data source.
7. Enter the "Thresholds".
8. Enable "Decode", if available.

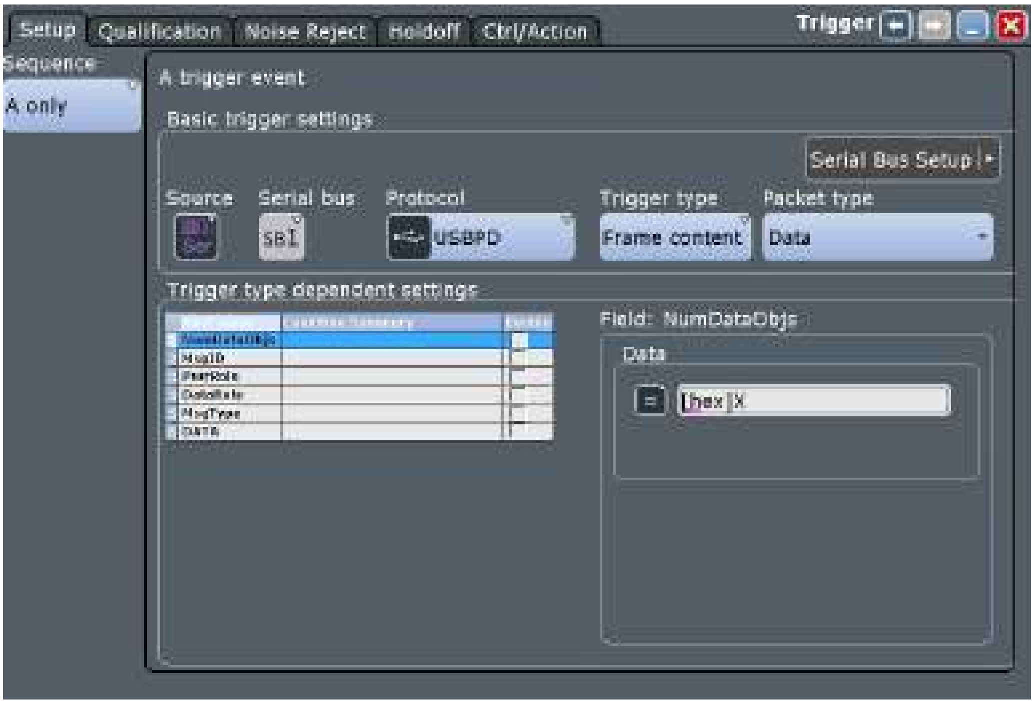
12.21.3 USBPD Trigger

If you need information on how to get started with triggering on USBPD signals, see Chapter 12.21.3.2, "Triggering on USBPD", on page 897. Otherwise proceed with the USBPD trigger settings.

12.21.3.1 USBPD Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = USBPD"

In this section, all trigger settings for USBPD are described. The user interface of the instrument guides you through the trigger setup.



Sequence: A only

Serial bus: SB1

Protocol: USBPD

Trigger type: Frame content

Packet type: Data

Field: NumDataObjs

Data: = [hex]X

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger Type
Selects the trigger type for USBPD analysis.

"Frame Start"	Triggers on a frame start.
"Frame Content"	Triggers on defined frame content type. You can specify the conditions, see Packet Type
"Errors"	Triggers on the enabled errors, see Error > Item name /Enable.

Remote command:
`TRIGger<m>:USBPd:TYPE` on page 1993

Packet Type
Selects the packet type for the "Frame content" type trigger of the USBPD analysis. For the available packet types, see "Frame packet types" on page 891.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

The trigger instant is the last criterion that is fulfilled.

Field name / Condition Summary / Enable
This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition Summary" is only shown in the table, if "Enable" is checked.

For an overview of frames and fields, see "Frame packet types" on page 891.

Remote command:
`TRIGger<m>:USBPd:FRAMe:FIELd<n>:ENABle` on page 1995

Error > Item name /Enable
This table lists the error conditions you can trigger on.

Remote command:
`TRIGger<m>:USBPd:ERRor:ENABle` on page 1993

Data
Defines for the selected field, how a data check is executed.

"Condition"	Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies data or sets the start value of a data range.
"Max"	Sets the the end value of a data range, if "Condition" is set to `INRange` or `OORange`.

Remote command:

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:DOPerator` on page 1995

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMAX` on page 1994

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMIN` on page 1994

Data BitState

Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (don't care).

Remote command:

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:BIT` on page 1993

Index

Defines for the selected field, how an index check is executed.

"Condition"	Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.
"Min"	Specifies the index or sets the start value of an index range.
"Max"	Sets the the end value of an index range, if "Condition" is set to `INRange`.

Remote command:

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:IOPerator` on page 1996

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMAX` on page 1996

`TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMIN` on page 1996

12.21.3.2 Triggering on USBPD

Prerequisite: A bus is configured for the USBPD signal to be analyzed.

In order to be able to trigger on an USBPD data, the "Show decode detail" field in the "Configuration" tab of the protocol setup should be disabled.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.21.3.1, "USBPD Trigger Settings", on page 895), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to USBPD, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "USBPD".
4. Tap "Trigger Type" and select the trigger type to be used for USBPD protocol analysis.
5. Depending on the selected trigger type, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.21.3.1, "USBPD Trigger Settings", on page 895.

12.21.4 USBPD Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Examples

The example in Figure 12-127 shows a simulated USBPD message. Among the long line of decoded frames, the zoom has selected a "Data" frame.

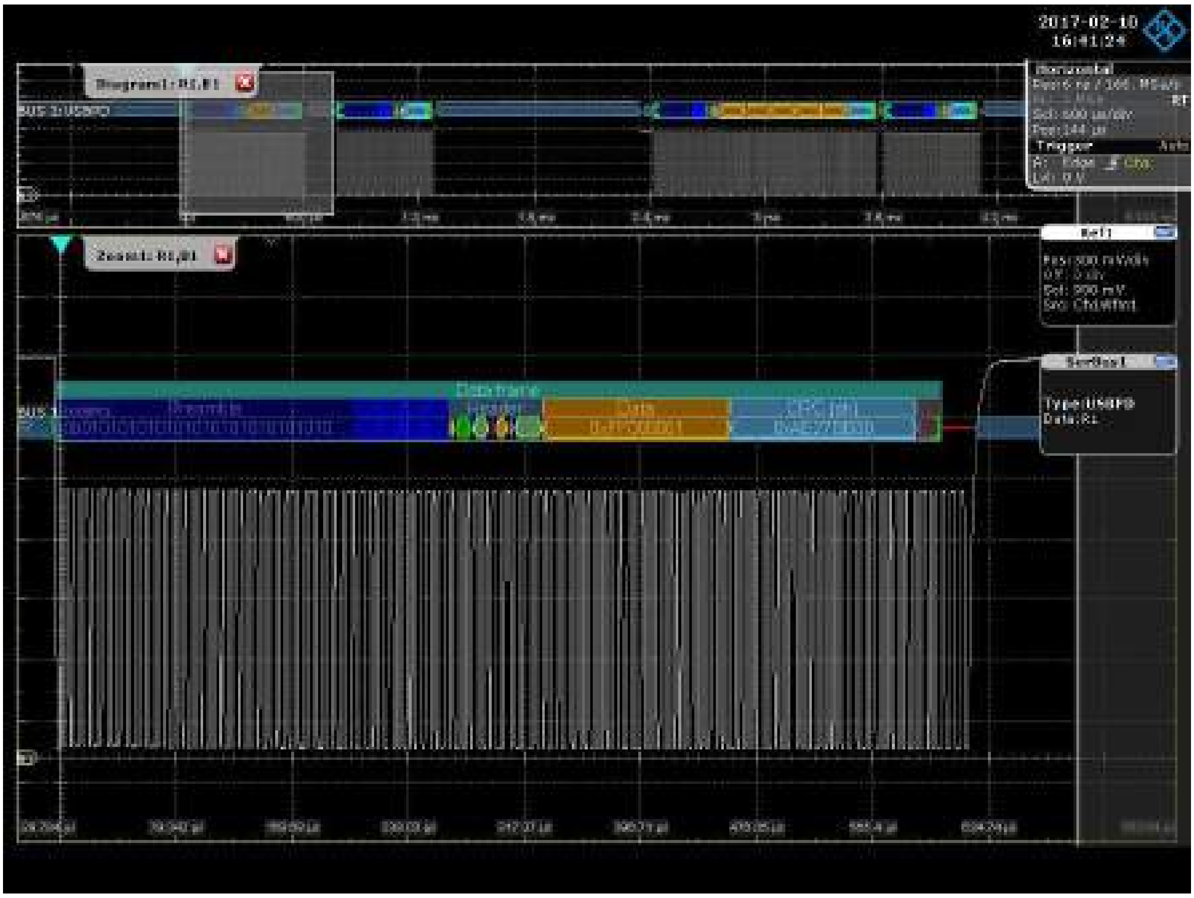


Figure 12-127: USBPD protocol: decoded and binary signal

Green brackets [...] = Start and end of frame
Dark green field = Header
Light blue fields = CRC checksum
Orange fields = Data bits

The example in Figure 12-128 shows the same simulated USBPD message as in Figure 12-127, but with overlayed decode results (upper table, showing frames) and decode results details (table below, showing decoded fields of the selected frame).

Frame	State	Start	Stop	Frame Type	Info	Data
1	Ok	-976 µs	-3.5 µs	Low Power Mode	Rp-3.0	---
2	Ok	-3.25 µs	601.5 µs	Data Message	Data frame	[illegible]
3	Ok	624.75 µs	782.75 µs	Low Power Mode	Rp-3.0	---
4	Ok	783 µs	1.2733 ms	Control Message	Control frame	---
5	Ok	1.284 ms	2.35 ms	Low Power Mode	Rp-3.0	---
6	Ok	2.35 ms	2.4125 ms	Low Power Mode	Rp-1.5	---
7	Ok	2.41275 ms	3.56175 ms	Data Message	Data frame	[illegible]

	State	Type	Numeric Value	Formatted Value
1	Ok	Preamble	[hex] 555555	0b010101010101
2	Ok	SOP1	[hex] 05	Sync-1
3	Ok	SOP2	[hex] 05	Sync-1
4	Ok	SOP3	[hex] 05	Sync-3
5	Ok	SOP4	[hex] 05	Sync-3
6	Ok	Extended	[hex] 00	0
7	Ok	NumDataObjs	[hex] 05	0x5
8	Ok	MsgID	[hex] 01	0x1
9	Ok	PwrRole/Plug	[hex] 01	1

Figure 12-128: USBPD protocol: decoded and binary signal, and decode results

Table 12-34: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Start	Time of frame start
Stop	Time of frame stop
Frame Type	Type of the frame
Info	Information about the frame
Data	Data of the frame

Table 12-35: Content of the "Decode results details" table

Column	Description
State	Overall state of the field
Type	Type (name) of field
Numeric value	The numeric value of the field
Status	Status of the field: OK or error

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.22.3, "Decode Results", on page 1997.

- `BUS<m>:USBPd:RESult:FCOunt?` on page 1997
- `BUS<m>:USBPd:RESult:FRAMe<n>:DATA?` on page 1997
- `BUS<m>:USBPd:RESult:FRAMe<n>:INFO?` on page 1999
- `BUS<m>:USBPd:RESult:FRAMe<n>:STARt?` on page 2000
- `BUS<m>:USBPd:RESult:FRAMe<n>:STATe?` on page 2000
- `BUS<m>:USBPd:RESult:FRAMe<n>:STOP?` on page 2000
- `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:FVAL?` on page 1998
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STATus?` on page 1998
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:TYPE?` on page 1999
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:VAL?` on page 1999

12.21.5 Search on Decoded USBPD Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

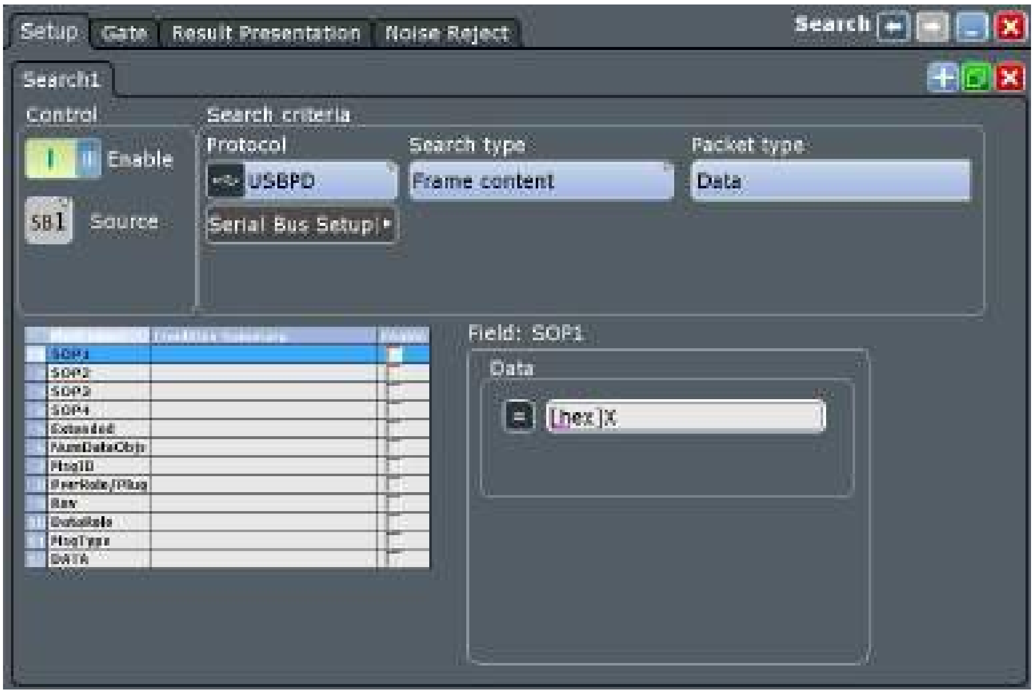
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

If you need information on how to get started with searching USBPD data, see Chapter 12.21.5.3, "Searching USBPD Data", on page 904. Otherwise proceed with the USBPD search setup.

12.21.5.1 USBPD Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for USBPD

Search criteria
Use the "Search criteria" dialog to define the frame type in which data is to be searched.



Protocol: USBPD
Search type: Frame content
Packet type: Data
Field: SOP1
Data

You can define individual search parameters for individual fields in the table below the "Search criteria" dialog. To specify these parameters, select a field in this table and define the data and/or index operators and values, or the bit state.

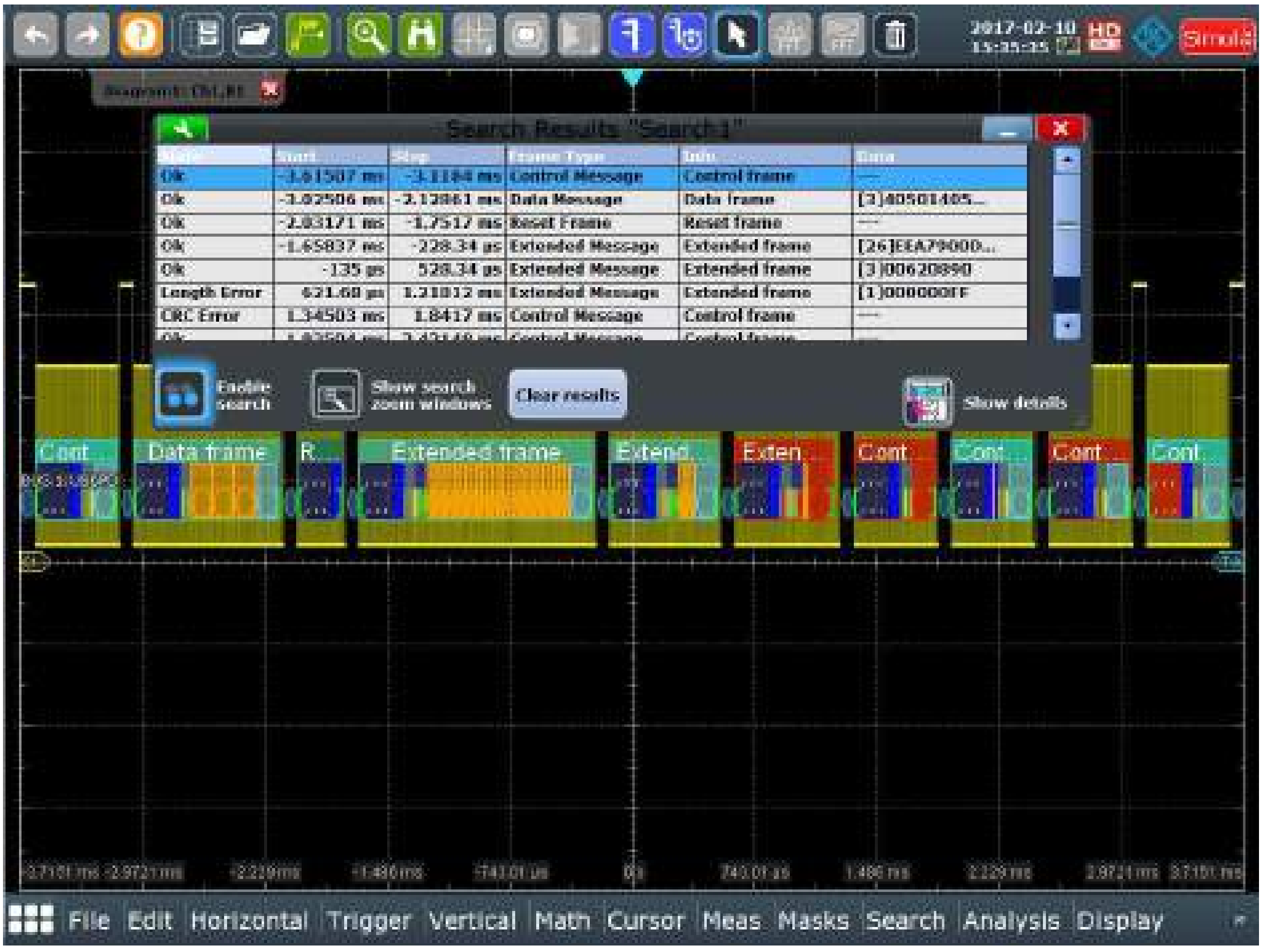
For a description of how to set the search conditions, see Chapter 12.21.3.1, "USBPD Trigger Settings", on page 895.

Remote command:
`SEARch:TRIGger:USBPd:TYPE` on page 2001
`SEARch:TRIGger:USBPd:FRAMe:SELect` on page 2002
`SEARch:TRIGger:USBPd:ERRor:ENABle` on page 2002
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:BIT` on page 2002
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMAX` on page 2003
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMIN` on page 2003
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DOPerator` on page 2004
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMAX` on page 2005
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMIN` on page 2005
`SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IOPerator` on page 2006

12.21.5.2 USBPD Search Results

▮ To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

If the "Show decode detail" field in the "Configuration" tab of the protocol setup is enabled, than the "Enable" serach button is disabled. Disable "Show decode detail" first, to be able to start the search.



State	Start	Stop	Frame Type	Info	Data
Ok	-3.61507 ms	-3.1184 ms	Control Message	Control frame	---
Ok	-3.02506 ms	-2.12861 ms	Data Message	Data frame	[3]40501405...
Ok	-2.83171 ms	-1.7517 ms	Reset Frame	Reset frame	---
Ok	-1.65837 ms	-228.34 µs	Extended Message	Extended frame	[26]EEA79000...
Ok	-135 µs	528.34 µs	Extended Message	Extended frame	[3]00620890
Length Error	621.68 µs	1.21812 ms	Extended Message	Extended frame	[1]000000FF
CRC Error	1.34503 ms	1.8417 ms	Control Message	Control frame	---

Figure 12-129: Search on USBPD frame

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

- `SEARch:RESult:USBPd:FCOunt?` on page 2007

- `SEARch:RESult:USBPd:FRAMe<m>:DATA?` on page 2007
- `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010
- `SEARch:RESult:USBPd:FRAMe<m>:INFO?` on page 2009
- `SEARch:RESult:USBPd:FRAMe<m>:STATe?` on page 2009
- `SEARch:RESult:USBPd:FRAMe<m>:STARt?` on page 2009
- `SEARch:RESult:USBPd:FRAMe<m>:STOP?` on page 2010
- `SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:TYPE?` on page 2008
- `SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STATus?` on page 2008
- `SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:VAL?` on page 2008
- `SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:FVAL?` on page 2007

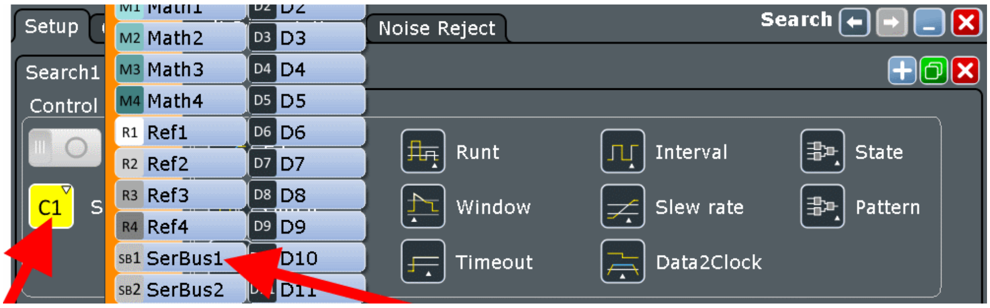
12.21.5.3 Searching USBPD Data

Prerequisite: A serial bus is configured for the USBPD signal to be decoded and analyzed.

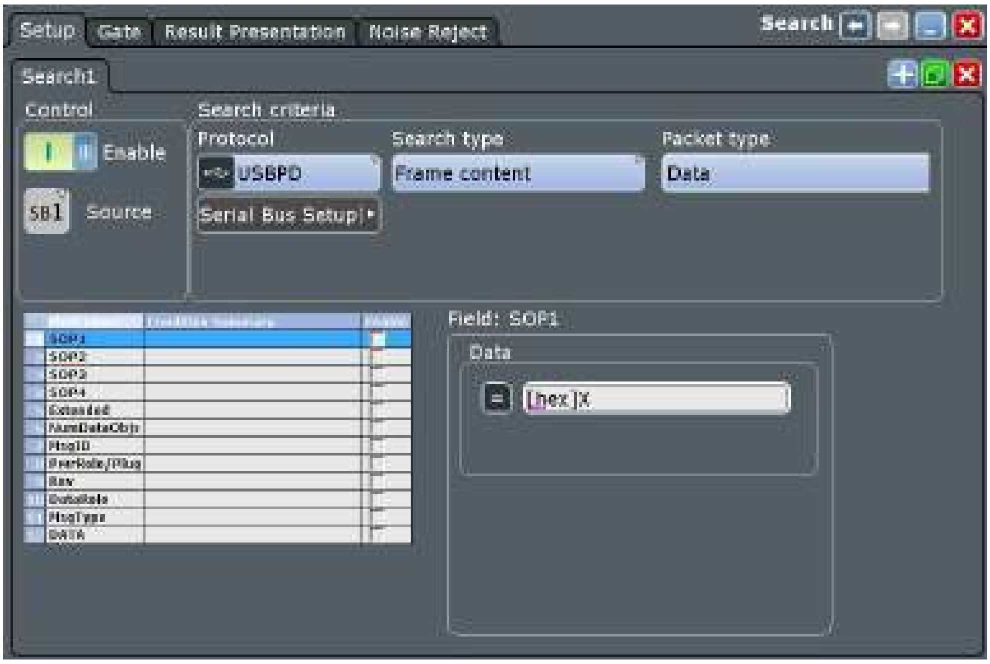
In order to be able to search for an USBPD data, the "Show decode detail" field in the "Configuration" tab of the protocol setup should be disabled. If "Show decode detail" is enabled, the "Enable" search button is disabled.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the + icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to USBPD (e.g. "SerBus1", unless already selected).



The search dialog for USBPD protocol analysis is opened.



4. Specify search criteria according to Chapter 12.21.5.1, "USBPD Search Setup", on page 902.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a USBPD decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   I ‖

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.22 SpaceWire (Option R&S RTO-K65)

The SpaceWire is a communication network standard used for spacecrafts. It is based on the IEEE 1355 standard of comunications and coordinated by the European Space Agency (ESA).

12.22.1 SpaceWire Basic

The SpaceWire links are a Point-toPoint (P2P) connections between a node and another node or a rooter. The link is full-duplex bidirectional serial data link.

The SpaceWire has two type of characters:

- Data characters containing a parity bit, a data control flag and eight bits of data.

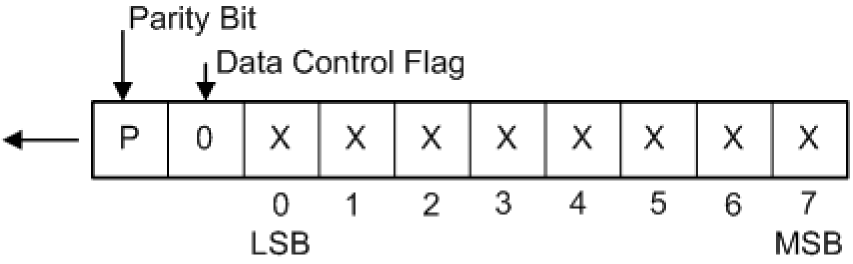


Figure 12-130: SpaceWire data characters

- Control characters containing a parity-bit, a data-control flag and the two-bit control code. The data control flag is set to 1 and indicates that this is a control character.

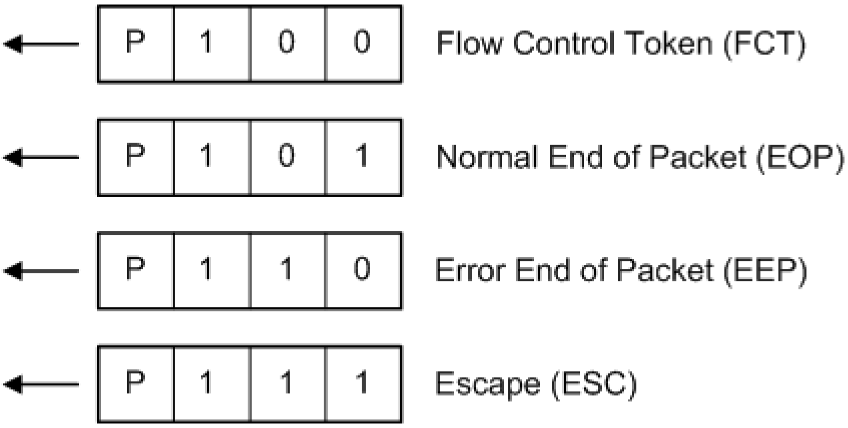


Figure 12-131: SpaceWire control characters

Additionally there are two control codes:

- NULL code consisting of an Escape (ESC) nad a Flow Control Token (FCT)
- Time Code consisting of an ESC followed by a single data character

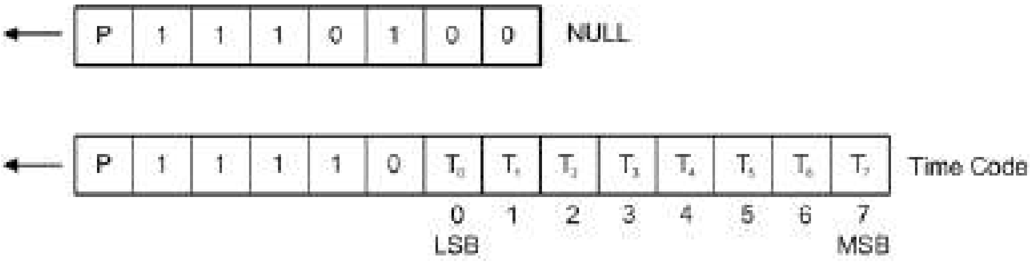


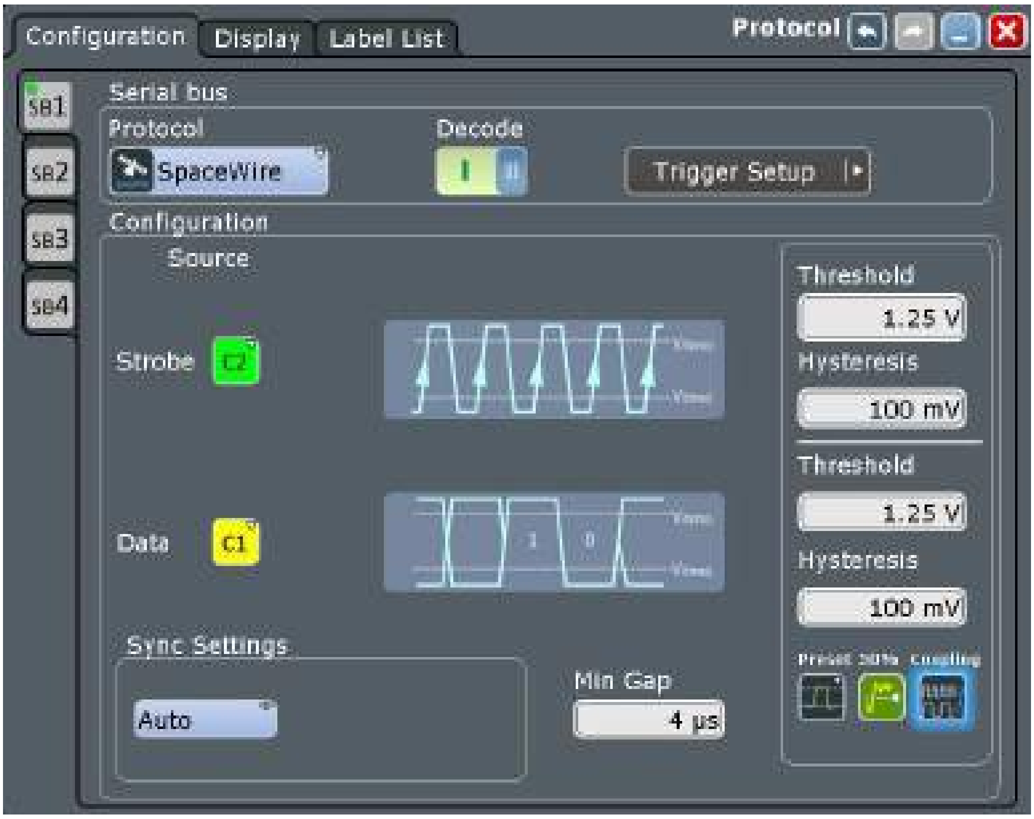
Figure 12-132: SpaceWire control codes

12.22.2 SpaceWire Configuration

12.22.2.1 SpaceWire Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = SpaceWire"

Make sure that the tab of the correct serial bus is selected on the left side.



Protocol: SpaceWire

Strobe: C2

Data: C1

Threshold: 1.25 V

Hysteresis: 100 mV

Threshold: 1.25 V

Hysteresis: 100 mV

Sync Settings: Auto

Min Gap: 4 µs

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Strobe
Selcts the source for the strobe signal.

Remote command:
`BUS<m>:SWIRe:STRBe:SOURce` on page 2013

Data
Selcts the source for the data signal.

Remote command:
`BUS<m>:SWIRe:DATA:SOURce` on page 2012

Threshold
Sets the threshold value for the strobe/data signal.

Remote command:
`BUS<m>:SWIRe:STRBe:THReshold` on page 2013
`BUS<m>:SWIRe:DATA:THReshold` on page 2012

Hysteresis
Sets a value for the hysteresis of the strobe/data signal.

Remote command:
`BUS<m>:SWIRe:STRBe:HYSTeresis` on page 2012
`BUS<m>:SWIRe:DATA:HYSTeresis` on page 2011

Sync Settings
Sets the mode for the synchronisation of the signal. In the auto mode the decoder will automatically do the packet align. In the manual mode you can set the align point manually with the "Bit Position" setting.

Remote command:
`BUS<m>:SWIRe:SYSLect` on page 2013

Bit Position ← Sync Settings
Sets the bit position, the align position for the manual synchronisation mode. This can be useful when parity errors exist in the signal, and parity check is the main indicator for the decoder to do packet alignment.

Remote command:
`BUS<m>:SWIRe:BPOSition` on page 2011

Min Gap
SpaceWire can have idle phases where neither strobe nor data signals are being sent. These "gaps" are identified in order to resume decoding after this idle time.

"Min Gap" sets the minimum duration of a gap. Any inactivity greater than this time will be interpreted as a gap and lead to a resynchronization to the signal.

Remote command:
`BUS<m>:SWIRe:MGAP` on page 2012

Preset
Presets the threshold and hysteresis values of the strobe and data signal.

The preset values may vary according to the measurement signal:

- 0.1 V - 100 mV Threshold, 10 mv Hysteresis
- 0.3 V - 300 mV Threshold, 30 mV Hysteresis
- 2 V - 1 V Threshold, 200 mV Hysteresis

Remote command:
`BUS<m>:SWIRe:PRESet` on page 2014

Set to 50%
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

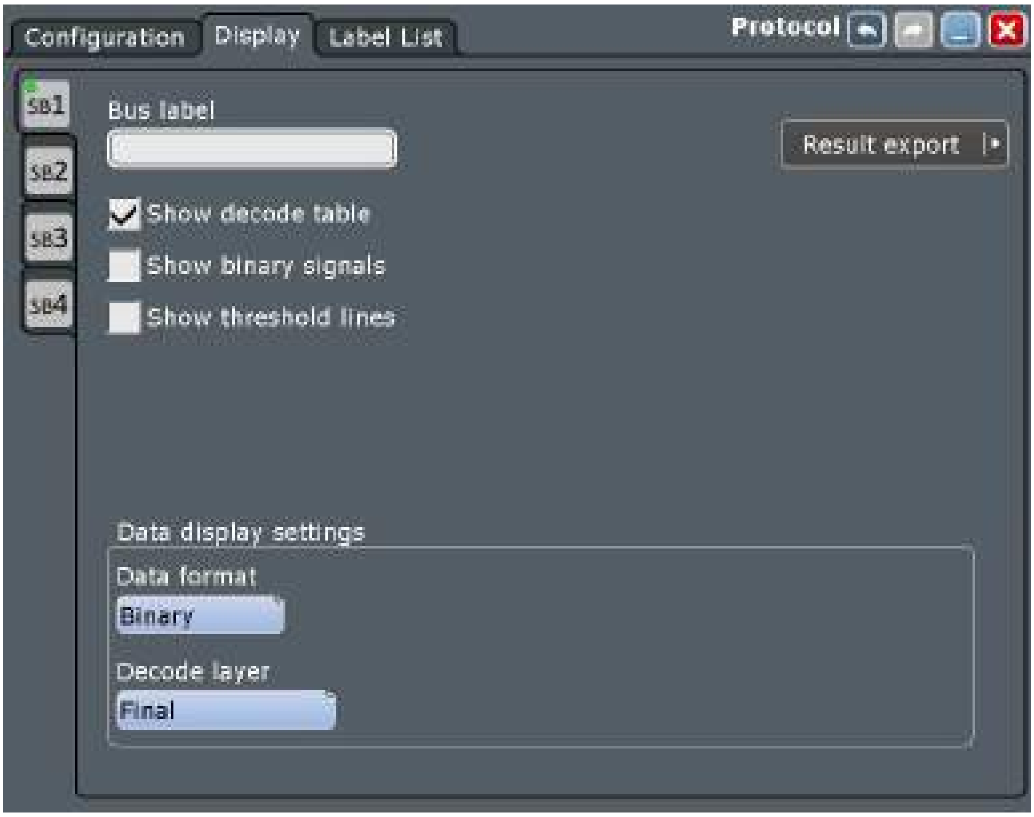
Remote command:
`BUS<m>:SETReflevels` on page 1495

Coupling
Enables coupling, i.e. the same threshold and hysteresis value is used for the strobe and data signal.

Remote command:
`BUS<m>:SWIRe:COUPling` on page 2013

12.22.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "SpaceWire" > "Display" tab



Bus label

☑ Show decode table

☐ Show binary signals

☐ Show threshold lines

Data display settings

Data format: Binary

Decode layer: Final

Decode Layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...

12.22.2.3 Configuring the SpaceWire Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "SpaceWire".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Select the source and polarity for the strobe and data signals.
7. Enter the "Threshold" and the "Hysteresis" for the strobe and data signals.
8. Set the "Sync Settings" and the "Bit Position" if required.
9. Enable "Decode", if available.

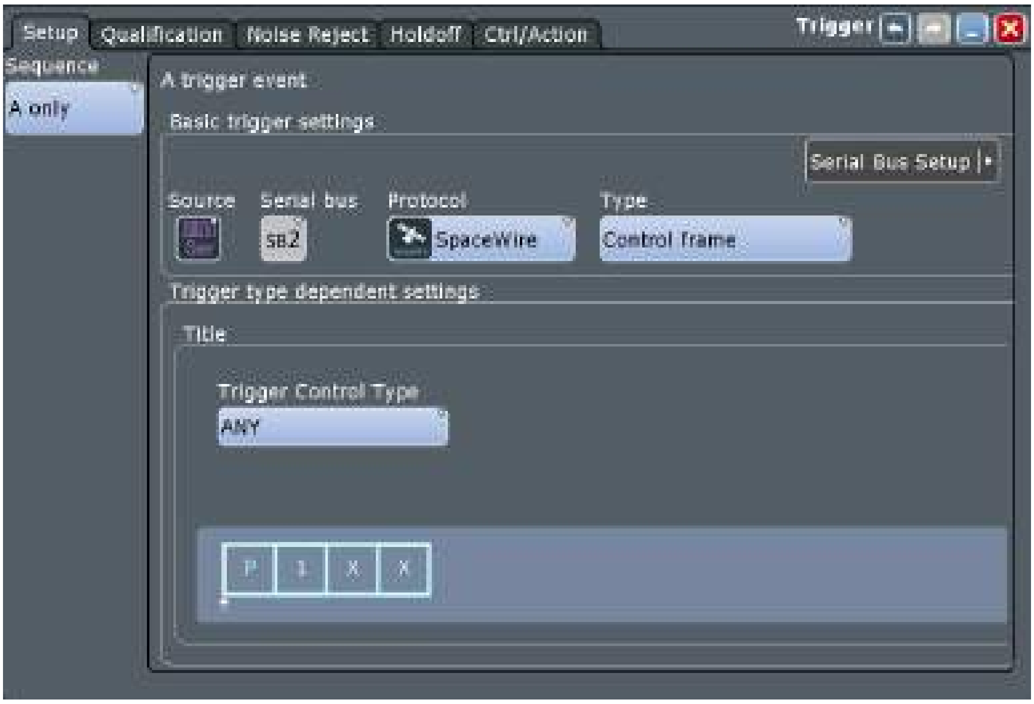
12.22.3 SpaceWire Trigger

12.22.3.1 SpaceWire Trigger Settings

Access: TRIGGER > "Source" = *Serial Bus* and "Protocol" = *SpaceWire*

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.



Sequence: A only

Source

Serial bus: SB2

Protocol: SpaceWire

Type: Control frame

Trigger Control Type: ANY

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

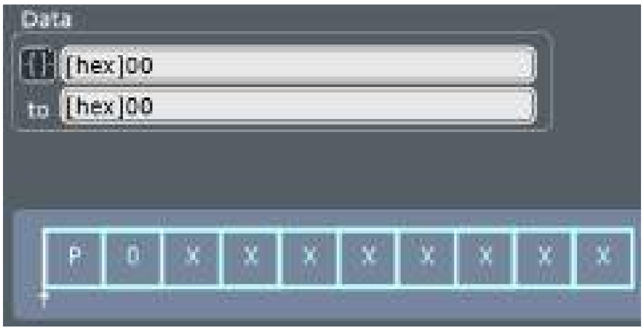
Type

Selects the trigger type for the SpaceWire analysis.

"Control frame" Sets the trigger to the selected control type frame.

Trigger Control Type: ANY

"Data pattern"	Sets the trigger to a defined data pattern or pattern range.

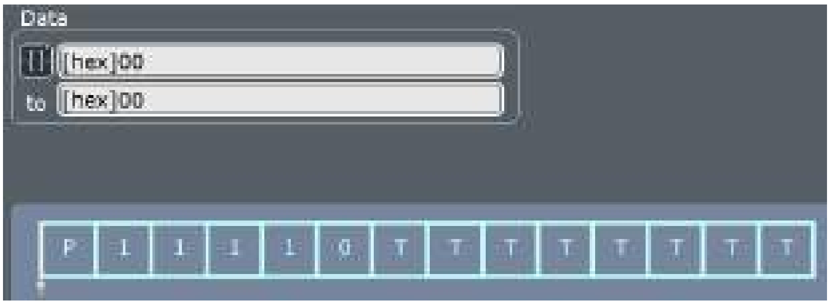


Data

[hex]00

to [hex]00

"NULL frame"	Sets the trigger to a null frame, a frame without usable data.
"Time Code"	Sets the trigger to a time-code control code. You can define the data pattern of the time code to be triggered on.



Data

[hex]00

to [hex]00

"ERRORs"	Triggers on an enabled error type.

Remote command:
`TRIGger<m>:SWIRe:TYPE` on page 2017

Trigger Control Type
Triggers on a specific control type character.

"ANY"	Any control type character
"FCT"	Flow Control Token character
"EOP"	Normal End of Packet character
"EEP"	Error End of Packet character

Remote command:
`TRIGger<m>:SWIRe:CTYPe` on page 2014

Data (Time Code)
Sets the specified data type for the time code to be triggered on. The data type setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.

"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SWIRe:TIME:CONDition` on page 2016
`TRIGger<m>:SWIRe:TIME:MAX` on page 2017
`TRIGger<m>:SWIRe:TIME:MIN` on page 2017

Data(Data Pattern)
Sets the specified data type for the data pattern to be triggered on. The data type setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SWIRe:DATA:CONDition` on page 2015
`TRIGger<m>:SWIRe:DATA:MAX` on page 2015
`TRIGger<m>:SWIRe:DATA:MIN` on page 2015

Parity Error
Checks the parity of every frame and triggers if the parity is even.

Remote command:
`TRIGger<m>:SWIRe:ERRor:PARity` on page 2016

ESC Error
Triggers on a escape error.

Remote command:
`TRIGger<m>:SWIRe:ERRor:ESC` on page 2016

12.22.3.2 Triggering on SpaceWire

Prerequisite: A bus is configured for the SpaceWire signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog, tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to SpaceWire, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "SpaceWire".
4. Select the "Trigger Type" to be used for SpaceWire protocol analysis.
5. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.22.3.1, "SpaceWire Trigger Settings", on page 910.

12.22.4 SpaceWire Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Figure 12-133 shows a decoded signal with ambiguous bits (the earliest, least significant, parity bit among all surviving tracks). In the honeycomb the ambiguous bits are marked in pink. Additionally they are reflected in the result table.

Figure 12-133: Decoded SpaceWire signal with ambiguous bits

The example in Figure 12-134 shows a decoded signal with existing parity errors. The errors are marked with red on the honeycomb and reflected in the results table.

Figure 12-134: Decoded SpaceWire signal with a parity error

Table 12-36: Content of the decode result table

Column	Description
State	Overall state of the frame
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point

Column	Description
Type	Frame type
Data	Data value

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.23.3, "Decode Results", on page 2017.

12.22.5 Search on Decoded SpaceWire Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 419.

12.22.5.1 SpaceWire Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for SpaceWire

Source: SB1

Type: Control frame

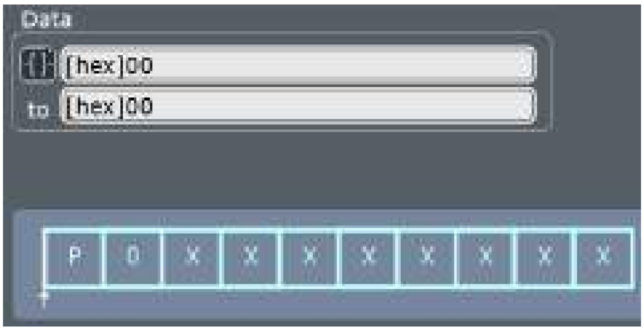
Trigger Control Type: ANY

Type
Sets the search type for the SpaceWire analysis.

"Control frame" Searches for the selected control type frame.

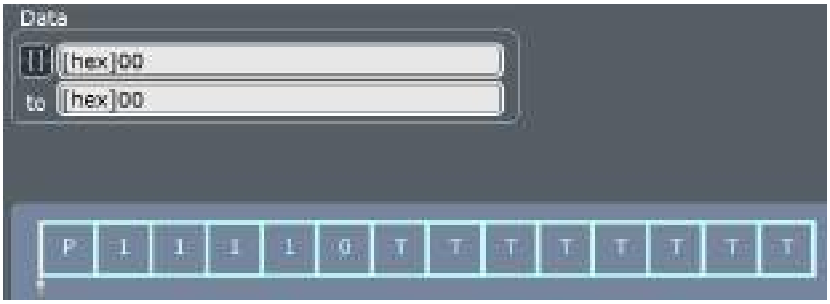
Trigger Control Type: ANY

"Data pattern" Searches for a defined data pattern or pattern range.



Data: [hex]00 to [hex]00

"NULL frame" Searches for a null frame, a frame without usable data.

"Time Code"	Searches for a time-code control code. You can define the data pattern of the time code to be searched for. 
"ERRORs"	Searches for an enabled error type.

Remote command:
`SEARch:TRIGger:SWIRe:TYPE` on page 2023

Trigger Control Type
Searches for a specific control type character.

"ANY"	Any control type character
"FCT"	Flow Control Token character
"EOP"	Normal End of Packet character
"EEP"	Error End of Packet character

Remote command:
`SEARch:TRIGger:SWIRe:CTYPe` on page 2020

Data (Time Code)
Sets the specified data type for the time code to be searched for. The data type setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:SWIRe:TIME:CONDition` on page 2022
`SEARch:TRIGger:SWIRe:TIME:MAX` on page 2023
`SEARch:TRIGger:SWIRe:TIME:MIN` on page 2023

Data(Data Pattern)
Sets the specified data type for the data pattern to be searched for. The data type setup consists of the condition and one or two data patterns.

"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:SWIRe:DATA:CONDition` on page 2021
`SEARch:TRIGger:SWIRe:DATA:MAX` on page 2021
`SEARch:TRIGger:SWIRe:DATA:MIN` on page 2021

Parity Error
Checks the parity of every frame and searches for even parity.

Remote command:
`SEARch:TRIGger:SWIRe:ERRor:PARity` on page 2022

ESC Error
Searches for an escape error.

Remote command:
`SEARch:TRIGger:SWIRe:ERRor:ESC` on page 2022

12.22.5.2 SpaceWire Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote commands:

- `SEARch:RESult:SWIRe:FCOunt` on page 2023
- `SEARch:RESult:SWIRe:FRAMe<m>:DATA?` on page 2024
- `SEARch:RESult:SWIRe:FRAMe<m>:STARt?` on page 2024
- `SEARch:RESult:SWIRe:FRAMe<m>:STATe?` on page 2024
- `SEARch:RESult:SWIRe:FRAMe<m>:STOP?` on page 2025
- `SEARch:RESult:SWIRe:FRAMe<m>:TYPE?` on page 2025

12.22.5.3 Searching SpaceWire

Prerequisite: A serial bus is configured for the SpaceWire signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 434.
3. Tap "Source" and select the serial bus that is set to SpaceWire (e.g. "SerBus1", unless already selected).
4. Specify search criteria according to Chapter 12.22.5.1, "SpaceWire Search Setup", on page 916.
5. To acquire a waveform, press SINGLE.

   The R&S RTO performs a SpaceWire decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTO displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 440 and "Navigating search results" on page 421.

12.23 PCIe Gen 1/2 (Option R&S RTO-K72)

R&S RTO-K72 is a firmware option that enables the R&S RTO to analyze Peripheral Component Interconnect Express (PCIe) signals encoded by the PCIe standard, generation 1 and 2.

For analysis, PCIe Gen 1/2 encoded signals can be triggered, decoded and searched.

12.23.1 The PCIe Protocol

The PCIe is a high-speed serial computer expansion bus standard.

The communication between two PCIe devices is performed through logical connections called links. Each link consists of a number of lanes. The lanes contain one differential signaling pair for receiving data and the other for transmitting it.

PCIe logical layers

The PCIe has three logical layers:

- Transaction layer: assembles and disassembles transaction layer packets (TLPs). TLP transfer information like read and write and some event types.
- Data link layer: used for link management and data integrity. Error detection and correction is also done in this layer. The data link layer produces data link layer packets(DLLP).
- Physical layer: includes the circuitry for the interface operation.

PCIe Packet Types

The communication between the layers is done through packets. All packet types that can be decoded by the R&S RTO are listed below.

SCPI name	Description	Type
MRD32 / MRD64	Memory Read Request for 32 bit/ 64 bit addresssing packet format	TLP
MRDLK32 / MRDLK64	Memory Read Request-Locked for 32 bit/ 64 bit addresssing packet format	TLP
MWR32 / MWR64	Memory Write Request for 32 bit/ 64 bit addresssing packet format	TLP
IORD	I/O Read Request	TLP
IOWR	I/O Write Request	TLP
CFGRD0 / CFGRD1	Configuration Read Type 0/1	TLP Type
CFGWR0 / CFGWR1	Configuration Write Type 0/1	TLP
TCfgRd / TCfgWr	Deprecated TLP Type	TLP
MSG	Message Request	TLP
MSGD	Message Request with data payload	TLP
CPL	Completion without Data	TLP
CPLD	Completion with Data	TLP
CPLLK	Completion for Locked Memory Read without Data	TLP
CPLDLK	Completion for Locked Memory Read	TLP
FA32 / FA64	Fetch and Add AtomicOp Request for 32 bit/ 64 bit addresssing packet format	TLP
SWP32 / SWP64	Unconditional Swap AtomicOp Request for 32 bit/ 64 bit addresssing packet format	TLP
CAS32 / CAS64	Compare and Swap AtomicOp Request for 32 bit/ 64 bit addresssing packet format	TLP
LPRFX	Local TLP Prefix	TLP

SCPI name	Description	Type
EPRFX	End-End TLP Prefix	TLP
ACK	Acknowledgement	DLLP
NAK	Negative acknowledgment	DLLP
PMEL1 / PMEL23	Power management Enter L1/ L23	DLLP
PMASRL1	Power management Active State Request L1	DLLP
PMRA	Power management request acknowledgment	DLLP
VENDS	Vendor Specific	DLLP
IFC1P / IFC2P	Initialization flow control 1/2 posted requests	DLLP
IFC1NP / IFC2NP	Initialization flow control 1/2 non posted requests	DLLP
IFC1CPL / IFC2CPL	Initialization flow control 1/2 completions	DLLP
UPDFCP	Update flow control 1/2 posted requests	DLLP
UPDFCNP	Update flow control non posted requests	DLLP
UPDFCCPL	Update flow control completions	DLLP
SKPOS	SKP ordered set	Ordered Set
TS1OS / TS2OS	Training sequence 1/2 ordered set	Ordered Set
FTSOS	Fast training sequence ordered set	Ordered Set
EIOS	Electrical idle ordered set	Ordered Set
EIEOS	Electrical idle exit ordered set	Ordered Set
COMPL	Compliance pattern	Ordered Set
MCOMPL	Modified Compliance pattern	Ordered Set
MRIFC1 / MRIFC2	Multi-root initialization flow control 1/2	Multi-root DLLP
MRUPDFC	Multi-root update flow control	Multi-root DLLP
MRINIT	Multi-root initialization	Multi-root DLLP
MRRESET	Multi-root reset	Multi-root DLLP

12.23.2 PCIe Gen 1/2 Configuration

12.23.2.1 PCIe Gen 1/2 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "PCIe Gen 1/2"

Make sure that the tab of the correct serial bus is selected on the left side.

Protocol: PCIe Gen 1/2

Generation: PCIe Gen1 (2.5 Gbit/s)

Link: x4

Lane 0: C1

Lane 1: C2

Lane 2: C3

Lane 3: C4

Low	High
-20 mV	20 mV
-20 mV	20 mV
-20 mV	20 mV
-20 mV	20 mV

CDR summary

Nominal bit rate	2.5 Gbps
Order	2nd order
Bandwidth	25 MHz
Rel. bandwidth	100
Damping	0.7

See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Generation

Selects the generation of the PCIe technology.

"PCIe Gen1 (2.5 Gbit/s) "	Selects the PCIe generation 1.0, standard introduced in 2003. It has a transfer rate of 2.5 Gbit/s.
"PCIe Gen2 (5 Gbit/s) "	Selects the PCIe generation 2.0, standard introduced in 2007. It has a transfer rate of 5 Gbit/s.

Remote command:
`BUS<m>:PCIE:GEN` on page 2027

Link

Selects the link width, the number of lanes that are used for the transmission of the data.

Remote command:
`BUS<m>:PCIE:LNKW` on page 2027

Descrambling

Enables descrambling of the data.

Remote command:
`BUS<m>:PCIE:DSCRambling` on page 2027

Lane 0/1/2/3
Select the signal sources for the logical lanes.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Remote command:
`BUS<m>:PCIE:LZER:SOURce` on page 2027
`BUS<m>:PCIE:LONE:SOURce` on page 2028
`BUS<m>:PCIE:LTWO:SOURce` on page 2028
`BUS<m>:PCIE:LTHRee:SOURce` on page 2028

Thresholds
Sets the threshold value for digitization of signals for each line.

Coupling ← Thresholds
Enables the same threshold value for all lanes.

Set to 50% ← Thresholds
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:SETReflevels` on page 1495

Thresholds Low ← Thresholds
Sets the lower threshold value for the respective lane.

Remote command:
`BUS<m>:PCIE:LONE:THRLow` on page 2028
`BUS<m>:PCIE:LTHRee:THRLow` on page 2028
`BUS<m>:PCIE:LTWO:THRLow` on page 2028
`BUS<m>:PCIE:LZER:THRLow` on page 2028

Thresholds High ← Thresholds
Sets the high threshold value for the respective lane.

Remote command:
`BUS<m>:PCIE:LONE:THRHigh` on page 2028
`BUS<m>:PCIE:LTHRee:THRHigh` on page 2028
`BUS<m>:PCIE:LTWO:THRHigh` on page 2028
`BUS<m>:PCIE:LZER:THRHigh` on page 2028

CDR Summary
Displays a summary of the CDR values. You can set these settings in the "CDR" tab, see Chapter 12.23.3, "PCIe Gen 1/2 CDR Configuration Settings", on page 926.

12.23.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = "PCIe Gen 1/2" > "Display" tab

Common display settings are explained in Chapter 12.1.2, "Display", on page 482.


Data display settings

Data format
Hex

Decode layer
8b/10b

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	...
"8b/10b"	...
"Scrambled 8b/10b"	...
"Bits"	...

12.23.2.3 Configuring PCIe Gen 1/2

For configuration, you assign the line to the input channel, set the threshold, the bitrate, and the sync symbol.

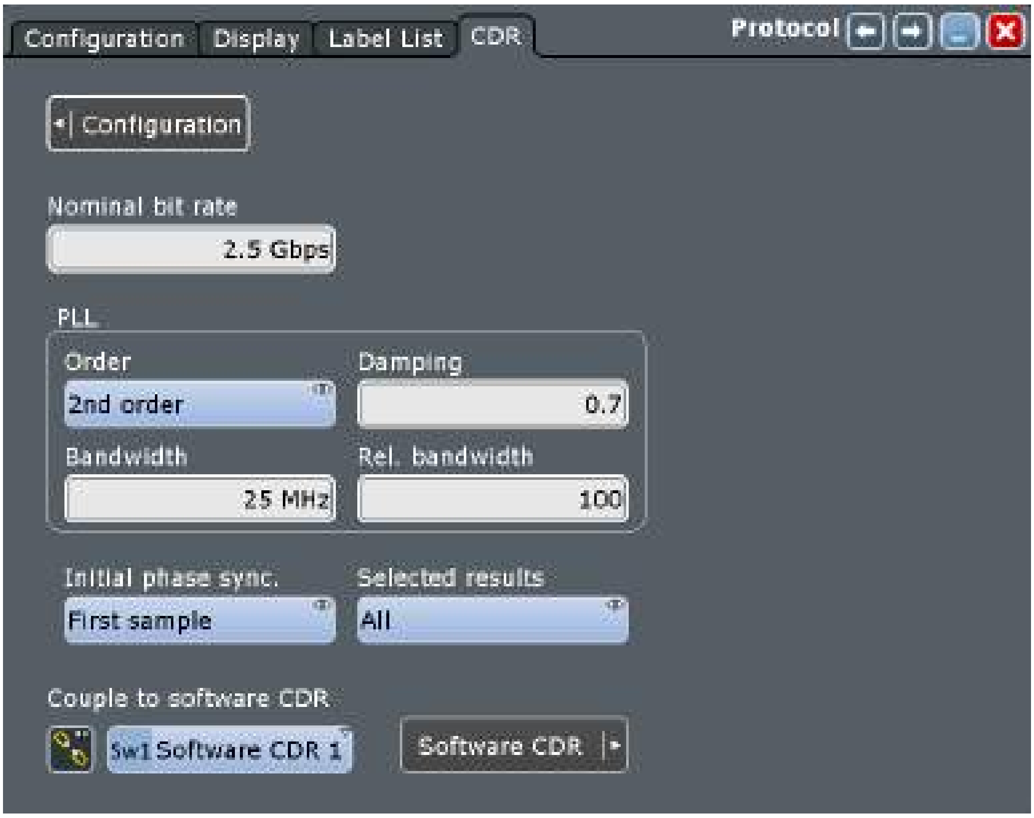
For details on configuration settings, see Chapter 12.23.2.1, "PCIe Gen 1/2 Configuration Settings", on page 922.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "PCIe Gen 1/2".
5. Tap the "Generation" button and select the PCIe protocol.
6. Tap the "Link" button and chose the link width.
7. Optionally, you can enter a "Bus label" on the "Display" tab.
8. Select the source for of the signal for each lane.
9. Check the threshold settings for each lane and adjust the values if necessary.

12.23.3 PCIe Gen 1/2 CDR Configuration Settings

The process of clock data recovery (CDR) generates a reference clock from a high-speed serial data stream that is sent without a dedicated clock signal. The generated clock signal matches the frequency and is aligned to the phase of the data stream. The recovered clock can be used to sample the data stream and to obtain the sequence of transmitted bits.

Access: PROTOCOL > "Configuration" tab > "Protocol" = "PCIe Gen 1/2" > "CDR" tab



Nominal bit rate: 2.5 Gbps

Order: 2nd order

Damping: 0.7

Bandwidth: 25 MHz

Rel. bandwidth: 100

Initial phase sync.: First sample

Selected results: All

Couple to software CDR: SW1 Software CDR 1

Nominal bit rate
Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:
`BUS<m>:CDR:BITRate` on page 2029

PLL settings
Phase-locked loop parameters are listed below.

Note: Nomial bit rate, bandwidth and relative bandwidth are interacting settings. Modifying one parameter also changes one of the dependent parameters.

"Order"	Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

"Bandwidth"	Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.
"Rel. bandwidth"	Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.
"Damping"	Sets the damping factor, which is only relevant for second order PLL.

Remote command:
`BUS<m>:CDR:PLL:ORDer` on page 2030
`BUS<m>:CDR:PLL:BWIDth` on page 2029
`BUS<m>:CDR:PLL:RELBwidth` on page 2030
`BUS<m>:CDR:PLL:DAMPing` on page 2029

Initial phase sync.
Defines the phase reference for the first clock edge.

"First sample"	The first clock edge matches the first sample of the waveform at the left border of the display.
"First data edge"	The first clock edge matches the first edge of the data signal.

Remote command:
`BUS<m>:CDR:SYNC` on page 2030

Selected results
The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges:

"After initial sync."	The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.
"All"	All clock edges are used.

Remote command:
`BUS<m>:CDR:RESults` on page 2030

Couple to software CDR
Couples the protocol CDR to the selected software CDR. For more information about it see, Chapter 16.2, "Clock Data Recovery", on page 1046.

12.23.4 PCIe Gen 1/2 Trigger

12.23.4.1 PCIe Gen 1/2 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = PCIe Gen 1/2"

Sequence: A only

Source

Serial bus: SB1

Protocol: PCIe Gen 1/2

Trigger type PCI express: TLP (Transaction layer)

TLP: Any Type

Sequence Number: [hex]XXX

TC: Any

Ordering: Any

Snoop: Any

Requester ID: [hex]XXXX

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type PCI express

Selects the trigger type for the PCI express analysis.

"TLP (Transaction layer)"	Sets the trigger on a defined type of the transaction layer packet.
"DLLP (Data link layer)"	Sets the trigger on a defined type of the data link layer packet.
"Ordered Sets"	Sets the trigger on a defined ordered set.
"Error Condition"	Sets the trigger on a selection of error conditions.

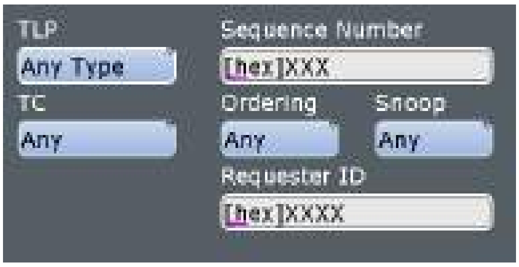
Remote command:

`TRIGger<m>:PCIE:TYPE` on page 2039

TLP (Transaction layer)

Specifies the trigger conditions for the transaction layer type trigger.

TLP ← TLP (Transaction layer)
Triggers on a transaction type.



"Any type"	Triggers on any transaction type.
"Mem"	Triggers on memory transaction type used for data transfers to memory-mapped locations.
"IO"	Triggers on I/O transaction type used for data transfers to I/O-mapped locations.
"Cfg"	Triggers on configuration transaction type used to setup the device functions.
"Msg"	Triggers on message transaction type used for transmitting diverse messages.
"Cpl"	Triggers on completion without data.
"FetchAdd"	Triggers on fetch and add atomic op request.
"Swap"	Triggers on unconditional swap atomic op request.
"CAS"	Triggers on compare and swap atomic op request transaction type.

Remote command:
`TRIGger<m>:PCIE:TLP:TYPE` on page 2039

Sequence Number ← TLP (Transaction layer)
Triggers on a sequence number, which indicates if any TLPs have been lost.

Remote command:
`TRIGger<m>:PCIE:TLP:SNUM` on page 2038

TC ← TLP (Transaction layer)
Triggers on a traffic class which is mapped on a specific virtual channel. The TC label is transmitted unmodified through the fabric.

Remote command:
`TRIGger<m>:PCIE:TLP:TCHN` on page 2039

Ordering ← TLP (Transaction layer)
Triggers on an ordering. The ordering can be relaxed or strong.

Remote command:
`TRIGger<m>:PCIE:TLP:ORDE` on page 2038

Snoop ← TLP (Transaction layer)
Triggers on a snoop state.

Remote command:
`TRIGger<m>:PCIE:TLP:SNOO` on page 2038

Requester ID ← TLP (Transaction layer)
Triggers on a requester ID, consisting of the requester's bus number, device number, and function number.

Remote command:
`TRIGger<m>:PCIE:TLP:REID` on page 2038

Device ID ← TLP (Transaction layer)
Triggers on a device ID, a field that can be assigned a value by the vendor for classifying root complex register blocks (RCRB). The Device ID is only valid for Configuration transaction. It is composed of 8-bit Bus number, 5-bit Device number and a 3-bit Function number.

Remote command:
`TRIGger<m>:PCIE:TLP:DEID` on page 2037

Read/Write ← TLP (Transaction layer)
Triggers on a read and/ or write state.

Remote command:
`TRIGger<m>:PCIE:TLP:MERW` on page 2037

Address Type ← TLP (Transaction layer)
Triggers on an address type. The address type can be 32 bit or 64 bit.

Remote command:
`TRIGger<m>:PCIE:TLP:ADRT` on page 2037

Type ← TLP (Transaction layer)
Triggers on a configuration type.

Remote command:
`TRIGger<m>:PCIE:TLP:CFGT` on page 2037

Routing ← TLP (Transaction layer)
Triggers on a selected message routing type.

Remote command:
`TRIGger<m>:PCIE:TLP:MSGR` on page 2038

Message Code ← TLP (Transaction layer)
Triggers on a specific message code.

Remote command:
`TRIGger<m>:PCIE:TLP:MSGC` on page 2038

Status ← TLP (Transaction layer)
Triggers on a completion status.

Remote command:
`TRIGger<m>:PCIE:TLP:CPLS` on page 2037

Completer ID ← TLP (Transaction layer)
Triggers on a completer ID, consisting of the completer's bus number, device number, and function number.

Remote command:
`TRIGger<m>:PCIE:TLP:CPID` on page 2037

DLLP Type
Sets the trigger to the type of DLLP. You can refine the settings for the different types according to their specifications.

Remote command:
`TRIGger<m>:PCIE:DLLP:TYPE` on page 2035

DLLP Any Type conditions
Sets the trigger to any type of DLLP.

DLLP MRDLLP conditions
Specifies the conditions for the multi-root trigger.

DLLP	Phase	VH FC
MRDLLP	Any	Any

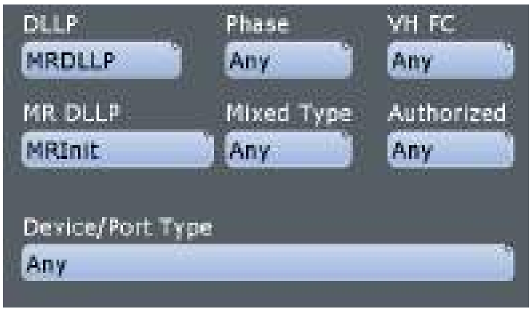
MR DLLP	Mixed Type	Authorized
MRInit	Any	Any

Device/Port Type
Any

MR DLLP ← DLLP MRDLLP conditions
Triggers on a multi-root type for the data link layer.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:TYPE` on page 2034

MRInit ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization protocol trigger.



DLLP	Phase	VH FC
MRDLLP	Any	Any

MR DLLP	Mixed Type	Authorized
MRInit	Any	Any

Device/Port Type
Any

Phase ← MRInit ← DLLP MRDLLP conditions
Triggers on a phase state.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:PHAS` on page 2033

VH FC ← MRInit ← DLLP MRDLLP conditions
Triggers on a virtual hierarchies flow control presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:VHFC` on page 2034

Mixed Type ← MRInit ← DLLP MRDLLP conditions
Triggers on a mixed type presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:MIXT` on page 2033

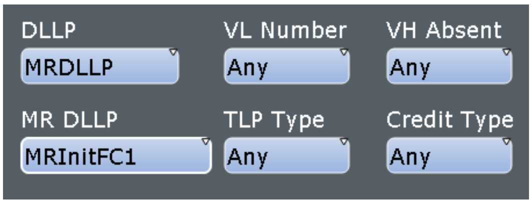
Authorized ← MRInit ← DLLP MRDLLP conditions
Triggers on an authorized state presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:AUTH` on page 2032

Device/Port Type ← MRInit ← DLLP MRDLLP conditions
Triggers on an device/port type.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:DVPT` on page 2032

MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization flow control protocol trigger.



DLLP: MRDLLP
VL Number: Any
VH Absent: Any
MR DLLP: MRInitFC1
TLP Type: Any
Credit Type: Any

VL Number ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on a virtual link (VL) number.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:VLNR` on page 2034

VH Absent ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on an absent virtual hierarchies (VH).

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:HABS` on page 2033

TLP Type ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on a transaction layer type for a multi-root data link layer trigger type.

"Any"	Any transaction layer type.
"P"	Posted credit.

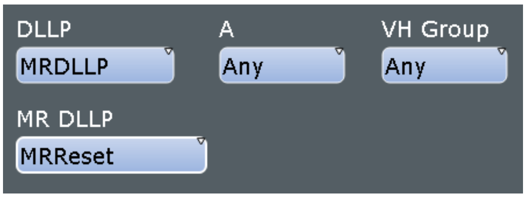
"N"	Non posted credit.
"Cpl"	Completion credit.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:TLPT` on page 2033

Credit Type ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on any, data or header credit type.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:CRET` on page 2032

MRReset ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root reset protocol trigger.



DLLP: MRDLLP
A: Any
VH Group: Any
MR DLLP: MRReset

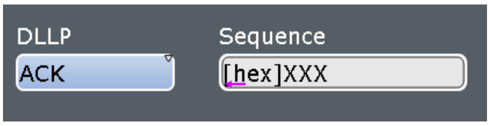
A ← MRReset ← DLLP MRDLLP conditions
Triggers on the value of the A bit (Ack/ Request).

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:RESA` on page 2033

VH Group ← MRReset ← DLLP MRDLLP conditions
Triggers on the selected virtual hierarchies group.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:VHGR` on page 2034

DLLP ACK/NAK conditions
Triggers on an acknowledgement (ACK)/ negative acknowledgment (NAK).

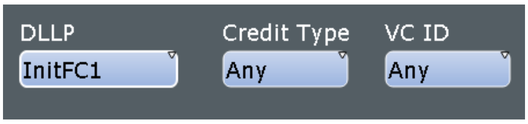


DLLP: ACK
Sequence: [hex]XXX

Sequence ← DLLP ACK/NAK conditions
Triggers on the sequence field indicating what TLPs are affected by the ACK/NAK.

Remote command:
`TRIGger<m>:PCIE:DLLP:SEQ` on page 2035

DLLP Init FC1/InitFC2/UpdateFC conditions
Triggers on flow control initialization/update conditions.



DLLP: InitFC1
Credit Type: Any
VC ID: Any

Credit Type ← DLLP Init FC1/InitFC2/UpdateFC conditions

Triggers on a credit type value.

"Any"	Triggers on any credit type.
"P"	Triggers on posted requests.
"NP"	Triggers on non posted requests.
"CPL"	Triggers on completions.

Remote command:
`TRIGger<m>:PCIE:DLLP:FCTL:CRET` on page 2032

VC ID ← DLLP Init FC1/InitFC2/UpdateFC conditions

Triggers on a virtual channel ID value.

Remote command:
`TRIGger<m>:PCIE:DLLP:FCTL:VCID` on page 2032

DLLP PM conditions

Triggers on a specified power management conditions.

DLLP: PM
PM Type: Any

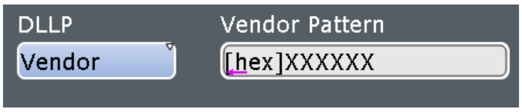
PM Type ← DLLP PM conditions

Triggers on a power management type.

Remote command:
`TRIGger<m>:PCIE:DLLP:POWM` on page 2035

DLLP Vendor conditions

Triggers on a specified vendor conditions.



DLLP: Vendor
Vendor Pattern: [hex]XXXXXX

Vendor Pattern ← DLLP Vendor conditions

Triggers on a vendor pattern.

Remote command:
`TRIGger<m>:PCIE:DLLP:VPAT` on page 2035

Ordered set condition

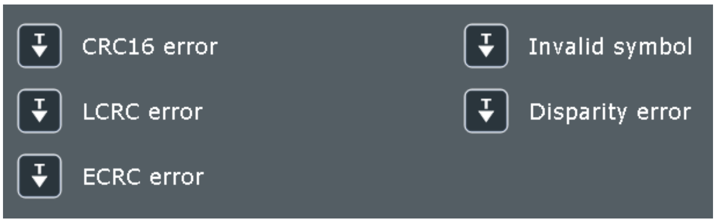
Triggers on an ordered set.

"SKP OS"	Triggers on an SKP ordered sets.
"Training Seq 1/2"	Triggers on a training sequence ordered set.
"Fast Training Seq"	Triggers on a fast training sequence ordered set.

"Electrical Idle OS"	Triggers on an electrical idle ordered set that must be send by the transmitter before it can enter the electrical idle.
"Electrical Idle Exit OS"	Triggers on an electrical idle exit ordered set
"Compliance Pattern"	Triggers on a compliance pattern ordered set.

Remote command:
`TRIGger<m>:PCIE:OSET:TYPE` on page 2036

Error Condition
Triggers on enabled error condition.



"CRC16 error"	Triggers on 16-bit cyclic redundancy check (CRC) errors.
"LCRC error"	Triggers on link cyclic redundancy check (LCRC) errors.
"ECRC error"	Triggers on end-to-end cyclic redundancy checksum (ECRC) errors.
"Invalid symbol"	Triggers on invalid symbol errors.
"Disparity error"	Triggers on disparity errors.

Remote command:
`TRIGger<m>:PCIE:ERRC:CRC` on page 2035
`TRIGger<m>:PCIE:ERRC:DISP` on page 2035
`TRIGger<m>:PCIE:ERRC:ECRC` on page 2036
`TRIGger<m>:PCIE:ERRC:INVP` on page 2036
`TRIGger<m>:PCIE:ERRC:LCRC` on page 2036

12.23.4.2 Triggering on PCIe Gen 1/2

Prerequisite: A bus is configured for the PCIe Gen 1/2 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.23.2.1, "PCIe Gen 1/2 Configuration Settings", on page 922), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

Ser

3. Tap "Serial bus" and select the serial bus that is set to PCIe Gen 1/2, e.g.:

   SB1

   The "Protocol" selection is then automatically set to "PCIe Gen 1/2".
4. Tap "Trigger Type PCI express" and select the trigger type to be used for PCIe Gen 1/2 protocol analysis.
5. Depending on the selected trigger type, more setup conditions can be specified.

For information on how to proceed with the configuration settings, see Chapter 12.23.4.1, "PCIe Gen 1/2 Trigger Settings", on page 927.

12.23.5 PCIe Gen 1/2 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in shows a simulated PCIe Gen 1/2 message.

Figure 12-135: PCIeGen 1/2 protocol: decoded and binary signal

Green brackets [...] = Start and end of frame
Dark green = TLP type packet
Green = DLLP type packet
Red field = Error

The example in Figure 12-136 shows PCIe Gen 1/2 decode results (upper table, showing packets) and decode results details (table below, showing decoded fields of the selected packet).

Figure 12-136: PCIe Gen 1/2 protocol: decoded and binary signal, and decode results

Upper table = Decode results table, see Table 12-37
Lower table = Decode results details, see Table 12-38

Table 12-37: Content of the "Decode results" table

Column	Description
State	Overall state of the packet
Start	Start time of the packet
Stop	Stop time of the packet
Type	Type of packet
Sequence Number	Sequence number
Tag	Tag of the packet
Length	Length of packet
Address	Value of the address
HdrFC	Credit value of the header
DataFC	Credit value of the payload data
Completion status	Completion status field value
Requester ID	Requester ID
Completer ID	Completer ID

Table 12-38: Content of the "Details" table

Column	Description
State	State of the field
Type	Field type
Hex-Value	Hexadecimal value of the field
Formatted	Formatted content of the field

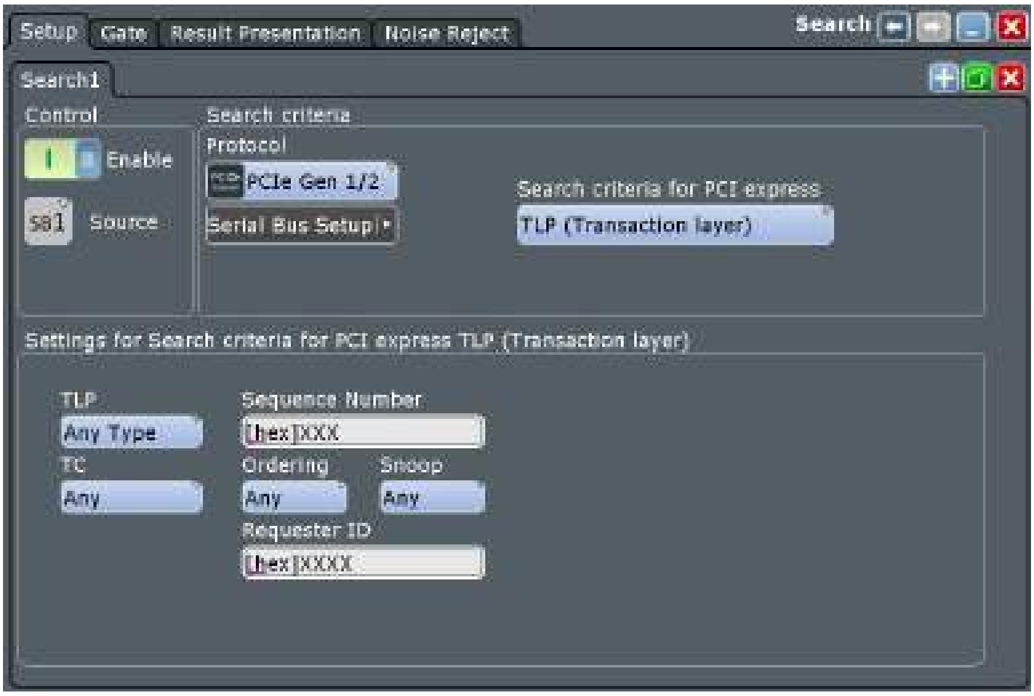
Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.24.4, "Decode Results", on page 2039.

12.23.6 PCIe Gen 1/2 Search

12.23.6.1 PCIe Gen 1/2 Search Settings

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for PCie



Source: SB1

Protocol: PCIe Gen 1/2

Search criteria for PCI express: TLP (Transaction layer)

Settings for Search criteria for PCI express TLP (Transaction layer)

TLP: Any Type

TC: Any

Sequence Number: hex XXX

Ordering: Any

Snoop: Any

Requester ID: hex XXXX

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Searches for PCI express

Selects the search type for the PCI express analysis.

"TLP (Transaction layer)"	Sets the search on a defined type of the transaction layer packet.
"DLLP (Data link layer)"	Sets the search on a defined type of the data link layer packet.
"Ordered Sets"	Sets the search on a defined ordered set.
"Error Condition"	Sets the search on a selection of error conditions.

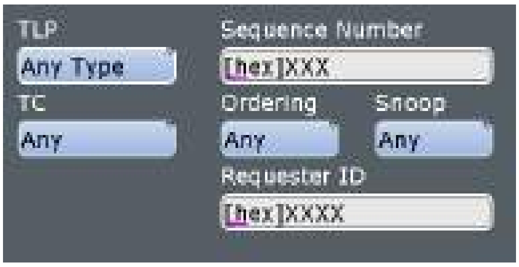
Remote command:
`SEARch:TRIGger:PCIE:TYPE` on page 2059

TLP (Transaction layer)

Specifies the search conditions for the transaction layer type search.

TLP ← TLP (Transaction layer)

Searches for a transaction type.


TLP: Any Type
TC: Any
Sequence Number: [hex]XXX
Ordering: Any
Snoop: Any
Requester ID: [hex]XXXX

"Any type"	Searches for any transaction type.
"Mem"	Searches for memory transaction type used for data transfers to memory-mapped locations.
"IO"	Searches for I/O transaction type used for data transfers to I/O-mapped locations.
"Cfg"	Searches for configuration transaction type used to setup the device functions.
"Msg"	Searches for message transaction type used for transmitting diverse messages.
"Cpl"	Searches for completion without data.

"FetchAdd"	Searches for fetch and add atomic op request.
"Swap"	Searches for unconditional swap atomic op request.
"CAS"	Searches for compare and swap atomic op request transaction type.

Remote command:
`SEARch:TRIGger:PCIE:TLP:TYPE` on page 2059

Sequence Number ← TLP (Transaction layer)
Searches for a sequence number, which indicates if any TLPs have been lost.

Remote command:
`SEARch:TRIGger:PCIE:TLP:SNUM` on page 2059

TC ← TLP (Transaction layer)
Searches for a traffic class which is mapped on a specific virtual channel. The TC label is transmitted unmodified through the fabric.

Remote command:
`SEARch:TRIGger:PCIE:TLP:TCHN` on page 2059

Ordering ← TLP (Transaction layer)
Searches for an ordering. The ordering can be relaxed or strong.

Remote command:
`SEARch:TRIGger:PCIE:TLP:ORDE` on page 2058

Snoop ← TLP (Transaction layer)
Searches for a snoop state.

Remote command:
`SEARch:TRIGger:PCIE:TLP:SNOO` on page 2058

Requester ID ← TLP (Transaction layer)
Searches for a requester ID, consisting of the requester's bus number, device number, and function number.

Remote command:
`SEARch:TRIGger:PCIE:TLP:REID` on page 2058

Device ID ← TLP (Transaction layer)
Searches for a device ID, a field that can be assigned a value by the vendor for classifying root complex register blocks (RCRB). The Device ID is only valid for Configuration transaction. It is composed of 8-bit Bus number, 5-bit Device number and a 3-bit Function number.

Remote command:
`SEARch:TRIGger:PCIE:TLP:DEID` on page 2057

Read/Write ← TLP (Transaction layer)
Searches for a read and/ or write state.

Remote command:
`SEARch:TRIGger:PCIE:TLP:MERW` on page 2057

Address Type ← TLP (Transaction layer)
Searches for an address type. The address type can be 32 bit or 64 bit.

Remote command:
`SEARch:TRIGger:PCIE:TLP:ADRT` on page 2056

Type ← TLP (Transaction layer)
Searches for a configuration type.

Remote command:
`SEARch:TRIGger:PCIE:TLP:CFGT` on page 2056

Routing ← TLP (Transaction layer)
Searches for a selected message routing type.

Remote command:
`SEARch:TRIGger:PCIE:TLP:MSGR` on page 2058

Message Code ← TLP (Transaction layer)
Searches for a specific message code.

Remote command:
`SEARch:TRIGger:PCIE:TLP:MSGC` on page 2057

Status ← TLP (Transaction layer)
Searches for a completion status.

Remote command:
`SEARch:TRIGger:PCIE:TLP:CPLS` on page 2057

Completer ID ← TLP (Transaction layer)
Searches for a completer ID, consisting of the completer's bus number, device number, and function number.

Remote command:
`SEARch:TRIGger:PCIE:TLP:CPID` on page 2056

DLLP Type
Sets the trigger to the type of DLLP. You can refine the settings for the different types according to their specifications.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:TYPE` on page 2052

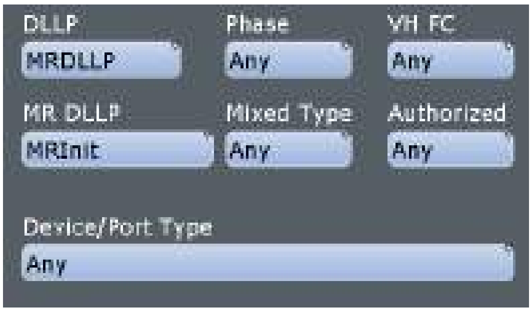
DLLP Any Type conditions
Sets the trigger to any type of DLLP.

DLLP MRDLLP conditions
Specifies the conditions for the multi-root trigger.

MR DLLP ← DLLP MRDLLP conditions
Searches for a multi-root type for the data link layer.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:TYPE` on page 2051

MRInit ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization protocol search.



Phase ← MRInit ← DLLP MRDLLP conditions
Searches for a phase state.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:PHAS` on page 2050

VH FC ← MRInit ← DLLP MRDLLP conditions
Searches for a virtual hierarchies flow control presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:VHFC` on page 2051

Mixed Type ← MRInit ← DLLP MRDLLP conditions
Searches for a mixed type presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:MIXT` on page 2050

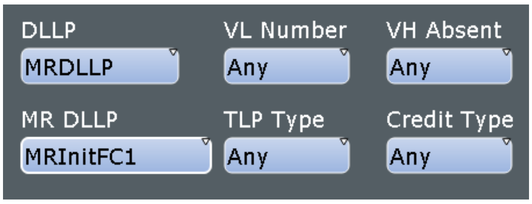
Authorized ← MRInit ← DLLP MRDLLP conditions
Searches for an authorized state presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:AUTH` on page 2049

Device/Port Type ← MRInit ← DLLP MRDLLP conditions
Searches for an device/port type.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:DVPT` on page 2049

MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization flow control protocol search.



DLLP: MRDLLP
VL Number: Any
VH Absent: Any
MR DLLP: MRInitFC1
TLP Type: Any
Credit Type: Any

VL Number ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for a virtual link (VL) number.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:VLNR` on page 2052

VH Absent ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for an absent virtual hierarchies (VH).

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:HABS` on page 2050

TLP Type ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for a transaction layer type for a multi-root data link layer trigger type.

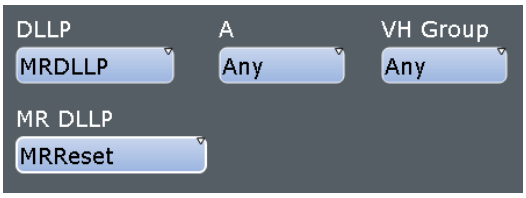
"Any"	Any transaction layer type.
"P"	Posted credit.
"N"	Non posted credit.
"Cpl"	Completion credit.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:TLPT` on page 2051

Credit Type ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for any, data or header credit type.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:FCTL:CRET` on page 2048

MRReset ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root reset protocol search.



DLLP: MRDLLP
A: Any
VH Group: Any
MR DLLP: MRReset

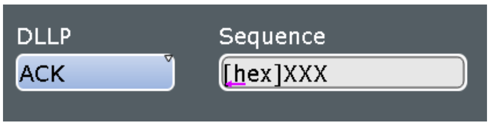
A ← MRReset ← DLLP MRDLLP conditions
Searches for the value of the A bit (Ack/ Request).

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:RESA` on page 2050

VH Group ← MRReset ← DLLP MRDLLP conditions
Searches for the selected virtual hierarchies group.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:VHGR` on page 2051

DLLP ACK/NAK conditions
Searches for an acknowledgement (ACK)/ negative acknowledgment (NAK).



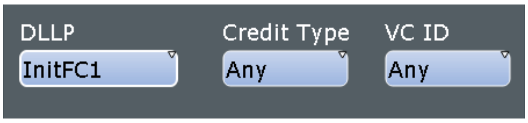
DLLP: ACK

Sequence: [hex]XXX

Sequence ← DLLP ACK/NAK conditions
Searches for the sequence field indicating what TLPs are affected by the ACK/NAK.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:SEQ` on page 2052

DLLP Init FC1/InitFC2/UpdateFC conditions
Searches for flow control initialization/update conditions.



DLLP: InitFC1

Credit Type: Any

VC ID: Any

Credit Type ← DLLP Init FC1/InitFC2/UpdateFC conditions
Searches for a credit type value.

"Any"	Searches for any credit type.
"P"	Searches for posted requests.
"NP"	Searches for non posted requests.
"CPL"	Searches for completions.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:FCTL:CRET` on page 2048

VC ID ← DLLP Init FC1/InitFC2/UpdateFC conditions
Searches for a virtual channel ID value.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:FCTL:VCID` on page 2049

DLLP PM conditions
Searches for a specified power management conditions.

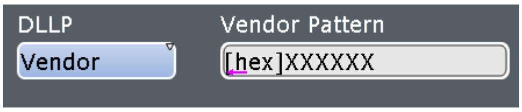
DLLP: PM

PM Type: Any

PM Type ← DLLP PM conditions
Searches for a power management type.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:POWM` on page 2052

DLLP Vendor conditions
Searches for a specified vendor conditions.



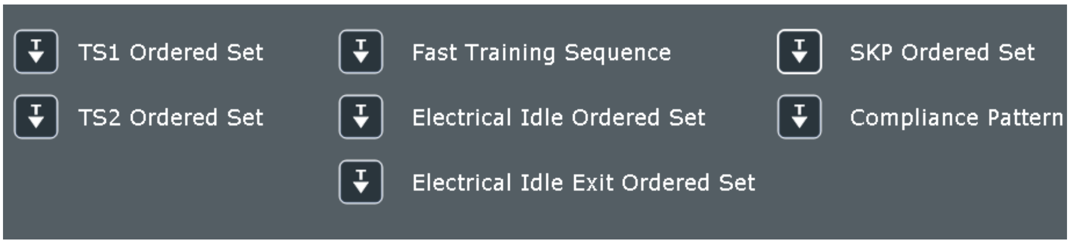
DLLP: Vendor

Vendor Pattern: [hex]XXXXXX

Vendor Pattern ← DLLP Vendor conditions
Searches for a vendor pattern.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:VPAT` on page 2053

Ordered set condition
Searches for the enabled ordered sets.

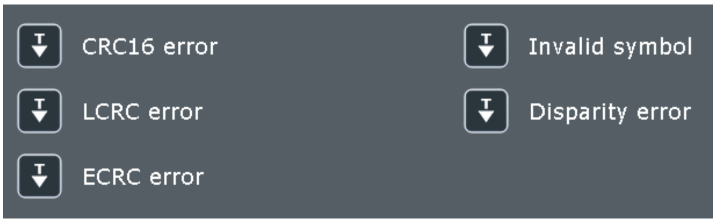


"SKP OS"	Searches for an SKP ordered sets.
"Training Seq 1/2"	Searches for a training sequence ordered set.
"Fast Training Seq"	Searches for a fast training sequence ordered set.
"Electrical Idle OS"	Searches for an electrical idle ordered set that must be send by the transmitter before it can enter the electrical idle.
"Electrical Idle Exit OS"	Searches for an electrical idle exit ordered set.
"Compliance Pattern"	Searches for a compliance pattern ordered set.

Remote command:
`SEARch:TRIGger:PCIE:OSET:COMP` on page 2054
`SEARch:TRIGger:PCIE:OSET:EIDE` on page 2054
`SEARch:TRIGger:PCIE:OSET:EIDL` on page 2055
`SEARch:TRIGger:PCIE:OSET:FTS` on page 2055

`SEARch:TRIGger:PCIE:OSET:SKIP` on page 2055
`SEARch:TRIGger:PCIE:OSET:TSONe` on page 2055
`SEARch:TRIGger:PCIE:OSET:TSTWo` on page 2056

Error Condition
Searches for enabled error conditions.



"CRC16 error"	Searches for 16-bit cyclic redundancy check (CRC) errors.
"LCRC error"	Searches for link cyclic redundancy check (LCRC) errors.
"ECRC error"	Searches for end-to-end cyclic redundancy checksum (ECRC) errors.
"Invalid symbol"	Searches for invalid symbol errors.
"Disparity error"	Searches for disparity errors.

Remote command:
`SEARch:TRIGger:PCIE:ERRC:CRC` on page 2053
`SEARch:TRIGger:PCIE:ERRC:DISP` on page 2053
`SEARch:TRIGger:PCIE:ERRC:ECRC` on page 2053
`SEARch:TRIGger:PCIE:ERRC:INVP` on page 2054
`SEARch:TRIGger:PCIE:ERRC:LCRC` on page 2054

12.23.6.2 PCIe Gen 1/2 Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

Figure 12-137: Search result tables

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

Remote Commands:

- `SEARch:RESult:PCIE:PCOunt?` on page 2066
- `SEARch:RESult:PCIE:PACKet<m>:ADDR?` on page 2060
- `SEARch:RESult:PCIE:PACKet<m>:CPID?` on page 2060
- `SEARch:RESult:PCIE:PACKet<m>:CPS?` on page 2061
- `SEARch:RESult:PCIE:PACKet<m>:DATA?` on page 2061
- `SEARch:RESult:PCIE:PACKet<m>:DFC?` on page 2061
- `SEARch:RESult:PCIE:PACKet<m>:FCOunt?` on page 2062
- `SEARch:RESult:PCIE:PACKet<m>:HFC?` on page 2063
- `SEARch:RESult:PCIE:PACKet<m>:LEN?` on page 2063
- `SEARch:RESult:PCIE:PACKet<m>:RQID?` on page 2064
- `SEARch:RESult:PCIE:PACKet<m>:SEQN?` on page 2064
- `SEARch:RESult:PCIE:PACKet<m>:STARt?` on page 2064
- `SEARch:RESult:PCIE:PACKet<m>:STATe?` on page 2064

- `SEARch:RESult:PCIE:PACKet<m>:STOP?` on page 2065
- `SEARch:RESult:PCIE:PACKet<m>:TAG?` on page 2065
- `SEARch:RESult:PCIE:PACKet<m>:TYPE?` on page 2065
- `SEARch:RESult:PCIE:PACKet<m>:FCOunt?` on page 2062
- `SEARch:RESult:PCIE:PACKet<m>:FLD<n>:FVAL?` on page 2062
- `SEARch:RESult:PCIE:PACKet<m>:FLD<n>:STATus?` on page 2062
- `SEARch:RESult:PCIE:PACKet<m>:FLD<n>:TYPE?` on page 2062
- `SEARch:RESult:PCIE:PACKet<m>:FLD<n>:VAL?` on page 2063

12.23.6.3 Searching for PCIe Gen 1/2

Prerequisite: A bus is configured for the PCIe Gen 1/2 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.23.2.1, "PCIe Gen 1/2 Configuration Settings", on page 922), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to PCIe Gen 1/2, e.g.:

   The "Protocol" selection is then automatically set to "PCIe Gen 1/2".
4. Tap "Trigger Type PCI express" and select the trigger type to be used for PCIe Gen 1/2 protocol analysis.
5. Depending on the selected trigger type, more setup conditions can be specified.

For information on how to proceed with the configuration settings, see Chapter 12.23.4.1, "PCIe Gen 1/2 Trigger Settings", on page 927.

12.24 CXPI (Option R&S RTO-K76)

The Clock Extension Peripheral Interface (CXPI) protocol defines a communication standards for the vehicles electric system. It is developed by the Society of Automotive Engineers of Japan, Inc. (JSAE).

12.24.1 The CXPI Protocol

This chapter provides an overview of the protocol characteristics, frame types and frame fields.

CXPI characteristics

Main characteristics of CXPI are:

- Carrier Sense Multiple Access (CSMA) and Collision Resolution (CR)
- The master sends pulse width modulated clock (PWMC)
- Support of the sleep/wake function to reduce power consumption
- Support of two methods for frame transfer management, the event trigger method and the polling method.
  The event trigger method can be used when the focus is placed on the responsiveness of the slave node communication. The polling method puts the focus on the communication periodicity.
- Maximum baud rate of 20kbit/s
- Up to 16 nodes connected to a communication bus

Frame types

The CXPI protocol defines three types of frames:

- **Normal frame**: it varies in length according to the frame transfer method. The PTYPE field is only used for the polling method.
  The normal frame is used to transfer compact data.

Figure 12-138: CXPI normal frame

- **Sleep frame**: it has a fixed length and fixed values for the PID and data fields. It is sent by the master node to command the slave nods to change into sleep state.

Figure 12-139: CXPI sleep frame

- **Long frame**: it varies in length according to the frame transfer method. The PTYPE field is only used for the polling method.
  The long frame is used to transfer large amount of data.

Figure 12-140: CXPI long frame

During measurements further type of frames may be also occur: PTYPE only, PID only and PTYPE + PID only.

Frame fields

The different frames may contain the following fields:

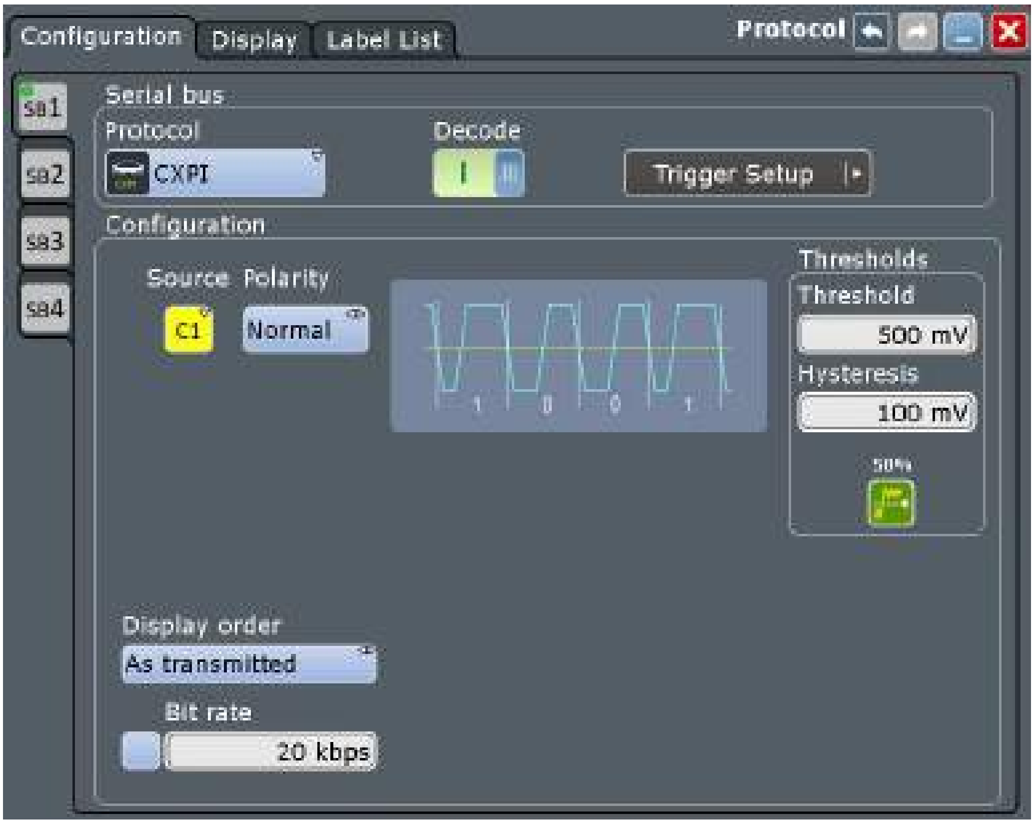
- **PID**: consists of a frame identifier (7 bits) and one parity bit.
- **Protected TYPE (PTYPE)**: a special PID field with a frame identifier of 00 (hex) and a parity of 1. It is used only in the polling method.
- **Frame information**: it consists of the following fields:
  - **Data Length Code (DLC)**: 4 bits that indicate the length of the data byte of a normal frame.
  - **Network Management (NM)**: 2 bits indicating if the frame is in wakeup or sleep mode.
  - **Counter (CT)**: 2 bits indicating the continuity of the frame.
  - **extension DLC**: 1 byte that is added to the frame information for long frames. It indicates the length of the data byte field of a long frame.
- **Data byte**: the length of the data byte field depends on the frame type. It contains the actual information of the frame.
- **Cyclic Redundancy Check (CRC)**: 1 byte for normal and sleep frames and 2 bytes for long frames. CRC errors can be detected to check if the received data is correct.

12.24.2 CXPI Configuration

12.24.2.1 CXPI Configuration Settings

Access: PROTOCOL key > "Configuration" tab > "Protocol" = "CXPI"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 481.

Source

Sets the source channel for the signal.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTO-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:CXPI:SDATa` on page 2068

Polarity

Selects if the polarity of the transmitted waveform is normal (high = 1) or inverted (low = 1).

Remote command:

`BUS<m>:CXPI:POLarity` on page 2068

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. If the signal value on the line is below the threshold, the signal state is low. The interpretation of high and low is defined by the Polarity.

There are two ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:CXPI:THReshold` on page 2068

Hysteresis
Sets a value for the hysteresis.

The hysteresis is applied as ("Threshold" +"Hysteresis") and ("Threshold" - "Hysteresis").

Remote command:
`BUS<m>:CXPI:HYSTeresis` on page 2068

Display order
Selects the order in which the signal is displayed in the honeycomb.

"As transmitted"	The signal is displayed in the order it occurs.
"Logical"	The signal is displayed according to the definition of the standard (MSB bit order).

Remote command:
`BUS<m>:CXPI:DORD` on page 2067

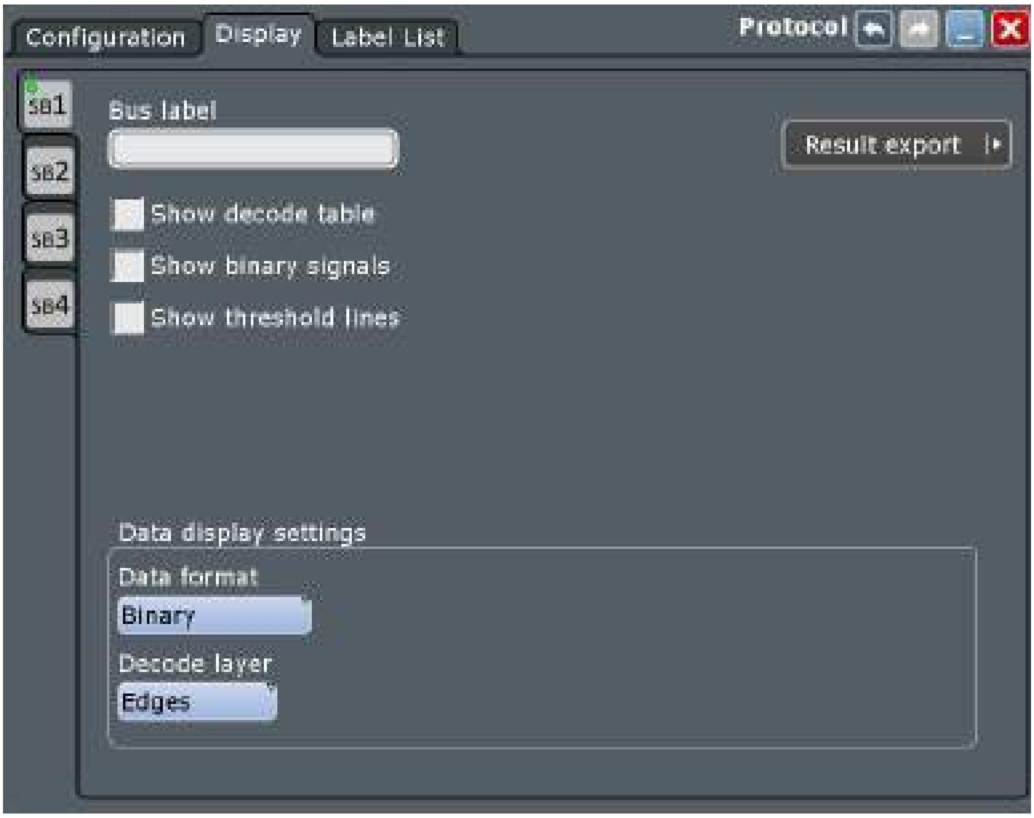
Bit rate/ Average bit rate
If enabled, sets the number of transmitted bits per second. If disabled, the bit rate is measured and the average bit rate in the acquisition window is displayed.

Remote command:
`BUS<m>:CXPI:BITRate:ENABle` on page 2066
`BUS<m>:CXPI:BITRate:VALue` on page 2067
`BUS<m>:CXPI:RESult:BITRate?` on page 2067

12.24.2.2 Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = CXPI" > "Display" tab

To enhance the decode possibilities of the CXPI protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Bus label

☐ Show decode table

☐ Show binary signals

☐ Show threshold lines

Data display settings

Data format: Binary

Decode layer: Edges

Common display settings are explained in Chapter 12.1.2, "Display", on page 482.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Edges"	...
"Final"	...
"Binary"	...
"Bits"	...

12.24.2.3 Configuring the CXPI Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

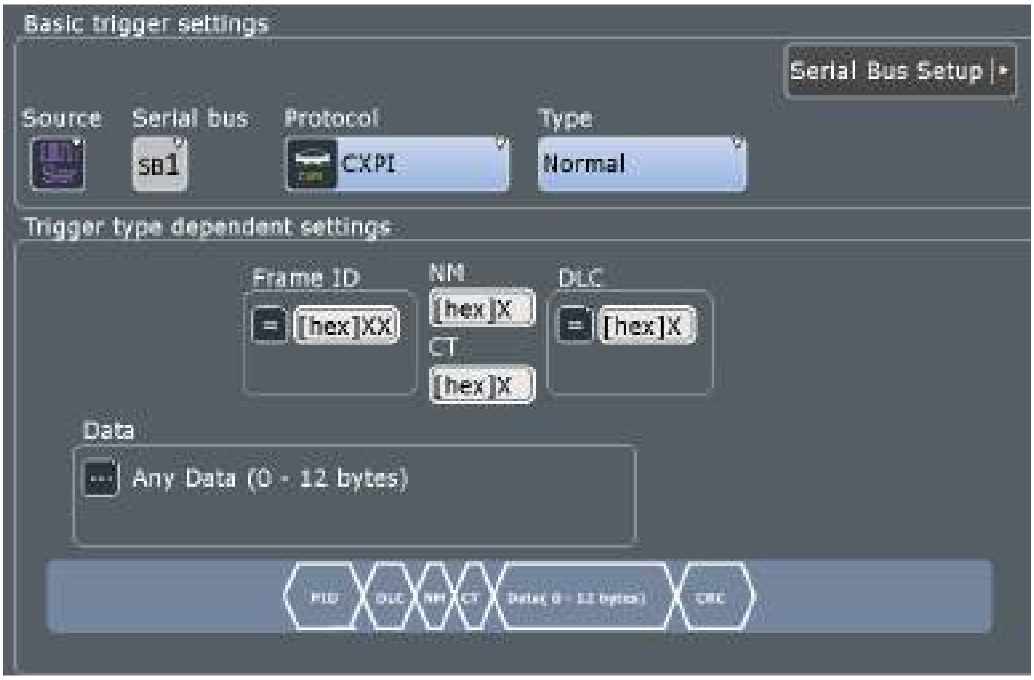
1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "CXPI".

5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Variant" button, and select the protocol.
7. Select the source and the polarity.
8. Enter the "Threshold" and the "Hysteresis".
9. If necessary, enable and set the "Bit rate".
10. Enable "Decode", if available.

12.24.3 CXPI Trigger

12.24.3.1 CXPI Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = CXPI"


Basic trigger settings

Source

Serial bus: SB1

Protocol: CXPI

Type: Normal

Trigger type dependent settings

Frame ID: = [hex]XX

NM: [hex]X

CT: [hex]X

DLC: = [hex]X

Data: Any Data (0 - 12 bytes)

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type for CXPI analysis.

Remote command:
`TRIGger<m>:CXPI:TYPE` on page 2076

Frame Start ← Trigger type

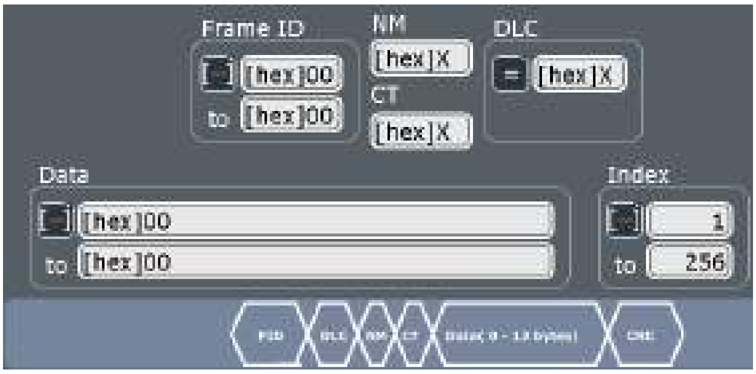
Triggers on a frame start.

Normal ← Trigger type

Triggers on a normal frame.

You can refine the trigger condition:

- Set a frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.
  See: "Frame ID" on page 960
- Set an NM value expected in the frame.
  See "NM" on page 962.
- Set a CT value expected in the frame.
  See: "CT" on page 962.
- Set a DLC pattern or DLC pattern range to trigger only on frames that fulfill these conditions.
  See: "DLC" on page 961.
- Set a data pattern condition to trigger only on frames that fulfill these conditions.
  See: "Data" on page 962.
- Set an index or index range to trigger only on frames that fulfill these conditions.
  See: "Index" on page 962.



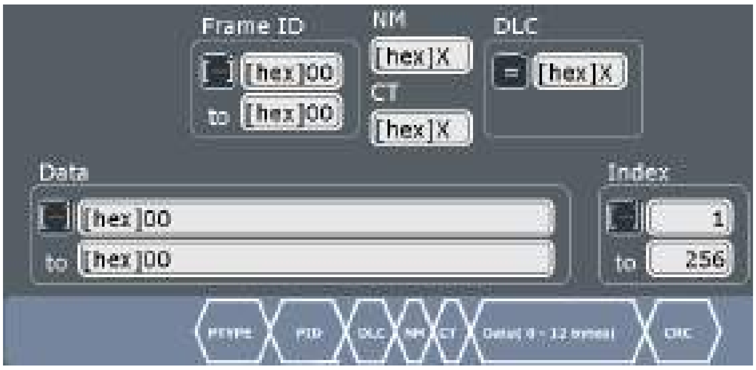
Normal Poll ← Trigger type

Triggers on a normal poll frame.

You can refine the trigger condition:

- Set a frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.
  See: "Frame ID" on page 960
- Set an NM value expected in the frame.
  See "NM" on page 962.

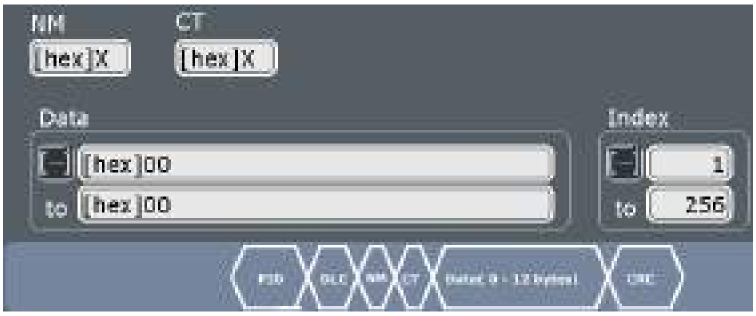
- Set a CT value expected in the frame.
  See: "CT" on page 962.
- Set a DLC pattern or DLC pattern range to trigger only on frames that fulfill these conditions.
  See: "DLC" on page 961.
- Set a data pattern condition to trigger only on frames that fulfill these conditions.
  See: "Data" on page 962.
- Set an index or index range to trigger only on frames that fulfill these conditions.
  See: "Index" on page 962.


Frame ID
= [hex]00
to [hex]00
NM
[hex]X
CT
[hex]X
DLC
= [hex]X
Data
= [hex]00
to [hex]00
Index
= 1
to 256

Sleep ← Trigger type
Triggers on a sleep frame.

You can refine the trigger condition:

- Set an NM value expected in the frame.
  See "NM" on page 962.
- Set a CT value expected in the frame.
  See: "CT" on page 962.
- Set a data pattern condition to trigger only on frames that fulfill these conditions.
  See: "Data" on page 962.
- Set an index or index range to trigger only on frames that fulfill these conditions.
  See: "Index" on page 962.

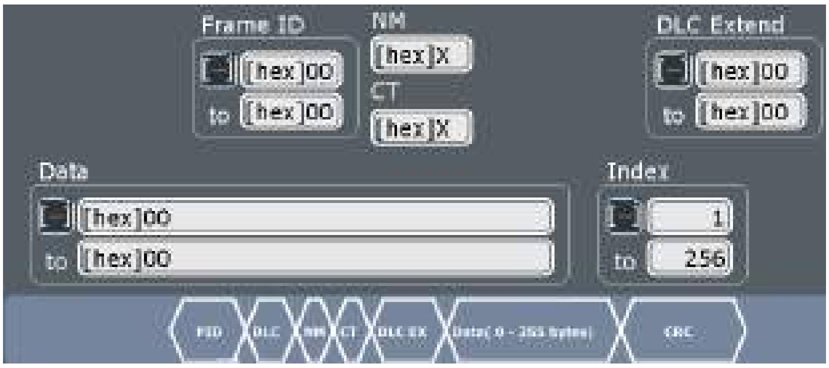

NM
[hex]X
CT
[hex]X
Data
= [hex]00
to [hex]00
Index
= 1
to 256

Long ← Trigger type
Triggers on a long frame.

You can refine the trigger condition:

- Set a frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.
  See: "Frame ID" on page 960

- Set an NM value expected in the frame.
  See "NM" on page 962.
- Set a CT value expected in the frame.
  See: "CT" on page 962.
- Set a DLC extend pattern or DLC extend pattern range to trigger only on frames that fulfill these conditions.
  See: "DLC Extend" on page 961.
- Set a data pattern condition to trigger only on frames that fulfill these conditions.
  See: "Data" on page 962.
- Set an index or index range to trigger only on frames that fulfill these conditions.
  See: "Index" on page 962.



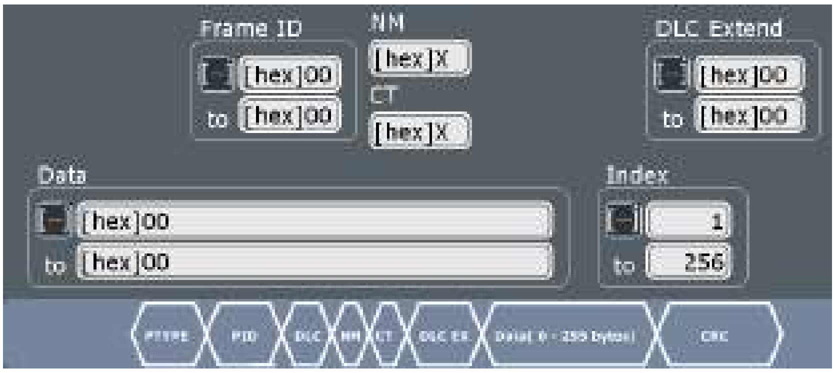
Frame ID [hex]00 to [hex]00
NM [hex]X
CT [hex]X
DLC Extend [hex]00 to [hex]00
Data [hex]00 to [hex]00
Index 1 to 256

Long Poll ← Trigger type

Triggers on a long poll frame.

You can refine the trigger condition:

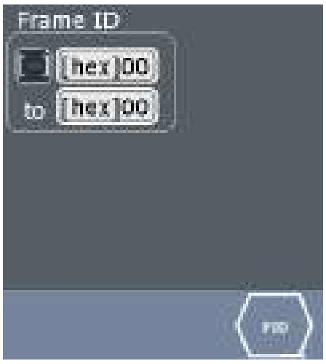
- Set a frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.
  See: "Frame ID" on page 960
- Set an NM value expected in the frame.
  See "NM" on page 962.
- Set a CT value expected in the frame.
  See: "CT" on page 962.
- Set a DLC extend pattern or DLC extend pattern range to trigger only on frames that fulfill these conditions.
  See: "DLC Extend" on page 961.
- Set a data pattern condition to trigger only on frames that fulfill these conditions.
  See: "Data" on page 962.
- Set an index or index range to trigger only on frames that fulfill these conditions.
  See: "Index" on page 962.



PID ← Trigger type
Triggers on a Protected ID (PID) field. A PID field consists of a frame identifier and a parity bit.

Optionally, you can define the frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.

See:"Frame ID" on page 960.



PTYPE ← Trigger type
Triggers on a Protected TYPE (PTYPE) field, a special PID field with a frame ID of 00 (hex) and a parity of 1. It is used only in the polling method.

PTYPE + PID ← Trigger type
Triggers on a PTYPE field followed by a PID field.

Optionally, you can define a frame ID pattern or a frame ID range to trigger only on frames that fulfill these conditions.

See:"Frame ID" on page 960.

Error ← Trigger type
Triggers if one or more of the following errors occur:

- "IFS Error"
  The inter-frame space (IFS) is a bit field after a frame that has a logical value 1. It is used to separate two consecutive frames. IFS errors occur when the length of the IFS field differs from the one defined in the protocol.
- "IBS Error"
  The inter-byte-space (IBS) is the interval between each byte within a frame. IBS errors occur when the length of the IBS field differs from the one defined in the protocol.
- "Length Error"
  Length error occurs when there are not enough bits/words to build a frame.
- "DLC Error"
  Data length code error occurs when the value of the DLC field is different from the data byte field value.In case of a DLC error it is still possible to build a frame, but there are too many/too few data words.
- "CRC Error"
  The transmitting node calculates the cyclic redundancy check (CRC) value of a frame and stores it into the CRC field of the frame. CRC error occurs when this CRC field value differs from the value calculated by the receiving node.
- "Parity Error"
  Triggers on a parity error indicating a transmission error.
- "UART Error"
  For the CXPIstandard, each 8-bit byte is transported as a 10 bit UART word, framed by a start bit (1) and stop bit (0). An UART error occurs if the identified symbol doesn't follow the described pattern, if it is to short or too long.

Frame ID
The frame identifier is a 7-bit field. Its setup consists of the condition and one or two frame patterns.

"Condition"	Defines the operator to set a specific frame identifier ("Equal" or "Not equal") or a frame identifier range.
"Frame ID min / Frame ID"	Defines the bit pattern of the frame identifier. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Frame ID max"	The second frame identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:CXPI:FID:CONDition` on page 2075

`TRIGger<m>:CXPI:FID:MAX` on page 2075

`TRIGger<m>:CXPI:FID:MIN` on page 2076

DLC

Sets the data length code, which indicates the length of the data byte.

The DLC setup consists of the condition and one or two DLC patterns.

"Condition"	Defines the operator to set a specific DLC ("Equal" or "Not equal") or a DLC range.
"DLC min / DLC "	Defines the bit pattern of the DLC. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"DLC max"	The second DLC pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:CXPI:DLC:CONDition` on page 2072

`TRIGger<m>:CXPI:DLC:MAX` on page 2073

`TRIGger<m>:CXPI:DLC:MIN` on page 2073

DLC Extend

Sets the extension data length code, which indicates the length of the data byte of a long frame.

The DLC extend setup consists of the condition and one or two DLC patterns.

"Condition"	Defines the operator to set a specific DLC extend ("Equal" or "Not equal") or a DLC extend range.
"DLC Extend min / DLC Extend"	Defines the bit pattern of the DLC extend. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"DLC Extend max"	The second DLC extend pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:CXPI:DEXTension:CONDition` on page 2071

`TRIGger<m>:CXPI:DEXTension:MAX` on page 2072

`TRIGger<m>:CXPI:DEXTension:MIN` on page 2072

Data

The data setup consists of the condition and one or two identifier pattern.

"Condition"	Defines the operator to set a specific data ("Equal" or "Not equal") or a data range.
"Data min / Data"	Defines the bit pattern of the data. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 488.
"Data max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:CXPI:DATA:DCONdition` on page 2069

`TRIGger<m>:CXPI:DATA:DMAX` on page 2070

`TRIGger<m>:CXPI:DATA:DMIN` on page 2070

Index

The data index setup consists of the condition and one or two index patterns.

"Condition"	Defines the operator to set a specific data index ("Equal" or "Not equal") or data index range.
"Index min / Index"	Defines the bit pattern of the data index.
"Index max"	The second data index is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`TRIGger<m>:CXPI:DATA:ICONdition` on page 2070

`TRIGger<m>:CXPI:DATA:IMAX` on page 2071

`TRIGger<m>:CXPI:DATA:IMIN` on page 2071

NM

Sets the value of the network management (NM) field, 2 bits indicating if the frame is in wakeup or sleep mode.

Remote command:

`SEARch:TRIGger:CXPI:NM` on page 2088

CT

Sets the value of the counter (CT), 2 bits indicating the continuity of the frame.

Remote command:

`TRIGger<m>:CXPI:CT` on page 2069

12.24.3.2 Triggering on CXPI

Prerequisite: A bus is configured for the CXPI signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.24.2.1, "CXPI Configuration Settings", on page 951), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to CXPI, e.g.:

   The "Protocol" selection is then automatically set to "CXPI".
4. Tap "Trigger Type CXPI" and select the trigger type to be used for CXPI protocol analysis.
5. Depending on the selected trigger type, more setup conditions can be specified.

For information on how to proceed with the configuration settings, see Chapter 12.24.3.1, "CXPI Trigger Settings", on page 955.

12.24.4 Search on Decoded CXPI Data

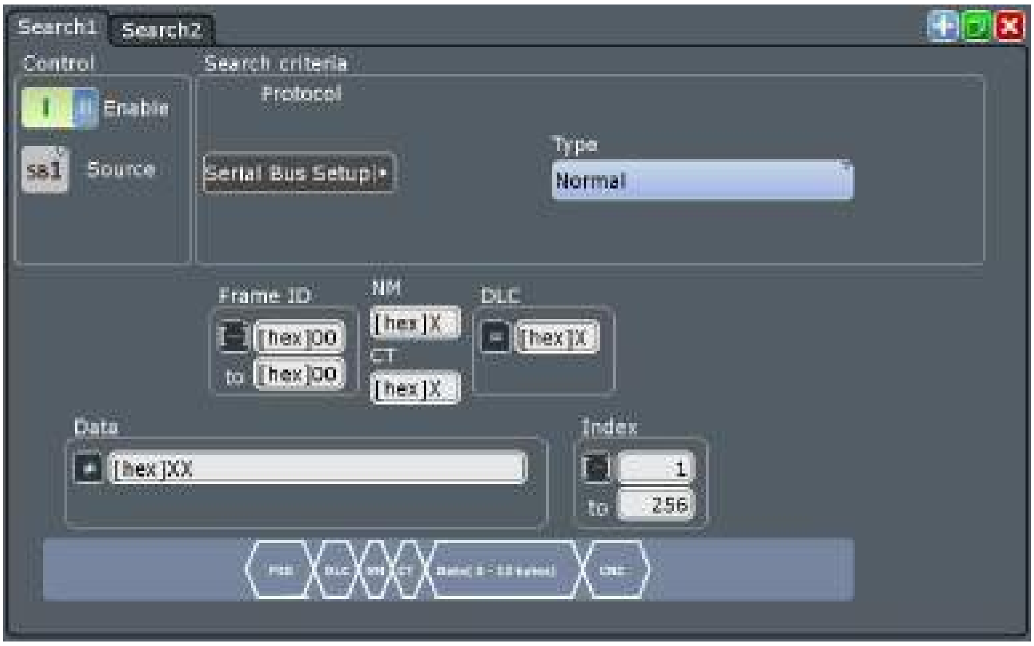
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 419.

12.24.4.1 Search Settings

Access: SEARCH > "Setup" tab



Type: Normal

Frame ID: [hex]00 to [hex]00

NM: [hex]X

CT: [hex]X

DLC: [hex]X

Data: [hex]XX

Index: 1 to 256

Search type

Selects the condition type for the CXPI search.

"Frame Start"	Searches for a frame start.
"Normal"	Searches for a normal frame. You can refine the search condition, see: • "Frame ID" on page 965 • "NM" on page 966 • "CT" on page 966 • "DLC" on page 965 • "Data" on page 966 • "Index" on page 966
"Normal Poll"	Searches for a normal poll frame. You can refine the search condition, see: • "Frame ID" on page 965 • "NM" on page 966 • "CT" on page 966 • "DLC" on page 965 • "Data" on page 966 • "Index" on page 966
"Sleep"	Searches for a sleep frame. You can refine the search condition, see: • "NM" on page 966 • "CT" on page 966 • "Data" on page 966 • "Index" on page 966

"Long"	Searches for a long frame. You can refine the search condition, see: • "Frame ID" on page 965 • "NM" on page 966 • "CT" on page 966 • "DLC Extend" on page 966 • "Data" on page 966 • "Index" on page 966
"Long Poll"	Searches for a long poll frame. You can refine the search condition, see: • "Frame ID" on page 965 • "NM" on page 966 • "CT" on page 966 • "DLC Extend" on page 966 • "Data" on page 966 • "Index" on page 966
"PID"	Searches for a PID field. You can refine the frame identifier, see "Frame ID" on page 965.
"PTYPE"	Searches for a PTYPE field
"PTYPE + PID"	Searches for a PTYPE field followed by a PID field. You can refine the frame identifier, see "Frame ID" on page 965.

Remote command:
`SEARch:TRIGger:CXPI:TYPE` on page 2089

Frame ID

Searches for a frame identifier pattern or a frame identifier range. The setup consists of the condition and one or two frame patterns.

The frame identifier setup settings are the same as in the CXPI trigger setup, see "Frame ID" on page 960.

Remote command:
`SEARch:TRIGger:CXPI:FID:CONDition` on page 2087
`SEARch:TRIGger:CXPI:FID:MAX` on page 2088
`SEARch:TRIGger:CXPI:FID:MIN` on page 2088

DLC

Searches for a DLC pattern or a DLC range. The setup consists of the condition and one or two DLC patterns.

The DLC setup settings are the same as in the CXPI trigger setup, see "DLC" on page 961.

Remote command:
`SEARch:TRIGger:CXPI:DLC:CONDition` on page 2085
`SEARch:TRIGger:CXPI:DLC:MAX` on page 2085
`SEARch:TRIGger:CXPI:DLC:MIN` on page 2085

DLC Extend

Searches for a DLC extend pattern or a DLC extend range. The setup consists of the condition and one or two DLC extend patterns.

The DLC extend setup settings are the same as in the CXPI trigger setup, see "DLC Extend" on page 961.

Remote command:
`SEARch:TRIGger:CXPI:DEXTension:CONDition` on page 2084
`SEARch:TRIGger:CXPI:DEXTension:MAX` on page 2084
`SEARch:TRIGger:CXPI:DEXTension:MIN` on page 2085

Data

Searches for a data pattern or a data range. The setup consists of the condition and one or two data patterns.

The data setup settings are the same as in the CXPI trigger setup, see "Data" on page 962.

Remote command:
`SEARch:TRIGger:CXPI:DATA:DCONdition` on page 2082
`SEARch:TRIGger:CXPI:DATA:DMAX` on page 2082
`SEARch:TRIGger:CXPI:DATA:DMIN` on page 2083

Index

Searches for a data index pattern or a data index range. The setup consists of the condition and one or two index patterns.

The index setup settings are the same as in the CXPI trigger setup, see "Index" on page 962.

Remote command:
`SEARch:TRIGger:CXPI:DATA:ICONdition` on page 2083
`SEARch:TRIGger:CXPI:DATA:IMAX` on page 2083
`SEARch:TRIGger:CXPI:DATA:IMIN` on page 2084

NM

Searches for the value of the network management (NM), 2 bits indicating if the frame is in wakeup or sleep mode.

Remote command:
`TRIGger<m>:CXPI:NM` on page 2076

CT

Searches for the value of the counter (CT), 2 bits indicating the continuity of the frame.

Remote command:
`SEARch:TRIGger:CXPI:CT` on page 2082

Error

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the CXPI trigger setup, see "Error" on page 960.

12.24.4.2 Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 420
- Chapter 10.4, "Result Presentation", on page 437

The columns in the search result table are the same as in the decoding table, see Chapter 12.24.5, "CXPI Decode Results", on page 968.

Remote commands:

- `SEARch:RESult:CXPI:FCOunt?` on page 2090
- `SEARch:RESult:CXPI:FRAMe<m>:STATe?` on page 2091
- `SEARch:RESult:CXPI:FRAMe<m>:STARt?` on page 2091
- `SEARch:RESult:CXPI:FRAMe<m>:STOP?` on page 2091
- `SEARch:RESult:CXPI:FRAMe<m>:TYPE?` on page 2092
- `SEARch:RESult:CXPI:FRAMe<m>:DATA?` on page 2090
- `SEARch:RESult:CXPI:FRAMe<m>:DLCV?` on page 2091
- `SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:TYPE?` on page 2092
- `SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:VALue?` on page 2093
- `SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:STATus?` on page 2092

12.24.4.3 Searching CXPI Data

Prerequisites: A CXPI bus is configured, see Chapter 12.24.2, "CXPI Configuration", on page 951, and "Decode" is enabled.

1. Press the SEARCH key on the front panel.
2. Tap the "Source" button and select the serial bus that is set to CXPI.

   "Protocol" shows the CXPI icon.
3. Tap "Type" and select the search type.

All trigger types are also available for search.

4. To refine the search settings, configure additional settings, which are available for many search types.
   For details, see Chapter 12.24.4.1, "Search Settings", on page 963.
5. Under "Control", "Enable" the search.

   The "Search Results" box opens.
6. Close the "Search" dialog box.
7. Press RUN STOP to start acquisition.
8. Stop acquisition, or tap "Show search zoom window".

   Now you can navigate the search results and analyze the signal.

12.24.5 CXPI Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 482

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Figure 12-141: Decoded CXPI signal, normal polling frame

green brackets [...] = start and end of frame
green frame header = frame state is ok
red frame header = error in frame
green = Frame type/ frame ID
green = DLC
grey = IBS
dark blue = CT
yellow = NM
orange = Data
red = Error occurred

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Frame	State	Start	Stop	Type	Data	DLC field
1	CRC Error	-14.0004 ms	-8.5997 ms	Normal Polling	[4]A1A2A3A4	4
2	CRC Error	-7.5497 ms	-50.2 µs	Sleep	[8]00FFFFFF...	8
3	CRC Error	999.9 µs	14.0000 ms	Long Polling	[14]A1A2A3A4...	14

Type : Normal Polling
State : CRC Error
Start : -14.0004 ms
Stop : -8.5997 ms

Data

Type	Numeric value	Status
P	[hex] 01	Ok
FrameID	[hex] 64	Ok
P	[hex] 00	Ok
CT	[hex] 00	Ok
NW	[hex] 02	Ok
DLC	[hex] 04	Ok
Data: 1	[hex] A1	Ok
Data: 2	[hex] A2	Ok
Data: 3	[hex] A3	Ok
Data: 4	[hex] A4	Ok
CRC (calc = 0xB)	[hex] 03	CRC Error

Figure 12-142: Decoded CXPI signal result tables, normal polling frame with CRC error

Table 12-39: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Start	Time of frame start
Stop	Time of frame stop
Type	Frame type: normal, normal polling, sleep, long, long polling, PID, PTYPE, PTYPE +PID, unknown, inter-frame-space
Data	Displays the first four data words in the frame. For the value of the following data words, refer to Content of the "Decode results details" table.
DLC field	Data length code, number of data bytes

Table 12-40: Content of the "Decode results details" table

Column	Description
Type	Type (name) of field
Numeric value	The numeric value of the field
Status	Status of the field: OK or error

Export of decode results

You can export the decode results to a CSV or HTML file:

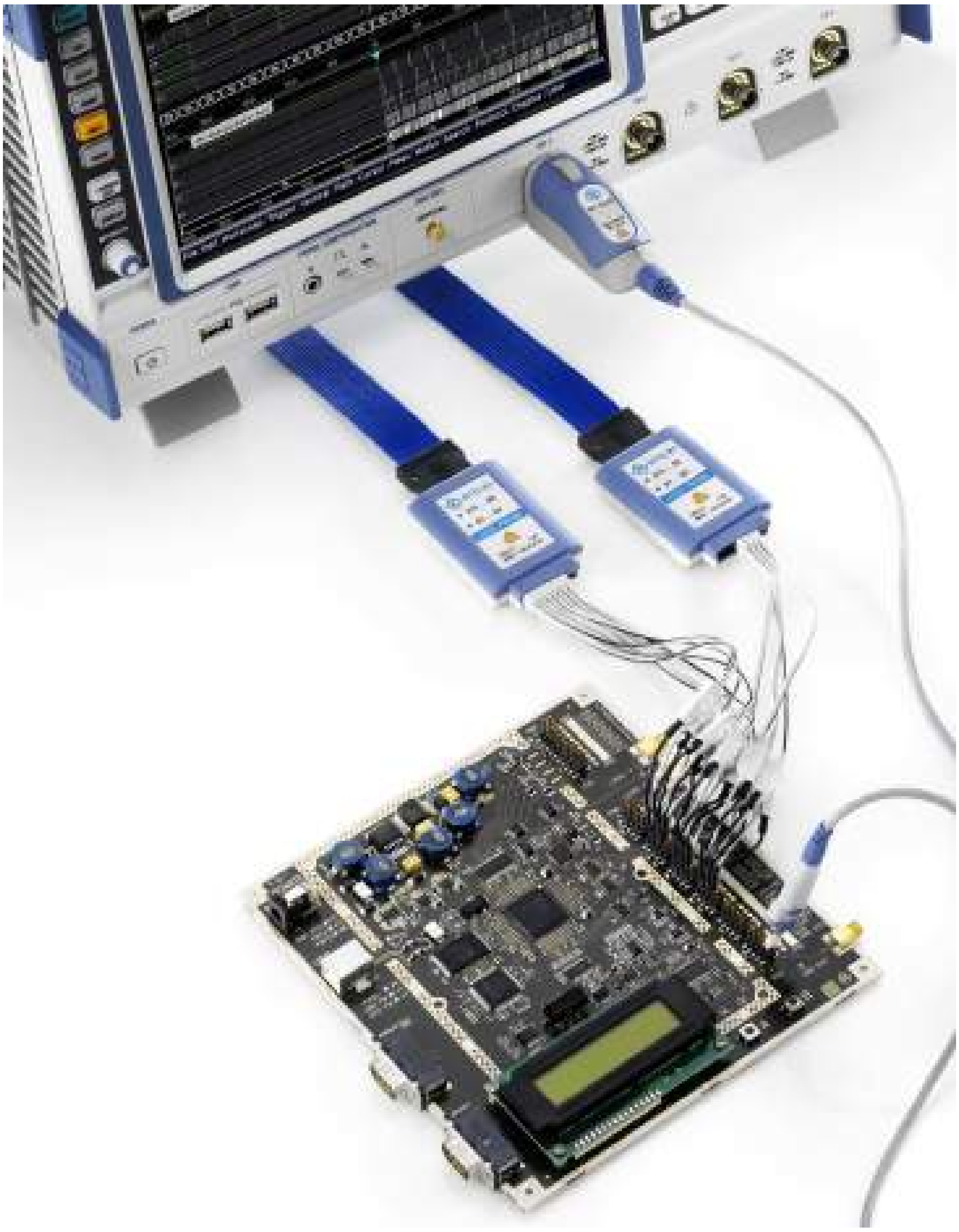
1. Press the SAVE RECALL key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.25.3, "Decode Results", on page 2077.

13 Mixed Signal Option (MSO, R&S RTO-B1)

The Mixed Signal Option R&S RTO-B1 adds logic analyzer functions to the classical oscilloscope functions. Using the MSO option, you can analyze and debug embedded systems with mixed-signal designs that use analog signals and correlated digital signals simultaneously.



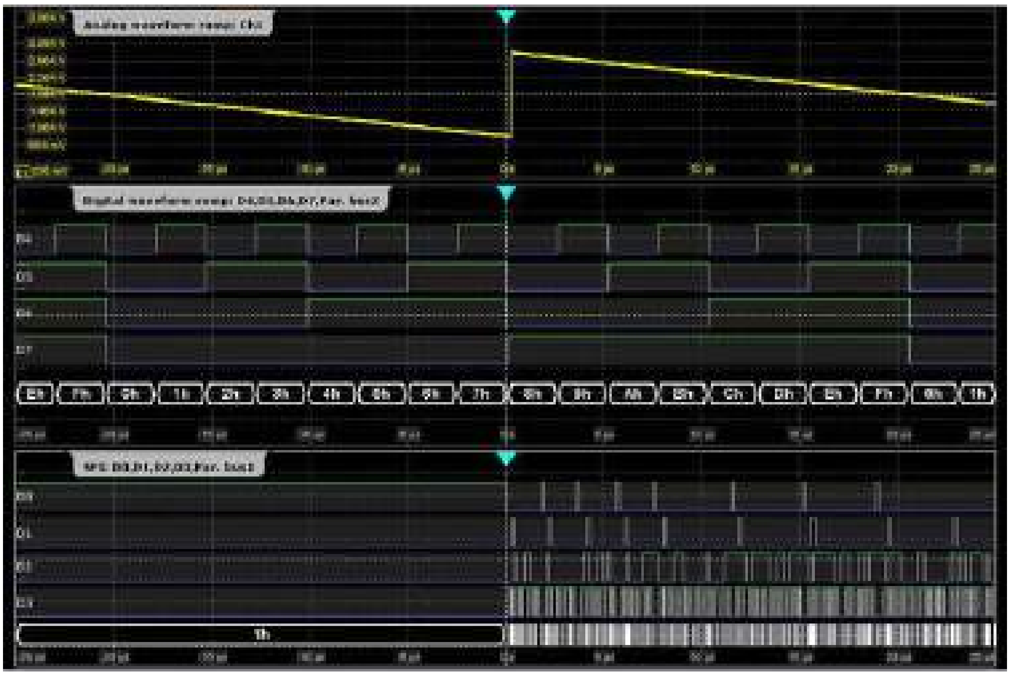
The Mixed Signal Option provides 16 digital channels grouped in two logic probes (pods) with 8 channels each. The instrument ensures that analog and digital waveforms are time-aligned and synchronized so that critical timing interactions between analog and digital signals can be displayed and tested. The automatic alignment compensates the skew between the probe connectors of the analog channels and the probe boxes of the digital channels.

13.1 Digital channels and parallel buses

Each digital channel can be displayed on the screen and used as trigger source. Digital channels may be grouped and displayed as a parallel bus. Up to four parallel buses can be configured; and two bus types are supported: clocked bus and unclocked bus. The clocked bus is available only on parallel bus 1 and 2. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

You can display each bus and use it as trigger source, as well. For each active parallel bus, the corresponding signal icon appears on the signal bar and indicates the assigned digital channels. Individual digital channels do not have a signal icon.

If one or more parallel buses are active, the roll mode is not available.

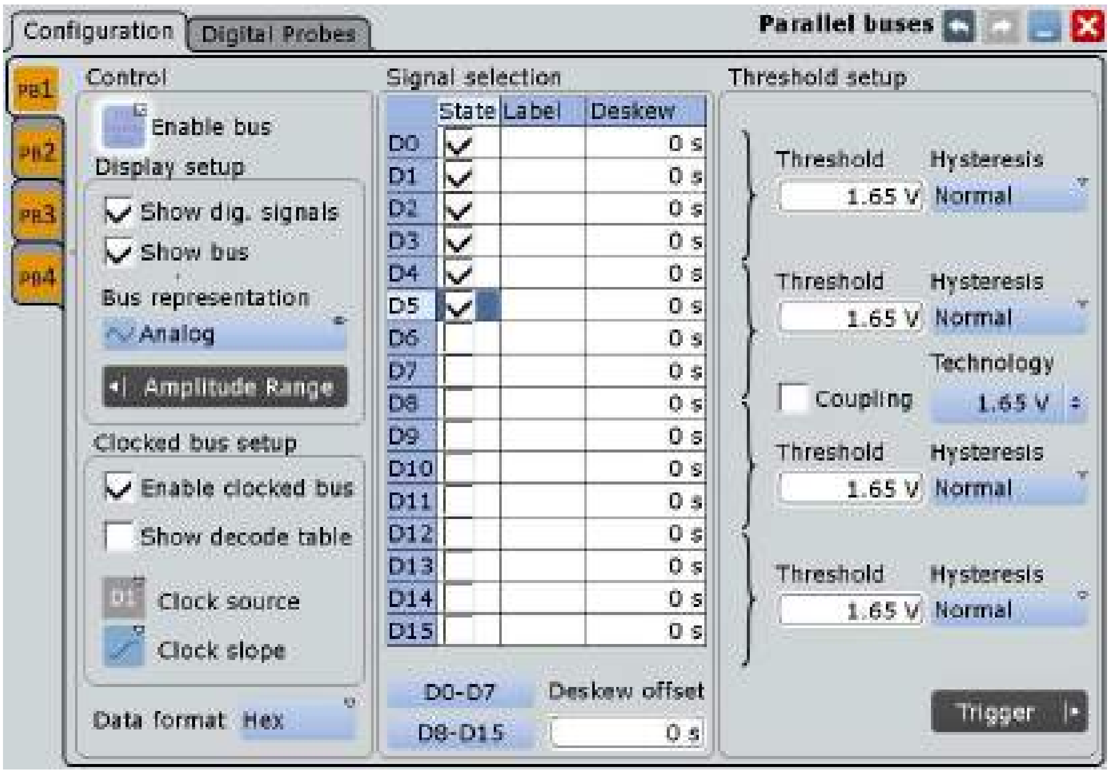


13.1.1 Parallel Buses - Configuration

Access: "Analysis" menu > "Parallel buses"

Digital channels can be displayed individually, and they can be grouped and displayed as a parallel bus. You can configure and enable up to 4 parallel buses. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

For clocked buses, you can display the decoded data in a result box.



☐ Enable bus

☑ Show dig. signals

☑ Show bus

Bus representation: Analog

☑ Enable clocked bus

☐ Show decode table

Data format: Hex

	State	Label	Deskew
D0	☑		0 s
D1	☑		0 s
D2	☑		0 s
D3	☑		0 s
D4	☑		0 s
D5	☑		0 s
D6	☐		0 s
D7	☐		0 s
D8	☐		0 s
D9	☐		0 s
D10	☐		0 s
D11	☐		0 s
D12	☐		0 s
D13	☐		0 s
D14	☐		0 s
D15	☐		0 s

D0-D7 D8-D15 Deskew offset: 0 s

Threshold	Hysteresis
1.65 V	Normal
1.65 V	Normal
1.65 V	Normal
1.65 V	Normal

☐ Coupling

Technology: 1.65 V

If you have configured several parallel buses and you want to modify the configuration or display settings, make sure that the tab of the correct bus is selected on the left side, and disable the bus before you change the settings.

Enable bus

Enables the selected parallel bus. The corresponding signal icon appears on the signal bar.

If another *active* bus already uses the same digital channel(s), the instrument disables the other bus and shows a message.

Remote command:

`BUS<m>:PARallel:STATe` on page 2097

Show dig. signals

If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Remote command:

`BUS<m>:PARallel:DISPlay:SHDI` on page 2100

Show bus

If enabled, the resulting bus signal and bus values are displayed in the diagram. Select the presentation type for the bus signal with Bus representation.

Remote command:

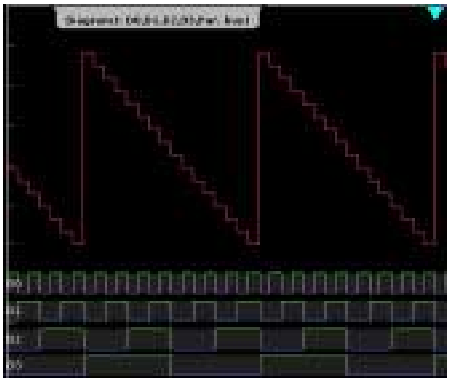
`BUS<m>:PARallel:DISPlay:SHBU` on page 2101

Bus representation

Defines how the parallel bus is displayed:

"Comb" Displays the decoded bus signal with bus values. When at least one digital channel changes its value, the bus value changes too.

"Analog" Displays the bus values as signal amplitudes, similar to an analog waveform. Thus, a quasi-analog waveform is created.

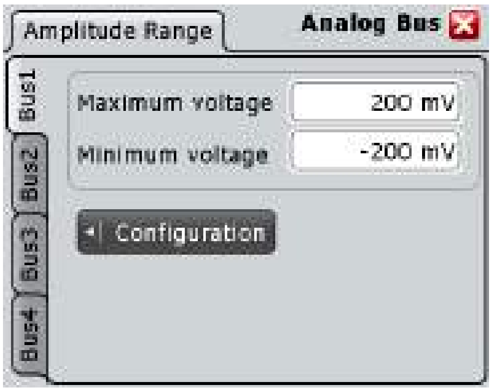


Remote command:

`BUS<m>:PARallel:DISPlay:BTYP` on page 2101

Amplitude Range

If the bus representation is "Analog", the amplitude range defines the voltage range for the display of the analog bus. The highest bus value corresponds to the "Maximum voltage", and the lowest bus value to the "Minimum voltage".



Maximum voltage 200 mV
Minimum voltage -200 mV

See also: "Bus representation" on page 975

Clocked bus setup
If a bus is a clocked bus, one of the digital channels serves as clock of the bus.

For an unclocked bus, the logical state of the bus is determined for each sample. For a clocked bus, the logical state is determined only at the specified clock edges.

The settings are only available for "Bus1" and "Bus2".

"Enable clocked bus"	Enable this option, if the bus is a clocked bus.
"Show decode table"	The decode table is only available for clocked buses to check the data words. If enabled, a results box opens with decoded values of the bus signal and its time. Each clock edge corresponds to one row in the table.
"Clock source"	Selects the digital channel used as clock.
"Clock slope"	Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Remote command:
`BUS<m>:PARallel:CLON` on page 2101
`BUS<m>:PARallel:CLOCk` on page 2102
`BUS<m>:PARallel:CLSLope` on page 2102

Data format
Sets the data format of bus values, which are displayed in the decode table and on the comb bus display. Available formats are: Hex, Ascii, Octal, Binary, Signed, and Unsigned.

Signed and Unsigned are integer data types with maximum 16 bit length. Unsigned is used for positive integers. Signed is used for positive and negative integers.

If the target file format is BIN, you can save only signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Remote command:
`BUSFormat` on page 1497

Signal selection

In the table, you select and configure the digital channels that are used in the selected bus.

"State"	Enables a digital channel, and assigns it to the bus.
"Label"	You can enter a name for each digital channel. The name is displayed in the diagram.
"Deskew"	Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument. You can also set a value that is applied to all digital channels, see "Deskew offset" on page 977.

Remote command:
`BUS<m>:PARallel:BIT<n>[:STATe]` on page 2097 (all buses)
`DIGital<m>:DISPlay` on page 2093 (Bus1)
`BUS<m>:PARallel:BIT<n>:LABel` on page 2100 (all buses)
`DIGital<m>:LABel` on page 2095 (Bus1)
`BUS<m>:PARallel:BIT<n>:DESKew` on page 2099 (all buses)
`DIGital<m>:DESKew` on page 2096 (Bus1)

D0-D7, D8-D15 ← Signal selection

The buttons select or deselect all digital channels of a pod at once.

Deskew offset ← Signal selection

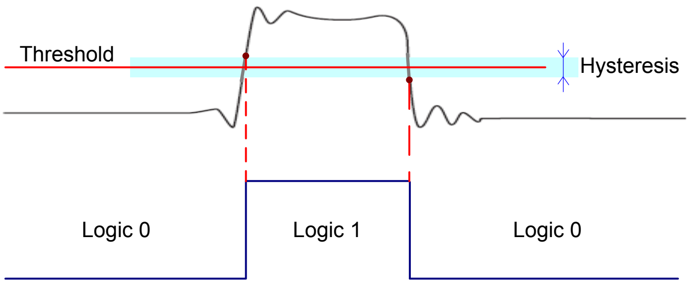
Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of the general "Deskew offset" and the individual "Deskew".

Remote command:
`BUS<m>:PARallel:DESoffset` on page 2100

Threshold setup

Sets the logical threshold. For each sample, the instrument compares the input voltage with the threshold value. If the input voltage is above the threshold, the signal state "1" is stored. Otherwise, the signal state "0" is stored if the input voltage is below the threshold.

To avoid the change of signal states due to noise, a hysteresis is considered.



By default, same threshold and hysteresis value is used for all digital channels and all parallel buses: "Coupling" is enabled.

You can also set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values, the settings of the last activated bus take effect.

The range of threshold levels and the minimum voltage swing are given in the data sheet.

"Threshold"	Enter the value directly in the field.
"Technology"	Selects the threshold voltage for various types of integrated circuits from a list and applies it to all digital channels. The value is set to "Manual" if a user-defined threshold was entered directly.
"Coupling"	Sets the threshold and the hysteresis for all digital channels and all buses to the same value.
"Hysteresis"	Defines the size of the hysteresis. Three values are available: ● Normal: the instrument sets a small value suitable for the signal and its settings. Use this setting for clean signals. ● Maximum: the instrument sets the maximum value that is possible and useful for the signal and its settings. Use this setting for noisy signals. ● Robust: sets different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. Use this setting for very noisy signals. See also: "Robust trigger" on page 209.

Remote command:

`BUS<m>:PARallel:TECHnology` on page 2098 (all buses)
`DIGital<m>:TECHnology` on page 2094 (bus1)
`BUS<m>:PARallel:THReshold<n>` on page 2097 (all buses)
`DIGital<m>:THReshold` on page 2094 (bus1)
`BUS<m>:PARallel:THCoupling` on page 2098 (all buses)
`DIGital<m>:THCoupling` on page 2095 (bus1)
`BUS<m>:PARallel:HYSTeresis<n>` on page 2099 (all buses)
`DIGital<m>:HYSTeresis` on page 2095 (bus1)

13.1.2 Parallel Buses - Digital Probes

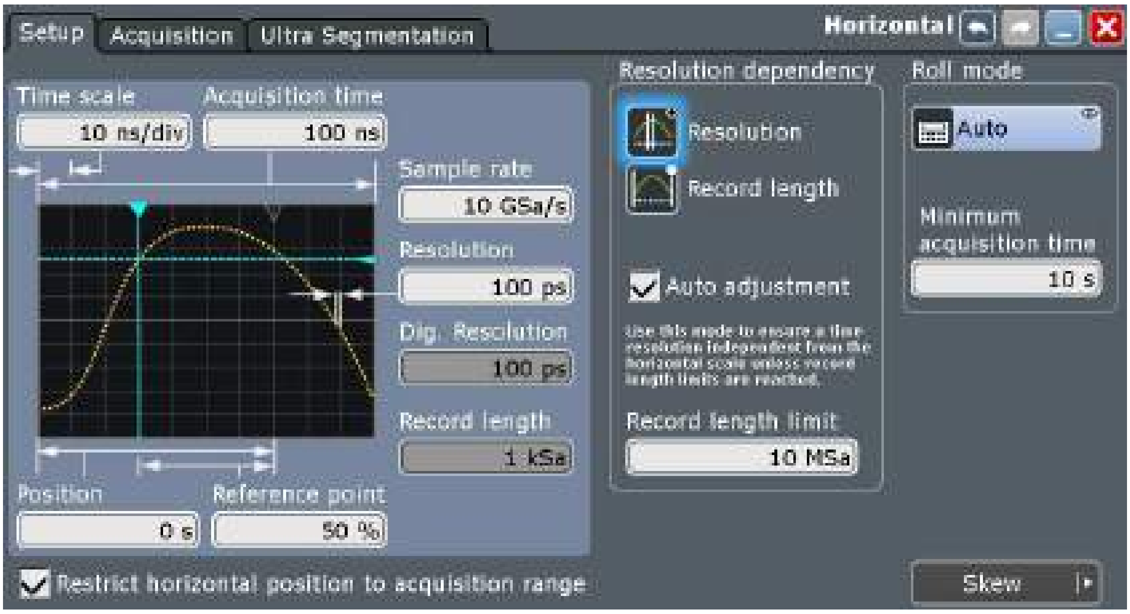
Access: "Analysis" menu > "Parallel buses" > "Digital Probes" tab

Logic probes provided by R&S are recognized by the instrument. The fields show the characteristics of each recognized probe (pod) for information. "Write EEPROM" and "Flash it" are service functions.

13.1.3 Digital Resolution

Access: RES REC LEN key

If an MSO option is installed and at least one digital channel is active, additional information appears on the "Setup" tab of the "Horizontal" dialog box.



Time scale: 10 ns/div

Acquisition time: 100 ns

Sample rate: 10 GSa/s

Resolution: 100 ps

Dig. Resolution: 100 ps

Record length: 1 kSa

Position: 0 s

Reference point: 50 %

☑ Restrict horizontal position to acquisition range

☑ Auto adjustment

Record length limit: 10 MSa

Auto

Minimum acquisition time: 10 s

Dig. resolution

Shows the current digital resolution of the digital channels. The maximum digital record length is always 200 MSa per digital channel. This number is independent of additionally installed memory.

Remote command:

`ACQuire:DRESolution?` on page 2103

13.1.4 Using Digital Probes

NOTICE

Ensuring accurate measurement results

The mixed-signal-option (MSO, R&S RTO-B1) with connected probe leads is considered as a test probe, according to EN 61326-2-1, clause 5.2.4.101. Therefore, the measurements are sensitive to electromagnetic interference. Consider additional shielding methods to avoid interference.

Consider the following guidelines for good probing practices:

- The ground lead from each digital channel group (D15–D8 and D7–D0) should be attached to the ground of the device under test if any channel within the group is being used for data capture. The ground lead improves signal fidelity to the oscilloscope, ensuring accurate measurements.
- For high-speed timing measurements (rise time < 3 ns), each digital channel probe should use its own ground.

---

1. Connect the digital probe cable to any of the MSO connectors on the rear panel of the instrument as shown on the Documentation Card delivered with the digital probe.
2. Connect the ground lead on each set of channels (each pod) with a probe grabber.
3. Connect a grabber to one of the probe leads.
4. Connect the grabber to a node in the circuit you want to test.
5. For high-speed signals, connect a ground lead to the probe lead, and connect the ground lead to ground in the device under test.
6. Repeat these steps until you have connected all points of interest.

13.1.5 Configuring Digital Channels and Parallel Buses

The configuration of a parallel bus includes the selection and setup of the digital channels, the configuration of the bus display, and, if required, the clock configuration.

For a detailed description of the settings, see Chapter 13.1.1, "Parallel Buses - Configuration", on page 973.

1. On the "Analysis" menu, tap "Parallel buses".
2. In the "State" column of the "Signal selection" table, enable the digital channels to be displayed and included in the bus.
   To enable or disable all channels of a pod at once, tap "D0-D7" or "D8-D15".

   Enabling one or more channels also enables the display of the signals - "Show dig. signals", and enables the parallel bus. If another active bus already uses the same digital channel(s), the instrument disables this bus and shows a message.
   The digital signals are shown in the diagram, and the signal icon of the parallel bus appears on the signal bar. Using this bus icon, you can minimize, arrange, and switch off the bus together with its channels in the same way as you do with any waveform.
3. Optionally, you can enter a "Label" for each digital channel, and a "Deskew" value to time-align the channel.
4. Set the logical thresholds as described in Chapter 13.1.6, "Setting the Logical Thresholds", on page 980.
5. If the bus has a clock signal, enable "Bus clocked" and select the "Clock source" and "Clock slope".

   Now the configuration of the parallel bus is completed.

13.1.6 Setting the Logical Thresholds

For a detailed description of the settings, see "Threshold setup" on page 977. Threshold settings are the same for all *active* parallel buses.

1. On the "Analysis" menu, tap "Parallel buses".
2. To set the thresholds, use one of the following ways:
    - Use the same value for all digital channels and all parallel buses: Enable "Coupling" and set one threshold value, either select a predefined "Technology" value or enter a user-defined value.
    - Set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values.
3. Set the "Hysteresis" for each threshold to avoid the change of signal states due to noise.

13.2 Display

You can adjust the display of the parallel bus signals and the individual digital channels to optimize the analysis of bus data:

- show the digital channels which are assigned to the bus, drag them to the optimal position, and scale them
- show the decoded bus signal in different ways:
    - comb display with numeric bus values
    - analog display with bus values as amplitudes (quasi-analog waveform)

  You can also drag the bus waveforms on the display and scale them.
- show the result box of the decoded clocked bus signal

Each parallel bus is shown in a separate diagram, and the diagrams can be minimized and arranged as usual.

The signal icon indicates the activities on the digital channels even if they are not displayed in the diagram, of if the acquisition has been stopped:

- blue: channel is low
- green: channel is high
- gray: channel state is changing

The display update rate of the oscilloscope is adapted to the visual perception of human eyes, and it is slower than the acquisition rate. All analog and digital waveforms that are acquired during one display update cycle are overlapped and displayed at once. Thus you can see the cumulative occurance of binary states and edge transitions on the screen at once. Bus signals are not overlapped.

The trigger point is always visible on the display, it cannot be moved outside ("Restrict horizontal position to acquisition range" is enabled automatically).

If digital channels are active, the trigger point is always visible on the display, it cannot be moved outside.

To access and analyze one or more specific acquisitions, you can use the History Viewer in the common way.

Furthermore, you can zoom in digital signals and bus signal in the same way as in analog waveforms.

See also:

- Chapter 6.4, "History", on page 281
- Chapter 6.1, "Zoom", on page 248

13.2.1 Parallel Bus - Decode Table

Decoding is available for clocked parallel buses.

The decode table shows the decoded data words of the bus signal and the corresponding time. Each clock edge corresponds to one row in the table. Below the table, you can select the data format of the bus values.

The results can be saved to a csv or html file, see Chapter 11.2.4, "Numeric Results", on page 462.

13.2.2 Adjusting the Display of Digital Channels and Parallel Buses

The display of digital channels and parallel buses is flexible, you can adjust it to your needs by combining the following settings:

1. Enable "Show bus" if you want to display the bus signal in the diagram. Under "Bus representation", select if you want to display the decoded bus signal with bus values ("Comb"), or show the bus values as amplitudes, similar to an analog waveform ("Analog").
2. Check the signal icon of the bus to monitor the activities on the digital channels even if they are not displayed in the diagram, of if the acquisition has been stopped:
    - blue: channel is low
    - green: channel is high
    - gray: channel state is changing
3. In the diagram, you can change the display order of the digital channels by dragging the individual channels to the required position.
4. To adjust the line height and vertical position of all digital channels at once, tap one of the digital channels and turn the vertical SCALE and POSITION rotary knobs. In the same way, you can move and scale the bus signal.

5. If the bus signal is displayed as quasi-analog waveform, you can doble-tap the waveform to open the "Parallel buses" dialog box.
6. To switch off the display of the digital channels, disable "Show signals".

13.3 Trigger

For digital trigger sources are all trigger types useful that require only one trigger level as trigger condition. This level is the logical threshold. Possible trigger sources are the individual digital channels, parallel bus signals, or any logical combination of digital channels. The following trigger types are available:

Table 13-1: Trigger types and digital trigger sources

Trigger type	Trigger source is		
	Digital channel	**Logic combination of digital channels**	**Parallel bus**
Edge	X	X	
Width	X	X	
Timeout	X	X	
Data2Clock	X		X
State		X	X
Pattern (with holdoff)		X	X
Serial Pattern	X	X	

For details, see: Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 983.

Additionally, you can define trigger holdoff conditions. See also Chapter 5.5, "Holdoff", on page 235.

13.3.1 Trigger Settings for Digital Signals and Parallel Buses

Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings.

The settings in the "Event" tab are:

13.3.1.1 Basic Trigger Settings

The basic trigger settings for MSO are the trigger source and the trigger type. They are selected in the upper part of the "Trigger" dialog box.

Make sure that the trigger sequence is set to "A only".

Additionally, you can define trigger holdoff conditions. See also Chapter 5.5, "Holdoff", on page 235.

Source
If the Mixed Signal Option is installed, the variety of trigger sources of the A-event setup is enhanced with specific digital trigger sources. You can select as trigger source:

- one of the digital channels "D0" ... "D15"
  D0 D1 D2
- a logic combination of digital channels: "Logic"
- one of the parallel buses "Par. bus1" ... "Par. bus4"
  PB1 PB2 PB3

Remote command:
`TRIGger<m>:SOURce` on page 1252

Type
Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings. For mixed signal analysis, the following trigger types are available:

- Edge, see page 984
- Width, see page 985
- Timeout, see page 987
- Data2Clock, see page 988
- State, see page 989
- Pattern, see page 990
- Serial Pattern, see page 992

Remote command:
`TRIGger<m>:PARallel:TYPE` on page 2104

13.3.1.2 Edge

Using the edge trigger, you can also trigger on a single digital channel (a logic bit), and a logical combination of digital channels.

Depending on the selected trigger source, different trigger settings are available. The trigger level is already set - in MSO the logical threshold is used as trigger level.

Figure 13-1: Edge trigger settings for trigger source = logical combination of digital channels (Logic)

Slope

Defines the edge - the state transition - of the signal.

"Rising"	Means a 0 to 1 transition of the state.
"Falling"	Means a 1 to 0 transition of the state.
"Either"	Triggers on any activity on the selected trigger source.

Remote command:
`TRIGger<m>:PARallel:EDGE:SLOPe` on page 2105

Logical expression

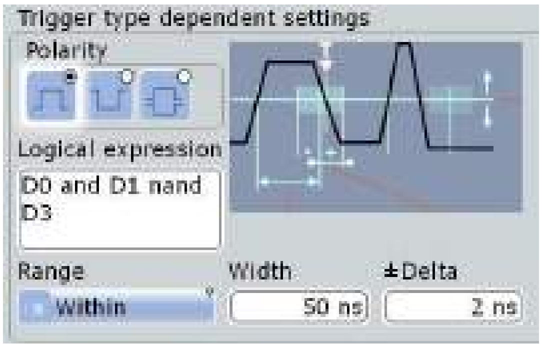
Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source". If the "Slope" is rising, the trigger occurs when the logical expression comes true. If the "Slope" is falling, the trigger occurs when the logical expression comes false.

Remote command:
`TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 2105

13.3.1.3 Width

The width trigger detects positive and/or negative pulses of a pulse width (duration) inside or outside of a defined time limit. It can trigger on a single digital channel or a logical combination of digital channels.

The instrument triggers at the end of the detected pulse.



Logical expression
D0 and D1 nand D3

Range	Width	±Delta
Within	50 ns	2 ns

Figure 13-2: Width trigger settings for trigger source = logical combination of digital channels

Range
Selects how the range of a pulse width is defined:

"Within"	Triggers on pulses inside a given time range. The time limit is defined by *Width ± Delta*.
"Outside"	Triggers on pulses shorter or longer than a given time range. The time limit definition is the same as for "Within" range.
"Shorter"	Triggers on pulses shorter than the given "Width".
"Longer"	Triggers on pulses longer than the given "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:RANGe` on page 2106

Width
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
`TRIGger<m>:PARallel:WIDTh:WIDTh` on page 2106

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:DELTa` on page 2107

Polarity
Sets the polarity of a pulse to "Positive", "Negative", or "Both".

When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Remote command:
`TRIGger<m>:PARallel:WIDTh:POLarity` on page 2106

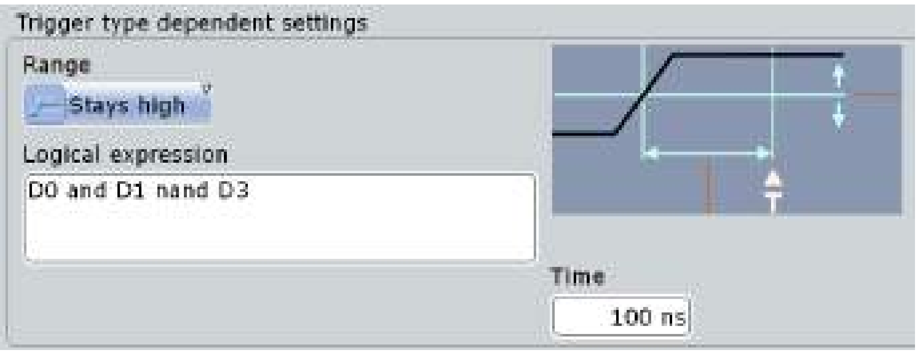
Logical expression
Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source". As long as the digital signals match the logical expression (true), the pulse is positive. Otherwise, the pulse is negative.

Remote command:
`TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 2105

13.3.1.4 Timeout

The timeout trigger event checks if the trigger source signal stays above or below the threshold voltage for a specified time lapse. In other words, the event occurs if the state condition remains unchanged for the specified time.

You can use the timeout trigger on a single digital channel, or a logical combination of digital channels.


Trigger type dependent settings

Range: Stays high

Logical expression: D0 and D1 nand D3

Time: 100 ns

Figure 13-3: Timeout trigger settings for trigger source = logical combination of digital channels

Range
Sets the state condition:

"Stays high"	The level of a digital channel stays above the threshold, or the logical expression for "Logic" trigger source is true.
"Stays low"	The level of a digital channel stays below the threshold, or the logical expression for "Logic" trigger source is false.
"High or low"	The signal state remains unchanged.

Remote command:
`TRIGger<m>:PARallel:TIMeout:RANGe` on page 2107

Time
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:PARallel:TIMeout:TIME` on page 2107

Logical expression
Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 2105

13.3.1.5 Data2Clock

The Data2Clock trigger event occurs when the state of the trigger source signal changes inside a given time before the clock edge (setup time) or after the clock edge (hold time). This trigger type is also known as setup/hold trigger. The trigger event occurs at the clock edge for which the setup and/or hold time was violated.

With Data2Clock trigger, you can trigger on a single digital channel, or a parallel bus to check several digital channels simultaneously. The clock signal is connected to one of the digital channels.

If you configure this trigger type for a parallel bus, the bus configration is adjusted by the instrument if necessary. The bus is defined as clocked bus, and the clock source of the trigger is set as clock source of the bus.

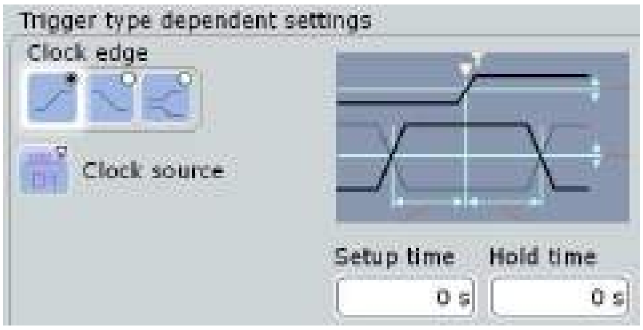


Figure 13-4: Data2clock trigger settings

Clock source
Selects the digital channel of the clock signal.

Remote command:
`TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue]` on page 2105
`TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 2105
`TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 2105

Clock edge
Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time reference point for the setup and hold time measurement.

Remote command:
`TRIGger<m>:PARallel:DATatoclock:CSOurce:EDGE` on page 2108

Setup time
Sets the minimum time *before* the clock edge while data should be stable and not change its state.

The setup time can be negative. In this case, the setup interval starts after the clock edge, and the hold time starts after the setup time has expired. Thus, the hold time is always positive. If you change the negative setup time, the hold time is adjusted by the instrument.

Remote command:
`TRIGger<m>:PARallel:DATatoclock:STIMe` on page 2108

Hold time

Sets the minimum time *after* the clock edge while data should be stable and not change its state.

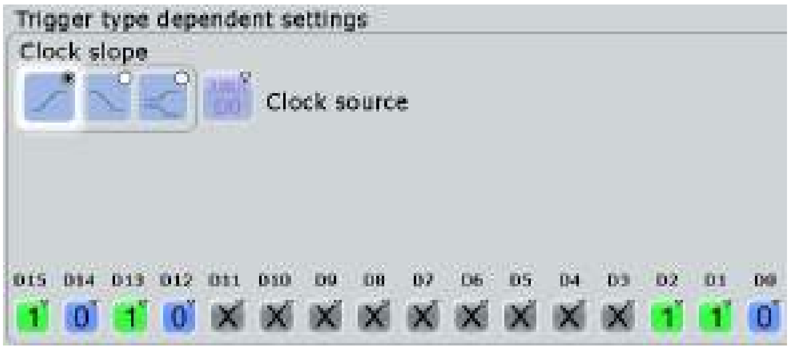
The hold time can be negative. In this case, the hold time ends before the clock edge, and the setup interval ends when the hold interval starts. Thus, the setup time is always positive. If you change the negative hold time, the setup time is adjusted by the instrument.

Remote command:

`TRIGger<m>:PARallel:DATatoclock:HTIMe` on page 2108

13.3.1.6 State

The state trigger detects the logical state of several logically combined digital channels at a given clock edge. The trigger source is a logical combination of digital channels or a parallel bus. The trigger occurs at the clock edge at which the state condition is true.



D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	0	1	0	X	X	X	X	X	X	X	X	X	1	1	0

Figure 13-5: State trigger settings for trigger source = parallel bus

Clock source

Selects the digital channel of the clock signal.

Remote command:

`TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue]` on page 2105

`TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 2105

`TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 2105

Clock edge

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Remote command:

`TRIGger<m>:PARallel:STATe:CSOurce:EDGE` on page 2109

Channel states

For each digital channel that is used in the bus, set the required state: 1, 0, or X (don't care).

Remote command:

`TRIGger<m>:PARallel:STATe:BIT<n>` on page 2109

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

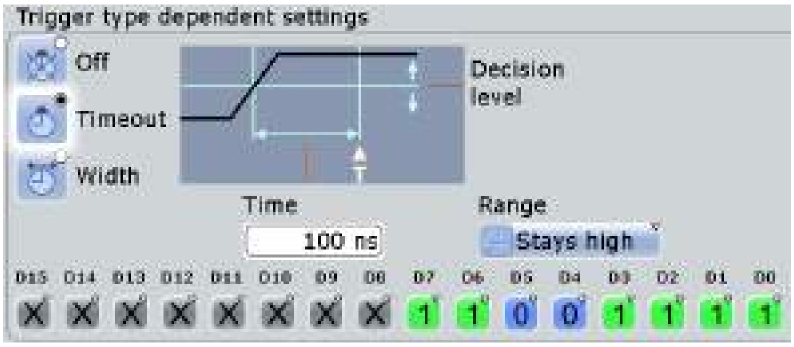
Remote command:

`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 2105

13.3.1.7 Pattern

The pattern trigger identifies a logical state of several logically combined digital channels (pattern) and a time limitation (holdoff). The pattern definition is defined by the logical expression, if "Logic" is used for trigger source. For a parallel bus trigger source, the pattern is defined by setting the state of each digital channel.

The timing starts when the pattern comes true. The decision level is the logical threshold.



Time: 100 ns

Range: Stays high

Figure 13-6: Pattern trigger settings for trigger source = parallel bus and timeout

Channel states

For each digital channel that is used in the bus, set the required state: 1, 0, or X (don't care).

Remote command:

`TRIGger<m>:PARallel:PATTern:BIT<n>` on page 2109

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:

`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 2105

Timing mode: Off, Timeout, Width

Sets the mode of the timing condition.

"Off"	No timing condition, only the logical pattern condition is relevant.
"Timeout"	Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Even in best-designed systems, there are slight delays between the signal when digital signals change states. This means that there are always transitional state conditions when signals are switching. See "Timeout settings" on page 991 for a description of the settings. The trigger event occurs when the pattern stays unchanged for the specified time.
"Width"	Sets a pulse width as timing condition, see "Width settings" on page 991. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit. Using this mode, you can, for example, trigger exclusively on unstable conditions - if the pattern is present for less than a specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:MODE` on page 2109

Timeout settings
The timeout settings "Range" and "Time" appear if the timing mode is set to "Timeout".

Range ← Timeout settings
Sets the state condition:

"Stays high"	The pattern stays true for the specified time.
"Stays low"	The pattern stays false for the specified time.
"High or low"	The pattern remains unchanged for the specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout:MODE` on page 2110

Time ← Timeout settings
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` on page 2110

Width settings
The width settings "Range", "Width" and "±Delta" appear if the timing mode is set to "Width".

Range ← Width settings
Selects how the range of a pulse width is defined:

"Within"	Triggers when the pattern comes false inside a given time range. The time limit is defined by *Width ± Delta*.
"Outside"	Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for "Within" range.
"Shorter"	Triggers when the pattern comes false before the given "Width" has expired.

"Longer" Triggers when the pattern comes false after the given "Width" has expired..

Remote command:
`TRIGger<m>:PARallel:PATTern:WIDTh:RANGe` on page 2110

Width ← Width settings
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum time limit, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
`TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]` on page 2111

±Delta ← Width settings
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

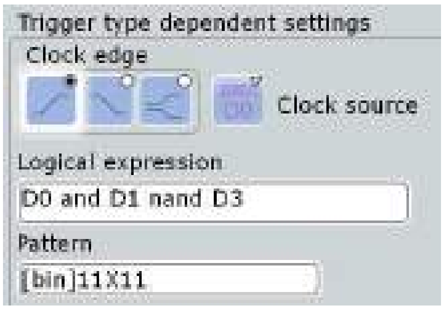
The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
`TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` on page 2111

13.3.1.8 Serial Pattern

The serial pattern trigger identifies a serial bit string trigger on a single digital channel, or for a logical combination of digital channels. The trigger requires a clocked bus; the bits are read at the specified clock edge. The trigger event occurs at the last clock edge of the serial bit string.

This trigger type allows you to trigger on specific address or data transmissions in serial input and output signals.



Logical expression: D0 and D1 nand D3

Pattern: [bin]11X11

Figure 13-7: Serial pattern trigger settings for trigger source = logical combination of digital channels

Clock edge
Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Remote command:
`TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE` on page 2112

Clock source
Selects the digital channel of the clock signal.

Remote command:
`TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue]` on page 2105
`TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 2105
`TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 2105

Logical expression
Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 2105
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 2105

Pattern
Defines the serial bit string on which to trigger. Touch and hold the "Pattern" field to open the "Bit Pattern Editor" where you can enter the pattern in various formats. The pattern has to be defined exactly, X (don't care) is not supported in binary format.

See also: Chapter 12.1.4, "Bit Pattern Editor", on page 488

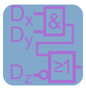
Remote command:
`TRIGger<m>:PARallel:SPATtern:PATTern` on page 2112

13.3.2 Triggering on Digital Signals and Parallel Buses

For a detailed description of the settings, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 983.

1. Press the TRIGGER key and select the "Events" tab.
2. Select the trigger "Source":
    - one of the digital channels "D0" ... "D15"

      D0 D1 D2
    - a logic combination of digital channels: "Logic"

    - one of the parallel buses "Par. bus1" ... "Par. bus4"

      PB1 PB2 PB3
3. Select the trigger "Type".

4. Under "Trigger type dependent settings", configure the trigger.
5. For trigger source "Logic", enter the logical expression of the digital channel combination. Tap and hold the "Logical expression" field until the "Qualification Editor" opens. It provides all logic operators that can be used in the expression.

D0 and D1 nand(D3)

13.4 Measurements on Digital Channels

For measurements on digital channels, the number of measurement categories and types is reduced to applicable measurement types.

These are:

- Period
- Frequency
- Positive and negative pulse
- Pulse count
- Delay
- Phase
- Positive and negative duty cycle
- Burst width
- Edge count

Except for delay measurement, the measurement types have the same settings and results for analog and digital sources.

Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

See also Chapter 7.2.5, "Amplitude/Time Measurements", on page 328.

13.5 Data export

The data of digital channels and parallel buses can be saved to file in the same way as analog waveform data. One digital channel or bus per file can be saved.

The data format of the stored values is defined with "Analysis" > "Parallel Bus Configuration" > "Data format". If the data is written to XML or CSV files, the selected format is used. If the target file format is BIN, you can save signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Only y-values are exported, the "Interleaved x/y" setting is not available.

Export of a digital channel

If the data of digital channels is stored in BIN format, one bit is written for each sample. 8 data samples are written in one byte (data word). For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

If saved to BIN file, the digital channel can be imported as reference waveform.

Export of a parallel bus

A parallel bus can be exported to file if "Enable bus" and "Show bus" are both activated.

All data formats can be saved to XML, CSV, and BIN files. If you save binary format to XML or CSV, you can see the values of each line for each sample.

In BIN files, 4 Bytes are written for each sample.

Importing parallel buses from BIN files is only possible if the bus was saved with quasi-analog bus representation.

See also:

- Chapter 11.2.6, "Saving and Loading Waveform Data", on page 466
- Chapter 11.2.2, "Waveforms - Export Settings", on page 456

Remote commands for export to file:

- `EXPort:WAVeform:SOURce` on page 1478
  `BUSFormat` on page 1497
- `EXPort:WAVeform:NAME` on page 1479
- `EXPort:WAVeform:SAVE` on page 1480

Remote commands for remote export:

- `FORMat[:DATA]` on page 1181
- `BUSFormat` on page 1497
- `BUS<m>:PARallel:DATA:HEADer?` on page 2113
- `BUS<m>:PARallel:DATA[:VALues]?` on page 2114
- `DIGital<m>:DATA:HEADer?` on page 2113
- `DIGital<m>:DATA[:VALues]?` on page 2113

13.6 Mathematics

A parallel bus that is displayed as quasi-analog waveform can be analyzed with FFT. To configure the FFT, use the "Advanced" mode and the formula editor.

13.7 Search

It is also possible to search on digital channels for specified events. Search conditions use the same parameters as the trigger event definition. You can search for edge, width, timeout, and Data2Clock conditions.

14 Waveform Generator (Option R&S RTO-B6)

The R&S RTO includes an integrated waveform generator which can generate input signals and patterns during testing.

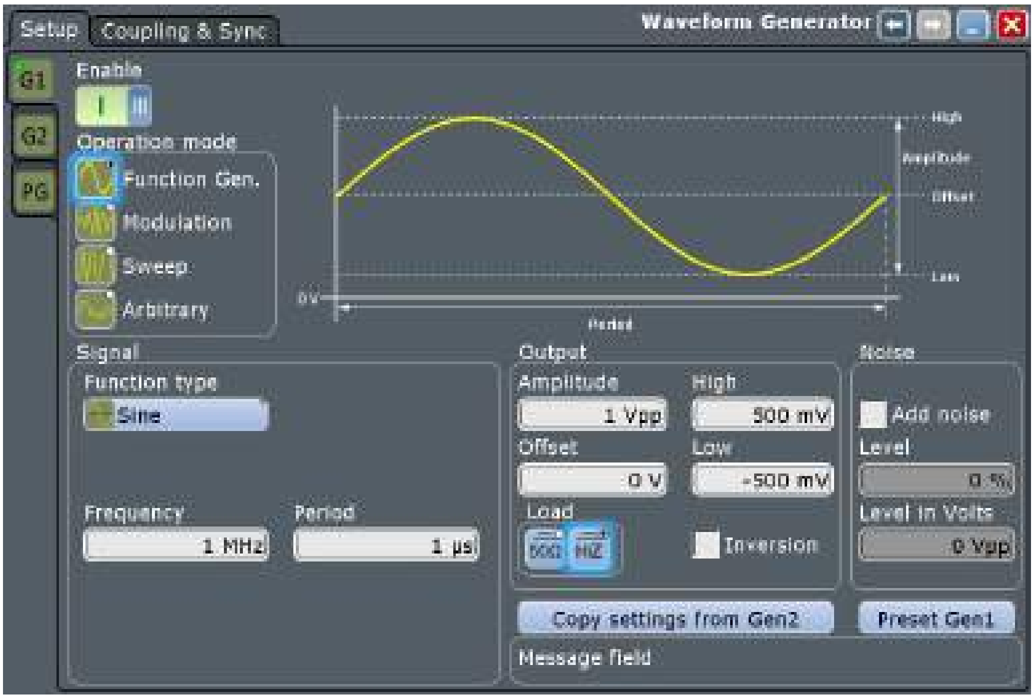
You can setup and output two waveform generators and a pattern generator. It is possible to couple and synchronize the settings of the different generators and enable them on a trigger signal. With each of the waveform generators, one can output simple functions, modulated sine waveform, arbitrary waveforms and sweep waveforms.

14.1 Setup of the Waveform Generator

Access: GEN 1/GEN 2 > "Setup" tab

The "Setup" tab is divided into several sections:

- General settings like enabling and presetting the waveform generator
- Signal settings, depending on the selected Operation mode refer to one of the following:
  - Chapter 14.1.2, "Function Generator", on page 999
  - Chapter 14.1.3, "Modulation", on page 1003
  - Chapter 14.1.4, "Sweep", on page 1009
  - Chapter 14.1.5, "Arbitrary", on page 1010
- "Output", including settings for defining the output see Chapter 14.1.6, "Output", on page 1014
- "Noise", settings for adding noise to the waveform, see Chapter 14.1.7, "Noise", on page 1015



Function type: Sine

Frequency: 1 MHz

Period: 1 µs

Amplitude: 1 Vpp

High: 500 mV

Offset: 0 V

Low: -500 mV

Level: 0 %

Level in Volts: 0 Vpp

Make sure that the tab of the correct waveform generator is selected on the left side.

The settings of the waveform generators are not affected by an instrument preset. Press "Preset Gen1/2" to preset the settings of the corresponding waveform generator.

14.1.1 General Settings

The general waveform generator settings are for enabling and presetting the generator and selecting the "Operation Mode".

Enable

Enables the waveform generator/ pattern generator and outputs the signal to the connectors.

Remote command:

`WGENerator<m>[:ENABle]` on page 2115

`PGENerator:ENABle` on page 2131

Operation mode

Selects the operation mode for the waveform generator. The "Signal" settings depend on the selected mode.

For the settings of the different operation modes, refer to:

- Chapter 14.1.2, "Function Generator", on page 999
- Chapter 14.1.3, "Modulation", on page 1003

- Chapter 14.1.4, "Sweep", on page 1009
- Chapter 14.1.5, "Arbitrary", on page 1010

Remote command:
`WGENerator<m>:SOURce` on page 2115

Copy settings from Gen1/Gen2
Copies all settings from Gen1/Gen2 and applies them to Gen2/Gen1.

Remote command:
`WGENerator<m>:ACOPy` on page 2114

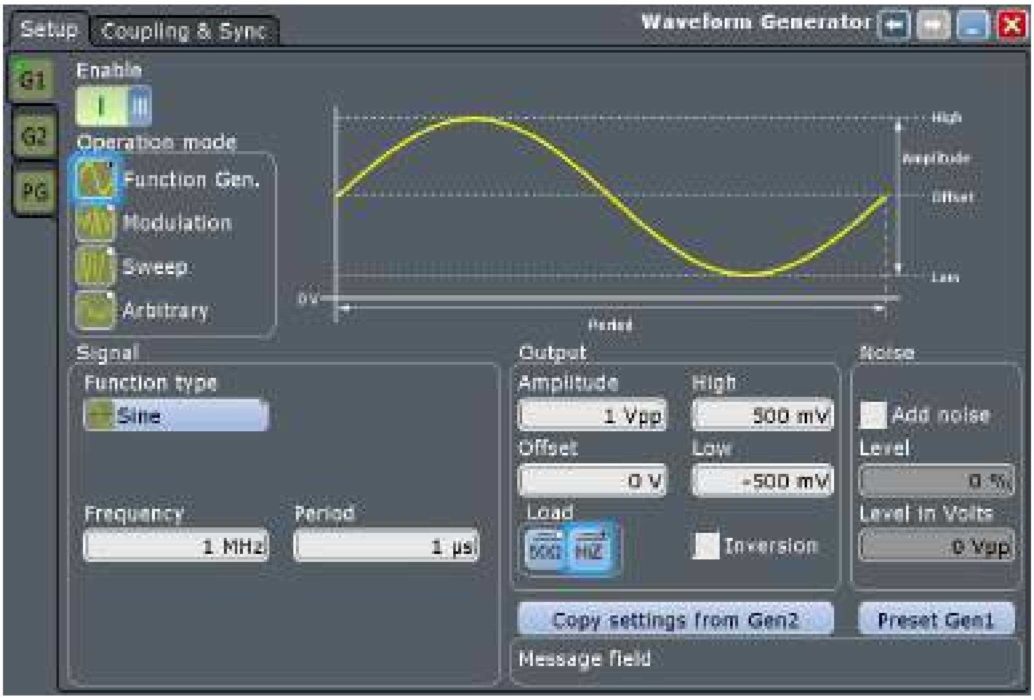
Preset Gen1/Gen2/Patt Gen
Sets the parameters of the generator to their default values. The settings of the generators are not affected by an instrument preset.

Remote command:
`WGENerator<m>:PRESet` on page 2115
`PGENerator:PRESet` on page 2132

Message
Displays relevant messages concerning the coupling and sync settings.

14.1.2 Function Generator

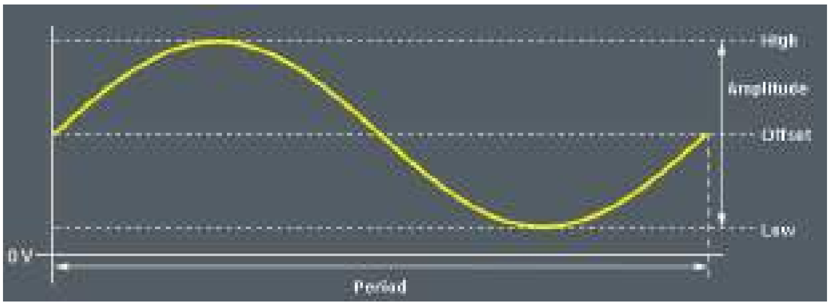
The R&S RTO function generator can generate input signals during testing. These signals can be used for example, when testing circuits.



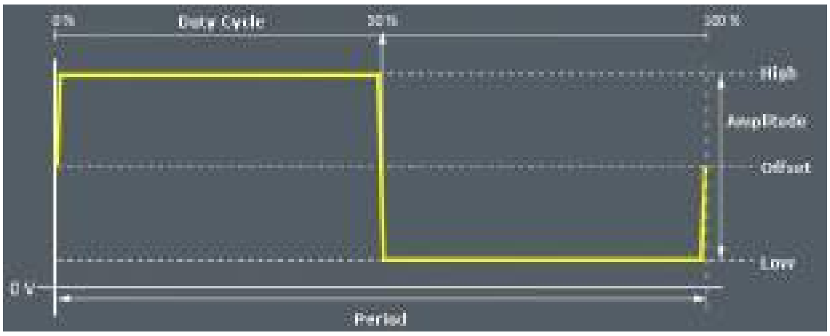
Function type: Sine
Frequency: 1 MHz
Period: 1 µs
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Level: 0 %
Level in Volts: 0 Vpp

Function type
Selects the type of waveform to be generated for the function generator.

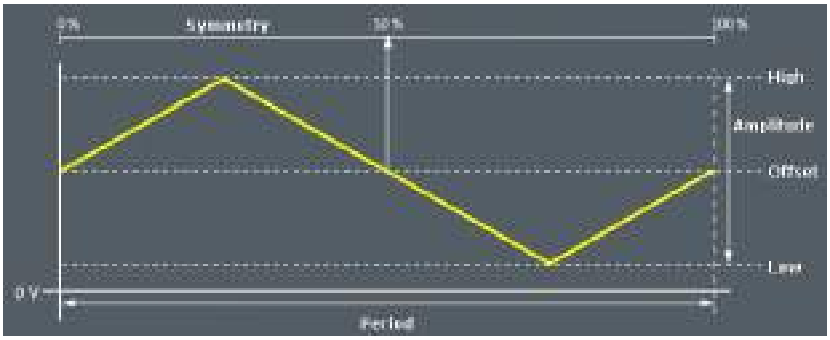
"Sine" Generates a sine wave. You can set its Frequency and Period.



"Square" Generates a square wave. You can set its Frequency, Period and Duty cycle.

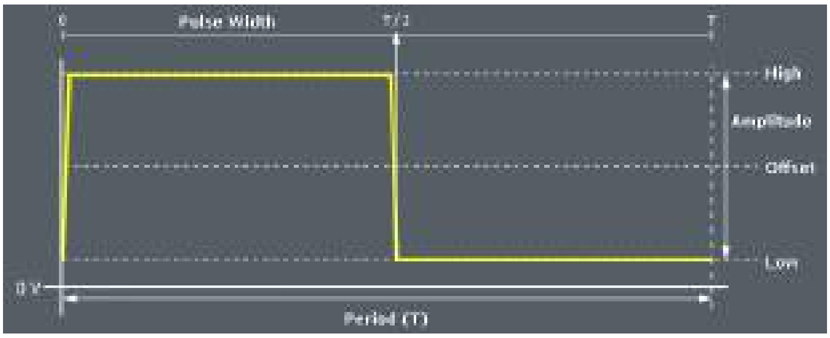


"Ramp" Generates a ramp signal. You can set its Frequency, Period and Symmetry.

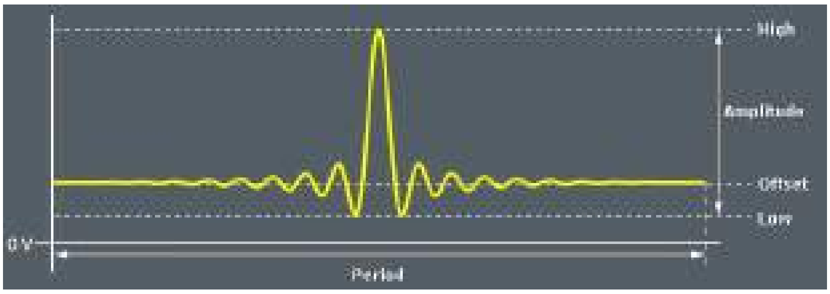


"DC" Generates a direct current (DC) signal. You can set the DC Level.

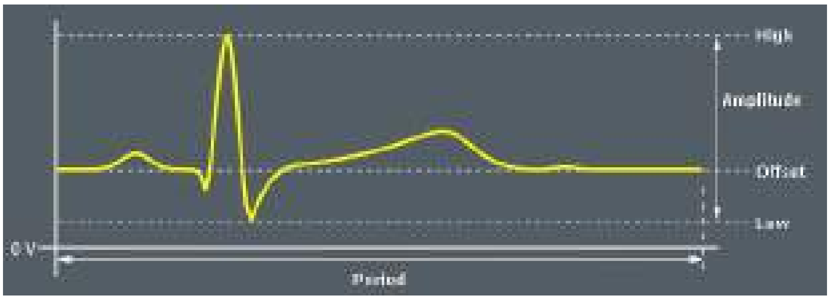
"Pulse" Generates a pulse signal. You can set the Frequency, Period and Pulse width.



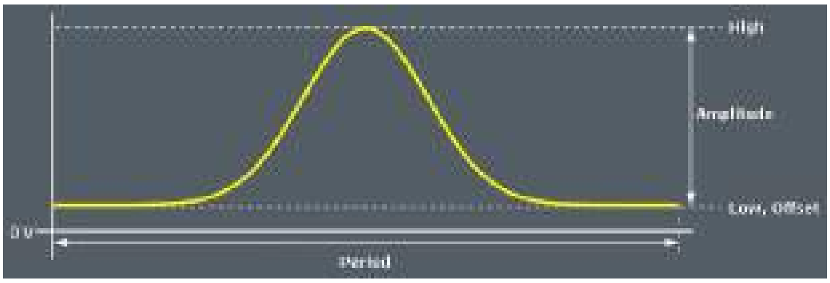
"Cardinal sine" Generates a cardinal sine wave. You can set the Frequency and Period.



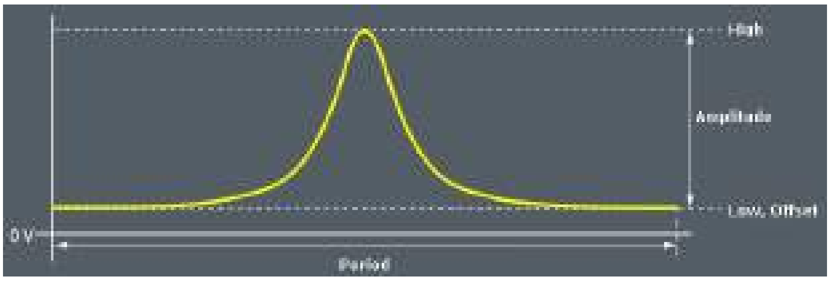
"Cardiac" Generates a cardiac signal. You can set the Frequency and Period.



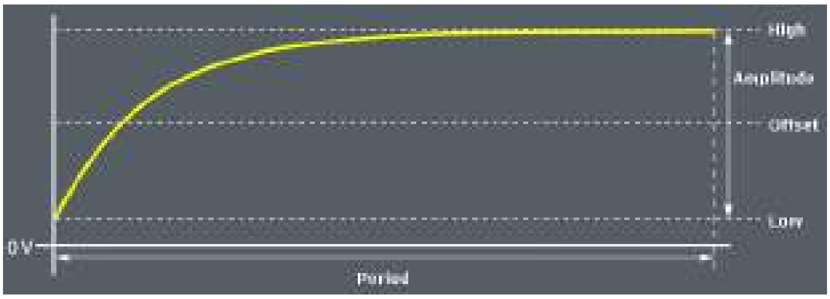
"Gauss" Generates a gauss signal . You can set the Frequency and Period.



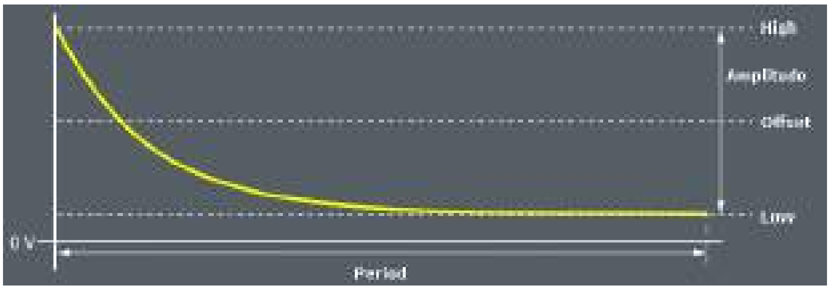
"Lorentz" Generates a Lorentz signal . You can set the Frequency and Period.



"Exp. rise" Generates an exponential rise signal. You can set the Frequency and Period.



"Exp. fall" Generates an exponential fall signal. You can set the Frequency and Period.



Remote command:
`WGENerator<m>:FUNCtion[:SELect]` on page 2115

Frequency
Sets the frequency of the waveform. The available frequency range depends on the selected "Function Type", see Frequency range of the function generator waveforms.

Table 14-1: Frequency range of the function generator waveforms

"Function type"	Min frequency	Max frequency
"Sine"	0.001 Hz	100 MHz
"Square"	0.001 Hz	30 MHz
"Ramp"	0.001 Hz	1 MHz
"DC"	-	-
"Pulse"	0.001 Hz	30 MHz
"Cardinal sine"	0.001 Hz	5 MHz

"Function type"	Min frequency	Max frequency
"Cardiac"	0.001 Hz	1 MHz
"Gauss"	0.001 Hz	25 MHz
"Lorentz"	0.001 Hz	10 MHz
"Exp.rise"	0.001 Hz	10 MHz
"Ep. fall"	0.001 Hz	10 MHz

The values of the "Frequency" and "Period" depend on each other, as:

Period = 1/ Frequency

Remote command:
`WGENerator<m>:FREQuency` on page 2116

Period
Sets the period of the waveform. The available period range depends on the selected "Function Type".

Remote command:
`WGENerator<m>:PERiod` on page 2116

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage of the period, the signal state is high.

Remote command:
`WGENerator<m>:FUNCtion:SQUare:DCYCle` on page 2117

Symmetry
Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create for example triangular waveforms.

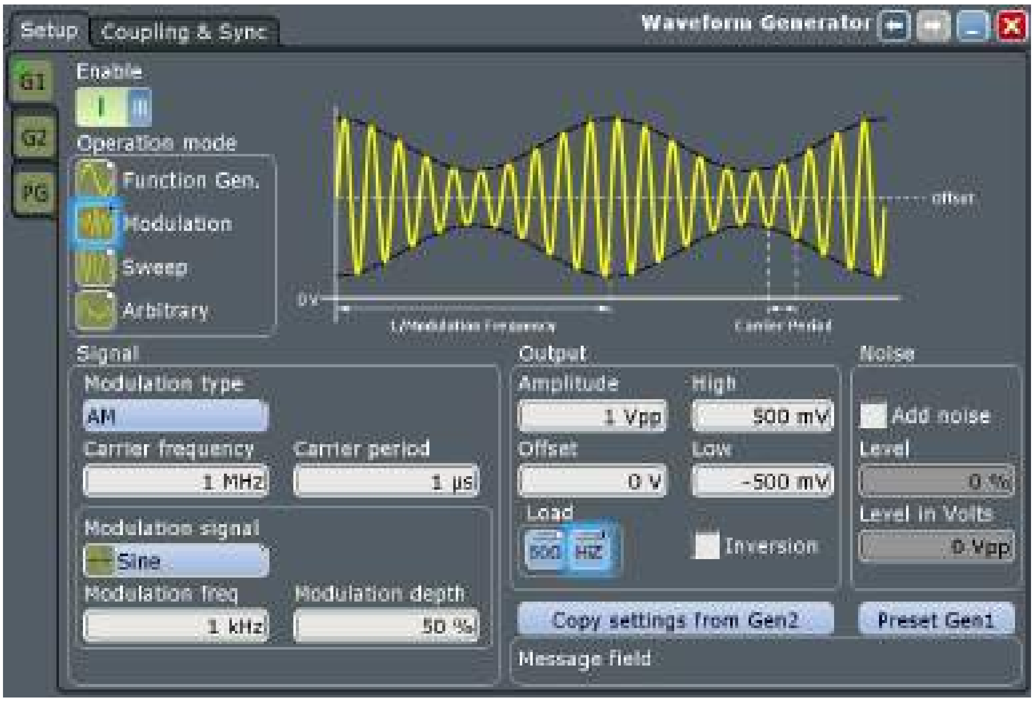
Remote command:
`WGENerator<m>:FUNCtion:RAMP[:SYMMetry]` on page 2116

Pulse width
Sets the pulse width, the pulse duration of the generated pulse waveform.

Remote command:
`WGENerator<m>:FUNCtion:PULSe[:WIDTh]` on page 2116

14.1.3 Modulation

Modulation is when properties of an original periodic waveform, the carrier signal, are varied according to a second modulating signal. The type of modulation used determines which properties are changed.



Modulation type: AM
Carrier frequency: 1 MHz
Carrier period: 1 µs
Modulation signal: Sine
Modulation freq: 1 kHz
Modulation depth: 50 %
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Level: 0 %
Level in Volts: 0 Vpp

14.1.3.1 General Settings

Consists of settings for selecting the modulation type.

Modulation type

Selects the modulation type, which defines how the carrier signal is modified.

"AM"	Amplitude modulation. See: Chapter 14.1.3.2, "AM Modulation", on page 1005.
"FM"	Frequency modulation. See: Chapter 14.1.3.4, "FM Modulation", on page 1007.
"PWM"	Pulse width modulation See: Chapter 14.1.3.3, "PWM Modulation", on page 1006
"FSK"	Frequency shift keying (FSK) modulation. See:Chapter 14.1.3.5, "FSK Modulation", on page 1008.

Remote command:
`WGENerator<m>:MODulation:TYPE` on page 2117

Carrier frequency

Sets the frequency of the carrier signal.

Remote command:
`WGENerator<m>:MODulation:CARRier:FREQuency` on page 2119

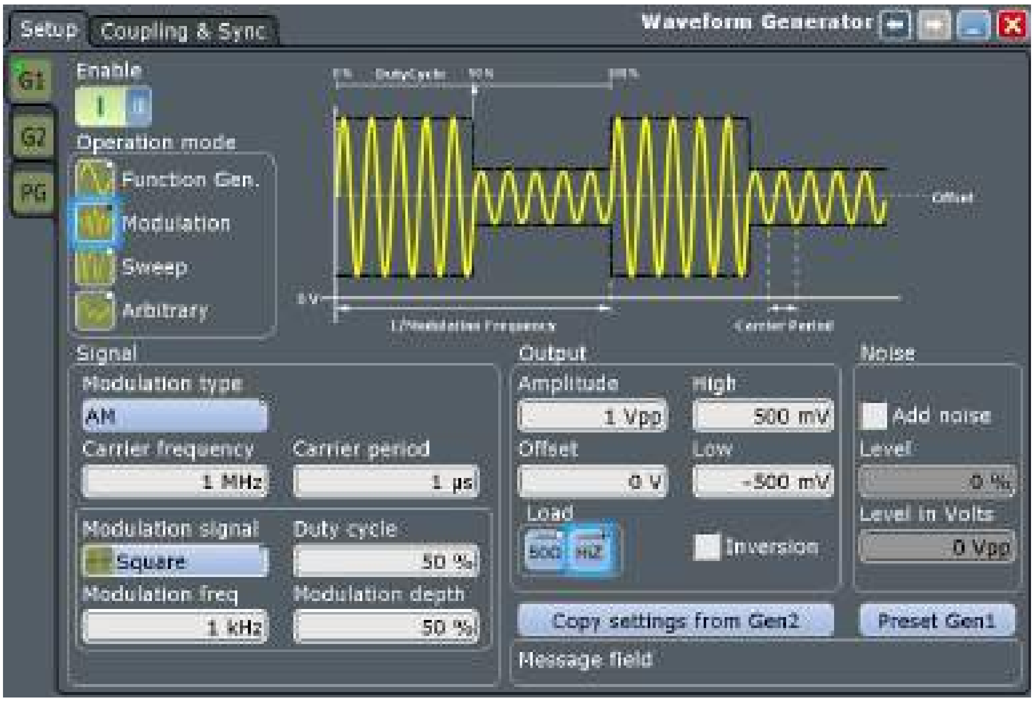
Carrier period

Sets the period of the carrier signal.

Remote command:
`WGENerator<m>:MODulation:CARRier:PERiod` on page 2119

14.1.3.2 AM Modulation

For amplitude modulation (AM), the amplitude of the carrier signal is varied according to the modulation signal.



Modulation type: AM
Carrier frequency: 1 MHz
Carrier period: 1 µs
Modulation signal: Square
Duty cycle: 50 %
Modulation freq: 1 kHz
Modulation depth: 50 %
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Load: 50Ω HiZ
☐ Inversion
☐ Add noise
Level: 0 %
Level in Volts: 0 Vpp

Modulation signal
Selects the type of the modulation signal for the AM modulation types.

Remote command:
`WGENerator<m>:MODulation:AM[:FUNCtion]` on page 2119

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
`WGENerator<m>:MODulation:AM:FREQuency` on page 2118

Modulation depth
Sets the modulation depth, the percentage of the amplitude range that is used for the modulation.

Remote command:
`WGENerator<m>:MODulation:AM:DEPTh` on page 2118

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

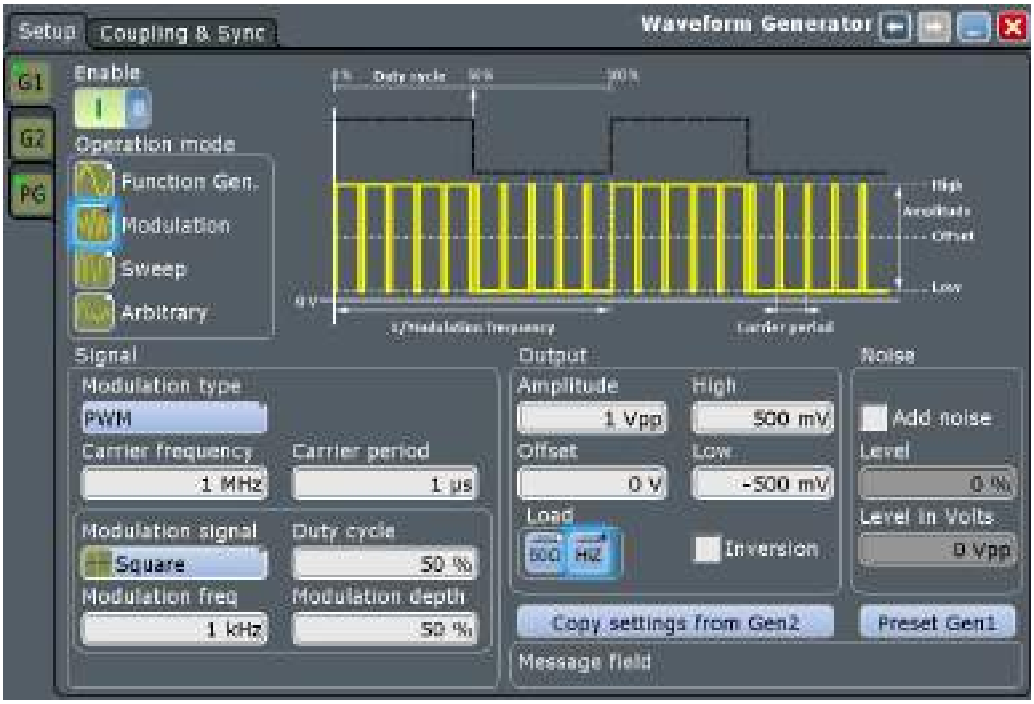
Remote command:
`WGENerator<m>:MODulation:AM:SYMMetry` on page 2119

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
`WGENerator<m>:MODulation:AM:DCYCle` on page 2118

14.1.3.3 PWM Modulation

For pulse width modulation (PWM), the time for which the signal is in a high state is varied according to the modulation signal.



Modulation type: PWM
Carrier frequency: 1 MHz
Carrier period: 1 µs
Modulation signal: Square
Duty cycle: 50 %
Modulation freq: 1 kHz
Modulation depth: 50 %
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Load: 50Ω Hiz
☐ Inversion
☐ Add noise
Level: 0 %
Level in Volts: 0 Vpp

Modulation signal
Selects the type of the modulation signal for the PWM modulation types.

Remote command:
`WGENerator<m>:MODulation:PWM[:FUNCtion]` on page 2123

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
`WGENerator<m>:MODulation:PWM:FREQuency` on page 2122

Modulation depth
Sets the modulation depth, the percentage of the pulse width range that is used for the modulation.

Remote command:
`WGENerator<m>:MODulation:PWM:DEPTh` on page 2122

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

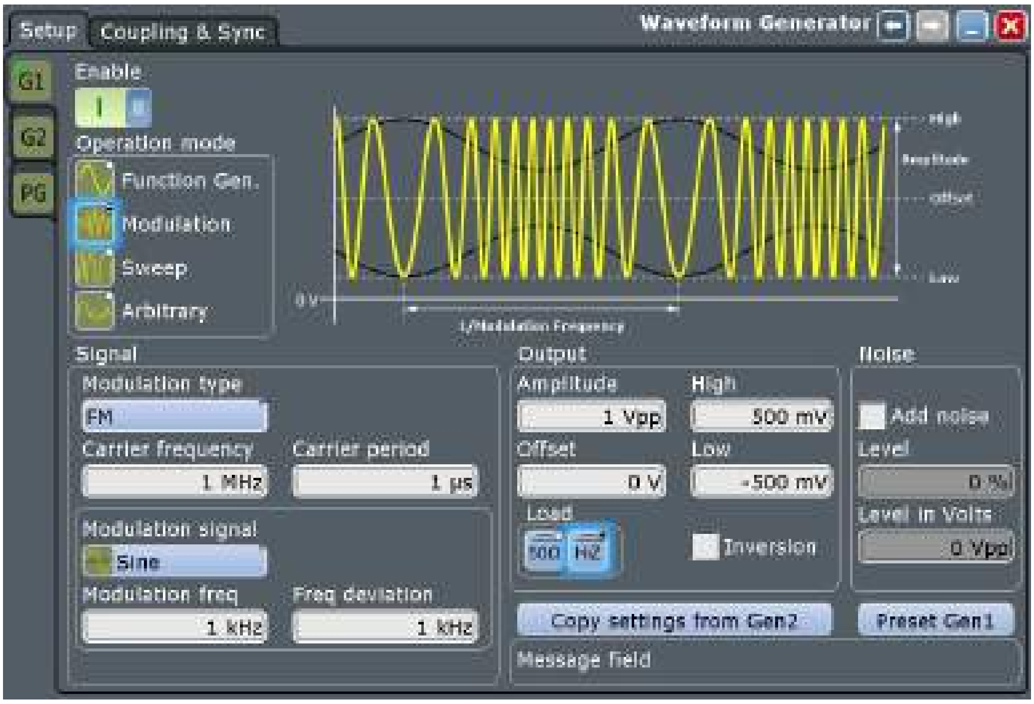
Remote command:
`WGENerator<m>:MODulation:PWM:SYMMetry` on page 2123

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
`WGENerator<m>:MODulation:PWM:DCYCle` on page 2122

14.1.3.4 FM Modulation

For frequency modulation (FM), the frequency of the carrier signal is varied according to the modulation signal.



Modulation type: FM
Carrier frequency: 1 MHz
Carrier period: 1 µs
Modulation signal: Sine
Modulation freq: 1 kHz
Freq deviation: 1 kHz
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Load: 50Ω HiZ
☐ Inversion
☐ Add noise
Level: 0 %
Level in Volts: 0 Vpp

Modulation signal
Selects the type of the modulation signal for the FM modulation types.

Remote command:
`WGENerator<m>:MODulation:FM[:FUNCtion]` on page 2121

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
`WGENerator<m>:MODulation:FM:FREQuency` on page 2120

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

Remote command:
`WGENerator<m>:MODulation:FM:SYMMetry` on page 2120

Freq deviation
Sets the frequency deviation, the maximum difference between and FM modulated signal and the carrier signal.

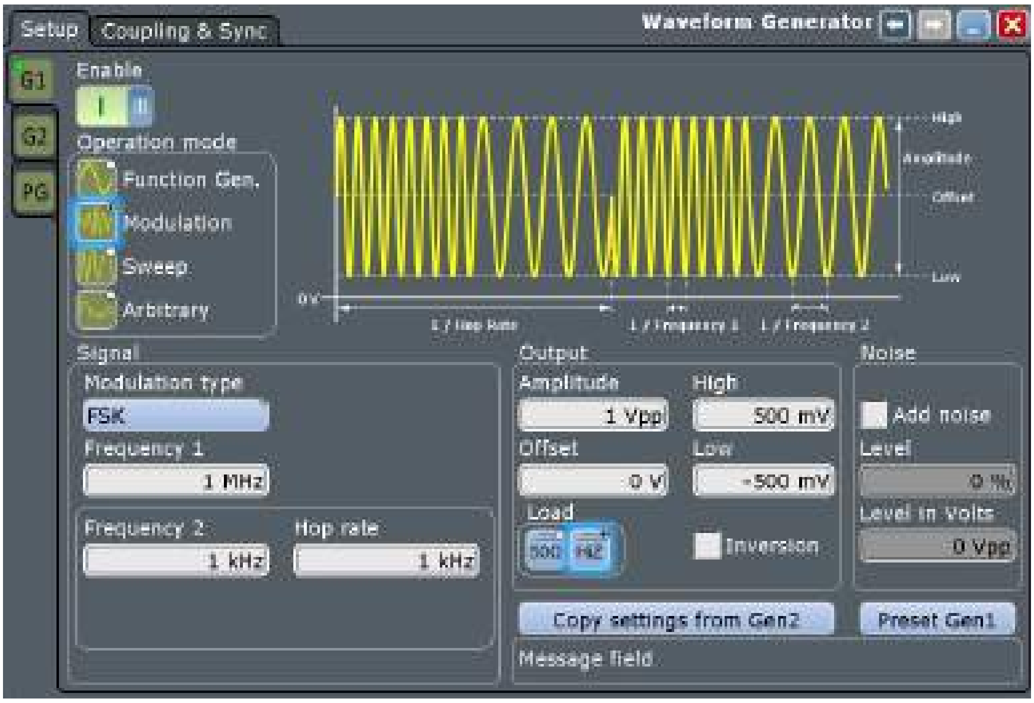
Remote command:
`WGENerator<m>:MODulation:FM:DEViation` on page 2120

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses the percentage of the period during which the waveform is active, i.e. the signal state is high.

Remote command:
`WGENerator<m>:MODulation:FM:DCYCle` on page 2120

14.1.3.5 FSK Modulation

For frequency shift keying (FSK) modulation, the signal switches between Frequency 1 and Frequency 2 at a Hop rate.



Modulation type: FSK
Frequency 1: 1 MHz
Frequency 2: 1 kHz
Hop rate: 1 kHz
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Level: 0 %
Level in Volts: 0 Vpp

Frequency 1
Sets the frequency of the first signal in FSK modulated signal.

Remote command:
`WGENerator<m>:MODulation:FSK:FONE` on page 2121

Frequency 2
Sets the frequency of the second signal in FSK modulated signal.

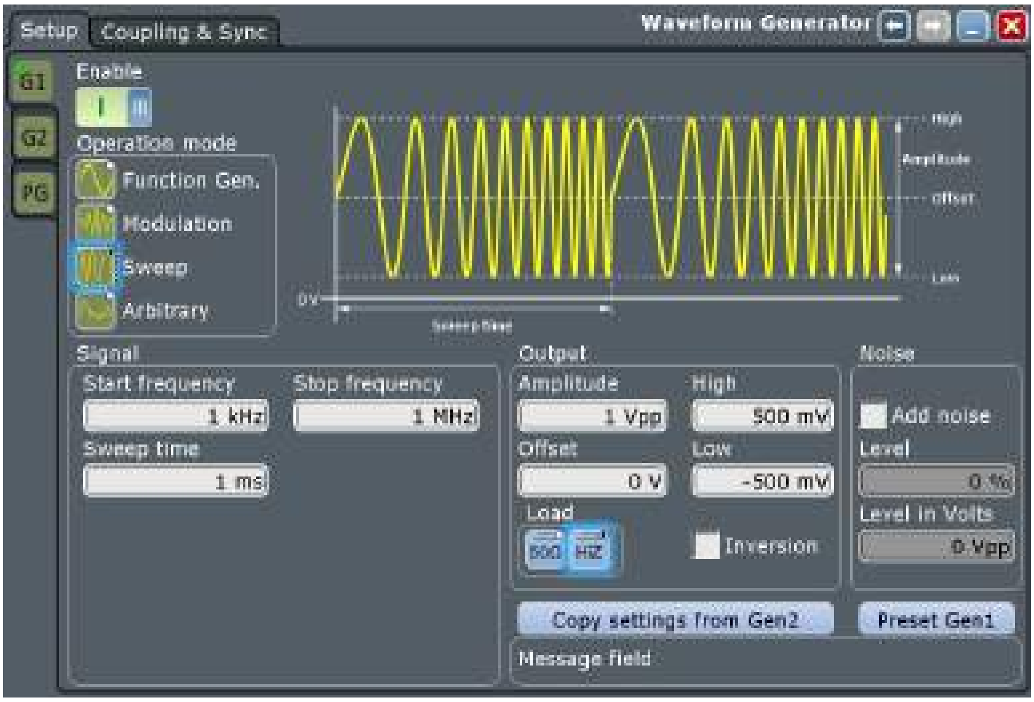
Remote command:
`WGENerator<m>:MODulation:FSK:FTWO` on page 2121

Hop rate
Sets the hop rate, the frequency at which signal switches between Frequency 1 and Frequency 2.

Remote command:
`WGENerator<m>:MODulation:FSK[:RATE]` on page 2122

14.1.4 Sweep

In the sweep mode, the R&S RTO generates a signal whose frequency gradually changes from the Start frequency to the Stop freuqency for a certain Sweep time.



Start frequency: 1 kHz
Stop frequency: 1 MHz
Sweep time: 1 ms
Amplitude: 1 Vpp
High: 500 mV
Offset: 0 V
Low: -500 mV
Level: 0 %
Level in Volts: 0 Vpp

Start frequency
Sets the start frequency of the sweep signal.

Remote command:
`WGENerator<m>:SWEep:FSTart` on page 2123

Stop freuqency
Sets the stop frequency of the sweep signal.

Remote command:
`WGENerator<m>:SWEep[:FEND]` on page 2124

Sweep time
Sets the duration of the sweep.

Remote command:
`WGENerator<m>:SWEep:TIME` on page 2124

14.1.5 Arbitrary

The arbitrary waveform generator allows you to output a user-defined waveform for testing your devices. You can output a waveform from a file or from the current R&S RTO reference curve format. Files in `*.csv` and `*.bin` formats are supported. This files must follow a defined structure. You can load `*.csv` files in an R&S Wave Gen format (see Content and format of the R&S wave gen *.csv files), Tektronix AFG format or Keysight WaveGen format.

Content and format of the R&S wave gen *.csv files

The R&S waveform generator format can contain the following values:

- Rate
- Time value
- Voltage value

If all the values are defined, the file format is as follows:

```
Rate = 5000000            //Sample rate of the arbitrary waveform.
0.000000E+000,-5.995     //Time value 1, Voltage value 1
1.237011E-005,-6.0       //Time value 2, Voltage value 2
.......
```

In this case, the rate is reflected in the "Sample Rate" field of the user interface. The total number of Time/Voltage values is reflected in the "Samples" of the user interface. Anything written after `//` is ignored as a comment.

You can define only some of the values. According to what you define, the file format looks different and is handled differently:

- With specified *Rate*:
  Time values are ignored. You can specify just rate and voltage values as below:

```
Rate = 5000000               //Sample rate of the arbitrary waveform
-5.995                       //Voltage value 1
-6.0                         //Voltage value 2
.......
```

- Without specified *Rate* and without specified *Time* values:

A sample rate of 1Mbps is used to calculate the waveform. You can change the "Sample rate" in the user interface. The voltage values are then played with this sample rate.

```
-5.995               //Voltage value 1
-6.0                  //Voltage value 2
.......
```

- Without specified *Rate* and wit specified *Time*:
  The timing information of the first 2 time values is used to calculate the sample rate.

Example:

Consider the following file:

```
0.000000E+000,-5.995    //Time value 1, Voltage value 1
1.237011E-005,-6.0      //Time value 2, Voltage value 2
```

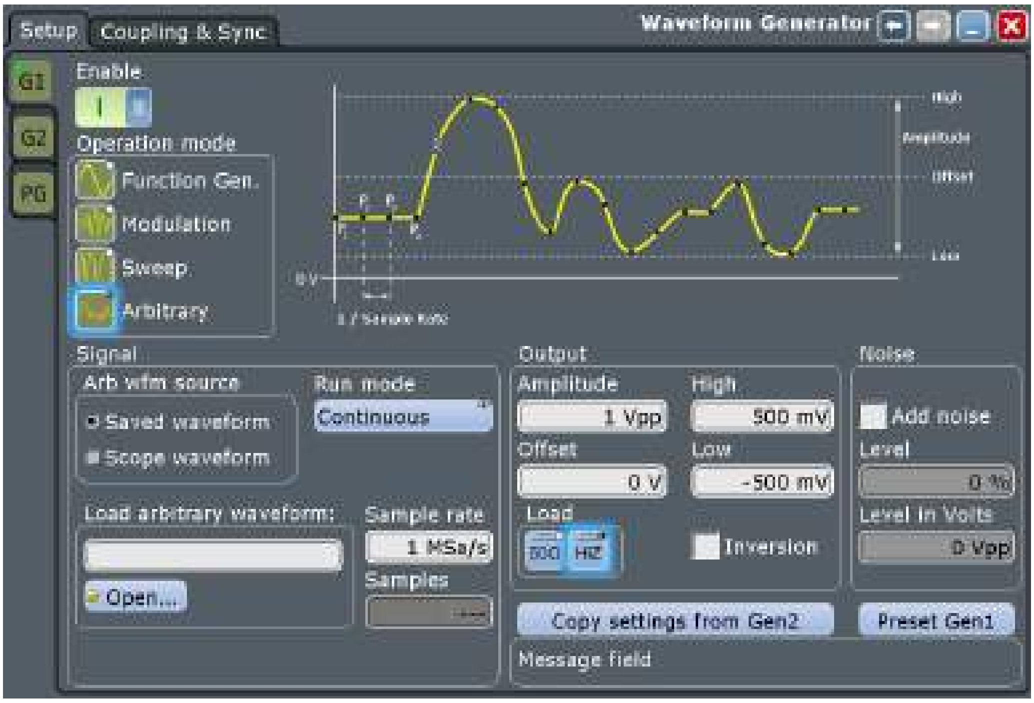
The sample rate is:

Sample rate = 1/ Time between first two samples =1 / 1.237011E-005 = 80.840KSampe/sec

Content and format of the R&S arbitrary generator *.bin files

The file stream should contain the following information in the given order:

Sample rate	[double format]
Number of samples	[double format]
Samples	[double format] * number of samples



14.1.5.1 General Settings

Arb wfm source

Selects the arbitrary waveform source. You can load an existing file or load the current oscilloscope waveform.

Remote command:

`WGENerator<m>:ARBGen[:SOURce]` on page 2127

Running mode

Selects the duration for which the signal of the arbitrary generator will be output after the trigger event. You can choose between a "Continuous" and "Single period" duration.

Remote command:

`WGENerator<m>:ARBGen:RUNMode` on page 2126

Sample rate

Sets the sample rate for the arbitrary waveform.

Remote command:

`WGENerator<m>:ARBGen:SRATe` on page 2127

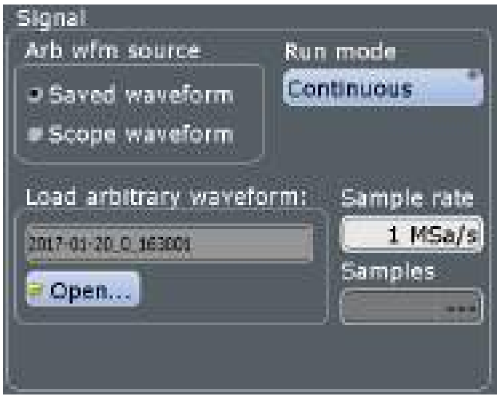
Samples

Displays the number of samples in the loaded waveform.

Remote command:

`WGENerator<m>:ARBGen:SAMPles?` on page 2126

14.1.5.2 Saved Waveform

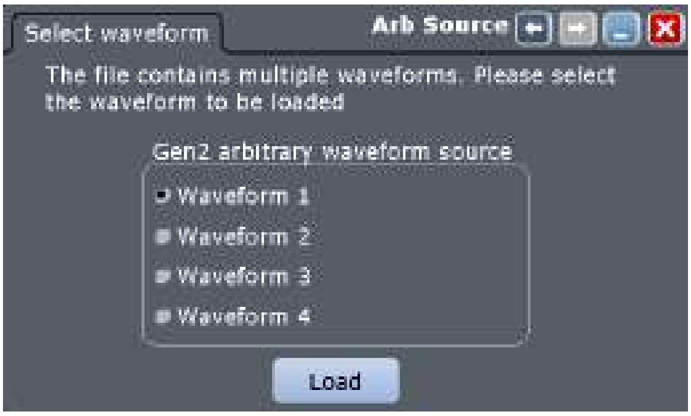


Load arbitrary waveform
Opens a file selection dialog box and loads the selected file. Supported are `.bin` and `.csv` extension files.

Remote command:
`WGENerator<m>:ARBGen:NAME` on page 2125
`WGENerator<m>:ARBGen:OPEN` on page 2126

Select waveform
When a multichannel file is loaded into the arbitrary waveform generator, a dialog appears to select which waveform from the file is loaded.

Select the waveform and press "Load" to load it into the arbitrary waveform generator.


The file contains multiple waveforms. Please select the waveform to be loaded

Remote command:
`WGENerator<m>:ARBGen:MULTichannel:NAME` on page 2125
`WGENerator<m>:ARBGen:MULTichannel:IMPort` on page 2125
`WGENerator<m>:ARBGen:MULTichannel:OPEN` on page 2125

14.1.5.3 Scope Waveform

Signal source
Selects the oscilloscope source, from which the arbitrary signal is loaded.

Remote command:
`WGENerator<m>:ARBGen:SELect` on page 2127

Load
Loads the waveform from the selected "Signal source".

Remote command:
`WGENerator<m>:ARBGen:COPY` on page 2124

14.1.6 Output

Amplitude
Sets the amplitude, peak to peak voltage, of the output waveform. It is defined as the voltage difference between the maximum ("High") and the minimum ("Low") voltage levels.

The "Amplitude" value is set for the currently selected "User Load". If the "User Load" is changed, the value of "Amplitude" is adapted to this new setting.

Remote command:
`WGENerator<m>:VOLTage[:VPP]` on page 2128

Offset
Sets a voltage offset

Remote command:
`WGENerator<m>:VOLTage:OFFSet` on page 2129

High
Sets the high signal level of the output waveform.

Remote command:
`WGENerator<m>:VOLTage:HIGH` on page 2128

Low
Sets the low signal level of the output waveform.

Remote command:
`WGENerator<m>:VOLTage:LOW` on page 2129

Inversion
Inverts the waveform at the offset level.

Remote command:
`WGENerator<m>:VOLTage:INVersion` on page 2129

User Load
Select the user load, the load of the DUT at its connection. You can select either a "50Ω" or a "HiZ" (high input impedance) load.

Remote command:
`WGENerator<m>:OUTPut[:LOAD]` on page 2128

DC Level
Sets the voltage DC level for the generated DC signal, for "Operation mode" >"Function Gen." and "Function type"> "DC".

Remote command:
`WGENerator<m>:VOLTage:DCLevel` on page 2128

14.1.7 Noise

Add Noise
Enables the adding of noise to the waveform.

Remote command:
`WGENerator<m>:MODulation:NOISe` on page 2130

Level
Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Remote command:
`WGENerator<m>:MODulation:NLPCent` on page 2130

Level in Volts
Displays the level of the noise in volts.

Remote command:
`WGENerator<m>:MODulation:NLABsolute?` on page 2130

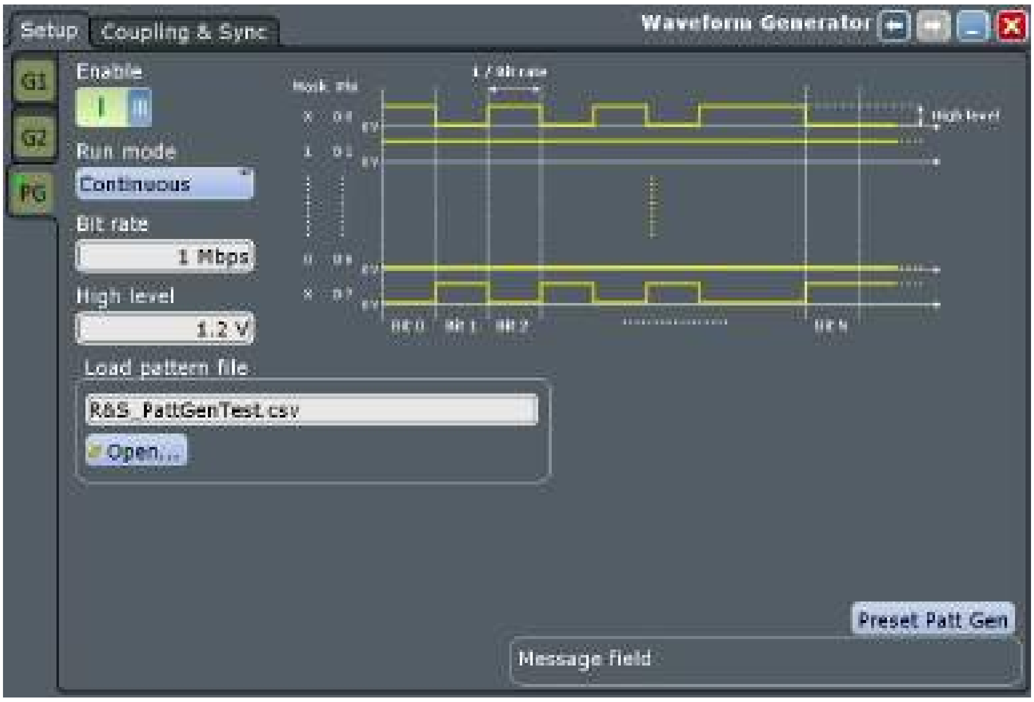
Level
For "Function type">"DC" only.

Sets the level for the DC signal.

Remote command:
`WGENerator<m>:MODulation:NDCLevel` on page 2130

14.2 Setup of the Pattern Generator

The pattern generator outputs parallel patterns.



Enable

Run mode: Continuous

Bit rate: 1 Mbps

High level: 1.2 V

Load pattern file: R&S_PattGenTest.csv

NOTICE

Using pattern generator accessories

The pattern generator with connected Patt Gen Cable and Patt Gen Board (1329.7054.02) is considered as a test probe, EN 61326-2-1, clause 5.2.4.101, note 1. Therefore normal operation may display increased emissions above the limits as specified in EN 55011 and/or reduced interference resistance as required in EN 61326-1, table 1, basic requirements.

If the cable and the board are connected, other surrounding electronic devices may be disturbed. Furthermore, signals at the analog generator outputs Gen1 and Gen2 may be distorted by surrounding devices.

The settings of the pattern generator are not affected by an instrument preset. Press "Preset Patt Gen" to preset the settings of the pattern generator.

Content and format of the pattern generator files

The pattern generator supports `.bin` or `.csv` file formats.

Content and format of the R&S *.csv files

The file's header have the following structure:

- Bit rate [double]: the number of transmitted bits per second. The value is reflected in the user interface.
- High level [double]: the value is reflected in the user interface.
- Mask [string of 8 characters made up of "X"/"1"/"0"] : defines how the output of the pattern generator looks like. The following values are defined:
  - *1'* means that the pin output is always at high level
  - *0'* means that the pin output is always at low level (close to 0V)
  - *X* means that the pin output varies according to the given pattern
- Data sample format [HEX, BIN, OCT, DEC]: indicates how the samples are going to be interpreted. Each sample is represented as 8bit value (corresponding to the 8bit pattern generator) considering the selected format.

Example: Sample format HEX

```
Format= HEX        // Defines the format of the pattern values [HEX, DEC, BIN, OCT]
0F -> Data Sample 1
21 -> Data Sample 2
........
```

The samples are mapped on the 8 pins of the pattern generator as follows:

```
=> Pattern Samples are:
D7   D6   D5   D4  D3   D2  D1   D0
0    0    0    0   1    1   1    1
0    0    1    0   0    0   0    1
```

Example: .csv pattern generator file

```
R&S Pattern Generator File
Rate= 1000000        // Bit Rate [double]
HLevel= 1.5         // High Voltage Level [double]
Mask= X111000X      // Masks the Pins to be used in the Pattern Generator
                    // [0 => always LOW, 1 => always HIGH, X/x => used in the Pattern]
Format= DEC         // Defines the format of the pattern values [HEX, DEC, BIN, OCT]0
1
2
3
....
200
```

Content and format of the R&S pattern generator *.bin files

For the content of the fields, refer to "Content and format of the R&S *.csv files" on page 1017.

The file stream should contain the following information in the given order:

• Bit rate	[double]
• High level	[double]
• Mask	[string of 8 characters made up of "X"/"1"/"0"]

Number of samples	[UINT32]
Data samples	[UINT8] * number of samples

Enable
Enables the waveform generator/ pattern generator and outputs the signal to the connectors.

Remote command:
`WGENerator<m>[:ENABle]` on page 2115
`PGENerator:ENABle` on page 2131

Running mode
Selects the duration for which the signal of the generator will be output after the trigger event. You can choose between a "Continuous" and "Single period" duration.

Remote command:
`PGENerator:RUNMode` on page 2132

Bit Rate
Sets the number of transmitted bits per second for the pattern generator.

Remote command:
`PGENerator:BITRate` on page 2131

High Level
Sets the high level of the signal.

Remote command:
`PGENerator:HLEVel` on page 2131

Load Pattern
Opens a dialog for selecting an existing pattern file. It is possible to load `.bin` or `.csv` files, see "Content and format of the pattern generator files" on page 1017.

Remote command:
`PGENerator:FILE:OPEN` on page 2131
`PGENerator:FILE[:NAME]` on page 2131

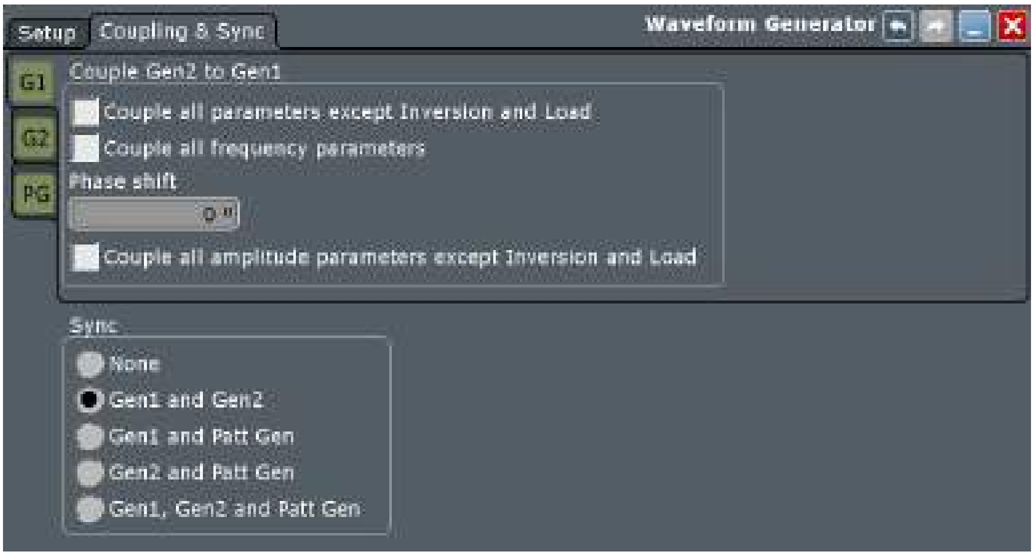
Preset Gen1/Gen2/Patt Gen
Sets the parameters of the generator to their default values. The settings of the generators are not affected by an instrument preset.

Remote command:
`WGENerator<m>:PRESet` on page 2115
`PGENerator:PRESet` on page 2132

14.3 Coupling and Sync Settings

Access: GEN 1/GEN 2 > "Coupling & Sync" tab.

In the R&S RTO, you can couple certain settings of the available waveform generators. If one of the available coupling options is enabled for one of the generators, then you cannot change the coupled parameters at the "Setup" tab of the other generator. The values for all coupled parameters are automatically taken from the master generator.



Couple Gen2 to Gen1

☐ Couple all parameters except Inversion and Load

☐ Couple all frequency parameters

Phase shift: 0 °

☐ Couple all amplitude parameters except Inversion and Load

Sync

○ None

● Gen1 and Gen2

○ Gen1 and Patt Gen

○ Gen2 and Patt Gen

○ Gen1, Gen2 and Patt Gen

Couple Gen 2 to Gen1/ Couple Gen 1 to Gen 2

Enables the coupling of the selected parameters of "Gen1" to "Gen2"/"Gen2" to "Gen1".

"Couple all parameters except Inversion and Load"

All signal, output and noise parameters of the generators are coupled, except for "Load" and "Inversion".

"Couple all frequency parameters"

All frequency parameters of the generators are coupled:

- For "Operation Mode" > "Function Gen.": "Frequency" and "Period"
- For "Operation Mode" > "Modulation": "Carrier frequency", "Carrier period", "Modulation freq", "Freq deviation", "Frequency 1", "Frequency 2" and "Hop rate"
- For "Operation Mode" > "Sweep": "Start frequency", "Stop frequency" and "Sweep time".
- For "Operation Mode" > "Arbitrary": "Arb wfm source", "Load arbitrary waveform" and "Signal source"

You can still change the other settings of the generators independently.

"Phase shift" Sets the phase shift between the waveform of "Gen1" and "Gen2" when the frequency parameters of the two waveforms are coupled.

"Couple all amplitude parameters except Inversion and Load"
All amplitude parameters of the generators are coupled:

- For all "Operation Mode": the output settings except of "Load" and "Inversion", "Amplitude", "High", "Offset" and "Low".
- For "Operation Mode" > "Function Gen.": "DC Level"
- For "Operation Mode" > "Modulation": "Modulation depth"

Remote command:
`WGENerator<m>:COUPling:ALL` on page 2132
`WGENerator<m>:COUPling:AMPLitude` on page 2132
`WGENerator<m>:COUPling:PHASeshift` on page 2132
`WGENerator<m>:COUPling[:FREQuency]` on page 2133

Sync
Selects, which signals generated from the waveform generator are synchronized.

Selecting one of the sync options indicates that the first samples of those signals are generated at the same time, irrespective of if the generators are on or off. Selecting one of the coupling options automatically syncs the signals generated by the two waveform generators.

Remote command:
`GENerator:SYNC[:COMBination]` on page 2133

14.4 Configuring the Waveform Generator

This chapter explains step-by-step how to configure the waveform generator.

14.4.1 Configuring a Function Waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Function Gen." button.
4. Select the "Function type" that you want to generate, e.g. "Sine".
5. Depending on the selected "Function type", configure the settings of the waveform like "Frequency" and "Period".
6. If necessary, change the "Output" settings or add "Noise" to the waveform.

7. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.2 Configuring a Modulation Waveform

Generating an AM modulated waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "AM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an PWM modulated waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "PWM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an FM modulated waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.

4. Tap "Modulation type" and select "FM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Freq deviation".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an FSK modulated waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "FSK".
5. Set the "Frequency 1", "Frequency 2" and the "Hop rate".
6. If necessary, change the "Output" settings or add "Noise" to the waveform.
7. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.3 Configuring a Sweep Waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Sweep" button.
4. Set the "Start frequency", the "Stop frequency" and the "Sweep time".
5. If necessary, change the "Output" settings or add "Noise" to the waveform.
6. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.4 Configuring an Arbitrary Waveform

Generating an arbitrary waveform from a saved file

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.

3. Under "Operation mode", enable the "Arbitrary" button.
4. Set the "Arb wfm source" to "Saved waveform".
5. Select the "Run mode".
6. Press "Open" and set the path to your saved arbitrary waveform.
7. Set the "Sample rate".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an arbitrary waveform from the scope waveform

1. Press the GEN 1 key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Arbitrary" button.
4. Set the "Arb wfm source" to "Scope waveform".
5. Select the "Run mode".
6. Press the "Signal source" button and select the channel source for the waveform.
7. Set the "Sample rate".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.5 Configuring a Pattern Generator Waveform

1. Press the GEN 1 key on the front panel.
2. At the left-hand side, select the vertical tab "PG".
3. Select the "Setup" tab.
4. Select the "Run mode".
5. Press "Open" and set the path to your saved pattern file.
6. Set the "Bit rate" and "High level".
7. Press "Open" and set the path to your saved arbitrary waveform.
8. Press the "Enable" button, to output the pattern at the output connector of the pattern generator.

14.5 DC Offset Alignment

Access: "Wave Gen" > "DC offset Allignment" tab

Before the start of the dc alignment procedure remove cables connected to Gen1 and Gen2

Date: 06.02.2017

Time: 15:57:04

Overall alignment state: Passed

Start Alignement
Starts the alignment of the DC offset.

Remote command:
`GENerator:ALIGnment:DC[:STARt]` on page 2134

Date
Displays the date of the last performed DC offset alignment.

Remote command:
`GENerator:ALIGnment:DC:RESult:DATE?` on page 2133

Time
Displays the time of the last performed DC offset alignment.

Remote command:
`GENerator:ALIGnment:DC:RESult:TIME?` on page 2134

Overall alignment state
Displays the result of the DC offset alignment.

Remote command:
`GENerator:ALIGnment:DC:RESult[:STATe]?` on page 2134

15 I/Q Software Interface (Option R&S RTO-K11)

The option R&S RTO-K11 "I/Q Software Interface" acquires modulated signals and outputs I/Q data for further analysis using other software, for example, MATLAB.

Rohde & Schwarz provides also specific software for analysis of I/Q data on external computer:

- R&S FS-K96 OFDM Vector Signal Analysis Software
- FS-K10xPC LTE Analysis Software

Except for the I/Q data recording, the option also provides the NFC trigger type, a specific trigger for Near Field Communication analysis.

15.1 I/Q Mode

Access: "App Cockpit" menu > "General" tab > "IQ" > "Acquisition" tab > "Option mode" = "IQ"

Acquisition mode: IQ

The I/Q mode is a special operating mode of R&S RTO. In this mode, the usual analyzing tools (cursor, zoom, measurements, FFT and so on) of the oscilloscope are deactivated. The instrument displays the magnitude of the I/Q vector to get an impression of the data before it is exported.

Triggering is performed on the input data before conversion to I/Q data, using the ususal R&S RTO trigger functionality. In case of complex input signals, the instrument triggers on one component of the complex signal (I or Q) depending on the selected trigger source.

1. Press the App Cockpit key in the Analysis section of the front panel.
2. In the "General" tab, select "IQ".
3. To set up the I/Q data recording, tap "IQ Sampling Setup".

Option mode
Sets the operation mode of the instrument.

"Normal"	Usual oscilloscope mode

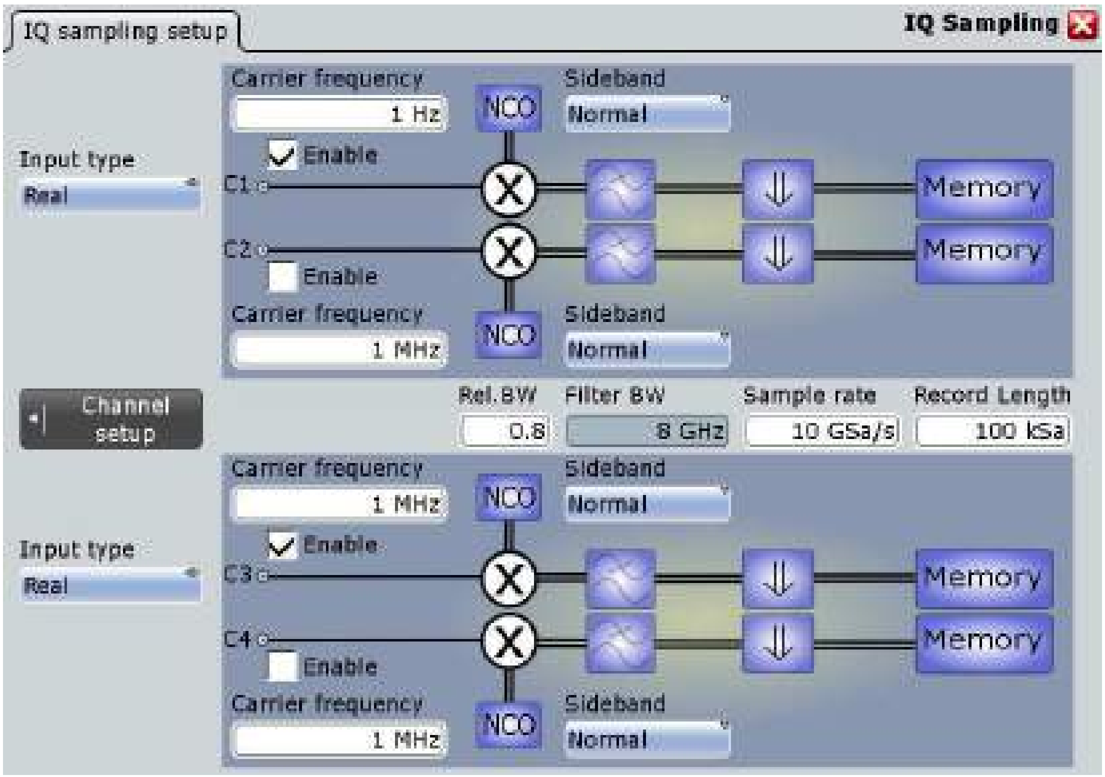
"IQ"	I/Q mode to record I/Q data, requires option R&S RTO-K11. The analyzing tools on the toolbar are deactivated, and the magnitude of the I/Q vector is displayed.
"High definition"	Mode with higher digital resolution, up to 16 bit. Requires option R&S RTO-K17.

Remote command:
`IQ:STATe` on page 2135
`HDEFinition:STATe` on page 1249

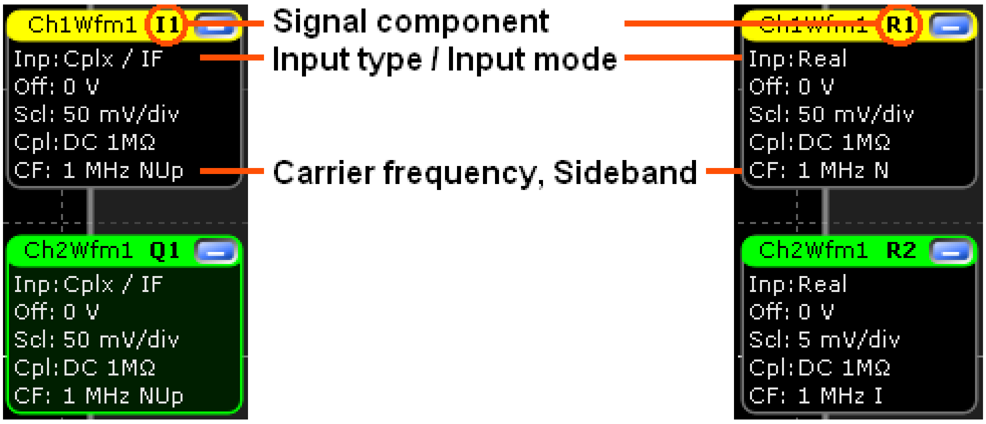
15.2 IQ Sampling Setup

In the "IQ Sampling" dialog box you configure the complete I/Q sampling for real and complex input signals.

Access: "App Cockpit" menu > "General" tab > "IQ" > "Acquisition" tab > "Option Mode" = "IQ" > "IQ Sampling Setup"



As is usual, the signal icons of the enabled channels show the current settings. In I/Q mode, the I/Q settings are shown:



Ch1Wfm1 I1
Inp:Cplx / IF
Off: 0 V
Scl: 50 mV/div
Cpl:DC 1MΩ
CF: 1 MHz NUp

Ch2Wfm1 Q1
Inp:Cplx / IF
Off: 0 V
Scl: 50 mV/div
Cpl:DC 1MΩ
CF: 1 MHz NUp

Ch1Wfm1 R1
Inp:Real
Off: 0 V
Scl: 50 mV/div
Cpl:DC 1MΩ
CF: 1 MHz N

Ch2Wfm1 R2
Inp:Real
Off: 0 V
Scl: 5 mV/div
Cpl:DC 1MΩ
CF: 1 MHz I

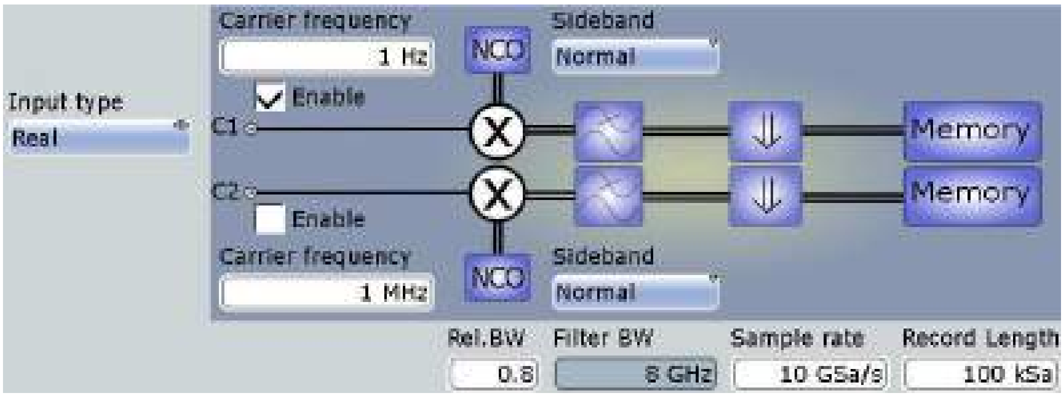
Figure 15-1: Signal icons. Left side: complex input signal in IF range with carrier frequency 1 MHz and normal/upper sideband. Ch 1 is the in-phase component, ch 2 the quadrature component. Right side: Real input signal with carrier frequency 1 MHz. Ch 1 has normal sideband, Ch2 has inverse sideband.

Input type, Input mode

"Input type" sets the format of the input signal. "Input mode" selects the frequency band of a complex input signal.

The R&S RTO I/Q Software Interface support three formats of input signals.

- Real RF signals



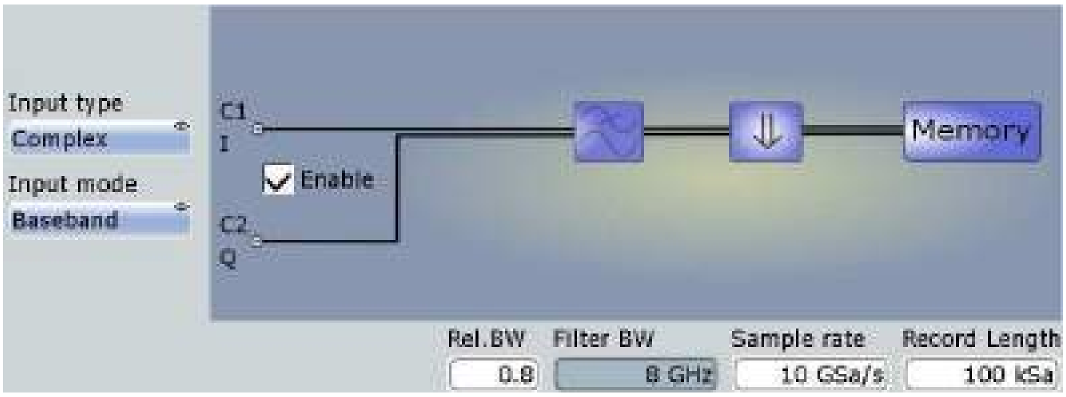
Input type: Real

Carrier frequency: 1 Hz
Sideband: Normal
☑ Enable

☐ Enable
Carrier frequency: 1 MHz
Sideband: Normal

Rel.BW: 0.8
Filter BW: 8 GHz
Sample rate: 10 GSa/s
Record Length: 100 kSa

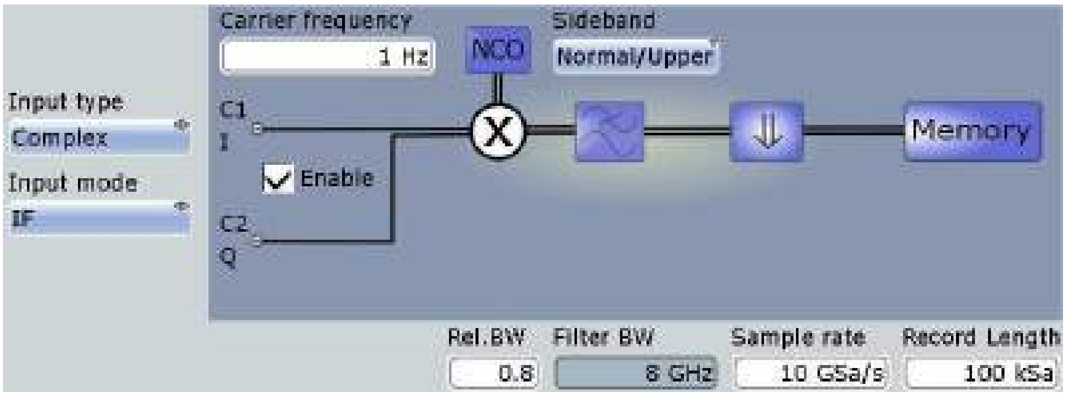
  - The input signal is down-converted, filtered and resampled to the sample rate of the output I/Q signal.
  - One channel is required for each input signal. Thus up to four real signals can be recorded in parallel.
  - Sideband settings: see "Sideband (real input)" on page 1030.
- Complex I/Q baseband signals



Input type: Complex
Input mode: Baseband
Rel.BW: 0.8
Filter BW: 8 GHz
Sample rate: 10 GSa/s
Record Length: 100 kSa

- The input signal is filtered and resampled to the sample rate of the output I/Q signal.
- Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component. Thus up to two complex input signals can be recorded in parallel.

- Complex I/Q signals in low IF range



Carrier frequency: 1 Hz
Sideband: Normal/Upper
Input type: Complex
Input mode: IF
Rel.BW: 0.8
Filter BW: 8 GHz
Sample rate: 10 GSa/s
Record Length: 100 kSa

- The input signal is down-converted, filtered and resampled to the sample rate of the output I/Q signal.
- Two input channels are required for each input signal, one for the in-phase component, and one for the quadrature component. Thus up to two complex input signals can be recorded in parallel.
- Sideband settings: see "Sideband (complex IF input)" on page 1031.

Remote command:
`CHANnel<m>:IQ:INPType` on page 2135
`CHANnel<m>:IQ:INPMode` on page 2135

Rel. BW, Filter BW
"Rel. BW" sets the bandwidth factor to define the filter bandwidth:

*Filter BW = Relative BW * Sample rate*

Remote command:
`IQ:RBWidth` on page 2136
`IQ:BWIDth?` on page 2136

Sample rate

Sets the required sample rate of the output I/Q data.

Remote command:
`IQ:SRATe` on page 2136

Record length

Sets the required record length of the output I/Q data. The resulting acquisition time of the I/Q data is:

Acquisition time = Record length / Sample rate

Remote command:
`IQ:RLENgth` on page 2136

Show channel

Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 1216

Carrier freq.

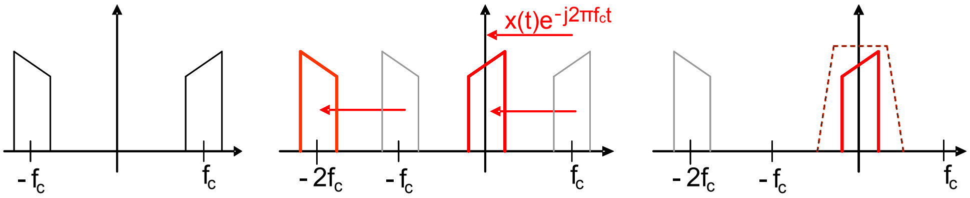
Sets the carrier frequency of the modulated RF signal or of the complex signal in IF range.

Remote command:
`CHANnel<m>:IQ:CFRequency` on page 2136

Sideband (real input)

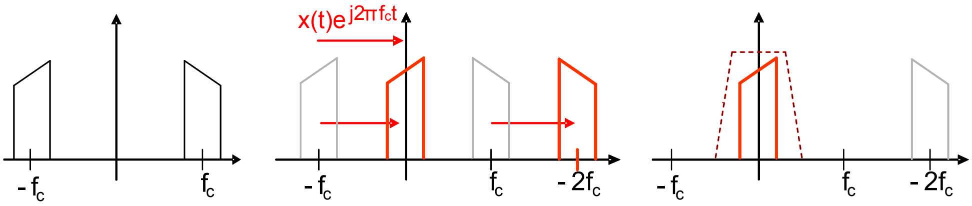
Defines the frequency position of the RF spectrum in the input signal: normal or inverse. The position is important for correct down-conversion and filtering.

- "Normal" position of the RF spectrum



Input signal, normal Down-conversion Filtering

- "Inverse" position of the RF spectrum

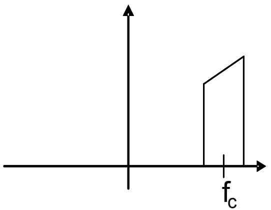


Input signal, inverse Down-conversion Filtering

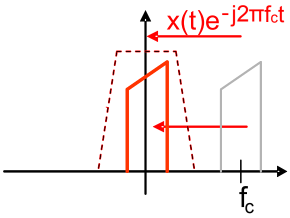
Remote command:
`CHANnel<m>:IQ:SBRF` on page 2137

Sideband (complex IF input)
Defines the sideband and the frequency position of complex modulated input signal in IF range.

- "Normal/Upper": Upper sideband in normal position

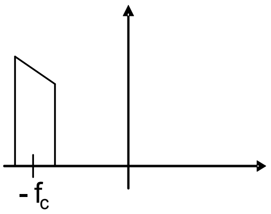


Input signal: normal position, upper sideband

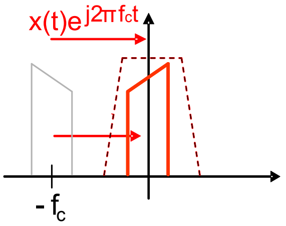


Down-conversion and filtering

- "Normal/Lower": Lower sideband in normal position

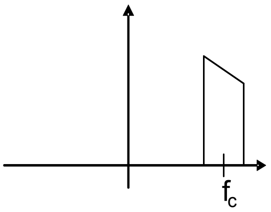


Input signal: normal position, lower sideband

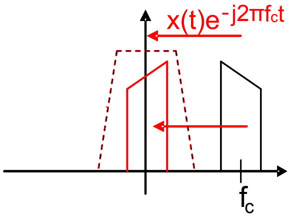


Down-conversion, filtering, and complex conjugation

- "Inverse/Upper": Upper sideband in inverse position

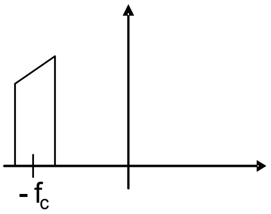


Input signal: inverse position, upper sideband

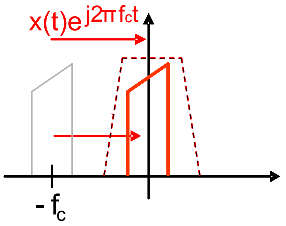


Down-conversion, filtering, and complex conjugation

- "Inverse/Lower": Lower sideband in inverse position



Input signal: inverse position, lower sideband



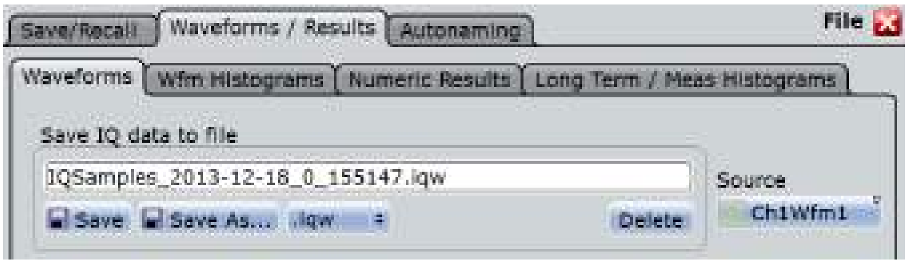
Down-conversion and filtering

Remote command:
`CHANnel<m>:IQ:SBIF` on page 2137

15.3 I/Q Data Output

The recorded I/Q data can be saved manually on hard disc or USB flash device for further analysis, or extracted using remote control from an external computer. If supported by the R&S analysis option, a direct connection and data usage via LAN is also possible.

Access: SAVE RECALL > "Waveforms / Results" tab > "Waveforms" tab



In I/Q mode, the "Waveforms" tab provides all functions to save the recorded I/Q data.

Source

Selects the channel for which the I/Q data is saved. For each input channel, a separate output file is written.

In case of a complex input signal that requires two input channels, the results of sources Ch1Wfm1 and Ch2Wfm1 are identical, as well as the results of Ch3Wfm1 and Ch4Wfm1.

Save IQ data to file

Enter the file name to save the I/Q data to. Double-tap the file name to open the file selection dialog box.

By default, the file name has the prefix "IQSamples_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save"	Saves the I/Q data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the I/Q data to the selected file. See also Chapter 11.6, "File Selection Dialog", on page 478.
".iqw/.iq.tar/.bin /.xml/.csv"	Selects the file format. IQW: specific format for analysis with R&S I/Q data analysis software. It contains the I and Q values in interleaved order. IQ.TAR: iq-tar file format, packed format containing several files: an I/Q parameter XML file, an I/Q data binary file, and an optional I/Q preview XSLT file (stylesheet). A detailed specification of the iq-tar file format is given in http://www.rohde-schwarz.com/en/manual/manual-r-s-iq-tar-file-format-specification-manuals-gb1_78701-37313.html. CSV, XML, and BIN: usual formats that are also used for common waveform export, see Chapter 11.2.1, "Waveform Export Files", on page 449.

Remote command:

`CHANnel<m>:IQ:DATA[:VALues]?` on page 2138

`CHANnel<m>:IQ:DATA:HEADer?` on page 2138

15.4 NFC Trigger

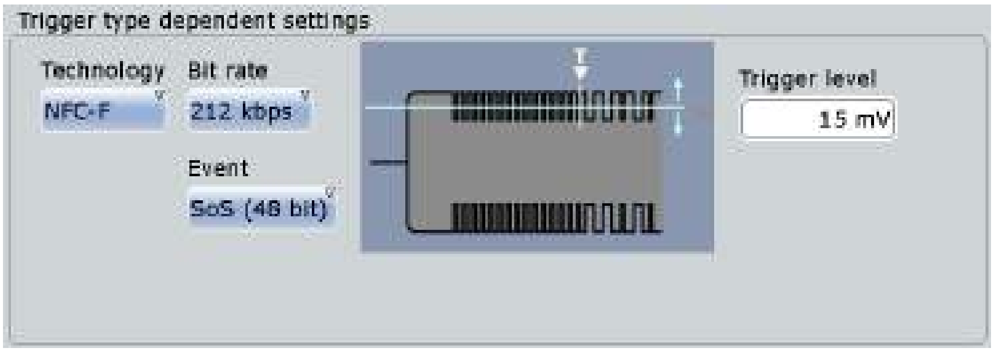
The Near Field Communication (NFC) trigger triggers on characteristic events of NFC signals, in particular on polling requests of a device, for example, of a mobile phone.

The trigger source is the NFC signal connected to one of the channel inputs.

You can analyze the triggered signal in two ways:

- In normal instrument mode, you can display and analyze the signal in the time domain.
- In IQ mode, you can acquire and save I/Q data for external analysis on a computer. The R&S RTO display shows the magnitude of the I/Q vector.

Access: TRIGGER > "Setup" tab > "Type" = NFC



Trigger type dependent settings

Technology: NFC-F

Bit rate: 212 kbps

Event: SoS (48 bit)

Trigger level: 15 mV

Technology
Selects the NFC technology, the communication protocol used by the input signal.

"NFC-A"	compatible to ISO/IEC 14443A
"NFC-B"	compatible to ISO/IEC 14443B
"NFC-F"	compatible to JIS X6319-4 (FeliCa)

Remote command:
`TRIGger<m>:NFC:TECHnology` on page 2139

Bit rate
Sets the bit rate of the signal. For NFC-A and NFC-B, the bit rate is always 106 kBit per second. For NFC-F, the bit rate can be either 212 or 424 kBit per second.

Remote command:
`TRIGger<m>:NFC:BITRate` on page 2139

Event
Sets the trigger on:

- NFC-A:
  ALL_REQ or SENS_REQ command (polling requests)
- NFC-B:
  ALLB_REQ or SENSB_REQ command
- NFC-F:
  Start of Sequence pattern with 48 bit or 96 bit length

Remote command:
`TRIGger<m>:NFC:EVENt` on page 2139

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

16 Jitter Analysis and Clock Data Recovery (Options R&S RTO-K12/13)

Jitter describes the timing errors in a system. It is a significant and undesired factor in high-speed serial communication designs because it causes transmission errors.

The jitter analysis option R&S RTO-K12 provides common analysis and visualization tools for signal integrity analysis and jitter characterization:

- Automated jitter measurements in time domain
- Track graph of jitter measurement results
- Jitter spectrum
- Eye mask definition and analysis
- Software-based clock data recovery

A wizard guides you through the configuration of most common jitter analysis tasks.

In addition, the option R&S RTO-K13 provides hardware-based clock data recovery. The resulting clock edge stream can be used as trigger source for the CDR trigger.

16.1 Jitter Measurements

The R&S RTO provides two ways to set up jitter measurements:

- The jitter wizard for most common jitter measurements
- The usual measurement setup in the "Jitter" category

Both ways are described in the following chapters.

16.1.1 Jitter Wizard

The jitter wizard guides you through the configuration of most common jitter analysis tasks:

- Period and frequency
- Cycle-to-cycle jitter
- Time interval error (TIE)

- Skew

After selecting and setting up the measurement type, you can adjust the scaling and the reference level and decide which results you want to see:

- Source signals
- Track of measurement
- Histogram of measurement
- FFT spectrum of track

Other jitter measurement types and more complex setups can be configured using the "Measurement" and "CDR Setup" dialog boxes which are described in the following chapters.

16.1.2 Jitter Measurement Types

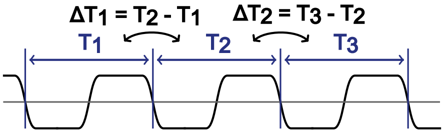
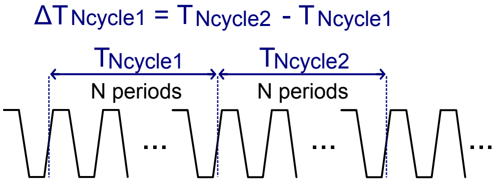
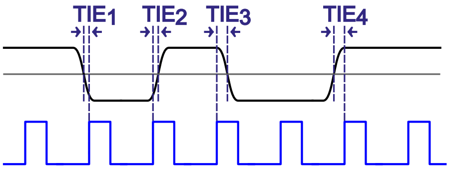
The measurement category "Jitter" gathers all measurement types which are useful for jitter analysis. The category contains jitter-specific measurement types and also some amplitude/time measurement types that are useful for jitter analysis:

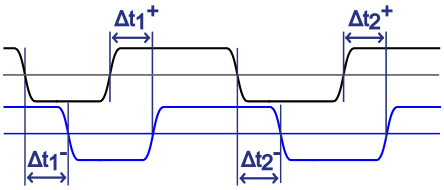
- Period
- Frequency
- Setup time
- Hold time
- Setup/Hold ratio

The amplitude/time measurement types are described in "Time Measurements" on page 329.

The specific jitter measurement types are described in Table 16-1.

Table 16-1: Jitter measurement types

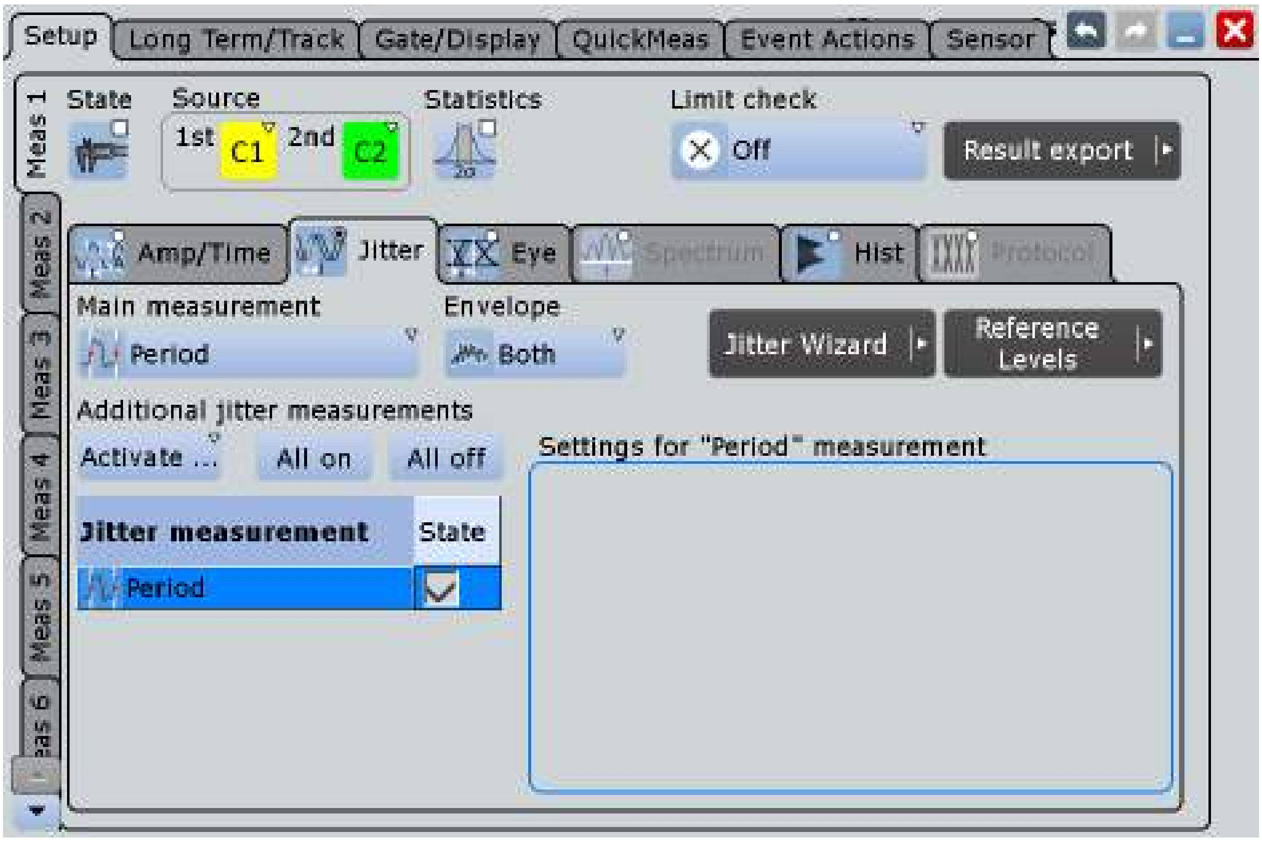
	Measurement type	Description/Result
	Cycle-cycle jitter	Difference between the periods of two adjacent cycles. The measurement is based on the period measurement. You can select the slope and the reference level on which the period is measured. $\Delta T_{Period\,k} = T_{Period\,k+1} - T_{Period\,k}$ for $k = 1,...,K-1$  See also: Chapter 16.1.3.2, "Clock Measurement Settings", on page 1040
	N-cycle jitter	Difference between the time of two adjacent groups of N cycles (periods) each. You can select the slope and the reference level on which the time is measured, and the number of periods in the groups. $\Delta T_{Ncycle\,k} = T_{Ncycle\,k+1} - T_{Ncycle\,k}$ for k = *cycle group index* 
	Cycle-cycle width	Difference between the pulse width of two adjacent cycles. The measurement is based on the pulse width measurement. You can select the pulse polarity to be measured. $\Delta T_{Pulse\,k} = T_{Pulse\,k+1} - T_{Pulse\,k}$ for $k = 1,...,K-1$
	Cycle-cycle duty cycle	Difference between the duty cycle of two adjacent cycles. The measurement is based on the duty cycle measurement. You can select the pulse polarity for the duty cycle measurement. $\Delta R_{Cyc\,k} = R_{Cyc\,k+1} - R_{Cyc\,k}$ for $k = 1,...,K-1$
	Time interval error	Time difference between the slope of the input signal and the slope of a reference signal. The reference signal can be a captured clock waveform, or a clock generated by clock data recovery (CDR, software algorithm or hardware generation). You can select the slope and the reference level on which the TIE is measured. $TIE_k = t_{Signal\,k} - t_{Clock\,k}$ for $k = 1,...,K$  See also: Chapter 16.1.3.3, "Data Measurement Settings", on page 1041
	Unit interval	Period of the clock signal. If no clock signal is available, it is recovered by CDR. The period is calculated as the time difference between two consecutive clock edges of the same polarity. $UI_k = t_{Clock\,k+1} - t_{Clock\,k}$ for $k = 1,...,K-1$

	Measurement type	**Description/Result**
	Data rate	Frequency of the clock signal. If no clock signal is available, it is recovered by CDR. The measurement is based on the unit interval measurement. $R_{Clock\ k} = 1 / UI_k$ for $k = 1,...,K-1$
	Skew delay	Delay between the edges of two interdependent waveforms. The measurement is a simplified variant of the "Delay" measurement assuming that both sources are similar except for the delay. $Skew\ delay = \Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$  See also: Chapter 16.1.3.4, "Delay Measurement Settings", on page 1043
	Skew phase	Phase difference between the edges of two waveforms. $Skew\ phase = Skew\ delay / Period * 360° = \Delta t_k / \Delta T_{Period\ k} * 360°$

Limit and margin checks are also available for jitter measurements, see Chapter 7.2.12, "Limit and Margin Checks", on page 363. Limit and margin checks are based on the amplitude/time measurements.

16.1.3 Jitter Measurement Settings

Jitter measurements are only available for sources in the time domain.



Jitter measurement	State
Period	☑

16.1.3.1 Measurement Type Selection

Main measurement
Defines the main jitter measurement type. This measurement is the one referred to if the measurement result is used as a source for math calculations. The main measurement cannot be disabled.

For details on the available measurement types, see Chapter 16.1.2, "Jitter Measurement Types", on page 1036.

Remote command:
`MEASurement<m>:MAIN` on page 1337

Additional jitter measurements
In addition to the main measurement type, further jitter measurements can be performed simultaneously. The selected measurement types are displayed in an overview table.

Beside the table, specific settings for the selected measurement type are shown. When you select a measurement type, check and adjust its specific setting(s).

For details on the available measurement types, see Chapter 16.1.2, "Jitter Measurement Types", on page 1036.

"Activate"	opens the measurement table to select individual measurements
"All on"	enables all available additional measurements.

"All off"	deactivates all selected measurements in the table.

Remote command:
`MEASurement<m>:ADDitional` on page 1338

16.1.3.2 Clock Measurement Settings

The cycle-cycle measurements are intended to analyze the quality of clock signals. They require a few settings for period and pulse width measurement.

See also: Table 16-1

Main measurement: N-cycle jitter

Envelope: Both

Additional jitter measurements

Jitter measurement	State
Cycle-cycle jitter	✓
N-cycle jitter	✓
Cycle-cycle width	✓
Cycle-cycle duty cycle	✓

Settings for "Cycle-cycle duty cycle" measuremer

Cycle begin: First edge

Reference level: middle

Pulse polarity: Positive

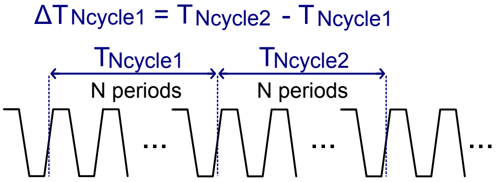
Cycle begin
Selects the slope at which the periods and thus the jitter is measured.

The setting is available for the following measurements: cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle.

"First edge"	Measures the period from the first edge that is found, no matter of its direction.
"Positive"	Measures the period at positive going edges.
"Negative"	Measures the period at negative going edges.
"Either"	Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock.

Remote command:
`MEASurement<m>:JITTer:CCSLope` on page 2141

Number of cycles
Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.



The parameter is available since FW 2.60. In this FW version, the algorithm of N-cycle measurement has been changed and the "Cycle offset" parameter has been removed.

Remote command:
`MEASurement<m>:JITTer:NCYCles` on page 2142

Data ref level
Selects the reference level of the data on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTO-K12).

Remote command:
`MEASurement<m>:AMPTime:DATA<n>:LSELect` on page 1353

Pulse polarity
Sets the polarity of pulses for which the pulse width is measured to obtain the cycle-cycle width and the cycle-cycle duty cycle.

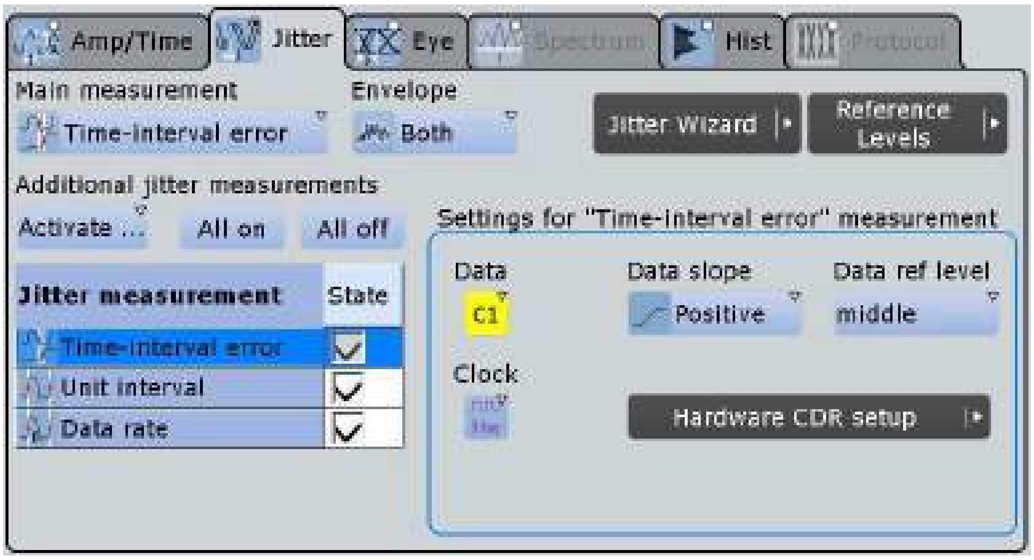
The setting is available for the following measurements: cycle-cycle width and cycle-cycle duty cycle.

"Positive"	Pulse width of positive pulses is measured.
"Negative"	Pulse width of negative pulses is measured.

Remote command:
`MEASurement<m>:JITTer:PULSe` on page 2142

16.1.3.3 Data Measurement Settings

The measurements time interval error, unit interval and data rate are intended to analyze serial data. The clock can be an explicit clock signal, or it can be recovered from the data signal using one of the clock recovery algorithms.



Main measurement: Time-interval error

Envelope: Both

Jitter measurement	State
Time-interval error	☑
Unit interval	☑
Data rate	☑

Data: C1

Data slope: Positive

Data ref level: middle

Clock

Defines the origin of the clock signal - wether an existing clock signal or waveform, or a clock generated using one of the CDR methods.

"Explicit signal"	The clock is an existing clock signal. Select the clock source, clock slope, and the reference level.
"Software CDR 1 / 2"	The clock is generated by a software algorithm. The R&S RTO provides two setups for software CDR, which can be configured and used independently. To configure the CDR, tap the "CDR Setup" button.
"Hardware CDR"	The clock is generated from the source signal by the integrated CDR circuitry. To configure the CDR, tap the "CDR Setup" button. The HW CDR must be active to perform the measurement. To activate HW CDR, use the trigger type "CDR", or the trigger type "Serial pattern" with active CDR. **Note:** For TIE measurement results with HW CDR, set "UI offset = 0". Other values introduce a timing offset in the results.

Remote command:

`MEASurement<m>:JITTer:CDRMode` on page 2143

Clock slope / Data slope

Set the edges that are used for measurements.

"Data slope" is only relevant for time interval error measurements with real clock signal.

"Positive"	The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge.
"Negative"	The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge.

"Either"	For clock edges, this option can be used for double data rate (DDR) signals. For data edges, it is the most common setting.

Remote command:
`MEASurement<m>:JITTer:SOURce<n>:TIESlope` on page 2143

Clock ref level

Selects the reference level of the clock on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTO-K12).

Remote command:
`MEASurement<m>:AMPTime:CLCK<n>:LSELect` on page 1353

Data ref level

Selects the reference level of the data on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

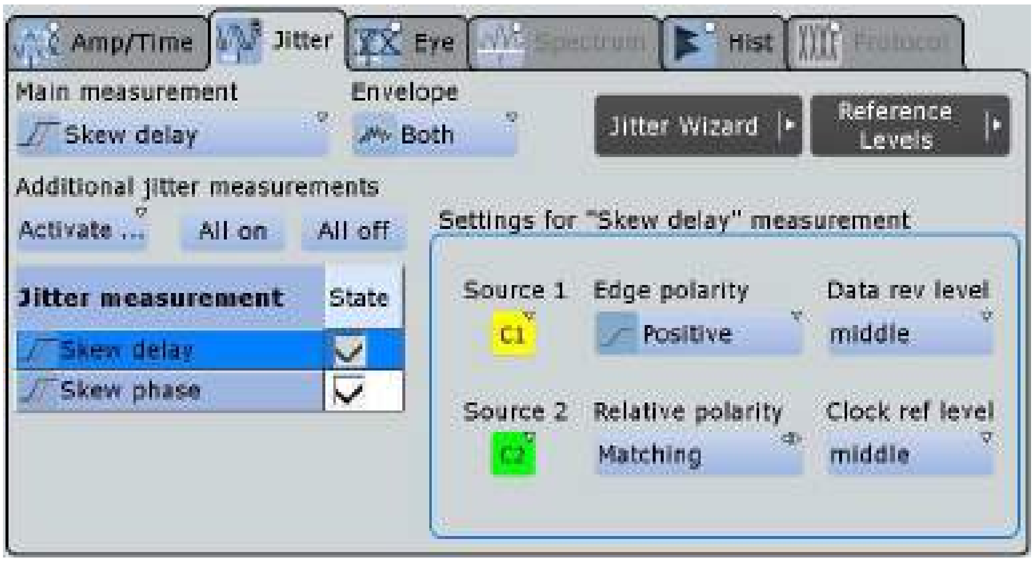
The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTO-K12).

Remote command:
`MEASurement<m>:AMPTime:DATA<n>:LSELect` on page 1353

16.1.3.4 Delay Measurement Settings

The measurements skew delay and skew phase are intended to measure the time difference between the edges of two waveforms. The measurements are simplified variants of the "Delay" and "Phase" measurements assuming that both sources are similar except for the delay.

See also: Table 16-1



Main measurement: Skew delay

Envelope: Both

Jitter measurement	State
Skew delay	☑
Skew phase	☑

Settings for "Skew delay" measurement

Source 1: C1

Edge polarity: Positive

Data ref level: middle

Source 2: C2

Relative polarity: Matching

Clock ref level: middle

Source 1, Source 2

"Source 1" is the reference signal, and "Source 2" is the the signal compared to the reference signal.

$Skew\ delay = \Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$

Edge polarity

Sets the edge of the first waveform from which the skew delay or phase is measured: positive, negative or both.

Remote command:

`MEASurement<m>:JITTer:SKWSlope` on page 2144

Relative polarity

Sets the edge of the second waveform relative to the first waveform.

"Matching"	Measures from positive to positive edge or from negative to negative edge.
"Inverse"	Measures from positive to negative edge or from negative to positive edge.

Remote command:

`MEASurement<m>:JITTer:SKWRelation` on page 2144

Data ref level / Clock ref level

See Chapter 16.1.3.3, "Data Measurement Settings", on page 1041

16.1.3.5 Measuring TIE with HW CDR

To measure the time interval error with hardware-recovered clock, the option R&S RTO-K13 is required.

1. Configure the HW CDR settings according to the characteristics of the measured signal: "Analysis" menu > "HW".
2. Set up the trigger:
   a) TRIGGER > "Events" tab > "Source" = channel of the input signal > Trigger type = CDR
   b) Tap "Find level" to determine the trigger level.
   c) Set "UI offset = 0".
3. Configure the measurement:
   a) On the "Meas" menu, select "Setup".
   b) Select the "1st Source" and the "Jitter" category.
   c) Tap "Main measurement" and select "Time interval error".
   d) Select the "Data slope" and the reference level to be used to measure the jitter.
   e) Select the "Clock = Hardware CDR".
   f) Enable the measurement: "State = On" (in the upper left corner of the dialog box).
   g) Enable "Statistics".

16.1.4 Jitter Statistics and Histogram

Since jitter is a random component of all signals, statistical measurement results are required to characterize the jitter.

To get measurements statistics of a jitter measurement

Prerequisite: the jitter measurement types are selected and configured, and the measurement is active.

1. Open the "Measurements" dialog box for the jitter measurement by tapping the "Tools" icon in the result box.
2. On the "Setup" tab, enable "Statistics".
3. On the "Gate/Display" tab, enable "Multiple meas".

The histogram plots the density of data. It shows the frequency of occurrence of the measurement values. The maximum count of a measurement value is assigned to the full height of the histogram diagram (= 1000). All other count values are displayed relative to the maximum.

To enable the histogram

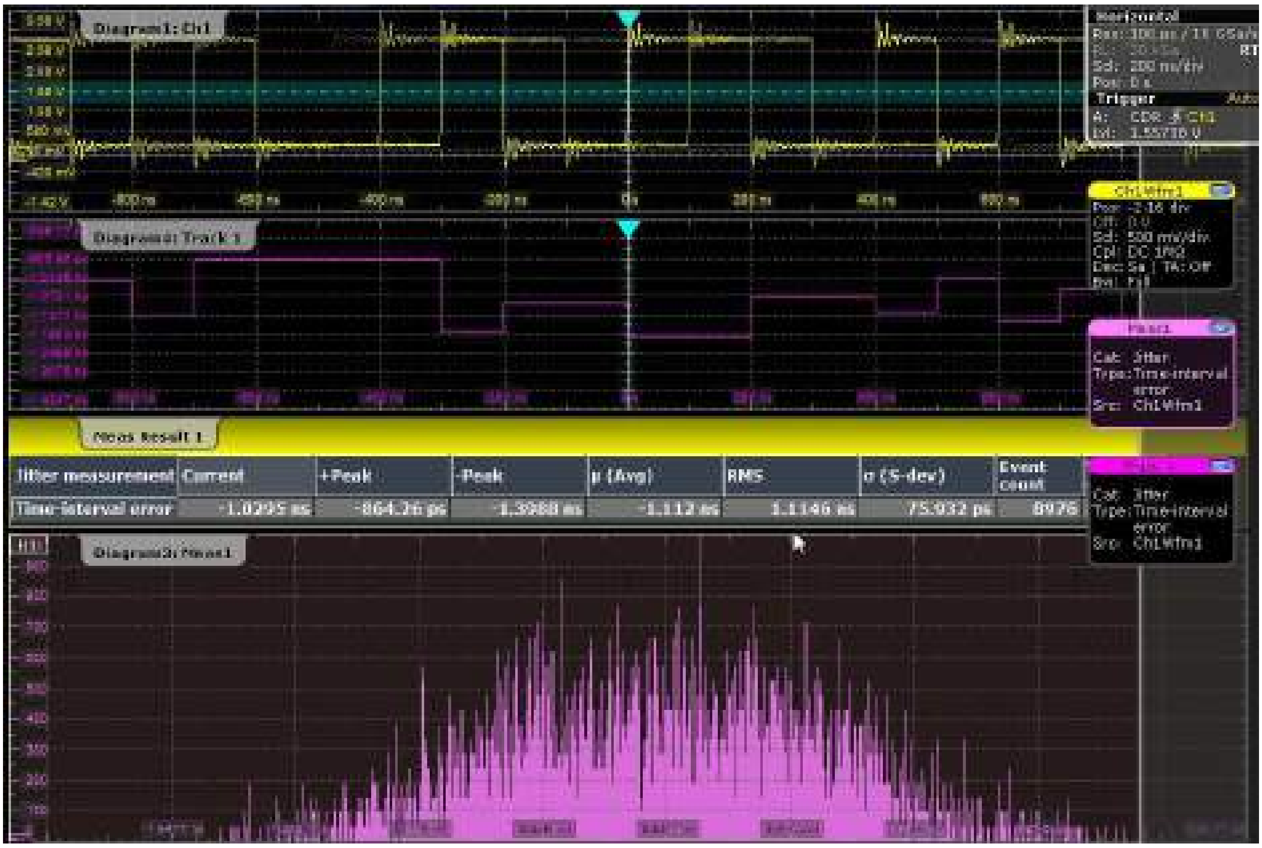
1. On the "Long Term/Track" tab, under "Histogram", tap "Enable".
2. If the histogram is not displayed as expected, disable "Continuous auto scale" and adjust the "Meas scale".

16.1.5 Track of Jitter Measurement Results

A track graph displays the results of the main jitter measurement from a single acquisition as a time-correlated waveform. To generate the track graph, multiple measurement points are required. Thus, enabling the track automatically activates the multiple measurement mode.

You can perform amplitude and time measurements on the track waveform: Configure a new measurement, e.g. "Meas2", that uses the track waveform as measurement source.

You can also zoom into the track waveform, perform cursor measurements on it, and export the track.



Jitter measurement	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count
Time-interval error	-1.0295 ns	-864.26 ps	-1.3988 ns	-1.112 ns	1.1146 ns	75.932 ps	8976

Figure 16-1: TIE measurement with CDR trigger, 10 Mbps, with track and histogram

16.1.6 Jitter Spectrum

An extension of jitter measurements is the FFT analysis of track waveforms of jitter measurements. The results are displayed in the frequency domain as a jitter spectrum. The modulation frequency is displayed on the horizontal axis, and the amplitude of modulation on the vertical axis. Using FFT, periodic components can be detected.

16.2 Clock Data Recovery

The process of clock data recovery (CDR) generates a reference clock from a high-speed serial data stream that is sent without a dedicated clock signal. The generated clock signal matches the frequency and is aligned to the phase of the data stream. The recovered clock can be used to sample the data stream, to obtain the sequence of transmitted bits, and to perform jitter measurements..

There are two ways to recover the clock signal:

- Using software algorithms that calculate the clock from data signal edges
- Using hardware CDR (option R&S RTO-K13)

The CDR methods and their usage are described in the following chapters:

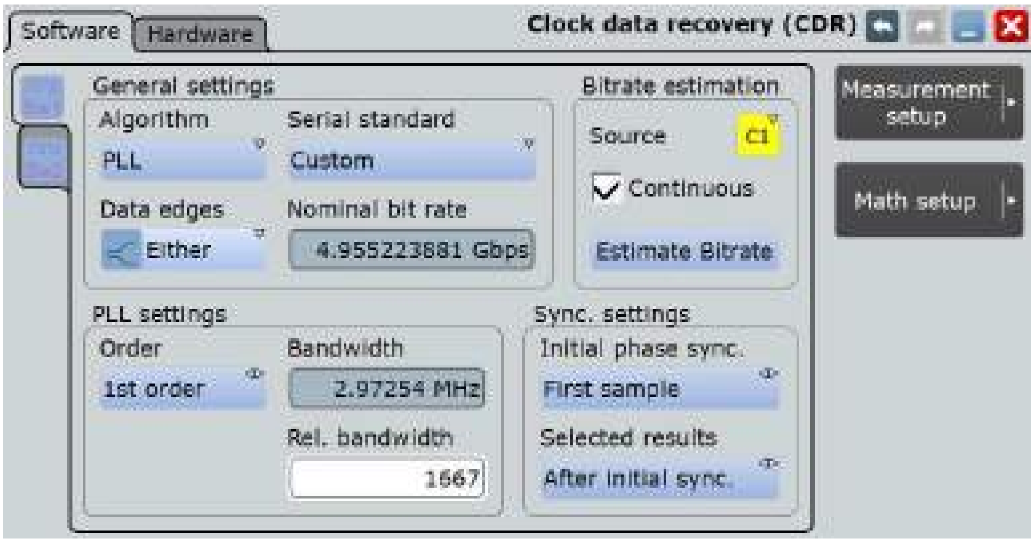
16.2.1 Software CDR

You can define two independent software CDR instances to recover clock signals. These clock signals are used for data timing measurements: time interval error, unit interval, and data rate (frequency of the clock signal).

Software CDR is based on acquired data, needs a synchronization time to set up the clock. To get correct measurement results, the data acquired during synchronization time has to be discarded. The less the bandwidth of the signal is, the

You can also display the recovered clock signal as a math waveform, see Chapter 16.2.3, "Displaying the Recovered Clock Signal", on page 1053.

Access: "Analysis" menu > "CDR Setup" > "SW"



Algorithm: PLL
Serial standard: Custom
Data edges: Either
Nominal bit rate: 4.955223881 Gbps
Source: C1
☑ Continuous
Order: 1st order
Bandwidth: 2.97254 MHz
Rel. bandwidth: 1667
Initial phase sync.: First sample
Selected results: After initial sync.

Algorithm
Sets the software algorithm that is used for clock data recovery.

"PLL"	PLL is the phase-locked loop control system. It can follow slow deviations in the frequency of the data stream. Thus, it acts as high-pass filter with respect to the jitter that remains on the signal.
"Constant freq."	CDR uses the nominal bit rate to generate the clock signal. The method assumes that the frequency of the signal is constant during the complete acquisition.

Remote command:
`CDR:SOFTware<m>:ALGorithm` on page 2145

Nominal bit rate

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:
`CDR:SOFTware<m>:BITRate` on page 2145

Data edges

Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Remote command:
`CDR:SOFTware<m>:ESLope` on page 2146

Bit rate estimation

Bit rate estimation analyzes the source signal based on the given "Nominal bit rate" and corrects the value.

"Source"	Selects the source of the data stream.
"Continuous"	Enables ongoing bit rate correction.
"Estimate bit rate"	Estimates the bit rate once, for the current acquisition.

PLL settings

Phase-locked loop parameters are listed below.

Note: Nomial bit rate, bandwidth and relative bandwidth are interacting settings. Modifying one parameter also changes one of the dependent parameters.

"Order"	Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.
"Bandwidth"	Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.
"Rel. bandwidth"	Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.
"Damping"	Sets the damping factor, which is only relevant for second order PLL.

Remote command:
`CDR:SOFTware<m>:PLL:ORDer` on page 2147
`CDR:SOFTware<m>:PLL:BWIDth` on page 2147
`CDR:SOFTware<m>:PLL:RELBwidth` on page 2147
`CDR:SOFTware<m>:PLL:DAMPing` on page 2148

Initial phase sync.

Defines the phase reference for the first clock edge.

"First sample"	The first clock edge matches the first sample of the waveform at the left border of the display.

"First data edge"	The first clock edge matches the first edge of the data signal.

Remote command:
`CDR:SOFTware<m>:SYNC` on page 2146

Selected results
The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges:

"After initial sync."	The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.
"All"	All clock edges are used.

Remote command:
`CDR:SOFTware<m>:RESults` on page 2146

16.2.2 Hardware CDR (Option R&S RTO-K13)

Hardware-based clock data recovery uses the digital CDR module to recover the clock edges. The generated clock is acquired similar to a waveform and occupies an adjacent analog channel. If the source is CH1, the recovered clock blocks CH2, and vice versa. CH3 and CH4 work in the same way. The occupied channel cannot be displayed, but the generated clock can be displayed as math waveform.

Hardware CDR is a continuous process, the recovered clock is always synchronized. HW CDR is the best way to analyze the jitter and eyes of continuous signals, and of buses that use Spread Spectrum Clocking. The complete data can be used, there is no synchronization time needed as with SW CDR, and no data must be discarded. Even short acquisitions are useable with HW CDR. For burst signals, HW CDR can be used for decoding, but it is inapplicable for eye and jitter measurement.

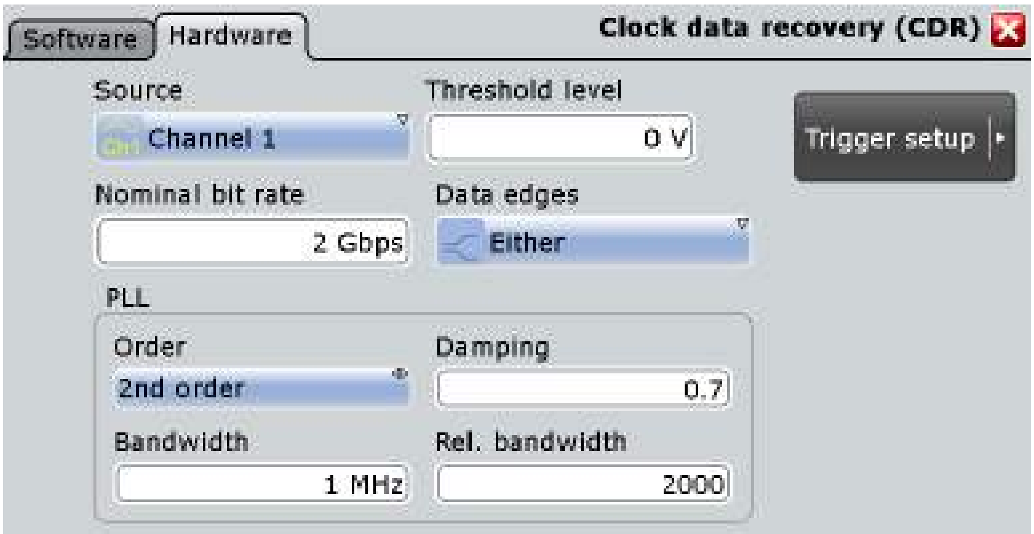
The recovered clock can be used:

- as trigger source for the CDR trigger, which is the basis for reliable jitter measurements, see Chapter 16.2.2.2, "CDR Trigger", on page 1051
- for the serial pattern trigger, see Chapter 16.2.2.3, "Serial Pattern Trigger Using CDR", on page 1052
- for TIE, unit interval and data rate mesurements, see Chapter 16.1.3.3, "Data Measurement Settings", on page 1041
- display the generated clock as math waveform, see Chapter 16.2.3, "Displaying the Recovered Clock Signal", on page 1053

Jitter measurements and the recovered clock math waveform, which are based on HW CDR, interpret and display the acquired jitter data. If you change the HW CDR settings, a new acquisition is required. To acquire jitter data with HW CDR, the trigger type "CDR" or the trigger type "Serial pattern" with active CDR is required.

16.2.2.1 Hardware CDR Setup

Access: "Analysis" menu > "CDR Setup" > "HW"



Source: Channel 1
Threshold level: 0 V
Nominal bit rate: 2 Gbps
Data edges: Either
Order: 2nd order
Damping: 0.7
Bandwidth: 1 MHz
Rel. bandwidth: 2000

Source
Selects the channel signal that is used for clock recovery.

The source cannot be changed if the CDR trigger is selected in the trigger setup. In this case, the instrument triggers on the recovered clock; trigger source and CDR source are the same.

Remote command:
`CDR:HARDware:SOURce` on page 2148

Threshold level
Sets the threshold to determine the position of rising and falling edges in the data input signal. The threshold level is also the trigger level for the specified input channel.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

Nominal bit rate
Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:
`CDR:HARDware:BITRate` on page 2148

Data edges
Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Remote command:
`CDR:HARDware:ESLope` on page 2149

PLL settings
Phase-locked loop parameters are listed below.

Note: Nomial bit rate, bandwidth and relative bandwidth are interacting settings. Modifying one parameter also changes one of the dependent parameters.

"Order"	Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.
"Bandwidth"	Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.
"Rel. bandwidth"	Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.
"Damping"	Sets the damping factor, which is only relevant for second order PLL.

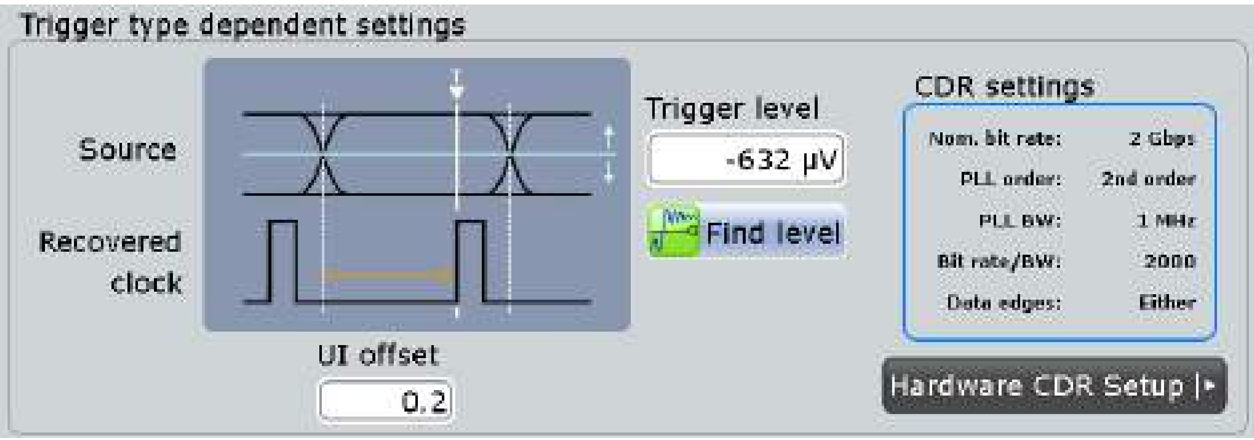
Remote command:
`CDR:HARDware:PLL:ORDer` on page 2149
`CDR:HARDware:PLL:BWIDth` on page 2149
`CDR:HARDware:PLL:RELBwidth` on page 2149
`CDR:HARDware:PLL:DAMPing` on page 2150

16.2.2.2 CDR Trigger

The CDR trigger triggers on the edges of the clock that is recovered from a data signal by the hardware CDR. The CDR trigger is the prerequisite for correct eye formation, and thus for correct jitter measurements and statistics.

The trigger point corresponds to the clock edge that indicates the bit start, and it considers the UI offset.

Access: directly from the hardware CDR setup, or TRIGGER > "Events" tab > "Type" = *CDR*



Trigger level: -632 µV

UI offset: 0.2

Nom. bit rate:	2 Gbps
PLL order:	2nd order
PLL BW:	1 MHz
Bit rate/BW:	2000
Data edges:	Either

UI offset
Defines an offset for the clock edge in relation to the bit start, the beginning of the unit interval. The UI offset is a number between 0 and 1. Value 0 sets the clock edge to the beginning of the bit period; value 0.5 sets the clock edge to the middle of the bit period.

If the recoverd clock signal is used for serial pattern trigger, set the UI offset to about 0.5.

Remote command:
`CDR:HARDware:UIOFfset` on page 2151

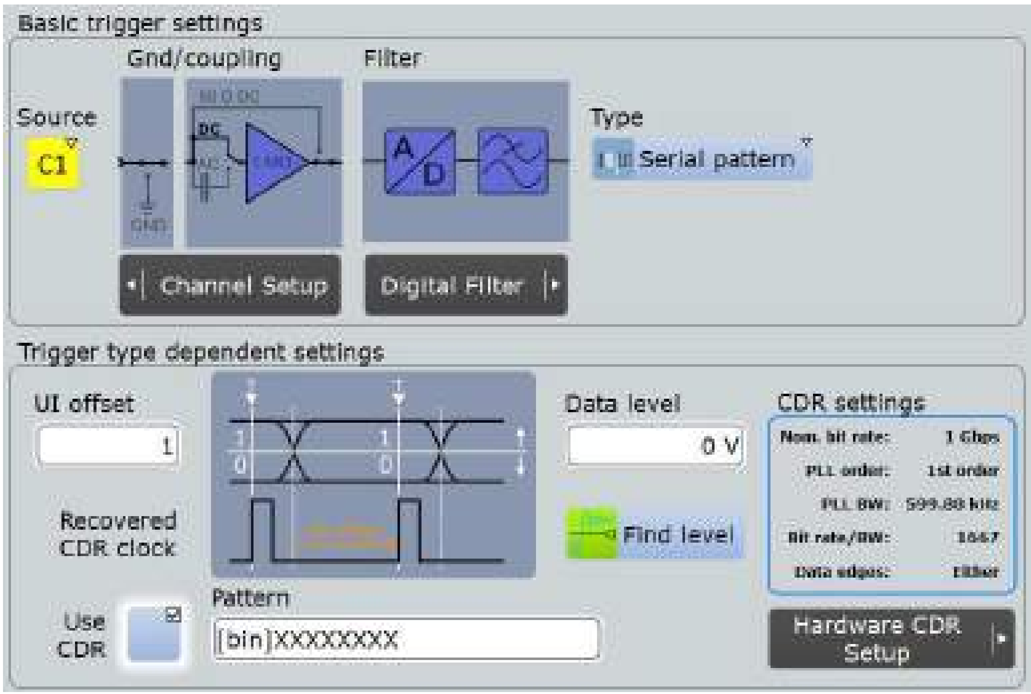
Trigger level
Sets the voltage level for the trigger event. For CDR, the trigger level is also the threshold level for the specified input channel.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1253

16.2.2.3 Serial Pattern Trigger Using CDR

If option R&S RTO-K13 is installed, you can use the recovered clock signal for the serial pattern trigger instead of a real clock signal.

1. Select the trigger source and the trigger type "Serial pattern".
2. Enable "Use CDR".
3. Set the "UI offset".
   To get correct data values, set the UI offset to about 0.5 (50% of the bit period).



Source: C1

Type: Serial pattern

UI offset: 1

Data level: 0 V

Pattern: [bin]XXXXXXXX

Use CDR: ☒

CDR settings

Nom. bit rate: 1 Gbps
PLL order: 1st order
PLL BW: 599.88 kHz
Bit rate/BW: 1667
Data edges: Either

Use CDR
Disables the clock source and enables the recovered clock signal generated by hardware CDR.

Requires R&S RTO-K13.

Remote command:
`TRIGger<m>:SPATtern:CDR` on page 2152

UI offset

See "UI offset" on page 1051.

16.2.3 Displaying the Recovered Clock Signal

The clock signal that is recovered by software or hardware CDR can be displayed as a math waveform. The generated waveform is time-correlated to the data waveform.

1. Prerequisite: Configure the CDR method and select the "CDR" trigger type.
2. Press the MATH key.
3. On the "Setup" tab, select the "Advanced" subtab.
4. Double-tap the entry field to open the formula editor.
5. Tap "More", and again "More".
6. Tap "Clear".
7. Tap "CDR" and select the CDR method.
8. Complete the expression:
   SW CDR: e.g. CDR(sw1,Ch1Wfm1)
   HW CDR: CDR(hw)
9. Tap "Enter".
10. Enable the math signal.

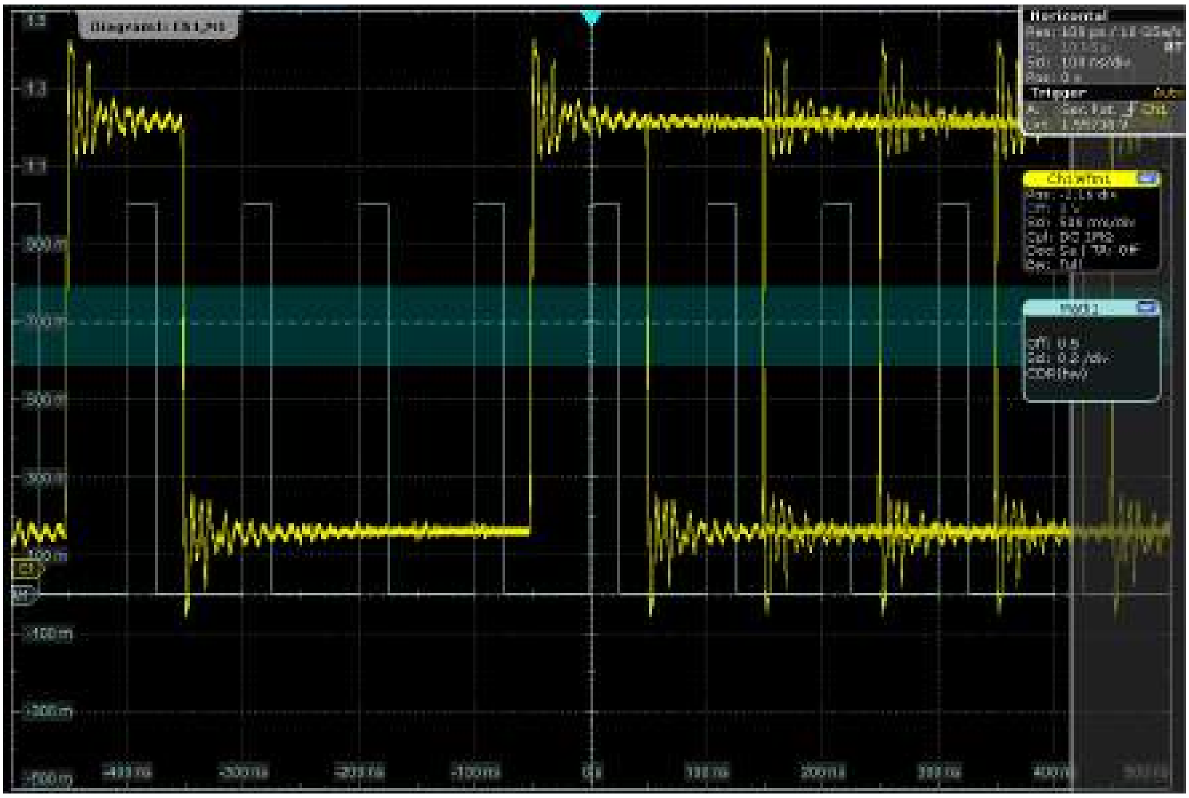


Figure 16-2: Data signal with 10 Mbps, serial pattern trigger on XXXX1000 with CDR and UI offset = 0.5, math waveform = CDR(hw)

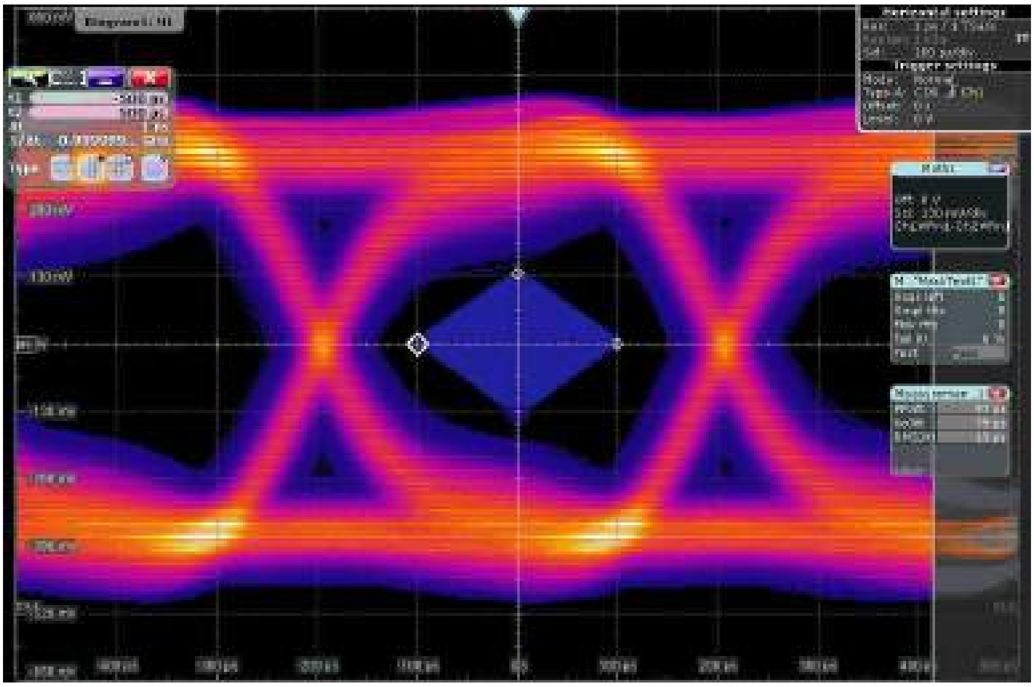
16.3 Mask Testing on Eye Diagrams

Mask testing on eye diagrams allows you to test data signals against eye shapes that are required in the standards. You can select the shape of the eye, enter its dimensions and position the eye on the display. The fail criteria is defined as usual for R&S RTO mask tests, see "Fail condition, Violation tolerance" on page 399.

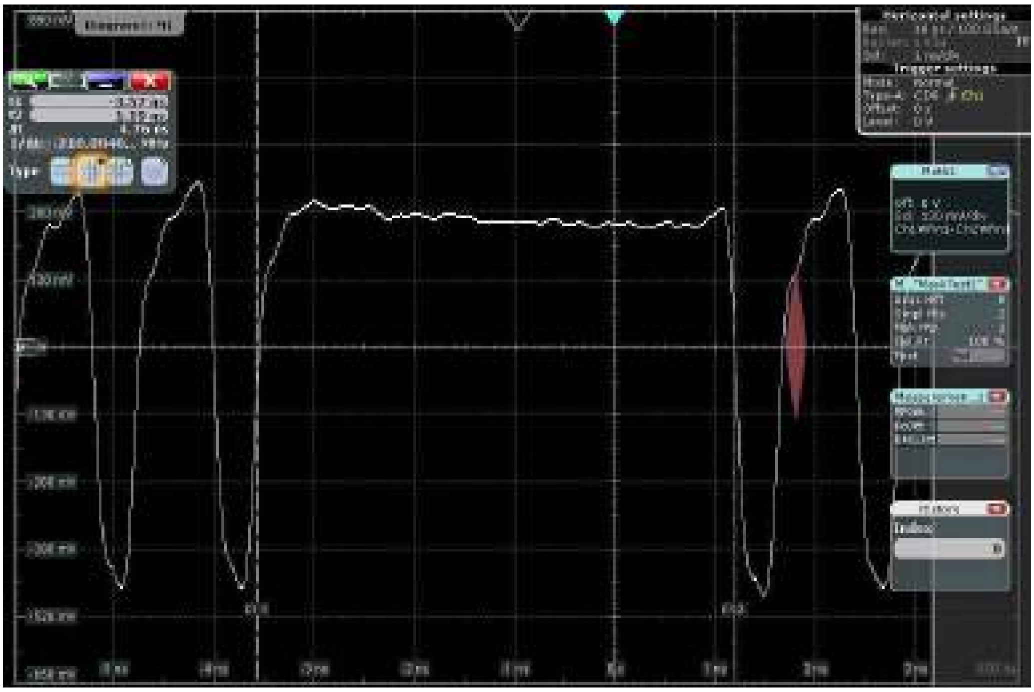
The eye mask definition cannot be saved as a mask test. You can save the settings as user defined preset and recall them by loading the preset file. See: Chapter 11.1.3, "User-defined Preset", on page 447.

Example:

Eye pattern on a 2.5 Gb/s differential signal using PLL. The eye is open with a PRBS31 pattern.

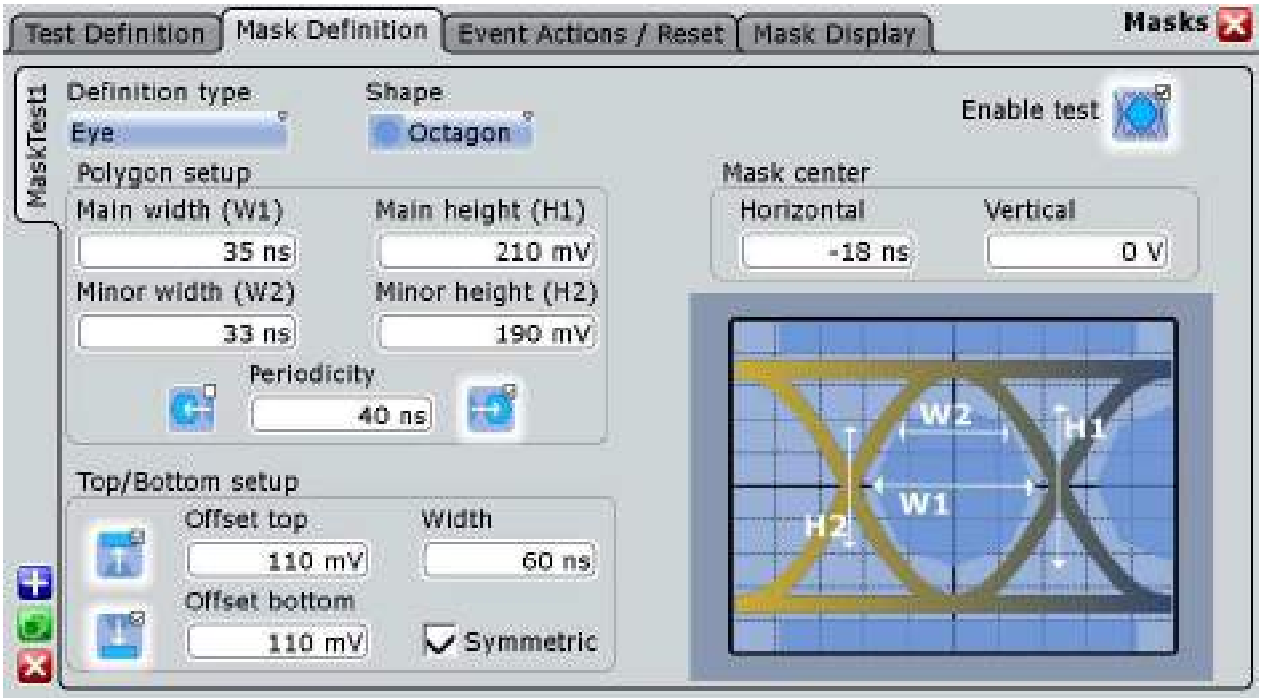


The mask test is set to stop on violation. When an error occurred, the history mode is used to show the cause of the failure. In this case, a single bit transition after a long run caused the error (12 ones followed by a single zero).



16.3.1 Mask Definition

The jitter option R&S RTO-K12 provides a further definition type to define a mask: "Definition type" = "Eye". The mask definition tab provides all settings that are needed to define the mask according to the relevant protocol standard.



Definition type: Eye
Shape: Octagon
Enable test

Polygon setup
Main width (W1): 35 ns
Main height (H1): 210 mV
Minor width (W2): 33 ns
Minor height (H2): 190 mV
Periodicity: 40 ns

Mask center
Horizontal: -18 ns
Vertical: 0 V

Top/Bottom setup
Offset top: 110 mV
Width: 60 ns
Offset bottom: 110 mV
☑ Symmetric

Shape
Defines the outline of the eye mask: square, diamond, hexagon or octagon.

Remote command:
`MTESt:EYEMask:TYPE` on page 2152

Main width (W1), Minor width (W2)
Main width defines the width of all eye mask shapes. Minor width defines the secondary width for hexagon and octagon mask shapes.

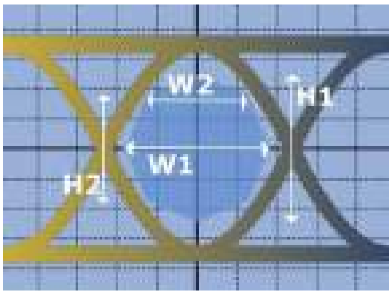


Figure 16-3: Main and minor widths and heights of an octagon eye mask

Remote command:
`MTESt:EYEMask:WIDTh<m>[:VALue]` on page 2153

Main height (H1), Minor height (H2)
Main height defines the height of all eye mask shapes. Minor height defines the secondary height for octagon mask shapes.

Remote command:
`MTESt:EYEMask:HEIGht<m>[:VALue]` on page 2153

Periodicity
The icons copy the eye shape to the left and to the right. The value defines the time distance between the shape centers.

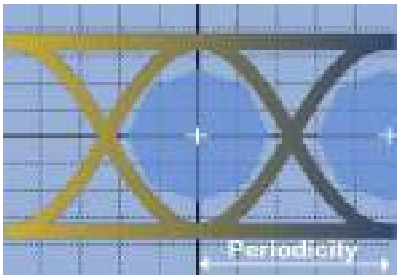


Figure 16-4: Eye mask with right periodicity

Remote command:
`MTESt:EYEMask:MSKLeft` on page 2153
`MTESt:EYEMask:MSKRight` on page 2153
`MTESt:EYEMask:HPERiod` on page 2154

Top/Bottom setup
The icons enable the upper and/or lower regions of the mask. Use the following settings to configure these regions:

"Offset top, Offset bottom"	Voltage distance from the eye shape center that limit the upper and lower regions.
"Symmetric"	Sets bottom and top offsets to the same value so that the outer regions are symmetric to the eye shape.
"Width"	Time width of the outer regions, symmetric to the eye shape center.

Remote command:
`MTESt:EYEMask:MSKBottom` on page 2154
`MTESt:EYEMask:MSKTop` on page 2154
`MTESt:EYEMask:BOFFset` on page 2154
`MTESt:EYEMask:TOFFset` on page 2154
`MTESt:EYEMask:TBSYmmetric` on page 2155
`MTESt:EYEMask:TBWidth` on page 2155

Mask center:Horizontal,Vertical
Set the horizontal (time) and vertical (voltage) values of the eye shape enter and thus define the position of the eye shape on the display.

Remote command:
`MTESt:EYEMask:HPOSition` on page 2155
`MTESt:EYEMask:VPOSition` on page 2155

Enable test
Starts the mask testing.

17 Power Analysis (Option R&S RTO-K31)

With the R&S RTO and option R&S RTO-K31 you can perform power analysis measurements.

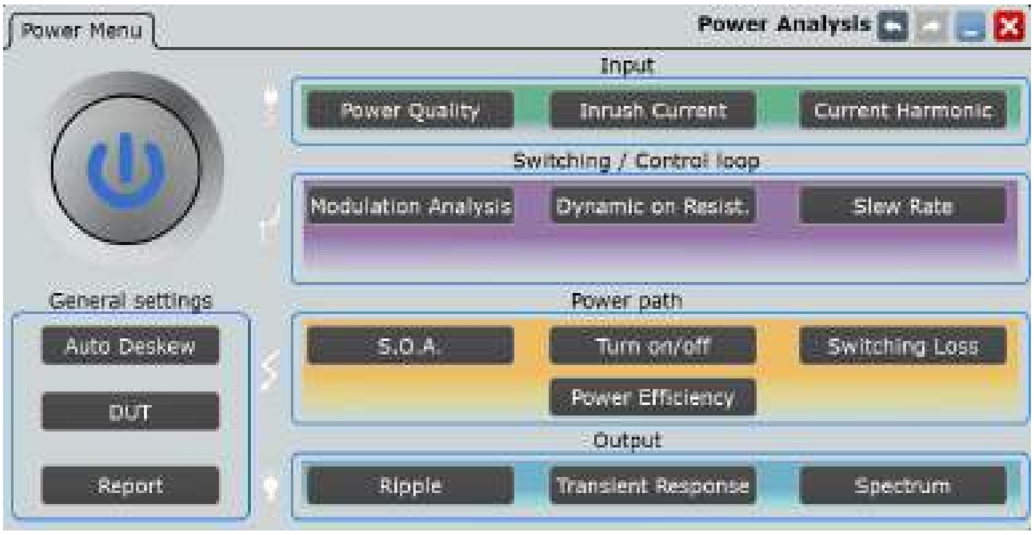
The following power measurements are available:

- Power Quality
- Inrush Current
- Current Harmonic
- Modulation Analysis
- Dynamic On Resistance
- Slew Rate
- Safe Operating Area (S.O.A.)
- Turn On/ Off
- Switching Loss
- Power Efficiency
- Output Ripple
- Transient Response
- Output Spectrum

17.1 Power Measurement Selection

Access: "Analysis"> "Power"

The "Power Menu" is the entry point to all power measurements and the general setting required for them.



The tab has several areas:

- "General Settings": general settings, that can be used by all measurements, like deskewing.
- "Input": measurements for performing input line analysis. They are used to measure the characteristics of the input power as well as the effects the power supply exudes to the input line.
- "Switching and Control Loop": measurements for characterizing the switching properties of a device.
- "Power Path": measurements for analysing the behavior of the devices that control the power flow through the switched-mode power supply (SMPS) circuit, including switching devices and inductors.
- "Output": measurements for characterizing the behavior and quality of the SMPS output voltage.

17.1.1 General Settings

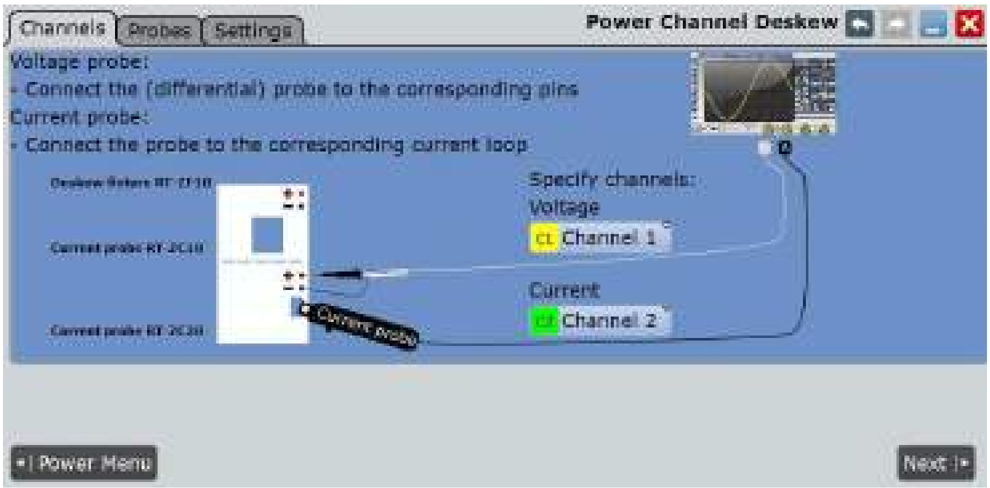
17.1.1.1 Auto Deskew

The "Auto Deskew" dialog box guides you through the auto deskew of your current and voltage probes.

Required equipment:

- R&S RT-ZF20 power deskew fixture
- Rohde & Schwarz voltage probe
- Rohde & Schwarz current probe

1. Select "Analysis" > "Power".
2. Under "General", select "Auto Deskew".
3. Connect the voltage probe and the current probe to the oscilloscope.
4. Connect the probes to the R&S RT-ZF20 power deskew fixture as shown in the "Channels" tab:



Voltage probe:
- Connect the (differential) probe to the corresponding pins

Current probe:
- Connect the probe to the corresponding current loop

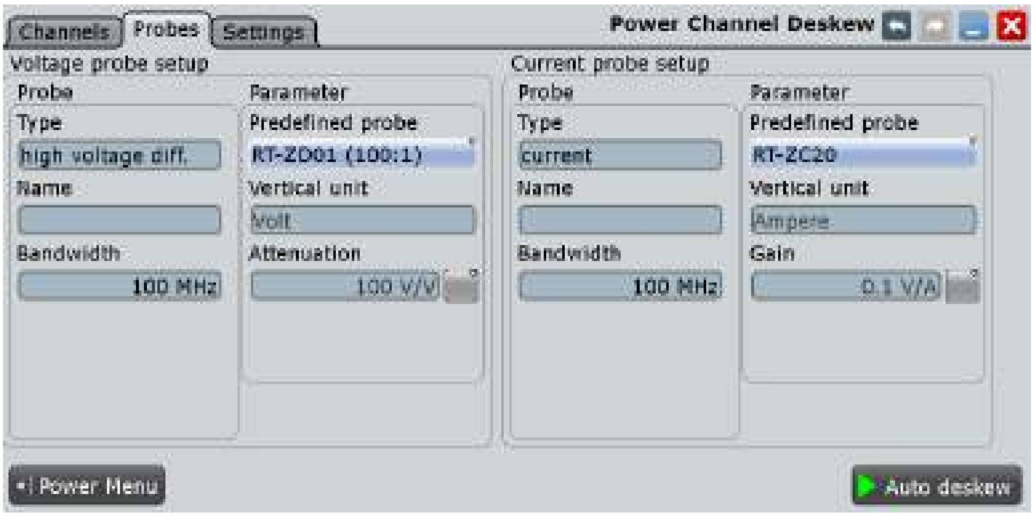
5. Select the correct channels for the "Current Source" and the "Voltage Source".
6. Tap "Next".
7. Check and complete the probe setup in the "Probes" tab.
   Current probes and high-voltage differential probes cannot be automatically detected by the instrument. Tap "Predefined probe" and select the correct probe type.
8. Tap the "Settings" tab.
9. Set the "Overwrite present skew setup" on page 1063 and "Activate user defined preset" on page 1063 options. These settings define whether the instrument uses the deskew result for user-defined preset and general skew settings.
10. Tap "Auto deskew".

    The probes are deskewed and the measurement can be started.

If no deskew fixture is available, you have to deskew your probes manually, see Chapter 4.8.2, "Skew", on page 196.

Probes

In the "Probes" tab you check and set up your voltage and current probes.



Voltage probe setup
Type: high voltage diff.
Name:
Bandwidth: 100 MHz
Predefined probe: RT-ZD01 (100:1)
Vertical unit: Volt
Attenuation: 100 V/V

Current probe setup
Type: current
Name:
Bandwidth: 100 MHz
Predefined probe: RT-ZC20
Vertical unit: Ampere
Gain: 0.1 V/A

Type, Name, Bandwidth
The fields show the characteristics of a recognized or predefined probe for information. If the instrument cannot recognize the probe, and the probe is not known, the "Type" is "None", and the other fields are empty.

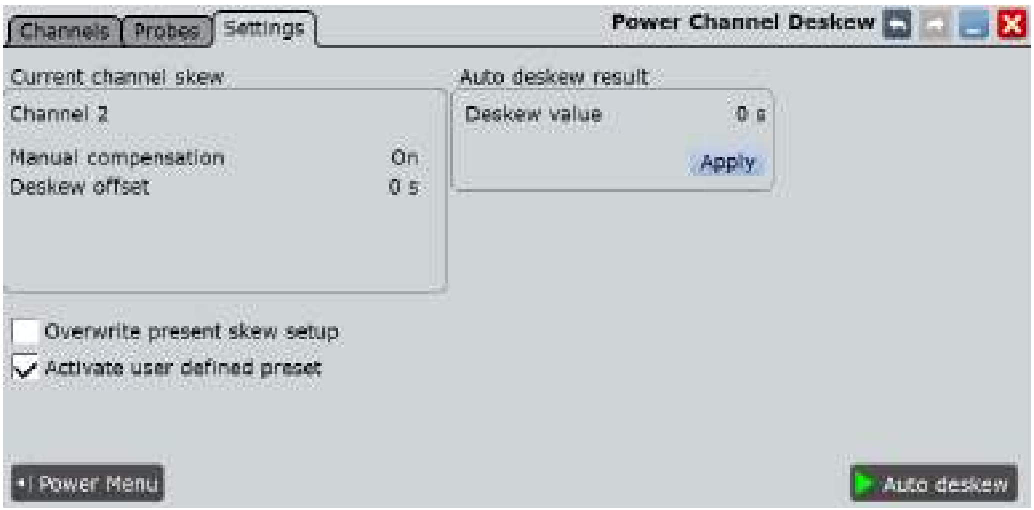
Remote command:
`PROBe<m>:SETup:TYPE?` on page 1222
`PROBe<m>:SETup:NAME?` on page 1222
`PROBe<m>:SETup:BANDwidth?` on page 1222

Predefined probe, Vertical unit, Attenuation
Current probes R&S RT-ZCxx, the high voltage active probe R&S RT-ZD01 and the transmission line probe R&S RT-ZZ80 are not recognized automatically but the parameters of these probes are known to the instrument. Select the correct probe type and enter additional parameters if required. The corresponding "Vertical unit" and the "Attenuation" or "Gain" are set.

For an auto deskew, only Rohde & Schwarz probes are supported.

Settings

In this tab you can define the preset behaviour and how the auto deskew results are stored.



Channel 2

Manual compensation On
Deskew offset 0 s

Deskew value 0 s

☐ Overwrite present skew setup
☑ Activate user defined preset

Current channel skew
Shows the skew settings of the channel connected to the current probe. Skew settings are defined in the "Horizontal > Skew" dialog box.

See also: Chapter 4.8.2, "Skew", on page 196

Overwrite present skew setup
If disabled, the instrument only stores the result of the auto deskew procedure as a separate value and doesn't use it. This value can be used at a later time for power measurements. The general skew offset under "Current channel skew" remains unchanged.

If enabled, the result of the auto deskew procedure is used for all measurements on the selected channel. It is shown under "Current channel skew".

Remote command:
`POWer:DESKew:RESet` on page 2157

Auto deskew result
Available only if "Overwrite present skew setup" is disabled.

"Deskew value"	Result of the auto deskew.

Remote command:
`POWer:DESKew:TIME?` on page 2158

"Apply"	Writes the result of the auto deskew to the "Skew offset" of the selected channel.

Remote command:
`POWer:DESKew:CURRent` on page 2157

Activate user defined preset
If enabled, the deskew values are written to a user defined preset file, and the user defined preset is enabled. Thus, the probe setup and deskew values are not influenced by a manual PRESET.

See also: Chapter 11.1.3, "User-defined Preset", on page 447.

Remote command:
`POWer:DESKew:UDPReset` on page 2158

Auto Deskew
Starts an auto deskew.

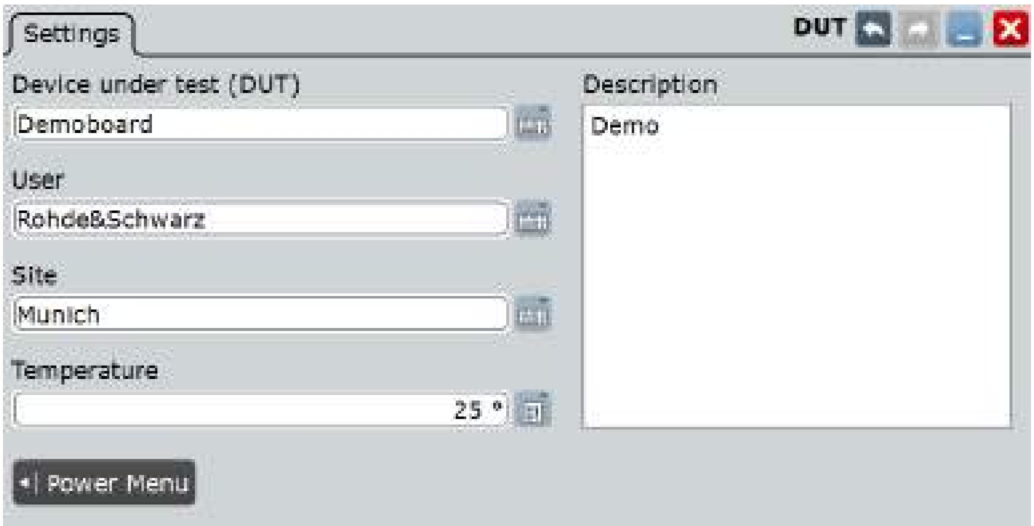
Make sure that the probes are configured correctly before you start the deskewing.

Remote command:
`POWer:DESKew:EXECute` on page 2157

17.1.1.2 DUT

Access: "Analysis" > "Power" > "DUT".

In this dialog you can describe your device under test (DUT). The information set in this dialog can be used on the title page for a report generated from the "Power Analysis" measurements, see "Content" on page 1068.



Device under test (DUT): Demoboard
User: Rohde&Schwarz
Site: Munich
Temperature: 25 °
Description: Demo

Device under test (DUT)
Enter a name for your DUT.

Remote command:
`POWer:REPort:DUT` on page 2159

User
Enter a user.

Remote command:
`POWer:REPort:USER` on page 2159

Site
Enter a site.

Remote command:
`POWer:REPort:SITE` on page 2159

Temperature
Enter the temperature.

Remote command:
`POWer:REPort:TEMPerature` on page 2159

Description
Enter a description.

Remote command:
`POWer:REPort:DESCription` on page 2159

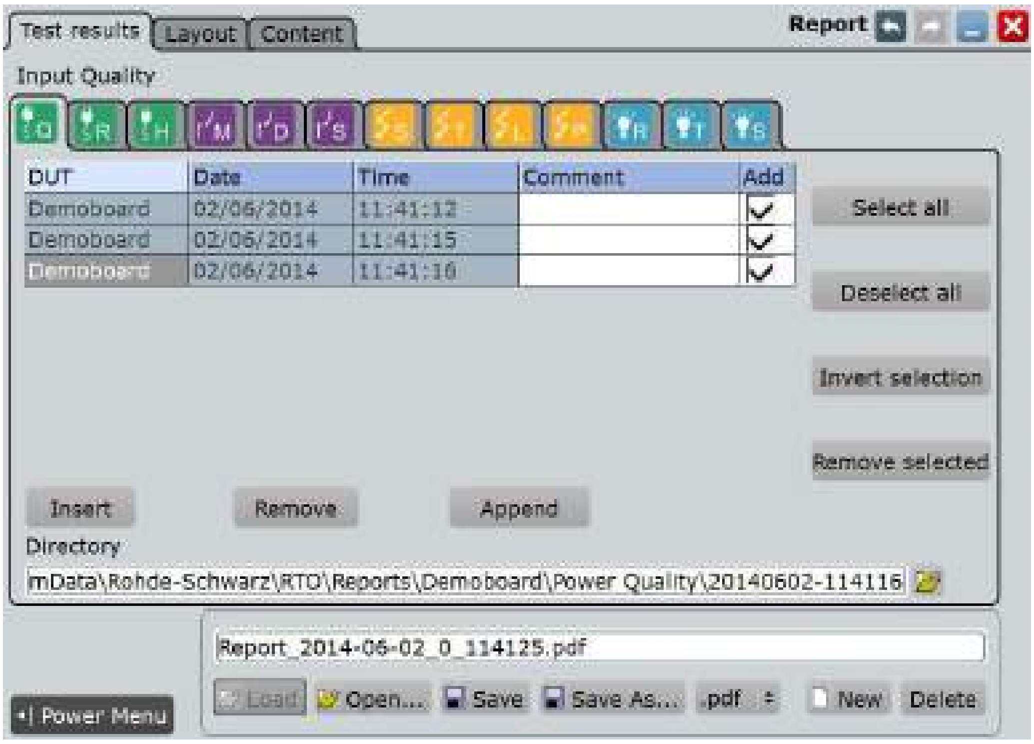
17.1.1.3 Report

Access "Analysis">"Power" > "Report".

Test Results

After executing a measurement, you can press "Add to report" and save the results. In this tab you can manage all saved measurement results.

At the top of the tab you can switch through the different "Power Analysis" measurements.



DUT	Date	Time	Comment	Add
Demoboard	02/06/2014	11:41:12		✓
Demoboard	02/06/2014	11:41:15		✓
Demoboard	02/06/2014	11:41:16		✓

Directory: mData\Rohde-Schwarz\RTO\Reports\Demoboard\Power Quality\20140602-114116

Report_2014-06-02_0_114125.pdf

Report Table
Shows a list of the available measurements.

After you select a Directory you can manage previous report results from this directory.To add a measurement report press "Insert" or "Append". To remove a measurement report press "Remove".

"DUT"	Shows the name of the DUT, see Chapter 17.1.1.2, "DUT", on page 1064.
"Date"	Shows the date of the measurement.
"Time"	Shows at what time, the measurement result was added to report.
"Comment"	Enters a comment.
"Add"	Adds the selected measurement to the report.

Remote command:
`POWer:REPort:TEST:ADD` on page 2161
`POWer:REPort:TEST:COMMent` on page 2163
`POWer:REPort:TEST:COUNt` on page 2163
`POWer:REPort:TEST:INSert` on page 2161
`POWer:REPort:TEST:LSENd?` on page 2163
`POWer:REPort:TEST:REMove` on page 2161

Selection
Manages the selection of the result reports.

Select all ← Selection
Selects all result reports.

Remote command:
`POWer:REPort:TEST:SEA` on page 2162

Deselect all ← Selection
Deselects all result reports.

Remote command:
`POWer:REPort:TEST:DSEA` on page 2162

Invert Selection ← Selection
Inverts the selection of all result reports, meaning that all selected result reports are deselected and vice versa.

Remote command:
`POWer:REPort:TEST:ISE` on page 2162

Remove selected ← Selection
Removes the selected result report.

Remote command:
`POWer:REPort:TEST:RSE` on page 2162

Directory
Selects the directory, from which previous report results are inserted into the report table. You can use this directory to insert previously recorded report data into the current report.

Remote command:
`POWer:REPort:TEST:DIRectory` on page 2162

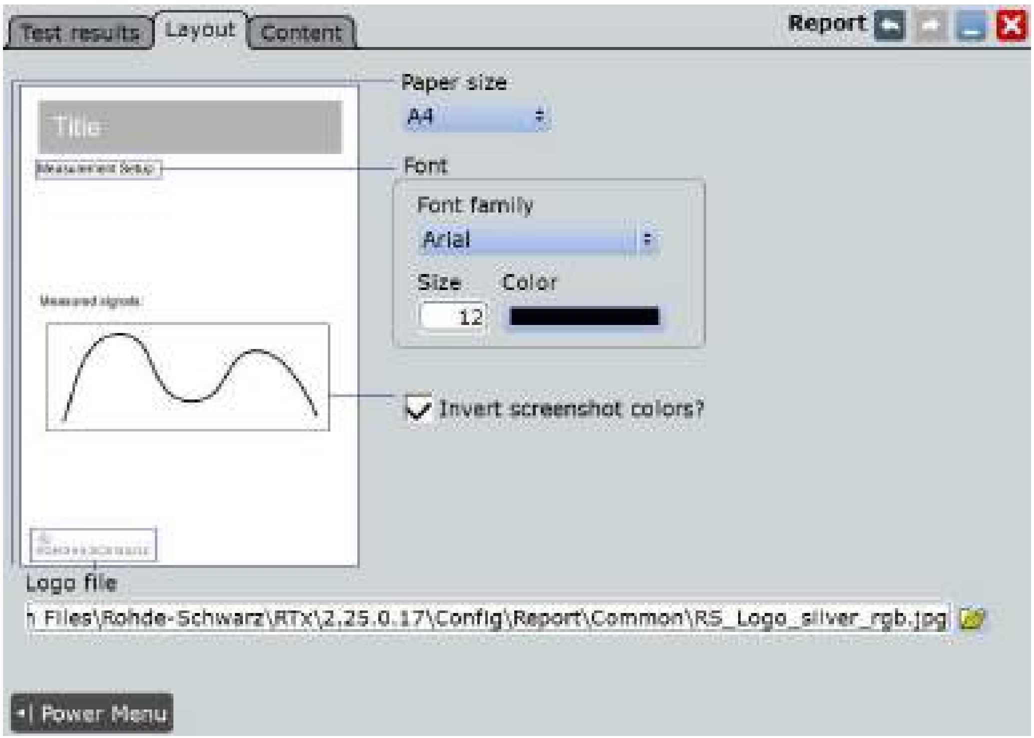
Report Path
Enter the file name to load or to save the report to, and select the file format with the format button on the right.

"Load"	Loads the most recently created report with the Windows default viewer application for the pdf/rtf file format.
"Open"	Opens a file selection dialog box and loads the selected file.
"Save"	Saves the data to the selected file.
"Save As..."	Opens the file selection dialog box and saves the data to the selected file.
".pdf/.rtf"	Selects the file format.
"New"	Creates new file.
"Delete"	Deletes the selected file.

Remote command:
`POWer:REPort:FILE:DELete` on page 2160
`POWer:REPort:FILE:NAME` on page 2160
`POWer:REPort:FILE:NEW` on page 2161
`POWer:REPort:FILE:SAVE` on page 2161

Layout

In this tab you can set up a layout for your report.



Paper size: A4
Font family: Arial
Size: 12
Color
☑ Invert screenshot colors?
Logo file: n Files\Rohde-Schwarz\RTX\2.25.0.17\Config\Report\Common\RS_Logo_silver_rgb.jpg

Paper size
Selects the paper size.

"A4"	Selects A4.

"US Letter"	Selects US Letter.

Remote command:
`POWer:REPort:PAPersize` on page 2160

Font
Sets the font for the report

Font Family ← Font
Selects the font family.

"Arial"	Selects the font Arial.
"Helvetica"	Selects the font Helvetica.

Remote command:
`POWer:REPort:FONT:FAMI` on page 2160

Size ← Font
Sets the font size.

Remote command:
`POWer:REPort:FONT:SIZE` on page 2160

Color ← Font
Sets the font color.

Remote command:
`POWer:REPort:FONT:COLO` on page 2159

Invert Screenshot Colors
Inverts the screenshot colors.

Remote command:
`POWer:REPort:INVert` on page 2162

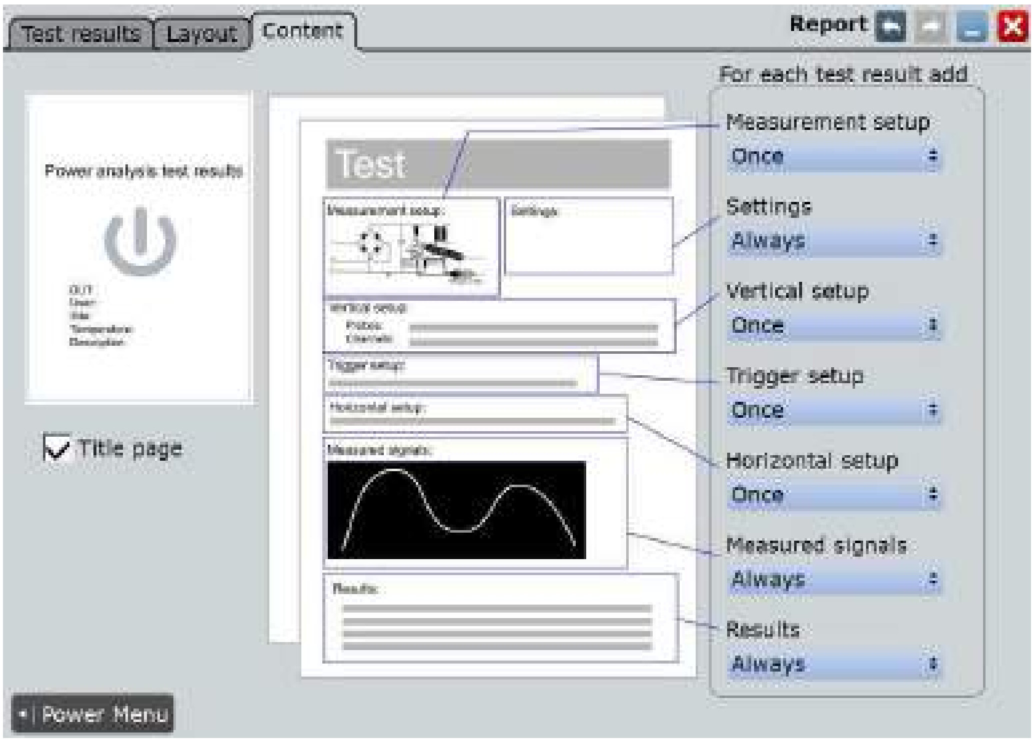
Logo File
Selects a path to a logo picture file.

Remote command:
`POWer:REPort:LOGO` on page 2160

Content

In this tab you can select the contents of your report. For each content you can select how often it is included in the report:

- "Always": Shows the respective contents for each measurement.
- "Never": Doesn't show the respective contents in the report.
- "Once": Shows the respective contents once at the beginning of the report.



☑ Title page

For each test result add

Measurement setup: Once

Settings: Always

Vertical setup: Once

Trigger setup: Once

Horizontal setup: Once

Measured signals: Always

Results: Always

Title Page

Adds a Title page to the report. The contents can be set up in the "DUT" dialog, see Chapter 17.1.1.2, "DUT", on page 1064.

Remote command:

`POWer:REPort:CONTent:TITLe` on page 2159

Measurement Setup

Adds a graphic of the measurement setup.

Remote command:

`POWer:REPort:CONTent:MSETup` on page 2159

Settings

Adds the settings of the analysis.

Remote command:

`POWer:REPort:CONTent:SETTings` on page 2159

Vertical Setup

Adds the vertical setup settings.

Remote command:

`POWer:REPort:CONTent:VSETup` on page 2159

Trigger Setup

Adds the trigger setup settings.

Remote command:

`POWer:REPort:CONTent:TSETup` on page 2159

Horizontal Setup
Adds the horizontal setup settings.

Remote command:
`POWer:REPort:CONTent:HSETup` on page 2159

Measured signals
Adds a diagram of the measured signal.

Remote command:
`POWer:REPort:CONTent:MSIGnal` on page 2159

Results
Adds the result box.

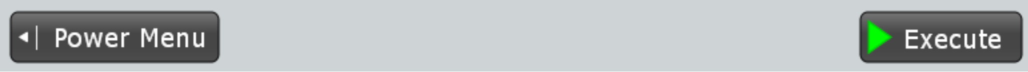
Remote command:
`POWer:REPort:CONTent:RESU` on page 2159

17.2 Overview of Power Measurement Setup

Each power analysis measurement dialog box consists of the following tabs:

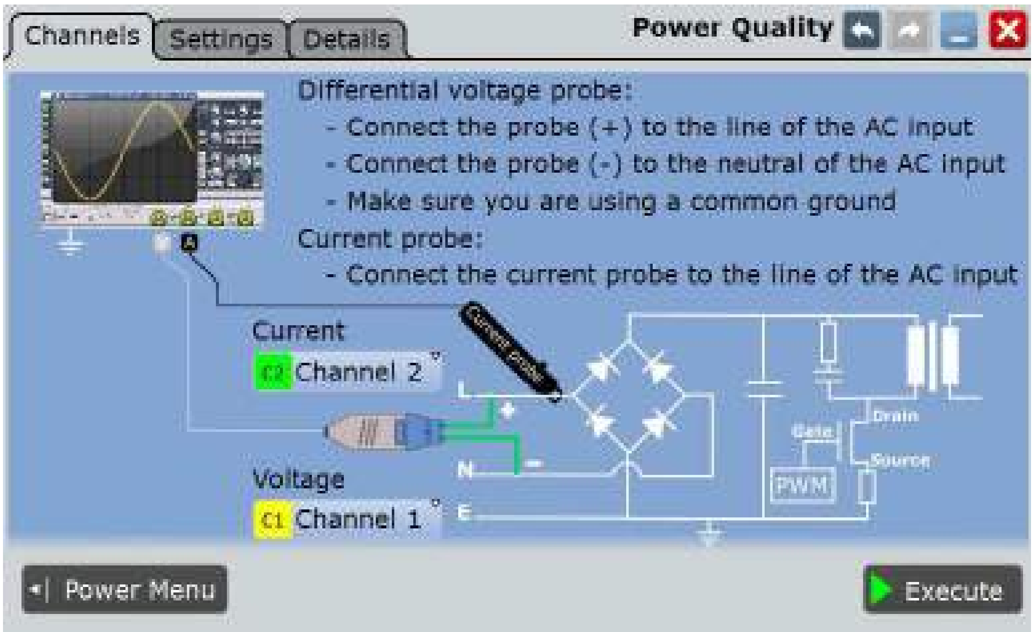
- Channels
- Settings
- Details

At the bottom of each tab you can find two buttons. Tapping "Power Menu", you can return to the power analysis measurement selection. "Execute" starts the power measurement.



17.2.1 Channels Tab

In the "Channels" tab you find information on the experimental setup of the selected power measurement. A short description explains what probes are needed and how to connect them. The description is supported by a block diagram of the experimental setup that shows the connection points for the probes.



Differential voltage probe:
- Connect the probe (+) to the line of the AC input
- Connect the probe (-) to the neutral of the AC input
- Make sure you are using a common ground

Current probe:
- Connect the current probe to the line of the AC input

Depending on the selected power measurement, one or two voltage sources and current sources are required.

Current Source
Sets the channel for the current source.

Remote command:
`POWer:SOURce:CURRent<1..2>` on page 2156

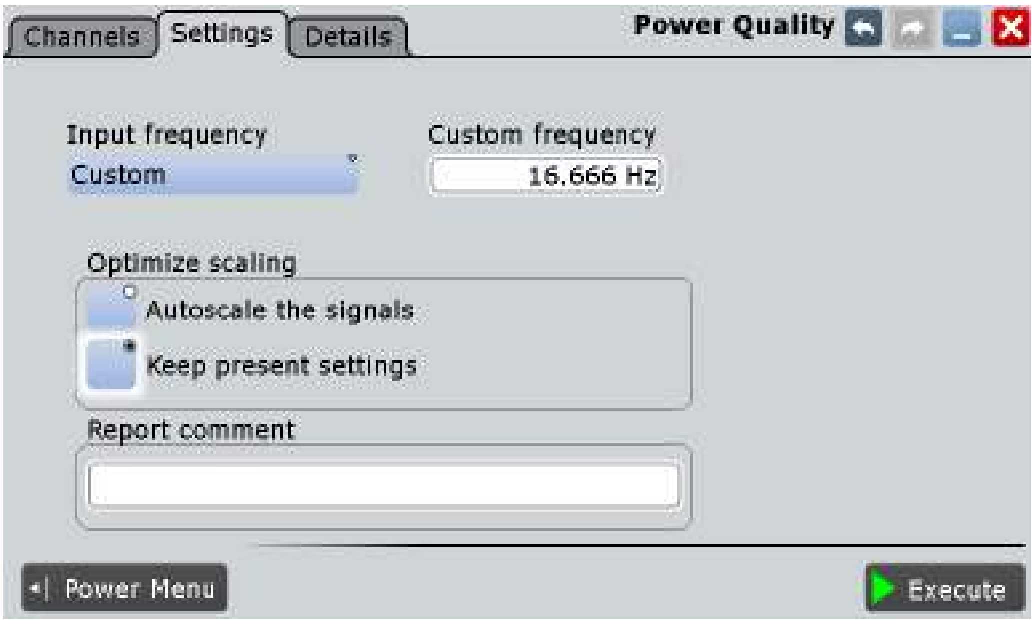
Voltage Source
Sets the channel for the voltage source input.

Remote command:
`POWer:SOURce:VOLTage<1..4>` on page 2157

17.2.2 Settings Tab

In the "Settings" tab you configure the measurement and display settings. The settings depend on the selected power measurement.

For detailed information, see the "Settings" chapter of the relevant power measurement description.



Input frequency: Custom

Custom frequency: 16.666 Hz

Optimize scaling

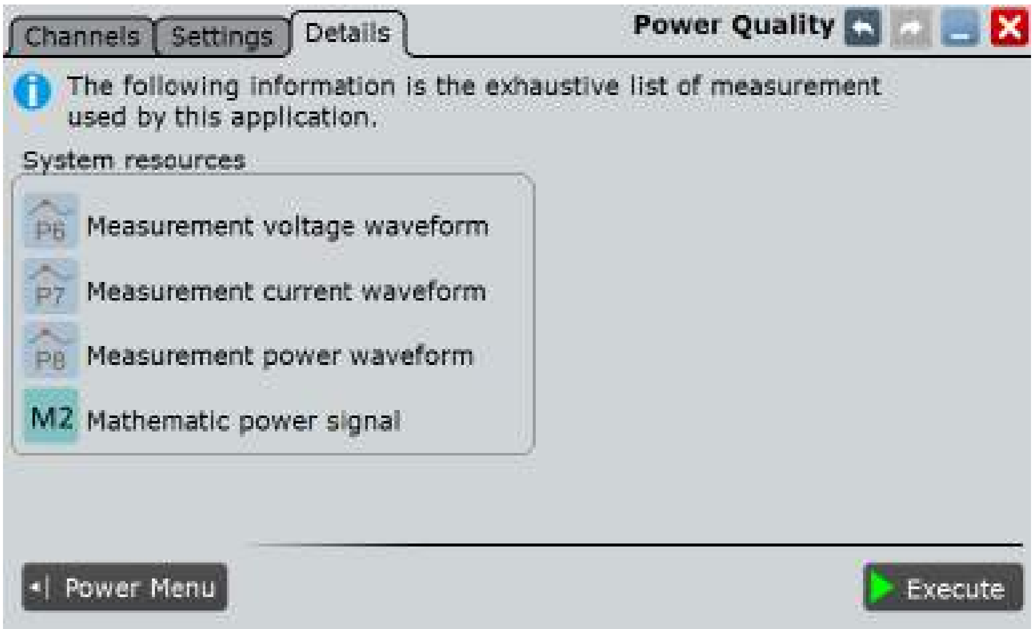
○ Autoscale the signals

● Keep present settings

Report comment

17.2.3 Details Tab

In the "Details" tab you find information on the measurement resources used by the selected power measurement.



The following information is the exhaustive list of measurement used by this application.

System resources

P6 Measurement voltage waveform

P7 Measurement current waveform

P8 Measurement power waveform

M2 Mathematic power signal

The following resources may be used:

- Measurements
- Mathematic waveforms
- Cursors
- XY-diagrams

The instrument enables the required resources when the power measurement is started.

17.3 Power Quality

In an electric circuit power is a measure for the rate of flow of energy at a certain point of the circuit. The real power of a circuit, or the energy that can be used for work, is the portion of energy that is transferred in one direction over a complete cycle of the AC waveform. In AC circuits, however, inductive and capacitive elements can store energy temporarily. This portion of the power flow known as reactive power is then returned to the source without doing any work.

The "Power Quality" analysis measurements include the real power, the reactive power and the apparent power as well as the power factor. The crest factors and the phase angle between the current and voltage are also measured. These properties describe the power transfer in the system and allow you to characterize the power quality of the system.

Required probes:

- Differential voltage probe
- Current probe

17.3.1 Power Quality Results

The results of "Power Quality" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - the power waveform that is the product of the current and voltage waveforms
- The result box displays the numeric measurement results.

Input Quality results

Voltage		Current		Power			
RMS	96 mV	RMS	88 mA	Power Factor	0	Phase	80 °
Peak	120 mV	Peak	121 mA	Power Real			8 W
Crest Factor V	1.319	Crest Factor I	1.437	Power Reactive			6 mVAR
Frequency	416.5311.. kHz	Frequency	500.195.. kHz	Power Apparent			8 mVA

To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P6" Meas 6 to measure the voltage
- "P7" Meas 7 to measure the current
- "P8" Meas 8 to measure the power
- "M2" Math 2 to calculate the power

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

Voltage and current results

The voltage and current results are defined as follows:

Result	Description
RMS	Square root of the mean of the square of the current or voltage averaged over N cycles
Peak	Highest measured magnitude value of the voltage or current
Crest factor	Peak value / RMS value
Frequency	Frequency of the signal

Power results

The power in a system is described by several physical quantities: real power, reactive power, complex power, and phase angle. In Figure 17-1 you can see how these quantities are related if the voltage and the current are sinusoidal signals.

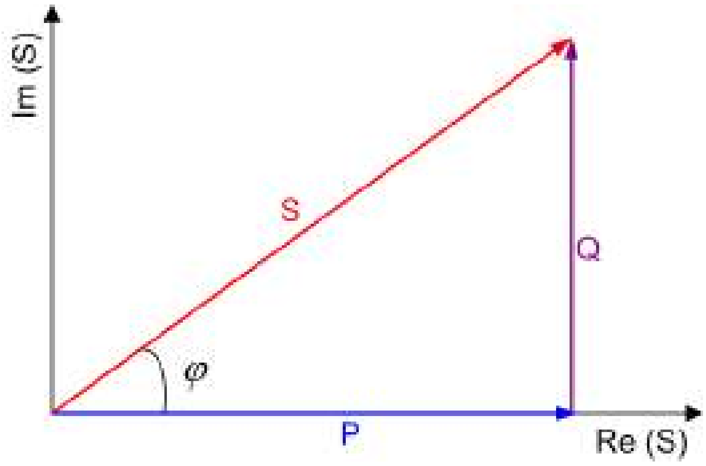


Figure 17-1: Power diagram for sinusoidal signals

P = real power [W]
Q = reactive power [VAR]
S = complex power [VA]
φ = phase angle between the current and the voltage sine waves [°]

The power results are defined as follows:

Result	Unit	Formula	Description
Power factor, P_{Factor}	-	$P_{Factor} = \|P\| / \|S\|$	Measure of the system efficiency. The value varies between -1 and 1.
Phase, φ	°	$\varphi = acos\ (P_{Factor})$	Phase angle between the current and the voltage sine waves.

Real power, P	W	$P = V_{INSTANTENEOUS} \cdot I_{INSTANTENEOUS}$ (averaged over N cycles)	Energy of the system that can be used to do work.
Reactive power, Q	VAR (Volt-Ampere reactive)	$Q = \|S\| \sin\varphi$	Power flow that is temporally stored in a system because of the inductive and capacitive elements.
Apparent power, |S|	VA	$\|S\| = V_{RMS} \cdot I_{RMS}$ (averaged over N cycles)	|S| is the magnitude of the vector sum of real and reactive power (the complex power S).

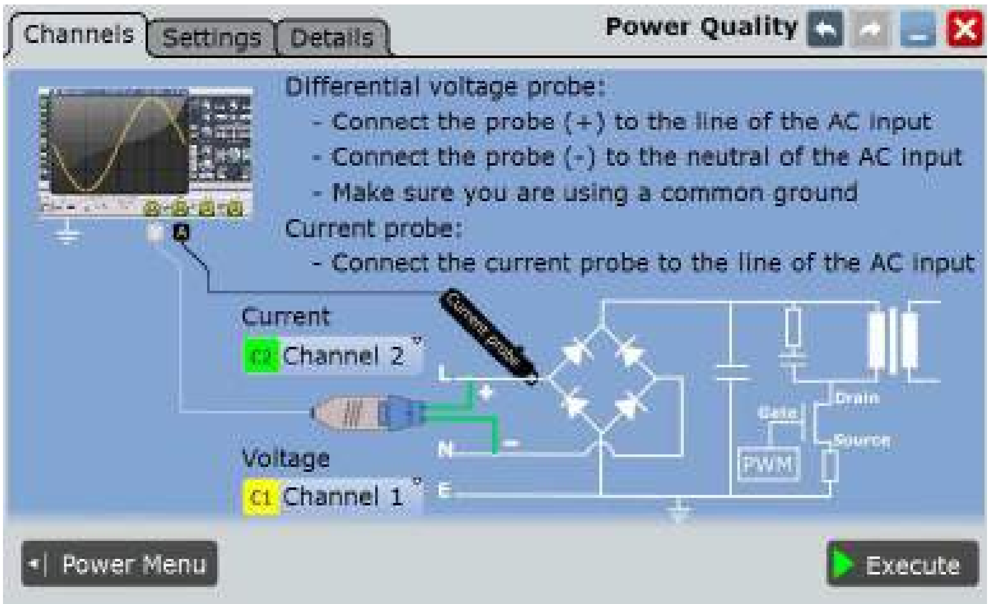
The following remote commands are used for handling the measurement results:

- `POWer:QUALity:RESult:CURRent:CREStfactor?` on page 2165
- `POWer:QUALity:RESult:CURRent:FREQuency?` on page 2165
- `POWer:QUALity:RESult:CURRent:PEAK?` on page 2165
- `POWer:QUALity:RESult:CURRent:RMS?` on page 2165
- `POWer:QUALity:RESult:POWer:APParent?` on page 2165
- `POWer:QUALity:RESult:POWer:PFACtor?` on page 2165
- `POWer:QUALity:RESult:POWer:PHASe?` on page 2165
- `POWer:QUALity:RESult:POWer:REACtive?` on page 2165
- `POWer:QUALity:RESult:POWer:REALpower?` on page 2165
- `POWer:QUALity:RESult:VOLTage:CREStfactor?` on page 2165
- `POWer:QUALity:RESult:VOLTage:FREQuency?` on page 2165
- `POWer:QUALity:RESult:VOLTage:PEAK?` on page 2165
- `POWer:QUALity:RESult:VOLTage:RMS?` on page 2165
- `POWer:QUALity:REPort:ADD` on page 2164

17.3.2 Configuring Power Quality

For details of the configuration settings, see Chapter 17.3.3, "Power Quality Settings", on page 1076.

1. Select "Analysis" > "Power".
2. Under "Input", select "Power Quality".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect the probe (+) to the line of the AC input
- Connect the probe (-) to the neutral of the AC input
- Make sure you are using a common ground

Current probe:
- Connect the current probe to the line of the AC input

Current: C2 Channel 2

Voltage: C1 Channel 1

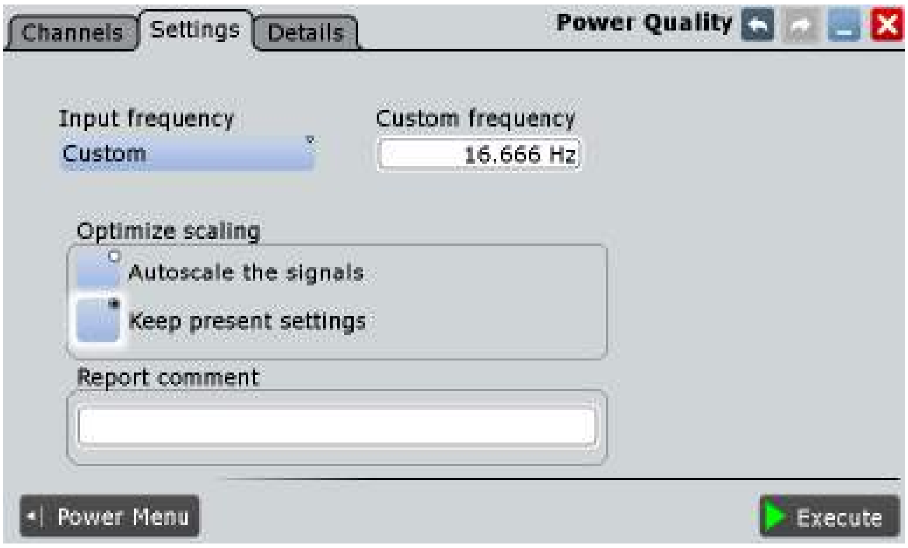
6. Select the correct channels of the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Input frequency" according to your signal.
9. Select an "Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current, the voltage and the power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 17.3.1, "Power Quality Results", on page 1073.

17.3.3 Power Quality Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the power measurement parameters and display settings.



Input frequency: Custom

Custom frequency: 16.666 Hz

Optimize scaling

○ Autoscale the signals

● Keep present settings

Report comment

Input frequency

Selects the input frequency of the source signal.

Remote command:

`POWer:QUALity:FREQ` on page 2164

Custom frequency

Sets the user-defined frequency if the "Input frequency" is set to "Custom".

Remote command:

`POWer:QUALity:FCUS` on page 2164

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:

`POWer:QUALity:AUTO` on page 2164

Report comment

In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute

Starts the "Power Quality" measurement.

Remote command:

`POWer:QUALity:EXECute` on page 2164

17.4 Inrush Current

The "Inrush Current" analysis measures the peak of the input current that is drawn by the device, when the device is first turned on.

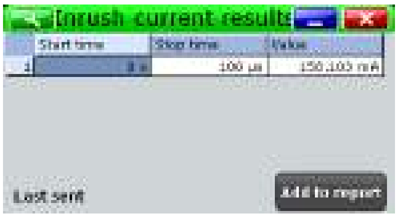
Required probes:

- Current probe

17.4.1 Inrush Current Results

The results of "Inrush Current" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the current waveform
- The result box displays the following numeric measurement results:
  - "Start time" / "Stop time" define the time period for the present gate
  - The "Value" stands for the maximum amplitude of the current for the present time period. This is the inrush current for the correspondent gate.



	Start time	Stop time	Value
1	0 s	100 µs	150.103 mA

To measure and display the inrush current, the instrument uses the following measurements and waveforms:

- "P1" to "P5": Meas 1 to Meas 5 to measure the inrush current of "Gate 1" to "Gate 5"

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The following remote commands are used for handling the measurement results:

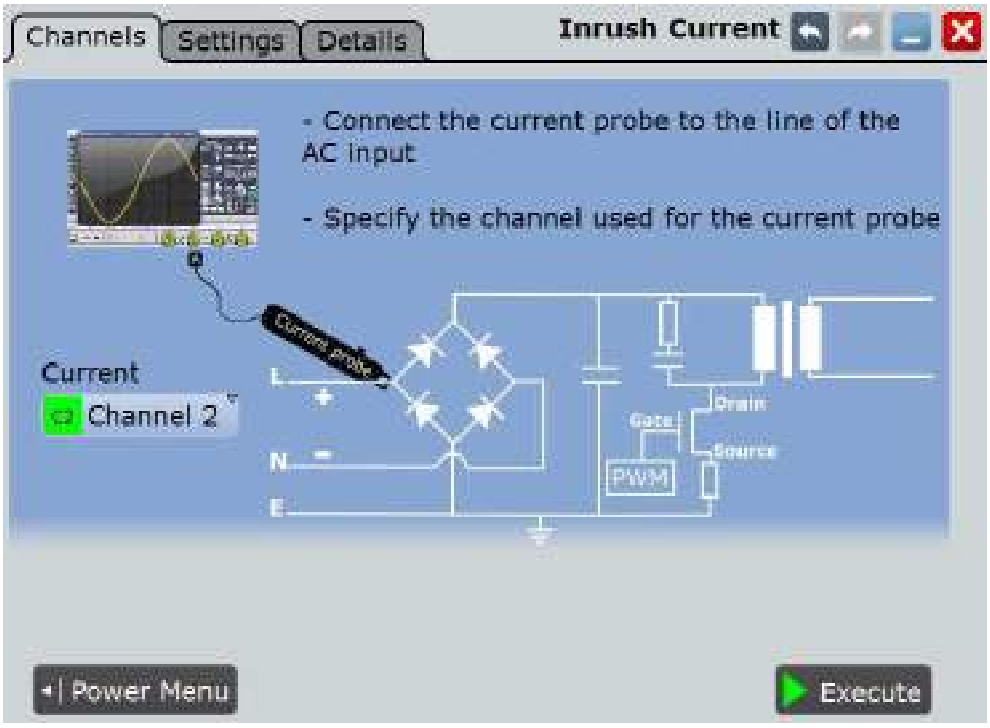
- `POWer:INRush:GATE<m>:VALue` on page 2166
- `POWer:INRush:REPort:ADD` on page 2167

17.4.2 Configuring Inrush Current

For details of the configuration settings, see Chapter 17.4, "Inrush Current", on page 1078.

1. Select "Analysis" > "Power".
2. Under "Input", select "Inrush Current".
3. Connect the current probe to the oscilloscope.

4. Select the correct channel for the "Current Source".
5. Select "Vertical" > "Probe Setup" > "Channel" and set your probe parameters.
6. Connect the probes to the DUT as shown in the "Channels" tab:



- Connect the current probe to the line of the AC input

- Specify the channel used for the current probe

Current: Channel 2

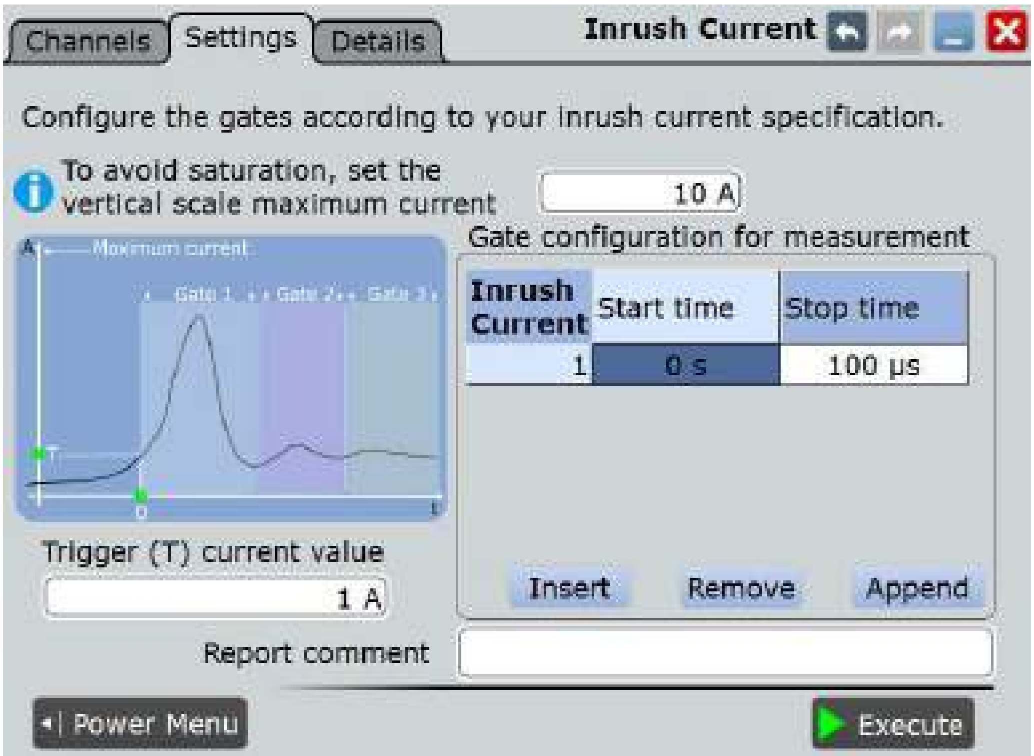
7. Select the "Settings" tab.
8. Set the "Trigger current value".
9. Set the "Maximum current" that shall be displayed in the vertical scale.
10. In the "Gate configuration" table, define the different time periods. You can set up to five different gates.
11. Tap "Execute".
12. Start the DUT.

    On the screen you can see the result box with the inrush current of each gate. For details, see Chapter 17.4.1, "Inrush Current Results", on page 1078.

17.4.3 Inrush Current Settings

In the "Channels" tab, you set the current source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the inrush current measurement parameters and display settings.



Configure the gates according to your inrush current specification.

To avoid saturation, set the vertical scale maximum current: 10 A

Gate configuration for measurement

Inrush Current	Start time	Stop time
1	0 s	100 µs

Trigger (T) current value: 1 A

Report comment:

Maximum current
Sets the maximum expected current for the vertical scale. Set the value according to your signal in order to avoid saturation.

Remote command:
`POWer:INRush:MAXCurrent` on page 2167

Trigger current value (T)
Sets the current value for the trigger. The measurement starts after the signal of the DUT reaches this current value.

Remote command:
`POWer:INRush:TRIGger` on page 2167

Gate Configuration
In this table you can configure different gates (time periods). You can configure up to five different gates. The time periods of the defined gates may overlap.

To add a gate press "Insert" or"Append". To remove a gate press "Remove".

Remote command:
`POWer:INRush:ADD` on page 2165
`POWer:INRush:INSert` on page 2165
`POWer:INRush:REMove` on page 2166

Inrush current ← Gate Configuration
Shows the index of the gate.

Remote command:
`POWer:INRush:COUNt?` on page 2166

Start time ← Gate Configuration
Sets the start measuring time for the selected gate.

Remote command:
`POWer:INRush:GATE<m>:STARt` on page 2166

Stop time ← Gate Configuration
Sets the stop measuring time for the selected gate.

Remote command:
`POWer:INRush:GATE<m>:STOP` on page 2166

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Inrush Current " measurement.

Remote command:
`POWer:INRush:EXECute` on page 2166

17.5 Current Harmonic

Current harmonics appear in an electric power system due to non linear electric loads. The harmonics can be ejected back into the AC line and disturb other equipment on the grid. In order to avoid this disturbance there are often standards of compliance that consumer or industry end-products should meet.

The "Current Harmonic" analysis tests the devices according to the pre-compliance standards EN 61000-3-2, MIL-STD-1399 and RTCA DO-160.

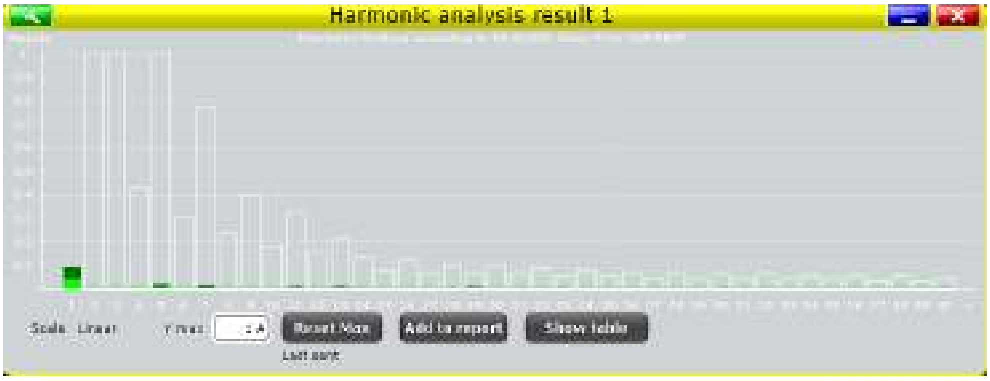
Required probes:

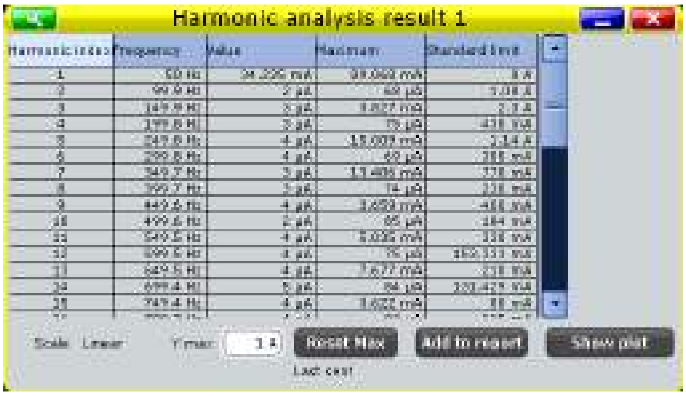
- Differential voltage probe
- Current probe

17.5.1 Current Harmonic Results

The results of "Current Harmonic" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - the power waveform
- The result box displays a bar chart or a table with the numerical measurement results up to the 40th harmonics.
  To switch the display, tap "Show table" or "Show plot" accordingly





To measure and display the current harmonic, the instrument uses the following measurements and waveforms:

- "P6" Meas 6 to measure the power waveform
- "P7" Meas 7 to measure the spectrum voltage
- "P8" Meas 8 to measure the spectrum current
- "M2" Math 2 to calculate the power
- "M3" Math 3 to calculate the FFT of the voltage
- "M4" Math 4 to calculate the FFT of the current

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The current harmonic results are defined as follows:

Result Table	Bar Chart Match	Description
Harmonic Index	Value of the X-Axis	The harmonic order
Frequency	-	The frequency value of the signal
Value	Value of the Y-Axis. Shown by a green bar	The present value of the current harmonic
Maximum	Shown by a darkened green bar	The maximum measured value

Result Table	Bar Chart Match	Description
Standard limit	Shown by a white bar	The maxim allowed value according to the selected standard
"Y max"	"Y max"	Sets the upper limit for the display of the Y scale. This value can be reset with the "Reset Max" button

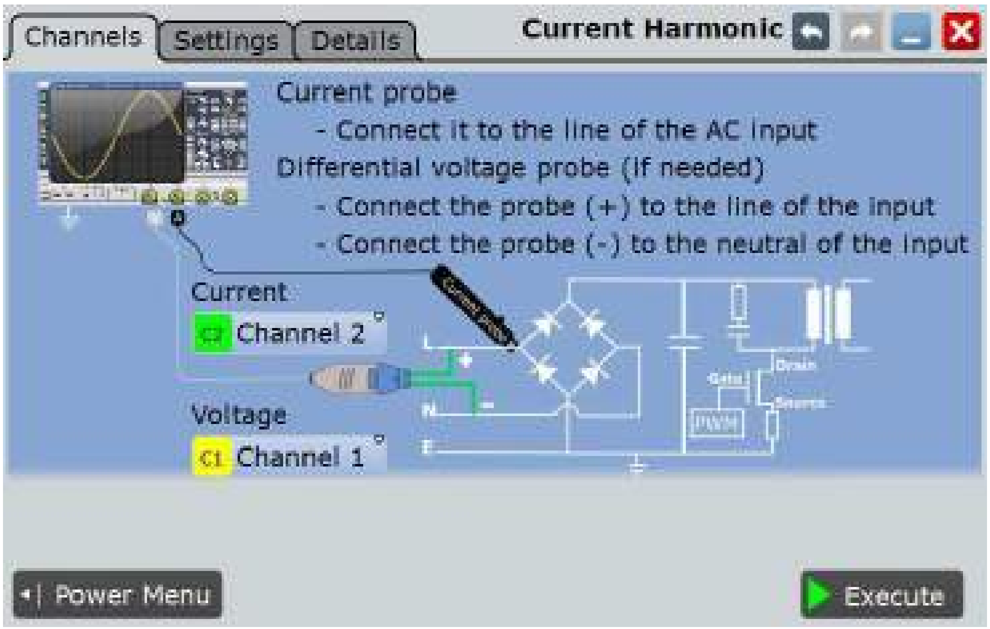
The following remote commands are used for handling the measurement results:

- `POWer:HARMonics:RESult<m>:FREQuency<n>:VALue?` on page 2169
- `POWer:HARMonics:RESult<m>:MAXValue<n>:VALue?` on page 2169
- `POWer:HARMonics:RESult<m>:STDinuse?` on page 2169
- `POWer:HARMonics:RESult<m>:STDValue<n>:VALue?` on page 2169
- `POWer:HARMonics:RESult<m>:VALue<n>:VALue?` on page 2169
- `POWer:HARMonics:REPort:ADD` on page 2168

17.5.2 Configuring Current Harmonic

For details of the configuration settings, see Chapter 17.5.3, "Current Harmonic Settings", on page 1084.

1. Select "Analysis">"Power".
2. Under "Power Analysis", select "Current Harmonic".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Current probe
- Connect it to the line of the AC input

Differential voltage probe (if needed)
- Connect the probe (+) to the line of the input
- Connect the probe (-) to the neutral of the input

Current: C2 Channel 2

Voltage: C1 Channel 1

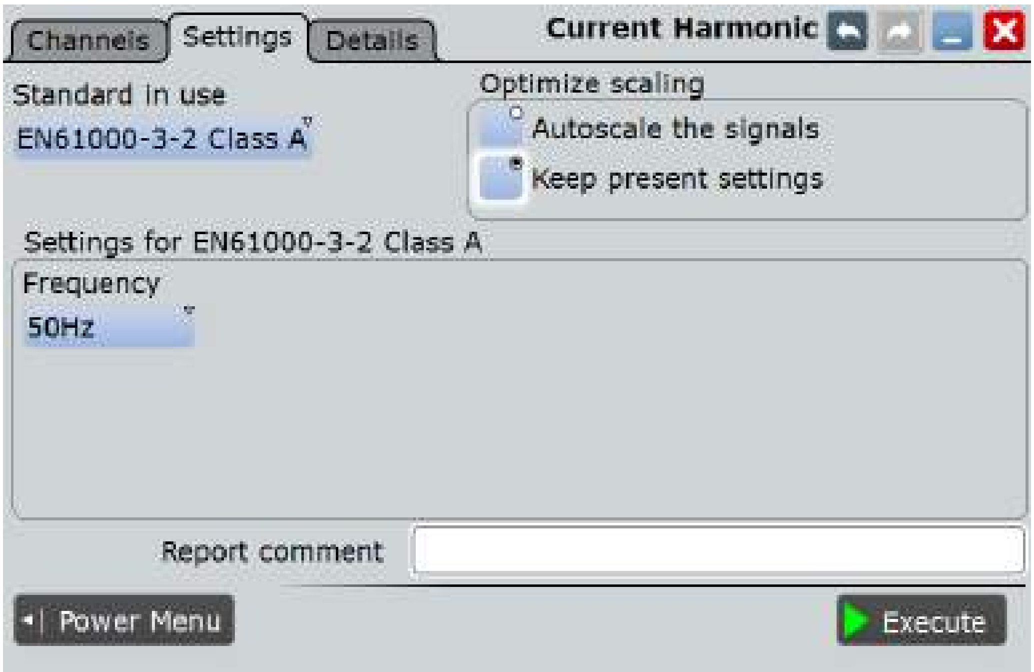
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Standard in use"
9. Set the "Frequency" according to your signal.
10. Select an"Optimize Scaling" option.
11. Tap "Execute".

    On the screen you can see the measurement of the current, the voltage and the power. Additionally there is a table giving information about important measurement parameters. For details, see Chapter 17.5.1, "Current Harmonic Results", on page 1081.

17.5.3 Current Harmonic Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the current harmonic measurement parameters and display settings.



Standard in use: EN61000-3-2 Class A

Optimize scaling:
○ Autoscale the signals
● Keep present settings

Settings for EN61000-3-2 Class A

Frequency: 50Hz

Report comment:

Standard in use

Select the standard in use. For a list of the available standards, see Table 17-1.

Table 17-1: Current Harmonic pre-compliance standards

Standard	Application
EN 61000-3-2 Class A	Balanced 3-phase equipment, household appliances (excluding equipment identified as class D), tools (excluding portable tools), dimmers for incandescent lamps, audio equipment
EN 61000-3-2 Class B	Portable tools, not professional arc welding equipment
EN 61000-3-2 Class C	Lighting equipment
EN 61000-3-2 Class D	PC, PC monitors, radio, or TV receivers with an input power less than or equal to 600W
MIL-STD-1399	Military shipboard user equipment
RTCA DO-160	Environmental tests of avionics hardware

Remote command:
`POWer:HARMonics:STAN` on page 2169

Frequency

Selects the frequency of the input signal.

Remote command:
`POWer:HARMonics:ENFR` on page 2168
`POWer:HARMonics:MIFR` on page 2168
`POWer:HARMonics:DOFR` on page 2168

Revised Current
Available only for "Standard" > "RTCA DO-160".

Selects how the results are evaluated. Available are the following settings:

- Evaluation with current source only
- Evaluation with voltage source and revised current law
  - Display opposite voltage harmonic result chart
  - Do not display voltage result

Remote command:
`POWer:HARMonics:EVAL` on page 2168
`POWer:HARMonics:VOLT` on page 2169

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:HARMonics:AUTO` on page 2168

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Current Harmonics" measurement.

Remote command:
`POWer:HARMonics:EXECute` on page 2168

17.6 Modulation Analysis

The "Modulation Analysis " measures the control pulse signal to a switching device.

Required probes:

- Differential voltage probe
- Current probe

17.6.1 Modulation Analysis Results

The results of "Modulation Analysis " measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage or the current waveform
  - for "Type >Turn on" a track of the frequency and the duty cycle.

- (Optional for "Type > Continuous" measurement) Two histograms display the density distribution of the measurement results in dependance of the frequency and the positive duty cycle.
- The result box displays the numeric measurement results.


Modulation analysis results

Amplitude/Time measurement	Current	+Peak	-Peak	µ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Frequency	25 MHz	25.063 MHz	24.938 MHz	24.999 MHz	24.999 MHz	18.297 kHz	1163	1163
Amplitude/Time measurement	Current	+Peak	-Peak	µ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Pos. duty cycle	50 %	50.251 %	49.75 %	49.957 %	49.997 %	0.044782 %	1163	1163

To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the positive duty cycle
- "P8" Meas 8 to measure the frequency

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

Table 17-2: Statistic result parameters

Label	Description
Current	Currently measured value
+Peak	Positive peak value (maximum)
-Peak	Negative peak value (minimum)
µ (Avg)	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured pulses
Wave count	Number of waveforms (acquisitions) the measurement is based on

"Modulation Analysis" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

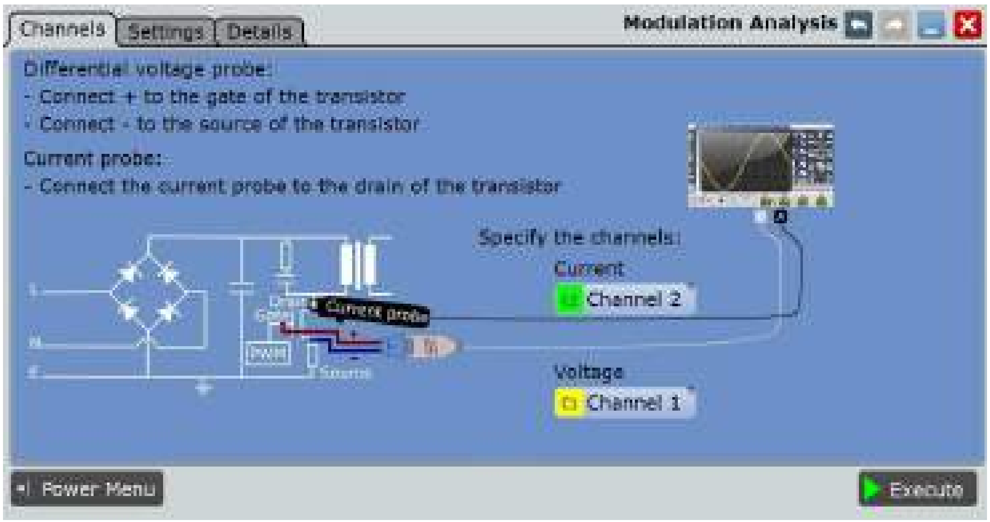
The following remote commands are used for handling the measurement results:

- `POWer:MODulation:RESult:ACTual?` on page 2171
- `POWer:MODulation:RESult:AVG?` on page 2171
- `POWer:MODulation:RESult:EVTCount?` on page 2171
- `POWer:MODulation:RESult:NPEak?` on page 2171
- `POWer:MODulation:RESult:PPEak?` on page 2171
- `POWer:MODulation:RESult:RMS?` on page 2171
- `POWer:MODulation:RESult:STDDev?` on page 2171
- `POWer:MODulation:RESult:WFMCount?` on page 2171
- `POWer:MODulation:REPort:ADD` on page 2171

17.6.2 Configuring Modulation Analysis

For details of the configuration settings, see Chapter 17.6.3, "Modulation Analysis Settings", on page 1088.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" select "Modulation Analysis".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect + to the gate of the transistor
- Connect - to the source of the transistor

Current probe:
- Connect the current probe to the drain of the transistor

Specify the channels:

Current: Channel 2

Voltage: Channel 1

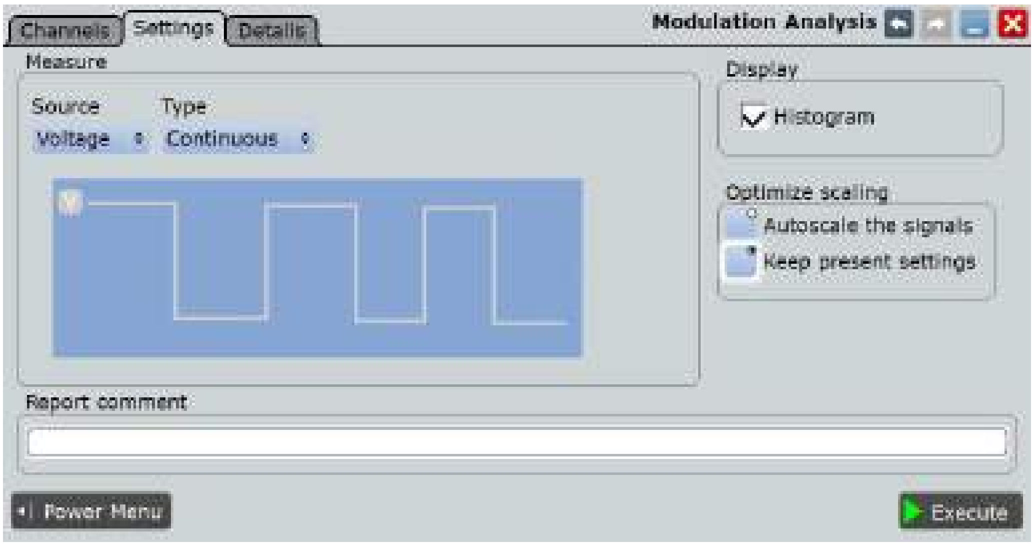
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Source" and the "Type" of measurement.
9. Select an "Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current or the voltage. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 17.6.1, "Modulation Analysis Results", on page 1086.

17.6.3 Modulation Analysis Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the modulation analysis parameters and display settings.



Source
Selects the source for the measurement.

Remote command:
`POWer:MODulation:SOURce` on page 2171

Type
Selects the type of signal flow for the measurement

"Continuous"	The measurement is running continuously.
"Turn on"	The measurement runs once when the DUT is turned on.

Remote command:
`POWer:MODulation:TYPE` on page 2171

Display Histogram
Available only for "Type" > "Continuous".

Enables the display of two histograms after the measurement is executed. The histograms show the density distribution of the measurement results in dependance of the frequency/ duty cycle in a graphic. Thus they illustrate the statistics of the measurements.

Remote command:
`POWer:MODulation:DHIStogram` on page 2170

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"	Automatically selects the most appropriate scale for the display of the results.
"Keep present settings"	The present display settings are not changed.

Remote command:
`POWer:MODulation:AUTO` on page 2170

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Modulation Analysis" measurement.

Remote command:
`POWer:MODulation:EXECute` on page 2170

17.7 Dynamic On Resistance

The "Dynamic ON Resistance" analysis measures the resistance of a switching device, during operation. Because voltage and current may vary in time, the resistance is not constant, thus it is called dynamic ON resistance. It is defined as the ratio dV/dI.

The resistance-related voltage should be measured during a stable part of the switch node waveform, when the undershoot and ringing have decayed, after the high-to-low voltage transition.

Required probes:

- Differential voltage probe
- Current probe

17.7.1 Dynamic On Resistance Results

The results of "Dynamic On Resistance" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
- The result box displays the dynamic on resistance value.

Resistance 1.2136 Ω

To measure and display the dynamic on resistance, the instrument uses the following measurements and waveforms:

- "P5" Meas 5 to measure the amplitude of the voltage
- "P6" Meas 6 to measure the amplitude of the voltage
- "P7" Meas 7 to measure the amplitude of the current
- "P8" Meas 8 to measure the amplitude of the current
- "C1 " Cursor 1 to measure gate ["t_0" ,"t_1"]
- "C2 " Cursor 2 to measure gate ["t_2" ,"t_3"]

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The dynamic on resistance displayed as the result is defined as:

$$R = \frac{V(t_2) - V(t_0)}{I(t_3) - I(t_1)}$$

The points "t_0" , "t_1", "t_2" and "t_3" are defined by the cursor lines displayed in the result diagram of the measurement. You can move the cursor lines to define another area of interest.

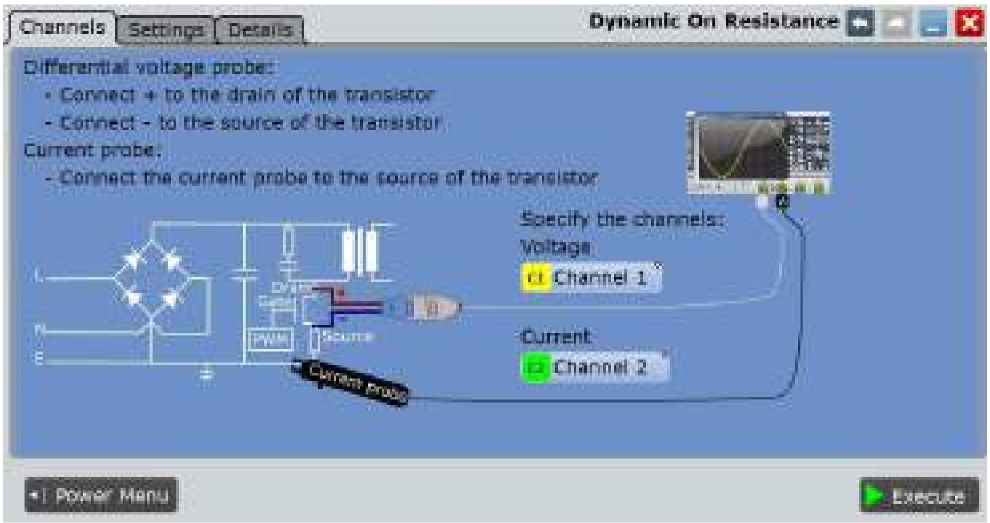
The following remote commands are used for handling the measurement results:

- `POWer:DONRes:RESult:RESistance?` on page 2173
- `POWer:DONRes:GATE<m>:STARt` on page 2172
- `POWer:DONRes:GATE<m>:STOP` on page 2172
- `POWer:DONRes:REPort:ADD` on page 2172

17.7.2 Configuring Dynamic On Resistance

For details of the configuration settings, see Chapter 17.7.3, "Dynamic On Resistance Settings", on page 1092.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" select "Dynamic On Resistance".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect + to the drain of the transistor
- Connect - to the source of the transistor

Current probe:
- Connect the current probe to the source of the transistor

Specify the channels:

Voltage: C1 Channel 1

Current: C2 Channel 2

6. Select the correct channels for the "Current Source" and the "Voltage Source".

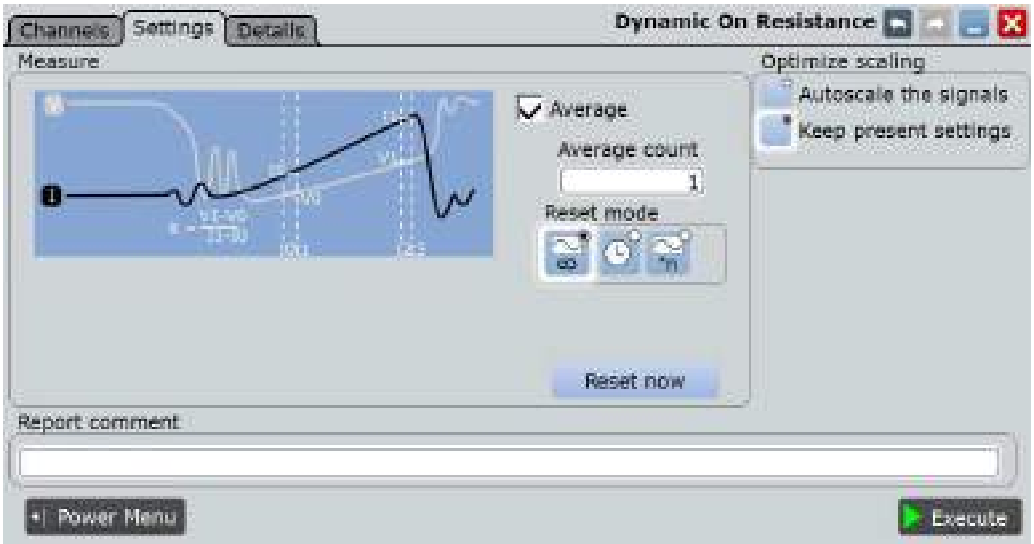
7. Select the "Settings" tab.
8. If "Average" is selected, enter the "Average count", that is the number of waveforms used for average calculation.
9. Set the reset condition for the average calculation:
   - If "Time" is selected, enter the "Reset time".
   - If "Waveforms" is selected, enter the "Reset count".
10. Select an "Optimize Scaling" option.
11. Tap "Execute".
12. If needed adjust the cursors manually. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement waveforms of the current and the voltage. Additionally, the result box displays the dynamic on resistance. For details, see Chapter 17.7.1, "Dynamic On Resistance Results", on page 1090.

17.7.3 Dynamic On Resistance Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the power measurement parameters and display settings.



☑ Average

Average count: 1

○ Autoscale the signals
● Keep present settings

Average
Enables the "Average" method for building the resulting waveform. The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function. The number of acquisitions for average calculation is defined with "Average count", and the "Reset mode" defines the restart condition.

Remote command:
`POWer:DONRes:AVG` on page 2172

Auto reset mode / Reset mode
Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1213
`ACQuire:ARESet:TIME` on page 1214
`ACQuire:ARESet:COUNt` on page 1214

Reset now
Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 1213

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"	Automatically selects the most appropriate scale for the display of the results.
"Keep present settings"	The present display settings are not changed.

Remote command:
`POWer:DONRes:AUTO` on page 2172

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Dynamic On Resistance" measurement.

Remote command:
`POWer:DONRes:EXECute` on page 2172

17.8 Slew Rate

The "Slew Rate" analysis measures the rate of change of the voltage or current waveform during the switching of the switching transistor.

Required probes:

- Differential voltage probe
- Current probe

17.8.1 Slew Rate Results

The results of "Slew Rate" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - a waveform of the derivative of voltage and current
- The result box displays the numeric measurement results. For a detailed description, see Table 17-2.

Amplitude/Time measurement	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Max	28.769 MV*Hz	28.526 MV*Hz	28.123 MV*Hz	21.417 MV*Hz	21.475 MV*Hz	1.5773 MV*Hz	4614	4614
Min	-21.155 MV*Hz	-20.083 MV*Hz	-39.526 MV*Hz	-21.542 MV*Hz	21.681 MV*Hz	1.6011 MV*Hz	4614	4614

To measure and display the slew rate, the instrument uses the following measurements and waveforms:

- "P8" Meas 8 to measure the amplitude of the current or voltage waveform
- "M2" Math 4 to calculate the time derivative of the current or voltage waveform
- "C1" Cursor 1 to determine the measurement area

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

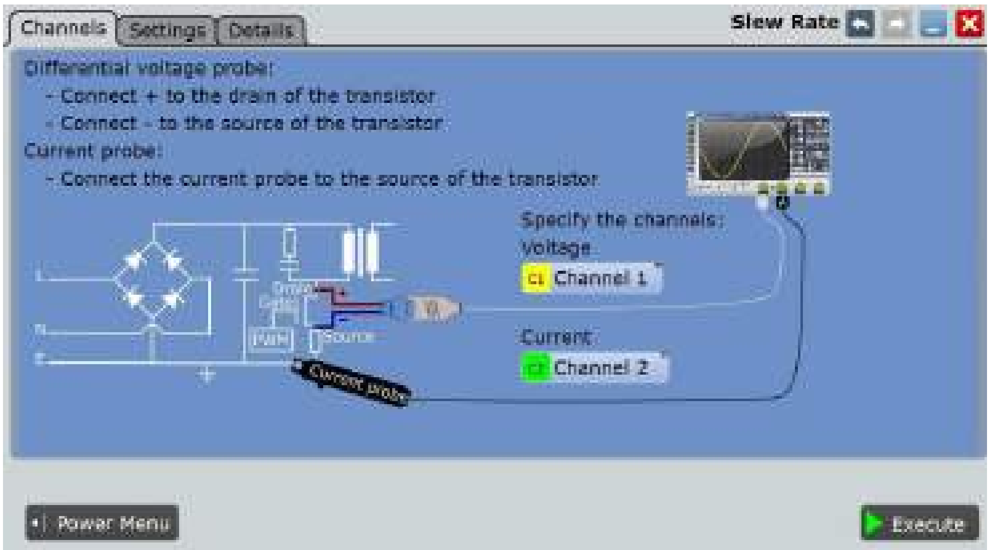
The following remote commands are used for handling the measurement results:

- `POWer:SLEWrate:RESult:ACTual?` on page 2175
- `POWer:SLEWrate:RESult:AVG?` on page 2175
- `POWer:SLEWrate:RESult:EVTCount?` on page 2175
- `POWer:SLEWrate:RESult:NPEak?` on page 2175
- `POWer:SLEWrate:RESult:PPEak?` on page 2175
- `POWer:SLEWrate:RESult:RMS?` on page 2175
- `POWer:SLEWrate:RESult:STDDev?` on page 2175
- `POWer:SLEWrate:RESult:WFMCount?` on page 2175
- `POWer:SLEWrate:REPort:ADD` on page 2175

17.8.2 Configuring Slew Rate

For details of the configuration settings, see Chapter 17.8.3, "Slew Rate Settings", on page 1095.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" dialog select "Slew Rate".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect + to the drain of the transistor
- Connect - to the source of the transistor

Current probe:
- Connect the current probe to the source of the transistor

Specify the channels:
Voltage: C1 Channel 1
Current: C2 Channel 2

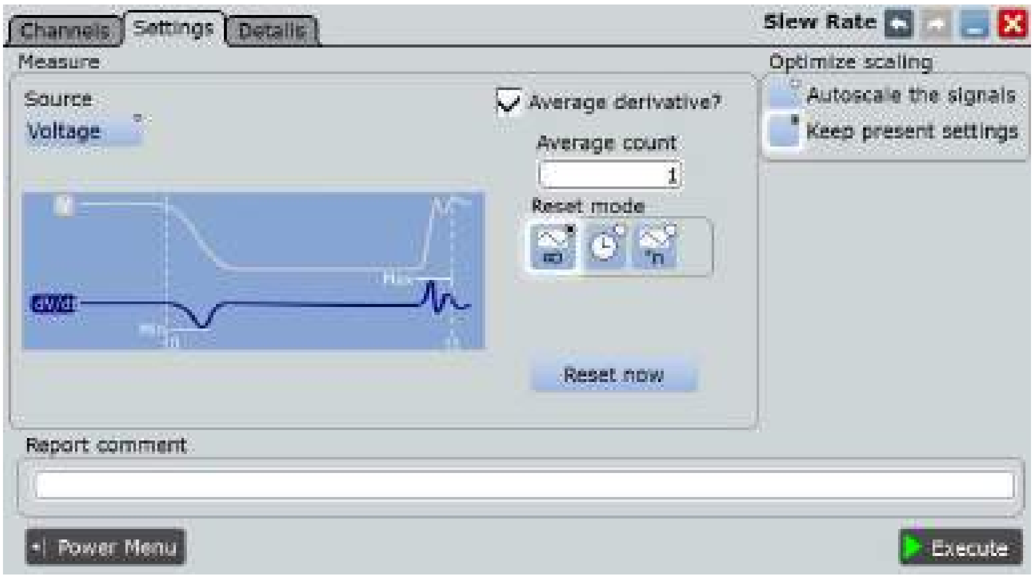
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Select the "Source".
9. If "Average" is selected, enter the "Average count", that is the number of waveforms used for average calculation.
10. Set the reset condition for the average calculation:
    - If "Time" is selected, enter the "Reset time".
    - If "Waveforms" is selected, enter the "Reset count".
11. Select an "Optimize Scaling" option.
12. Tap "Execute".

    On the screen you can see the measurement waveforms of the slew rate, the current and the voltage. The result box with numeric measurement results is shown. For details, see Chapter 17.8.1, "Slew Rate Results", on page 1094.

17.8.3 Slew Rate Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the slew rate measurement parameters and display settings.



Source: Voltage

☑ Average derivative?

Average count: 1

Source

Selects dV/dt or dI/dt as the source of the measurement.

Remote command:

`POWer:SLEWrate:SOURce` on page 2173

Average

Enables the "Average" method for building the resulting waveform. The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function. The number of acquisitions for average calculation is defined with "Average count", and the "Reset mode" defines the restart condition.

Remote command:

`POWer:SLEWrate:AVGDeriv` on page 2174

Auto reset mode / Reset mode

Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:

`ACQuire:ARESet:MODE` on page 1213

`ACQuire:ARESet:TIME` on page 1214

`ACQuire:ARESet:COUNt` on page 1214

Reset now
Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 1213

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:SLEWrate:AUTO` on page 2173

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Slew Rate" measurement.

Remote command:
`POWer:SLEWrate:EXECute` on page 2174

17.9 Safe Operating Area (S.O.A.)

The safe operating area is defined by the voltage and current conditions over which a power semiconductor device is expected to operate without self-damage. The "Safe Operating Area" analysis provides a diagram of the safe operating conditions of your device.

Required probes:

- Differential voltage probe
- Current probe

17.9.1 Safe Operating Area Results

The results of "Safe Operating Area" measurements are provided in the following ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform

- A logarithmic or linear XY diagram of the calculated voltage (x-axis) and current (y-axis) waveforms. This curve is a graphical representation of the power handling capability of the device under various conditions.
- The result box displays the numeric measurement results. Additionally, you can see the mask definition and change the scale in the "SOA Control" dialog. If the state of "Enable mask test" is "On" an extra result box appears, see also Table 17-3.

Volt	Ampere
1 mV	10 mA
13 mV	10 mA

Mask scale definition
Log-Log
● Logarithmic view
○ Linear view

Acq. Completed	3583
Acq. Remaining	0
State	Running
Sample hits	72160
Acquisition hits	1097
Fail rate	[illegible]
Test result	Fail

To measure and display the safe operating area, the instrument uses the following measurements and diagrams:

- "XY1" XY Diagram 1 to measure the logarithmic waveform
- "XY2" XY Diagram 2 to measure the linear waveform
- "M1" Math 1 to calculate the voltage signal
- "M2" Math 2 to calculate the current signal

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The results of the safe operating area mask test are described in Table 17-3.

Table 17-3: Results of the mask test

Result	Description
Acq. completed	Number of tested acquisitions
Acq. remaining	Remaining acquisitions until "Average count / Nx Single count" is reached

Result	Description
State	Shows if the test has been completed. The state is set to "Finished" when "Nx Single count" acquisitions are tested and the number of "Acq. remaining" is 0. As long as the number of tested acquisitions is less the "Nx Single count" number, the state is "Running". If you run the acquisition with RUN STOP, or the number of played history acquisitions exceeds "Nx Single count", the mask testing is performed according to fail criteria settings independently of the test state. The testing is not stopped when the state is set to "Finished".
Sample hits	Number of samples that hit the mask
Acquisition hits	Number of acquisitions that contained at least one sample hit
Fail rate	Ratio of acquisition hits to the number of tested acquisitions
Test result	A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits

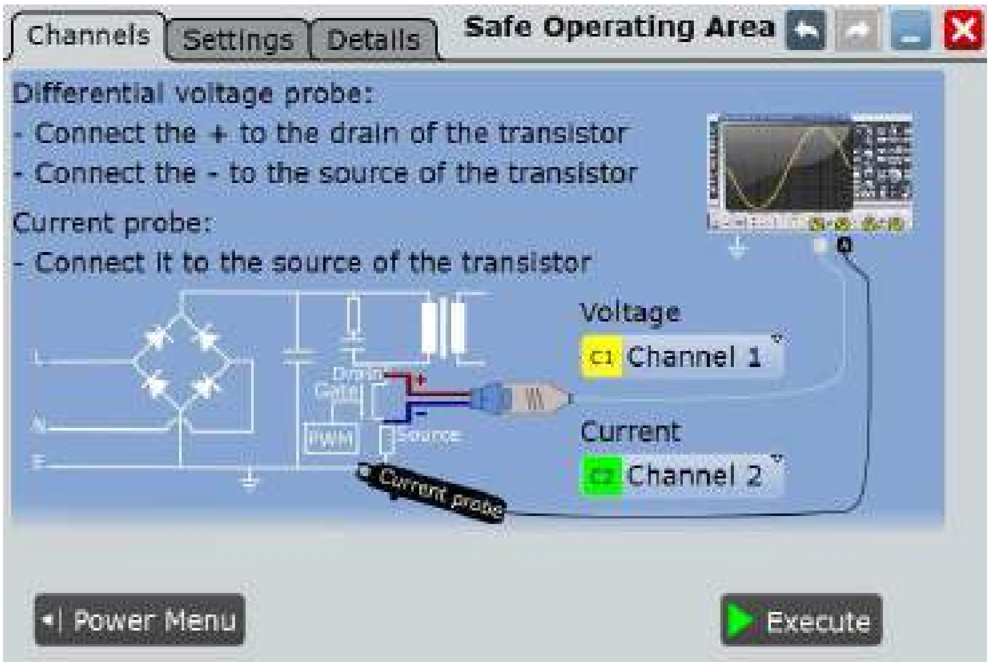
The following remote commands are used for handling the measurement results:

- `POWer:SOA:SWITch` on page 2178
- `POWer:SOA:REPort:ADD` on page 2177

17.9.2 Configuring Safe Operating Area

For details of the configuration settings, see Chapter 17.9.3, "Safe Operating Area Settings", on page 1100.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Safe Operating Area".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect the + to the drain of the transistor
- Connect the - to the source of the transistor

Current probe:
- Connect it to the source of the transistor

Voltage: C1 Channel 1

Current: C2 Channel 2

6. Select the correct channels of the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Select the state of the "Enable mask test".
9. Select the "Scale".
10. Define the SOA Points.
11. Tap "Execute".

    On the screen you can see the measurement waveforms of the Additionally, the result box with numeric measurement results is shown. For details, seeChapter 17.9.1, "Safe Operating Area Results", on page 1097.

17.9.3 Safe Operating Area Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the safe operating area parameters and display settings.

Enable mask test
Off

Scale
Log-Log

SOA Point Definition - Log

Volt	Ampere
1 mV	10 mA

Enable mask test

Enables a mask test.

Remote command:

`POWer:SOA:MASK` on page 2177

Scale

Selects the scale for the result diagram.

Remote command:

`POWer:SOA:SCALe` on page 2178

SOA point definition

In this table you can set voltage-current points to define a mask for the safe point opearing area. If "Enable mask test > On" you can check whether the signal remains within the specified limits.

To add a point press "Insert" or "Append". To remove a point press "Remove".

Remote command:

`POWer:SOA:LINear:ADD` on page 2176
`POWer:SOA:LOGarithmic:ADD` on page 2176
`POWer:SOA:LINear:COUNt?` on page 2176
`POWer:SOA:LOGarithmic:COUNt?` on page 2176
`POWer:SOA:LINear:INSert` on page 2177
`POWer:SOA:LOGarithmic:INSert` on page 2177
`POWer:SOA:LINear:REMove` on page 2176
`POWer:SOA:LOGarithmic:REMove` on page 2176

Volt ← SOA point definition

Sets the voltage value of the SOA point.

Remote command:
`POWer:SOA:LINear:POINt<m>:VOLTage` on page 2177

Ampere ← SOA point definition
Sets the current value of the SOA point.

Remote command:
`POWer:SOA:LINear:POINt<m>:CURRent` on page 2177

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Safe Operating Area" measurement.

Remote command:
`POWer:SOA:EXECute` on page 2176

17.10 Turn On/ Off

"Turn On/Off" analysis measures the time that a power supply needs to reach a certain percentage of the steady state output level when initially turned on or turned off.

Common measuring scenarios include:

- Turn on time: measurement of the time it takes for the DC output to reach 90 % of the expected steady state level, after the power supply is initially turned on.
- Turn off time: measurement of the time it takes for the DC output to reach 10 % of the expected steady state level, after the power supply is initially turned off.

Required probes:

- Differential voltage probe
- Passive or differential voltage probe

17.10.1 Turn On/ Off Results

The results of "Turn On/ Off" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the input voltage waveform
  - the output voltage waveform
- The result box displays the "Turn on time" or the "Turn off time".

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The"Turn on time" is measured as the time between the trigger point ("Trigger level on" value is reached) and the time the given percentage of the "Steady state level" is reached, see Figure 17-2.

The"Turn off time" is measured as the time between the trigger point, delayed with the set "Time", ("Trigger level on" value is reached) and the time the given percentage of the "Steady state level" is reached, see Figure 17-3.

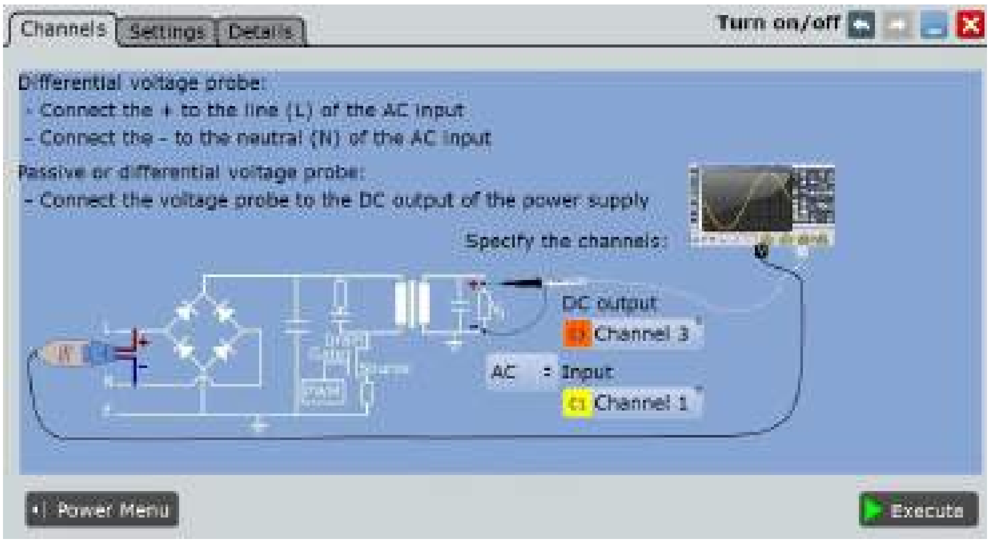
The following remote commands are used for handling the measurement results:

- `POWer:ONOFf:RESult:TOFF?` on page 2179
- `POWer:ONOFf:RESult:TON?` on page 2179
- `POWer:ONOFf:REPort:ADD` on page 2179

17.10.2 Configuring Turn On/ Off

For details of the configuration settings, see Chapter 17.10.3, "Turn On/ Off Settings", on page 1104.

1. Select "Analysis">"Power".
2. Under "Power Path", select "Turn On/ Off".
3. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect the + to the line (L) of the AC input
- Connect the - to the neutral (N) of the AC input

Passive or differential voltage probe:
- Connect the voltage probe to the DC output of the power supply

Specify the channels:

DC output: C3 Channel 3

AC = Input: C1 Channel 1

4. Select the correct channels for the "DC output" and the "AC input" or the "DC input".
5. Select the "Settings" tab.
6. Select whether you want to measure "Turn on" or "Turn off".
7. Set the "Steady state level" and the "Trigger level " according to your requirements.

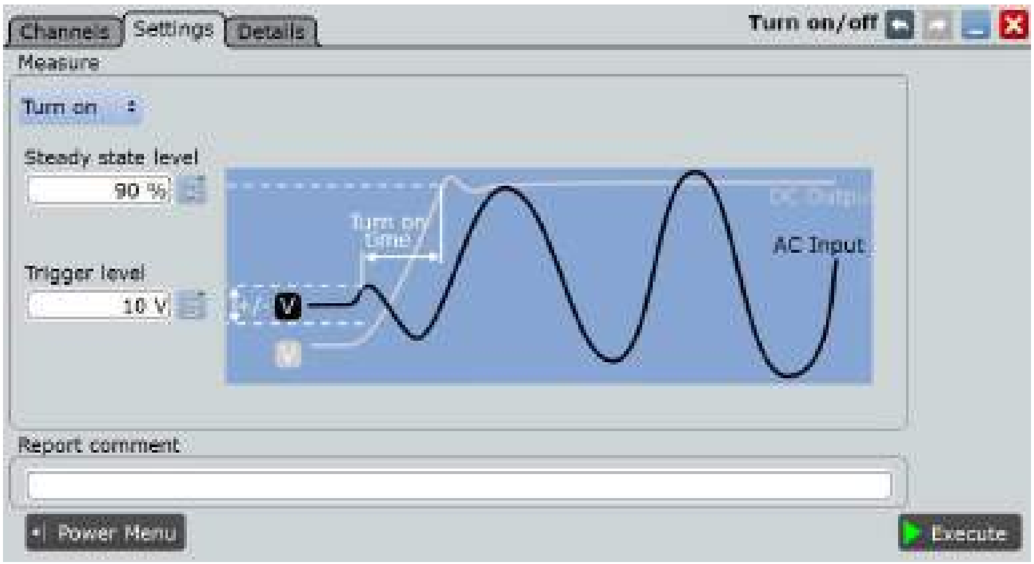
8. Tap "Execute".
9. Turn on/off the DUT.

   On the screen you can see the measurement. Additionally, the result box displays the turn on or the turn off time. For details, see Chapter 17.10.1, "Turn On/ Off Results", on page 1102.

17.10.3 Turn On/ Off Settings

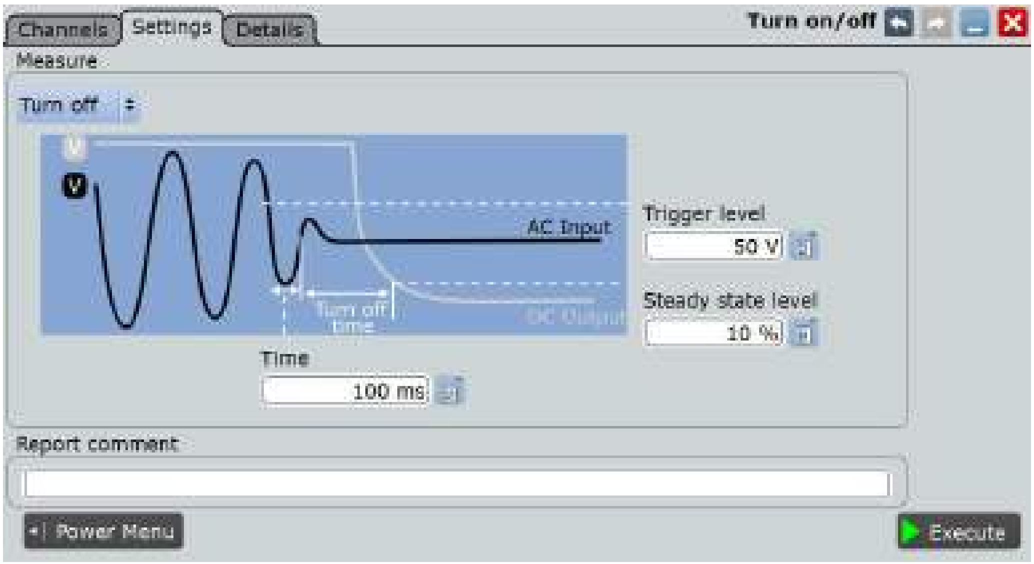
In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the turn on and the turn off parameters.



Measure
Turn on
Steady state level
90 %
Trigger level
10 V
Report comment

Figure 17-2: Settings turn on time



Measure: Turn off

Trigger level: 50 V

Steady state level: 10 %

Time: 100 ms

Report comment:

Figure 17-3: Settings turn off time

Input Type
To acces this setting select the "Channels" tab.

Selects the AC or DC input type.

Remote command:
`POWer:ONOFf:INPut` on page 2179

Measurement Type
Selects the"Turn on" or the "Turn off " measurement.

Remote command:
`POWer:ONOFf:TYPE` on page 2180

Turn on
Enables the configuration of the turn on time measurement.

Steady state level-Turn on ← Turn on
Sets the percentage of the steady state level of the DC output that has to be reached.

Remote command:
`POWer:ONOFf:DSON` on page 2179

Trigger level on ← Turn on
Triggers the beginning of the measurements at the moment the AC or DC input voltage reaches the set value.

Remote command:
`POWer:ONOFf:ATON` on page 2178
`POWer:ONOFf:DTON` on page 2178

Turn off
Enables the configuration of the turn off time measurement.

Steady state level- Turn off ← Turn off
Sets the percentage of the steady state level of the DC output that has to be reached.

Remote command:
`POWer:ONOFf:DSOFf` on page 2179

Trigger level ← Turn off
Triggers the beginning of the measurements at the moment the AC or DC input voltage reaches the set value.

Remote command:
`POWer:ONOFf:ATOFf` on page 2178
`POWer:ONOFf:DTOFf` on page 2178

Time ← Turn off
Sets the time the start of the measurement of the turn off time is delay with, after the trigger point.

Remote command:
`POWer:ONOFf:TIME` on page 2179

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Power Quality" measurement.

Remote command:
`POWer:ONOFf:EXECute` on page 2179

17.11 Switching Loss

The "Switching Loss" analysis measures the power and energy losses of a switching device, that occur during the switching phases and the conduction phase of the switching transistor.

Required probes:

- Differential voltage probe
- Current probe

17.11.1 Switching Loss Results

The results of "Switching Loss" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - the power waveform

- The result box displays the numeric measurement results for the enabled measurement parameters in dependance of the energy and the power. To switch the display, tap "Energy" or "Power" accordingly.
  For a detailed description, see Table 17-2.

Switching Loss Results

	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Switching frequency	25 MHz	25.063 MHz	24.938 MHz	25.002 MHz	25.002 MHz	11.067 kHz	939	939
Turn on	14.495 pJ	14.764 pJ	14.319 pJ	14.522 pJ	14.522 pJ	55.786 fJ	939	939
Turn off	-150.16 pJ	-149.36 pJ	-150.57 pJ	-150.06 pJ	150.06 pJ	141.46 fJ	939	939
Conduction	52.31 pJ	52.845 pJ	51.932 pJ	52.355 pJ	52.356 pJ	137.34 fJ	939	939
Non conduction	102.36 pJ	103.33 pJ	102.28 pJ	102.79 pJ	102.79 pJ	142.88 fJ	939	939
Total	18.679 pJ	20.02 pJ	18.493 pJ	19.265 pJ	19.267 pJ	249.99 fJ	939	939

Switching Loss Results

	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Switching frequency	25 MHz	25.063 MHz	24.938 MHz	25.001 MHz	25.001 MHz	13.867 kHz	540	540
Turn on	361.21 μW	369.12 μW	350.01 μW	363.07 μW	363.07 μW	1.4188 μW	540	540
Turn off	-3.7435 mW	-3.7421 mW	-3.7645 mW	-3.7518 mW	3.7518 mW	3.4786 μW	540	540
Conduction	1.3109 mW	1.3212 mW	1.2984 mW	1.309 mW	1.309 mW	3.4703 μW	540	540
Non conduction	2.5668 mW	2.5803 mW	2.5585 mW	2.5699 mW	2.5699 mW	3.5069 μW	540	540
Total	487.35 μW	499.66 μW	463.74 μW	481.61 μW	481.65 μW	6.1242 μW	540	540

To measure and display the switching loss, the instrument uses the following measurements and cursors:

- "P3"... "P8": Meas 3 ... Meas 8 to measure the voltage
- "M4" Math 4 to calculate the power
- "C3" Cursor 3 to define time points "t_0" and "t_1"
- "C4" Cursor 4 to define time points "t_2" and "t_3"

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

"Switching Loss" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

The switching loss phases that can be defined during the measurement are shown in Figure 17-4 and described in Table 17-4.

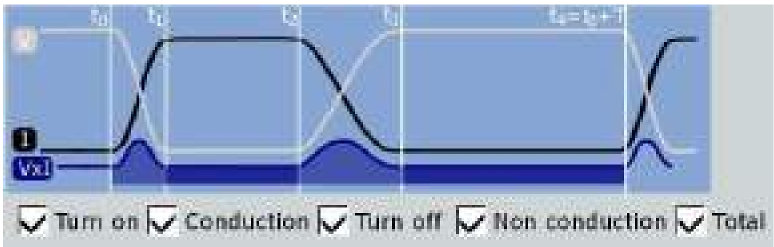


Figure 17-4: Switching loss phases

Table 17-4: Switching loss phases

Phase	Definition Points	Description
Turn on	The area between "t_0" and "t_1"	The time after switching the device, during which the current rises until it reaches the saturation current level.
Conduction	The area between "t_1" and "t_2"	The time during which the voltage is at the transistors saturated minimum and the current flows.
Turn off	The area between "t_2" and "t_3"	The time during which after a short delay time the voltage rises until it reaches its final value.
Non conduction	The area between "t_3" and "t_4"	The time during current doesn't flow. The losses during this period should be theoretically zero.
Total	The area between "t_0" and "t_4"	The period of one switching cycle.

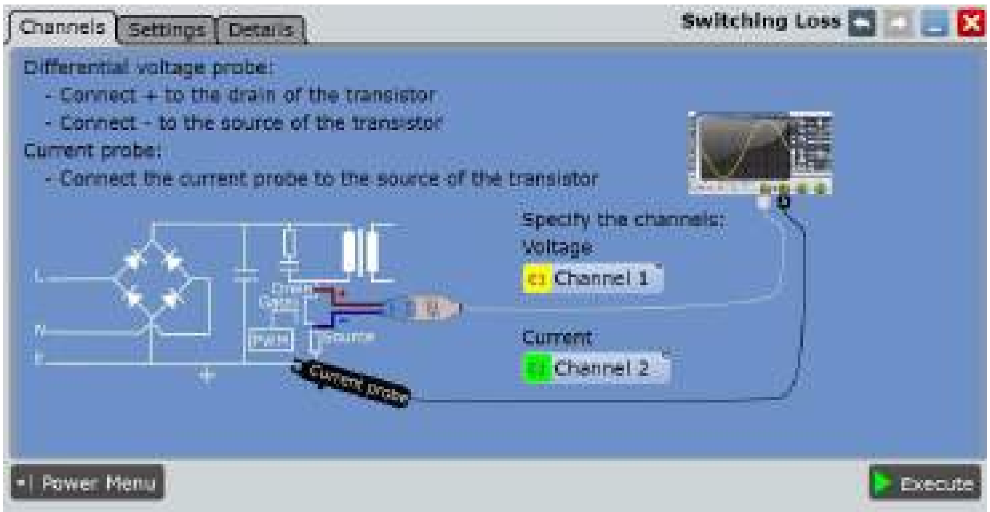
The following remote commands are used for handling the measurement results:

- `POWer:SWITching:GATE:COND:STARt` on page 2182
- `POWer:SWITching:GATE:COND:STOP` on page 2182
- `POWer:SWITching:GATE:NCON:STARt` on page 2182
- `POWer:SWITching:GATE:TOFF:STARt` on page 2182
- `POWer:SWITching:GATE:TOFF:STOP` on page 2182
- `POWer:SWITching:GATE:TON:STARt` on page 2182
- `POWer:SWITching:GATE:TON:STOP` on page 2182
- `POWer:SWITching:RESult:ENERgy:ACTual?` on page 2182
- `POWer:SWITching:RESult:ENERgy:AVG?` on page 2182
- `POWer:SWITching:RESult:ENERgy:EVTCount?` on page 2182
- `POWer:SWITching:RESult:ENERgy:NPEak?` on page 2182
- `POWer:SWITching:RESult:ENERgy:PPEak?` on page 2182
- `POWer:SWITching:RESult:ENERgy:RMS?` on page 2182
- `POWer:SWITching:RESult:ENERgy:STDDev?` on page 2182
- `POWer:SWITching:RESult:ENERgy:WFMCount?` on page 2182
- `POWer:SWITching:RESult:POWer:ACTual?` on page 2182
- `POWer:SWITching:RESult:POWer:AVG?` on page 2182
- `POWer:SWITching:RESult:POWer:EVTCount?` on page 2182
- `POWer:SWITching:RESult:POWer:NPEak?` on page 2182
- `POWer:SWITching:RESult:POWer:PPEak?` on page 2182
- `POWer:SWITching:RESult:POWer:RMS?` on page 2182
- `POWer:SWITching:RESult:POWer:STDDev?` on page 2183
- `POWer:SWITching:RESult:POWer:WFMCount?` on page 2183
- `POWer:SWITching:REPort:ADD` on page 2181

17.11.2 Configuring Switching Loss

For details of the configuration settings, see Chapter 17.11.3, "Switching Loss Settings", on page 1109.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Switching Loss".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Differential voltage probe:
- Connect + to the drain of the transistor
- Connect - to the source of the transistor

Current probe:
- Connect the current probe to the source of the transistor

Specify the channels:

Voltage: C1 Channel 1

Current: C2 Channel 2

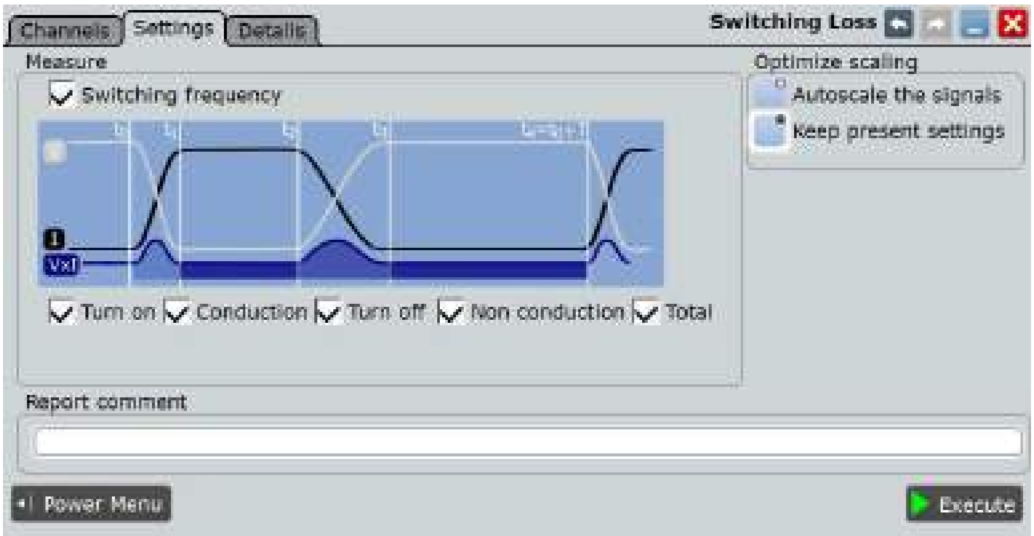
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Enable the parameters you want to measure.
9. Select an"Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current, the voltage and the power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 17.11.1, "Switching Loss Results", on page 1106.

17.11.3 Switching Loss Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the switching loss parameters and display settings.



Measure

In this area you can select the parameters that are included in the analysis after executing the measurement.

Switching frequency ← Measure

Enables the measurements of the switching frequency. If disabled you can enter the value of the switching frequency.

Remote command:

`POWer:SWITching:SWIFrequency` on page 2181
`POWer:SWITching:SWIT` on page 2181

Turn on

Enables the measurements during the turn on period.

Remote command:

`POWer:SWITching:TON` on page 2181

Conduction

Enables the measurements during the conduction period.

Remote command:

`POWer:SWITching:COND` on page 2181

Turn off

Enables the measurements during the turn off period.

Remote command:

`POWer:SWITching:TOFF` on page 2181

Non conduction

Enables the measurements during the non conduction period.

Remote command:

`POWer:SWITching:NCON` on page 2181

Total

Enables the measurements of the total period

Remote command:
`POWer:SWITching:TOTal` on page 2181

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:SWITching:AUTO` on page 2181

Report comment

In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute

Starts the "Switching Loss" measurement.

Remote command:
`POWer:SWITching:EXECute` on page 2181

17.12 Power Efficiency

This measurement requires a 4-channel oscilloscope (R&S RTOxxx4).

"Power Efficiency" analysis measures the input and the output power of a power supply. The power efficiency of the power supply is then calculated as the ratio of the output power and the input power.

Required probes:

- Two differential voltage probes
- Two current probes

17.12.1 Power Efficiency Results

The results of "Power Efficiency" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage input waveform
  - the current input waveform
  - the voltage output waveform
  - the voltage input waveform

  - the power input waveform
  - the power output waveform
- The result box displays the numeric measurement results of the "Input power", "Output power" and the "Efficiency". For a detailed description, see Table 17-2.

To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the input power waveform
- "P8" Meas 8 to measure the output power waveform
- "M2" Math 2 to calculate the input power
- "M3" Math 3 to calculate the output power

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

"Power Efficiency" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

The following remote commands are used for handling the measurement results:

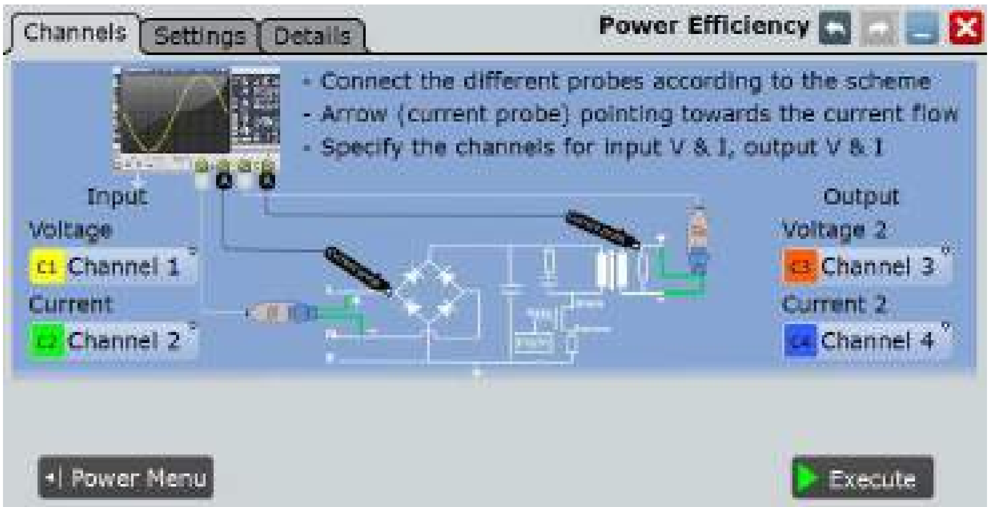
- `POWer:EFFiciency:RESult<m>:ACTual?` on page 2184
- `POWer:EFFiciency:RESult<m>:AVG?` on page 2184
- `POWer:EFFiciency:RESult<m>:EVTCount?` on page 2184
- `POWer:EFFiciency:RESult<m>:NPEak?` on page 2184
- `POWer:EFFiciency:RESult<m>:PPEak?` on page 2184
- `POWer:EFFiciency:RESult<m>:RMS?` on page 2184
- `POWer:EFFiciency:RESult<m>:STDDev?` on page 2184
- `POWer:EFFiciency:RESult<m>:WFMCount?` on page 2184
- `POWer:EFFiciency:REPort:ADD` on page 2183

17.12.2 Configuring Power Efficiency

For details of the configuration settings, see Chapter 17.12.3, "Power Efficiency Settings", on page 1113.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Power Efficiency".
3. Connect the differential voltage probes and the current probes to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.

5. Connect the probes to the DUT as shown in the graphic of the "Channels" tab:



- Connect the different probes according to the scheme
- Arrow (current probe) pointing towards the current flow
- Specify the channels for input V & I, output V & I

Input
Voltage: C1 Channel 1
Current: C2 Channel 2

Output
Voltage 2: C3 Channel 3
Current 2: C4 Channel 4

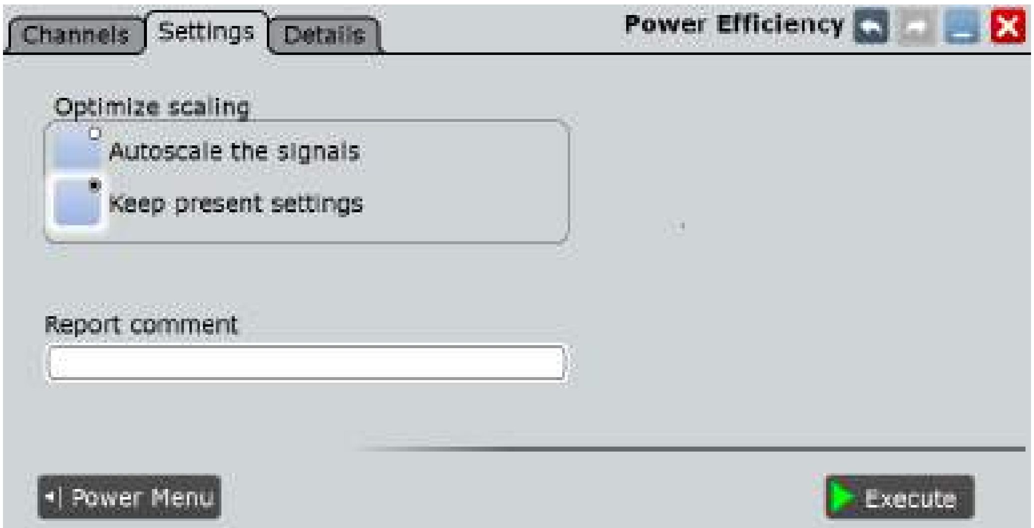
6. Select the correct channels for the "Current Source" and the "Voltage Source" of the input and the output.
7. Select the "Settings" tab.
8. Select an "Optimize Scaling" option.
9. Tap "Execute".

   On the screen you can see the measurement waveforms of the input power and the output power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 17.12.1, "Power Efficiency Results", on page 1111

17.12.3 Power Efficiency Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the power efficience display settings.



Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:EFFiciency:AUTO` on page 2183

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Power Effieciency" measurement.

Remote command:
`POWer:EFFiciency:EXECute` on page 2183

17.13 Output Ripple

The "Output Ripple" analysis measures the ripple of the device output. You can measure the voltage ripple alone or the voltage and the current ripple simultaneously. In this measurement the peak-to peak extremes of the output DC signal are of interest. The measurement also includes the AC-RMS of the output DC signal, that is calculated as a standard derivation.

Required probes:

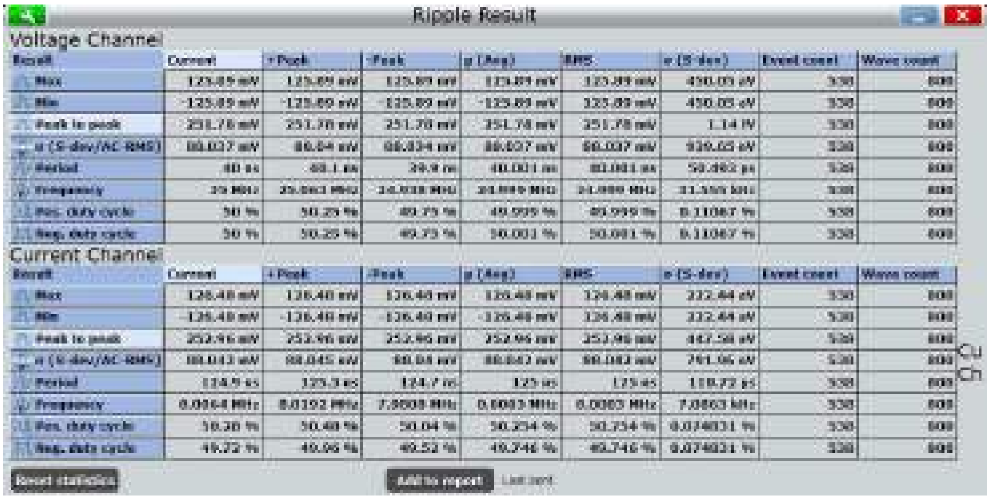
- Voltage probe

- (Optional) Current probe

17.13.1 Output Ripple Results

The results of "Output Ripple" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - (optional) the current waveform
- The result box displays the numeric measurement results for the voltage and for the current ripple. For details, see Table 17-5 and Table 17-2.



To measure and display the output ripple, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the current
- "P8" Meas 8 to measure the voltage

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

Table 17-5: Properties output ripple

	Meas. type	Symbol	Description/Result
	Max	X_{Max}	Absolute maximum value of the waveform.
	Min	X_{Min}	Absolute minimum value of the waveform.
	Peak to peak	X_{PkPk}	Peak-to-peak value of the waveform: the difference of maximum and minimum values. $X_{Ampl} = X_{Max} - X_{Min}$

	Meas. type	Symbol	Description/Result
σ	σ (S-dev/AC-RMS)	σ_X	Standard deviation of the waveform samples
	Period	T_{Period}	Time of the left-most signal period of the waveform - the time difference between two consecutive waveform edges measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
f	Frequency	f_{Period}	Frequency of the signal, reciprocal value of the period. $f_{Period} = 1 / T_{Period}$
	Pos. duty cycle	R_{PosCyc}	Positive duty cycle: Width of a positive pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$
	Neg. duty cycle	R_{NegCyc}	Negative duty cycle: Width of a negative pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$

"Ripple" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

The following remote commands are used for handling the measurement results:

- `POWer:RIPPle:RESult:FREQuency:AVG?` on page 2186
- `POWer:RIPPle:RESult:FREQuency:EVTCount?` on page 2186
- `POWer:RIPPle:RESult:FREQuency:NPEak?` on page 2186
- `POWer:RIPPle:RESult:FREQuency:PPEak?` on page 2186
- `POWer:RIPPle:RESult:FREQuency:RMS?` on page 2186
- `POWer:RIPPle:RESult:FREQuency:STDDev?` on page 2187
- `POWer:RIPPle:RESult:FREQuency:WFMCount?` on page 2187
- `POWer:RIPPle:RESult:FREQuency[:ACTual]?` on page 2186
- `POWer:RIPPle:RESult:MAXimum:AVG?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:EVTCount?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:NPEak?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:PPEak?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:RMS?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:STDDev?` on page 2187
- `POWer:RIPPle:RESult:MAXimum:WFMCount?` on page 2187
- `POWer:RIPPle:RESult:MAXimum[:ACTual]?` on page 2187
- `POWer:RIPPle:RESult:MINimum:AVG?` on page 2188

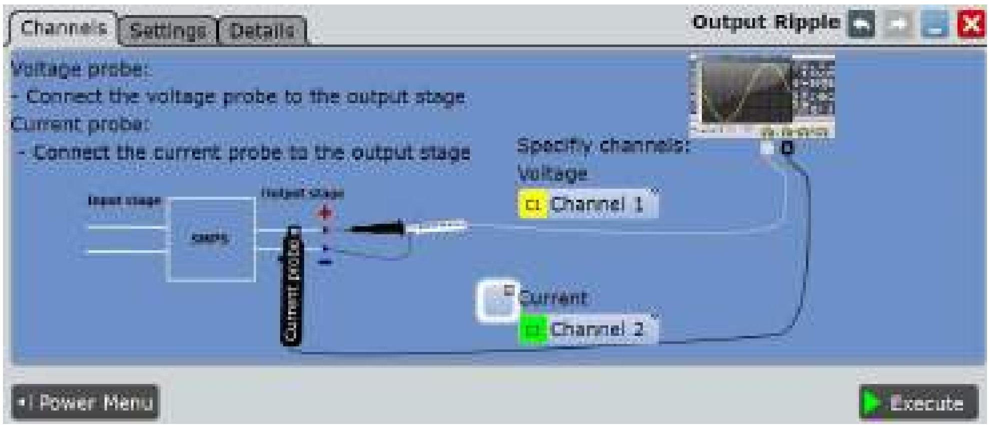
- `POWer:RIPPle:RESult:MINimum:EVTCount?` on page 2188
- `POWer:RIPPle:RESult:MINimum:NPEak?` on page 2188
- `POWer:RIPPle:RESult:MINimum:PPEak?` on page 2188
- `POWer:RIPPle:RESult:MINimum:RMS?` on page 2188
- `POWer:RIPPle:RESult:MINimum:STDDev?` on page 2188
- `POWer:RIPPle:RESult:MINimum:WFMCount?` on page 2188
- `POWer:RIPPle:RESult:MINimum[:ACTual]?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:AVG?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:EVTCount?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:NPEak?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:PPEak?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:RMS?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:STDDev?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle:WFMCount?` on page 2188
- `POWer:RIPPle:RESult:NDCYcle[:ACTual]?` on page 2188
- `POWer:RIPPle:RESult:PDCYcle:AVG?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:EVTCount?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:NPEak?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:PPEak?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:RMS?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:STDDev?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle:WFMCount?` on page 2189
- `POWer:RIPPle:RESult:PDCYcle[:ACTual]?` on page 2189
- `POWer:RIPPle:RESult:PDEL:AVG?` on page 2189
- `POWer:RIPPle:RESult:PDEL:EVTCount?` on page 2189
- `POWer:RIPPle:RESult:PDEL:NPEak?` on page 2189
- `POWer:RIPPle:RESult:PDEL:PPEak?` on page 2189
- `POWer:RIPPle:RESult:PDEL:RMS?` on page 2189
- `POWer:RIPPle:RESult:PDEL:STDDev?` on page 2189
- `POWer:RIPPle:RESult:PDEL:WFMCount?` on page 2189
- `POWer:RIPPle:RESult:PDEL[:ACTual]?` on page 2189
- `POWer:RIPPle:RESult:PERiod:AVG?` on page 2190
- `POWer:RIPPle:RESult:PERiod:EVTCount?` on page 2190
- `POWer:RIPPle:RESult:PERiod:NPEak?` on page 2190
- `POWer:RIPPle:RESult:PERiod:PPEak?` on page 2190
- `POWer:RIPPle:RESult:PERiod:RMS?` on page 2190
- `POWer:RIPPle:RESult:PERiod:STDDev?` on page 2190
- `POWer:RIPPle:RESult:PERiod:WFMCount?` on page 2190

- `POWer:RIPPle:RESult:PERiod[:ACTual]?` on page 2190
- `POWer:RIPPle:RESult:STDDev:AVG?` on page 2190
- `POWer:RIPPle:RESult:STDDev:EVTCount?` on page 2190
- `POWer:RIPPle:RESult:STDDev:NPEak?` on page 2190
- `POWer:RIPPle:RESult:STDDev:PPEak?` on page 2190
- `POWer:RIPPle:RESult:STDDev:RMS?` on page 2191
- `POWer:RIPPle:RESult:STDDev:STDDev?` on page 2191
- `POWer:RIPPle:RESult:STDDev:WFMCount?` on page 2191
- `POWer:RIPPle:RESult:STDDev[:ACTual]?` on page 2190
- `POWer:RIPPle:REPort:ADD` on page 2186

17.13.2 Configuring Output Ripple

For details of the configuration settings, see Chapter 17.13.3, "Output Ripple Settings", on page 1119.

1. Select "Analysis" > "Power".
2. Under "Output", select "Ripple".
3. Connect the voltage probe to the oscilloscope.
4. If you want to measure the current ripple enable the current channel and connect the current probe to the oscilloscope.
5. If you want to measure both the voltage and the current ripple deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
6. Connect the probes to the DUT as shown in the "Channels" tab:



Voltage probe:
- Connect the voltage probe to the output stage

Current probe:
- Connect the current probe to the output stage

Specify channels:

Voltage: C1 Channel 1

Current: C2 Channel 2

7. Select the correct channels for the "Voltage Source" and the "Current Source".
8. Select the "Settings" tab.
9. Set the "SMPS switching frequency" according to your signal.
10. Select an "Optimize Scaling" option.

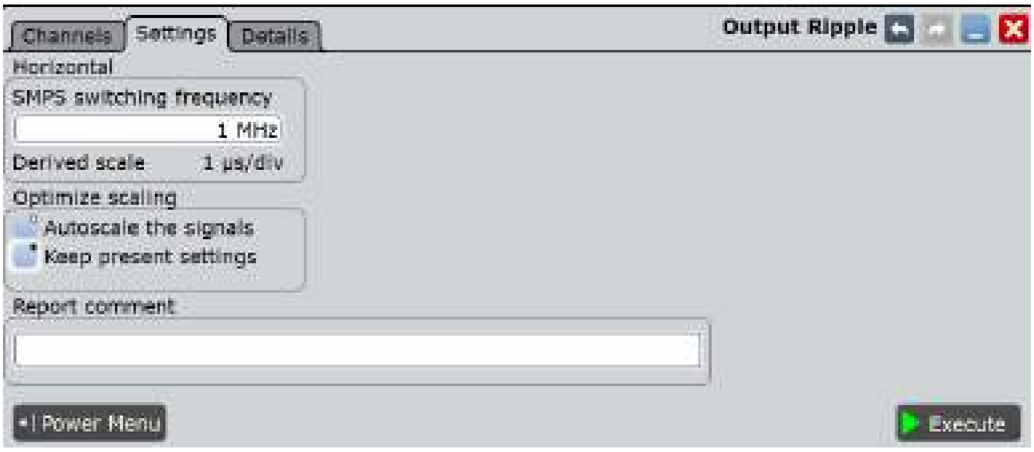
11. Tap "Execute".

    On the screen you can see the measurement waveforms of the current and the voltage. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 17.13.1, "Output Ripple Results", on page 1115.

17.13.3 Output Ripple Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070 and `POWer:RIPPle:CURRent` on page 2186)

In the "Settings" tab you configure the ripple parameters and display settings.



SMPS switching frequency: 1 MHz
Derived scale: 1 µs/div
○ Autoscale the signals
● Keep present settings

Horizontal
Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal
Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:
`POWer:RIPPle:FREQuency` on page 2186

Derived scale ← Horizontal
Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"	Automatically selects the most appropriate scale for the display of the results.
"Keep present settings"	The present display settings are not changed.

Remote command:
`POWer:RIPPle:AUToscale` on page 2186

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Output Ripple" measurement.

Remote command:
`POWer:RIPPle:EXECute` on page 2186

17.14 Transient Response

The "Transient Response" analysis measures the response of a system to a change from equilibrium. This response is described by different properties like the rise time, the overshoot, the settling time, the peak time and the delay time.

Required probes:

- One or two voltage probes
- Current probe

17.14.1 Transient Response Results

The results of "Power Quality" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform(s)
  - the current waveform
- The result box displays the numeric measurement results.

Transient Response Result

Rise time	---
Overshoot level	1.0121 %
Settling time	200 µs
Peak time	100 µs
Delay to trigger	---

To measure and display the transient response, the instrument uses the following measurements and waveforms:

- "P8" Meas 8 to measure the rise time, the overshoot and delay to trigger
- "C1" Cursor 3 to measure the peak time
- "C2" Cursor 2 to measure the delay to trigger

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The results describing the transient response of the system are shown in Figure 17-5 and described in Table 17-6.

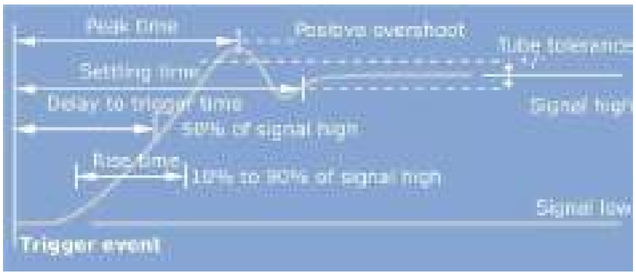


Figure 17-5: Graphical presentation of the transient response properties

Table 17-6: Transient response

Result	Description
Rise time	The time needed for the signal to change from 10% to 90% of the specified signal high.
Overshoot level	The maximum swing level above the signal high.
Settling time	The time elapsed from the trigger event to the time the output enters and remains within the tube tolerance band.
Peak time	The time needed for the response to reach the first peak of the overshoot.
Delay to trigger	The time needed for the response to reach half of the signal high value, after the trigger event.

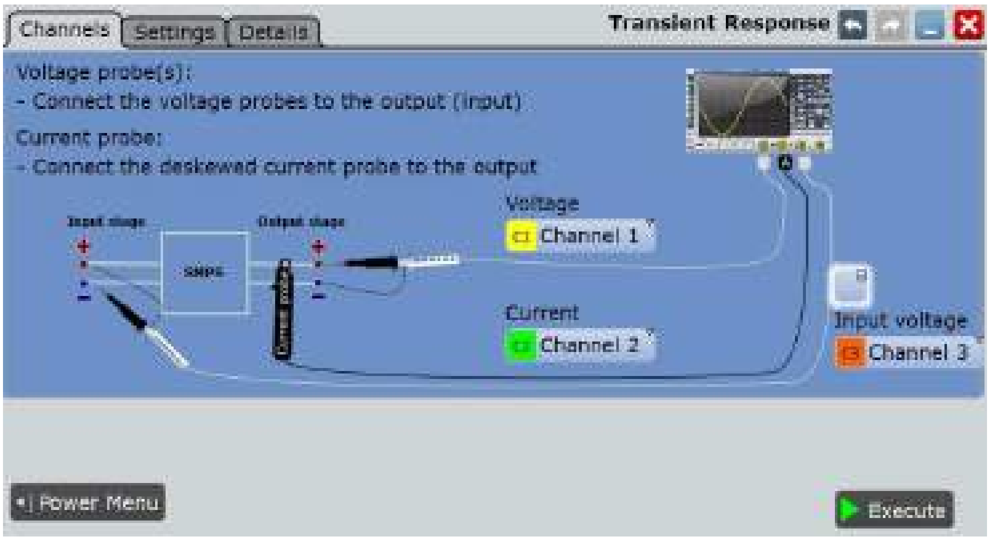
The following remote commands are used for handling the measurement results:

- `POWer:TRANsient:RESult[:ACTual]?` on page 2192
- `POWer:TRANsient:REPort:ADD` on page 2192

17.14.2 Configuring Transient Response

For details of the configuration settings, see Chapter 17.14.3, "Transient Response Settings", on page 1122.

1. Select "Analysis" > "Power".
2. Under "Output", select "Transient Response".
3. Connect the voltage probe(s) and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 17.1.1.1, "Auto Deskew", on page 1060.
5. Connect the probes to the DUT as shown in the "Channels" tab:



Voltage probe(s):
- Connect the voltage probes to the output (input)

Current probe:
- Connect the deskewed current probe to the output

Voltage: Channel 1

Current: Channel 2

Input voltage: Channel 3

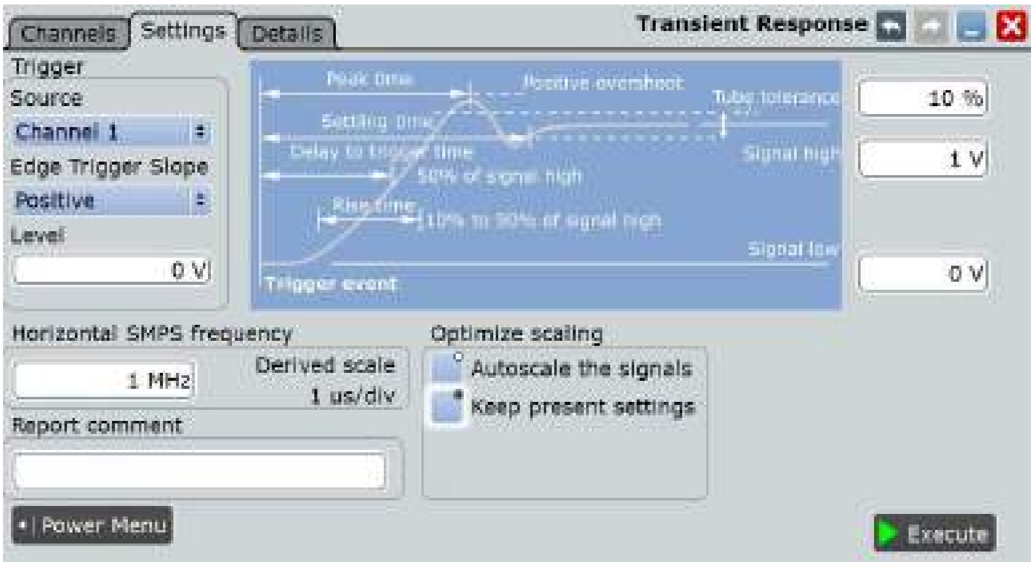
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Trigger" settings according to your signal.
9. Set the "Tube tolerance", "Signal high" and "Signal low" according to your requirements.
10. Set the "SMPS switching frequency" according to your device.
11. Select an "Optimize Scaling" option.
12. Tap "Execute".
13. If needed adjust the cursors manually. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement of the current and the voltage . Additionally there is a table giving information about important measurement parameters. For details, see Chapter 17.14.1, "Transient Response Results", on page 1120.

17.14.3 Transient Response Settings

In the "Channels" tab, you set the current source and the voltage sources, see also: Chapter 17.2.1, "Channels Tab", on page 1070 and `POWer:TRANsient:INPut` on page 2192.

In the "Settings" tab you configure the transient response measurement parameters and display settings.



Trigger
Source
Channel 1
Edge Trigger Slope
Positive
Level
0 V

Tube tolerance 10 %
Signal high 1 V
Signal low 0 V

Horizontal SMPS frequency
1 MHz
Derived scale
1 us/div

Optimize scaling
○ Autoscale the signals
● Keep present settings

Report comment

Trigger
Sets the properties of the trigger.

Source ← Trigger
Sets the source channel of the trigger.

Remote command:
`POWer:TRANsient:TRGChannel` on page 2193

Edge Trigger Slope ← Trigger
Sets the edge type for the trigger event.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge.

Remote command:
`POWer:TRANsient:TRGSlope` on page 2193

Level ← Trigger
Sets the voltage or current level for the trigger event.

Remote command:
`POWer:TRANsient:TRGLevel` on page 2193

Tube tolerance
Specifies a tolerated error band for the signal level.

Remote command:
`POWer:TRANsient:HYSTeresis` on page 2192

Signal high
Sets the expected signal high voltage value.

Remote command:
`POWer:TRANsient:SIGHigh` on page 2193

Signal low
Sets the expected signal low voltage value.

Remote command:
`POWer:TRANsient:SIGLow` on page 2193

Horizontal
Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal
Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:
`POWer:TRANsient:FREQuency` on page 2192

Derived scale ← Horizontal
Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:TRANsient:AUToscale` on page 2191

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Transient Response" measurement.

Remote command:
`POWer:TRANsient:EXECute` on page 2192

17.15 Output Spectrum

"Output Spectrum" analysis measures the spectrum of the output voltage. The results can be applied to see typical side effect problems of the SMPS application, such as switching frequency components of internal SMPS.

Required probes:

- Voltage probe

17.15.1 Output Spectrum Results

After executing the "Output Spectrum" measurement the following windows are displayed:

The results of "Power Quality" measurements are provided in two ways:

- Two diagrams that shows the graphical presentation of:
  - the voltage waveform
  - the spectrum
- The result box displays the positions of the measured peaks. The peaks are found by an automatic peak search.
  Note: If no results are found, check and correct the FFT settings.

Harmonics Count 34

Index	Frequency	Value
1	25.0244141 MHz	0.010761261 dBm
2	50.0488281 MHz	-69.435684204 dBm
3	75.0732422 MHz	-9.68576622 dBm
4	100.0976562 MHz	-63.600738525 dBm
5	125.1220703 MHz	-14.144641876 dBm
6	150.1464844 MHz	-69.135513306 dBm
7	175.1708984 MHz	-16.895078659 dBm
8	200.1953125 MHz	-65.642837524 dBm
9	225.2197266 MHz	-18.00513092 dBm
10	250.2441406 MHz	-64.680496216 dBm
11	275.2685547 MHz	-20.920433044 dBm

To measure and display the output spectrum, the instrument uses the following measurements and waveforms:

- "M4" Math 4 to calculate the magnitude of the FFT for the voltage source values

The used resources are listed in the "Details" tab. See also: Chapter 17.2.3, "Details Tab", on page 1072.

The measured peaks have different origin. Analyzing the frequencies gives information about the influences on the output signal.

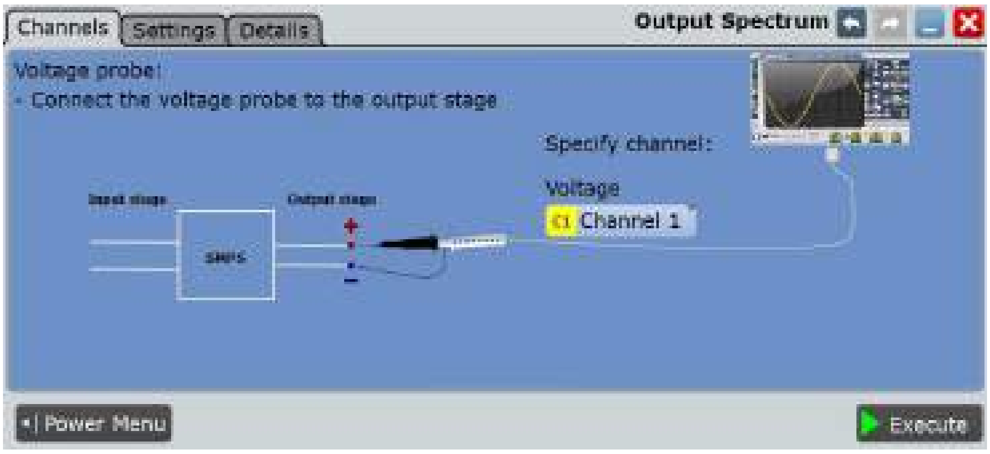
The following remote commands are used for handling the measurement results:

- `POWer:SPECtrum:RCOunt?` on page 2194
- `POWer:SPECtrum:RESult<m>:FREQuency?` on page 2195
- `POWer:SPECtrum:RESult<m>:LEVel?` on page 2195
- `POWer:SPECtrum:REPort:ADD` on page 2194

17.15.2 Configuring Output Spectrum

For details of the configuration settings, see Chapter 17.15.3, "Output Spectrum Settings", on page 1126.

1. Select "Analysis">"Power".
2. Under "Output", select "Spectrum".
3. Select the "Channels" tab.
4. Connect the probe to the DUT and to the oscilloscope as shown in the graphic:



Voltage probe:

- Connect the voltage probe to the output stage

Specify channel:

Voltage

C1 Channel 1

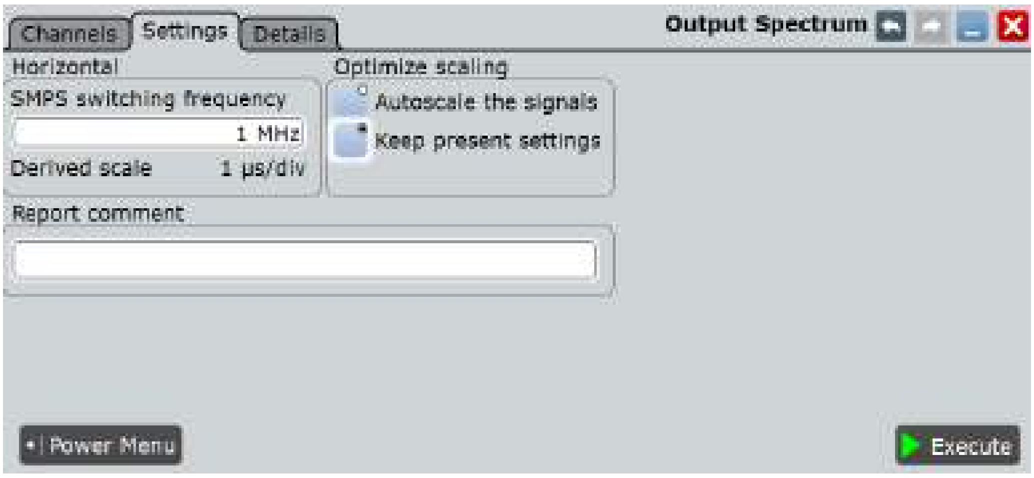
5. Select the correct channel for the "Voltage Source".
6. Select the "Settings" tab.
7. Set the "SMPS switching frequency" according to your signal.
8. Select an "Optimize Scaling"option.
9. Tap "Execute".
10. Set the positions of the cursors according to the measured spectrum. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement of the spectrum. Additionally, the result box shows the position of the peaks. For details, see Chapter 17.15.1, "Output Spectrum Results", on page 1125.

17.15.3 Output Spectrum Settings

In the "Channels" tab, you set the voltage source, see also: Chapter 17.2.1, "Channels Tab", on page 1070.

In the "Settings" tab you configure the spectrum measurement parameters and display settings.



Horizontal

Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal

Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:

`POWer:SPECtrum:FREQuency` on page 2194

Derived scale ← Horizontal

Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"

Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"

The present display settings are not changed.

Remote command:

`POWer:SPECtrum:AUToscale` on page 2194

Report comment

In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute

Starts the "Output Spectrum" measurement.

Remote command:

`POWer:SPECtrum:EXECute` on page 2194

18 Compliance Tests

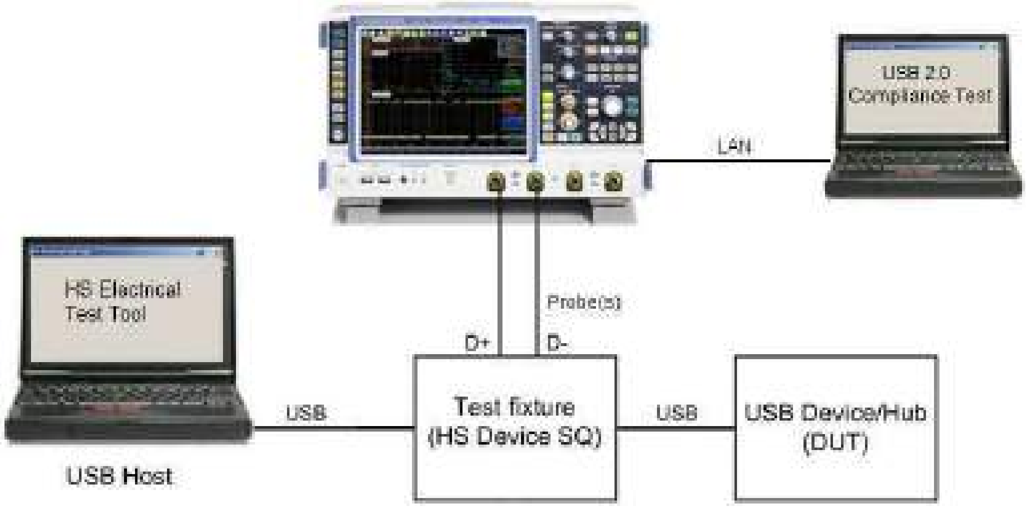
Thanks to the high measurement accuracy of the R&S RTO, the oscilloscope can be used for reliable compliance testing on the physical layer of high-speed bus interfaces. For fast and easy compliance testing, you need the free-of-charge R&S ScopeSuite. The software guides you step-by-step through the test sequences, configures the oscilloscope, automatically performs measurements and compiles the results in a measurement report. Detailed, image-based instructions make it easy to correctly connect the oscilloscope and the probes to the test fixture set and the device under test.

The R&S ScopeSuite can be installed on a test computer or directly on the R&S RTO. If the R&S ScopeSuite is installed on the oscilloscope, you can start it directly in the firmware menu: "Analysis" menu > "Start Compliance Test".

18.1 USB 2.0 Compliance Test (Option R&S RTO-K21)

The R&S RTO-K21 option enables the automatic testing of USB 2.0 compliance (high-speed) as well as USB 1.1 (full-speed) and USB 1.0 (low-speed).

As an example, the test setup for USB device tests is shown below.



The test fixture and the USB compliance test procedures are described in separate manuals:

- "R&S®RTO-K21 USB 2.0 Compliance Test, Test Procedures"
- "R&S®RT-ZF1 USB 2.0 Compliance Test Fixture Set, Manual"

18.1.1 Test Equipment

For USB 2.0 compliance tests, the following test equipment is recommended:

- R&S RTO oscilloscope with 4 channels and at least 2 GHz bandwidth.

For full speed and low speed compliance tests, a 4-channel R&S RTO with less than 2 GHz bandwidth is sufficient.

- R&S RT-ZF1 USB 2.0 compliance test fixture set, which consists of the load board and the signal quality board.
- Probes:
  - 2x single-ended active probes with at least 2 GHz bandwidth
  - 1x differential active probe with at least 2 GHz bandwidth
- HMF2550 or Tabor WX2182B/WX2182C arbitrary waveform generator for automatic receiver sensitivity tests.
  For manual receiver sensitivity tests, any AWG can be used.
- R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTO.
- R&S RTO-K21 USB 2.0 compliance test option (required option, installed on the R&S RTO)
- Make sure that you use the latest version of the USBHSET tool. Check the following websites for downloads:
  - USB 3.0 host: www.usb.org/developers/tools/
  - USB 2.0 host: www.usb.org/developers/tools/usb20_tools/

  Regularly check the USB-IF website compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard for USB-IF compliance updates.

18.2 Ethernet Compliance Tests (Option R&S RTO-K22/K23/K24/K25)

The Ethernet compliance test options enable the automatic testing of various Ethernet standards 10BASE-T, 100BASE-TX, 1000BASE-T, 2.5GBASE-T, 5GBASE-T, 10GBASE-T, and BroadR-Reach.

The test fixture and the Ethernet compliance test procedures are described in the separate manuals:

- "R&S®RTO-K22/K23/K24/K25 Ethernet Compliance Test, Test Procedures"
- "R&S®RT-ZF2 Ethernet Compliance Test Fixture Set, Manual"

18.2.1 Test Equipment

For Ethernet compliance tests, the following test equipment is needed:

- **10/100/1000BASE-T Ethernet compliance tests:**
  - R&S RTO oscilloscope with at least 600 MHz bandwidth
  - Differential probe with at least 1 GHz bandwidth
  - R&S RTO-K22 10/100/1000BASE-T Ethernet compliance test option (required option, installed on the R&S RTO)
  - R&S RT-ZF2 Ethernet test fixture set

  - For energy-efficient Ethernet tests, in addition:
    R&S RTO-K86 EEE test option
    R&S RT-ZF5 Ethernet test fixture set for 100/1000BASE-T EEE tests
    R&S RT-ZF4 test fixture for 10BASE-Te tests
- **2.5GBASE-T Ethernet compliance tests:**
  - R&S RTO oscilloscope with at least 600 MHz bandwidth
    For precise power spectral density and power level measurements up to 1 GHz, it is recommended to use an oscilloscope and a differential probe with 1 GHz bandwidth each.
  - Differential probe with at least 1GHz bandwidth
  - R&S RTO-K25 2.5/5GBASE-T Ethernet compliance test option (required option, installed on the R&S RTO)
  - R&S RT-ZF2 Ethernet test fixture set
- **5GBASE-T Ethernet compliance tests:**
  - R&S RTO oscilloscope with at least 1 GHz bandwidth
    For precise power spectral density and power level measurements up to 1.5 GHz, it is recommended to use an oscilloscope and a differential probe with 1.5 GHz bandwidth each.
  - Differential probe with at least 1.5 GHz bandwidth
  - R&S RTO-K25 2.5/5GBASE-T Ethernet compliance test option (required option, installed on the R&S RTO)
  - R&S RT-ZF2 Ethernet test fixture set
- **10GBASE-T Ethernet compliance tests:**
  - R&S RTO oscilloscope with at least 2 GHz bandwidth
    For precise power spectral density and power level measurements up to 3 GHz, it is recommended to use an oscilloscope and a differential probe with 3 GHz bandwidth each.
  - Differential probe with at least 3 GHz bandwidth
  - R&S RTO-K23 10GBASE-T Ethernet compliance test option (required option, installed on the R&S RTO)
  - R&S RT-ZF2 Ethernet test fixture set
- **100BASE-T1 compliance tests:**
  - R&S RTO oscilloscope with at least 600 MHz bandwidth
  - Differential probe with 1 GHz bandwidth
  - R&S RTO-K24 100BASE-T1 compliance test option (required option, installed on the R&S RTO)
  - R&S RT-ZF2 Ethernet test fixture set
  - R&S RT-ZF3 Frequency converter for test cases that require an ARB generator
- **1000BASE-T1 compliance tests:**
  - R&S RTO oscilloscope with at least 2 GHz bandwidth
  - Differential probe with 2 GHz bandwidth
  - R&S RTO-K87 100BASE-T1 compliance test option (required option, installed on the R&S RTO)

  - R&S RT-ZF2 Ethernet test fixture set
  - R&S RT-ZF3 Frequency converter for test cases that require an ARB generator
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTO.
- HMF2550 or Tabor WX2182B/WX2182C arbitrary waveform generator for automatic disturber tests.
- R&S ZVL/ZNB/ZNC/ZND vector network analyzer for automatic return loss measurements.
  For manual measurements, also other AWGs and VNAs can be used.

18.3 D-PHY Compliance Tests (Option R&S RTO-K26)

The option R&S RTO-K26 enables the automatic processing of D-PHY compliance tests.

The D-PHY compliance test procedures are described in a separate manual:

- "R&S®RTO-K26 D-PHY Compliance Test, Test Procedures"

18.3.1 Test Equipment

For D-PHY compliance tests, the following test equipment is needed:

- R&S RTO oscilloscope with 4 channels and at least 4 GHz bandwidth
- For measuring the clock signal (+ and -): either 1 differential probe or 2 single-ended probes with at least 4 GHz bandwidth. However, note that D-PHY Group 2 and Group 4 tests require 2 probes for the clock signal.
- For measuring the data signal (+ and -): 2 probes with at least 4 GHz bandwidth
- R&S RTO-K26 D-PHY compliance test option (required option, installed on the R&S RTO)
- Recommended test fixture for LP-TX tests: MIPI D-PHY Capacitive Load (C_{LOAD}) Fixture from The University of New Hampshire InterOperability Laboratory (UNH-IOL)
- Recommended termination board for HS-TX tests: MIPI D-PHY Reference Termination Board (RTB) from The University of New Hampshire InterOperability Laboratory (UNH-IOL)
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTO.

18.4 eMMC Compliance Tests (Option R&S RTO-K92)

The option R&S RTO-K92 enables the automatic processing of eMMC compliance tests.

The eMMC compliance test procedures are described in a separate manual:

- "R&S®RTO-K92 eMMC Compliance Test, Test Procedures"

18.4.1 Test Equipment

For eMMC compliance tests, the following test equipment is needed:

- R&S RTO oscilloscope with at least 1 GHz bandwidth
- A probe with at least 1.5 GHz bandwidth
- R&S RTO-K92 eMMC compliance test option (required option, installed on the R&S RTO)
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTO.

19 Network and Remote Operation

This chapter describes the usage of the embedded operating system on the instrument, the setup of network connections, and the interfaces and protocols used for remote control. It also explains how to start a remote control session.

Firmware update

Your instrument is delivered with the latest firmware version.

Firmware updates and the "Release Notes" describing the improvements and modifications are provided on the Internet at www.rohde-schwarz.com/ product/rto.html > "Downloads" > "Firmware".

How to update the firmware is described in the "Release Notes" of the R&S RTO.

Software options

See Chapter 3.6.3, "Activating Options", on page 132

The current chapter contains the following sections:

19.1 Operating System

The R&S RTO has a Windows Embedded Standard 7 64 bit operating system.

The operating system has been configured according to the instrument's features and needs. To ensure that the instrument software functions properly, certain rules must be adhered to when using the operating system.

NOTICE

Risk of causing instrument unusability

The instrument is equipped with a Windows operating system. Additional software can therefore be installed on the instrument. The use and installation of additional software may impair instrument function. Thus, run only programs that Rohde & Schwarz has tested for compatibility with the instrument software.

The drivers and programs used on the instrument under Windows have been adapted to the instrument. Existing instrument software must always be modified using only update software released by Rohde & Schwarz.

Changes in the system setup are only required if the network configuration does not comply with the default settings (see Chapter 19.2.1, "Connecting the Instrument to the Network", on page 1136).

19.1.1 Virus Protection

Take appropriate steps to protect your instruments from infection. Use strong firewall settings and scan any removable storage device used with a Rohde & Schwarz instrument regularly. It is also recommended that you install anti-virus software on the instrument. Rohde & Schwarz does NOT recommend running anti-virus software in the background ("on- access" mode) on Windows-based instruments, due to potentially degrading instrument performance. However, Rohde & Schwarz does recommend running it during non-critical hours.

For details and recommendations, see the following Rohde & Schwarz white paper:

- 1DC01: Malware Protection Windows 7

19.1.2 Service Packs and Updates

Microsoft regularly creates security updates and other patches to protect Windows-based operating systems. These are released through the Microsoft Update website and associated update server. Instruments using Windows, especially those that connect to a network, should be updated regularly.

For details and recommendations, see the Rohde & Schwarz White Paper 1DC01: Malware Protection.

19.1.3 Logon

Windows requires that users identify themselves by entering a user name and password in a logon window. You can set up two types of user accounts, either an administrator account with unrestricted access to the computer/domain or a standard user account with limited access.

If the instrument is connected to the network, you are automatically logged on to the network at the same time you log on to the operating system. As a prerequisite, the user name and the password must be identical under Windows and on the network. The instrument provides an auto-logon function that can be configured for user and administrator access. The configuration requires the user name and password. All users except for the administrator are treated as standard user with limited access. See also: "Log on as" on page 102

By default, the user name for the administrator account is "instrument", and the user name for the standard user account is "NormalUser". In both cases the initial password is "894129". You can change the password for the standard user in the Windows configuration :"Start" menu > "Settings > Control Panel > User Accounts". Some administrative tasks require administrator rights, e.g. the configuration of a LAN network.

To configure the auto-logon for admistrator

Starting situation: the auto-logon is configured for a standard user.

1. Press the Setup key and select the "System" tab.
2. Set "Logon as" to "None".
3. Restart the instrument an log on as administrator.
4. Set the "Logon as" to "Admin autologon" and enter the admistrator's password.

19.1.4 Accessing Windows functionality

All required Windows settings can be changed using the touchscreen and the on-screen keyboard that is part of the Windows system. However, modification is easier if you connect a mouse and/or keyboard to the instrument.

To access Windows

- ► On the "File" menu, select "Minimize application".

  The application is minimized to the task bar and the "Start" menu becomes available.

To access Windows using an external keyboard

1. To open the "Start" menu, press the Windows key or the CTRL + ESC key combination on your keyboard.
2. To access the desktop, press the Windows key + D on your keyboard.

To access Windows settings directly from the firmware

Important Windows settings can be accessed directly from the R&S RTO interface.

1. Press the Setup key and tap the "System" tab.
2. Select one of the settings buttons to access the corresponding Windows dialog box.

   Once you have opened a Windows dialog box, the task bar and the "Start" menu are also available.

19.2 Setting Up a Network (LAN) Connection

A LAN connection is the prerequisite for all network operations. The LAN connection settings can be configured directly in the Windows operating system, or with LXI (LAN eXtension for Instruments).

The R&S RTO is equipped with a network interface and can be connected to an Ethernet LAN (local area network). Provided the network administrator has assigned you the appropriate rights and adapted the Windows firewall configuration, you can use the interface, for example:

- To transfer data between a controlling device and the test device, e.g. to run a remote control program.
  See chapter "Remote Control".
- To access or control the measurement from a remote computer using the "Remote Desktop" application (or a similar tool)
- To connect external network devices (e.g. printers)
- To transfer data from a remote computer and back, e.g. using network folders

This section describes how to configure the LAN interface. It includes the following topics:

- Chapter 19.2.1, "Connecting the Instrument to the Network", on page 1136
- Chapter 19.2.2, "Assigning the IP Address", on page 1137

LXI

The R&S RTO supports the LXI core features. LXI gives you direct access to the LAN settings described below.

19.2.1 Connecting the Instrument to the Network

There are two methods to establish a LAN connection to the instrument:

- A non-dedicated network (Ethernet) connection from the instrument to an existing network made with an ordinary RJ-45 network cable. The instrument is assigned an IP address and can coexist with a computer and with other hosts on the same network.
- A dedicated network connection (Point-to-point connection) between the instrument and a single computer made with a (crossover) RJ-45 network cable. The computer must be equipped with a network adapter and is directly connected to the instrument. The use of hubs, switches, or gateways is not required, however, data transfer is still performed using the TCP/IP protocol. You must assign an IP address to the instrument and the computer, see Chapter 19.2.2, "Assigning the IP Address", on page 1137.

NOTICE

Risk of network failure

Consult your network administrator before performing the following tasks:

- Connecting the instrument to the network
- Configuring the network
- Changing IP addresses
- Exchanging hardware

Errors can affect the entire network.

► To establish a non-dedicated network connection, connect a commercial RJ-45 cable to one of the LAN ports.
To establish a dedicated connection, connect a (crossover) RJ-45 cable between the instrument and a single PC.

If the instrument is connected to the LAN, Windows automatically detects the network connection and activates the required drivers.

The network card can be operated with a 10/100/1000 Mbps Ethernet IEEE 802.3u interface.

19.2.2 Assigning the IP Address

Depending on the network capacities, the TCP/IP address information for the instrument can be obtained in different ways.

- If the network supports dynamic TCP/IP configuration using the Dynamic Host Configuration Protocol (DHCP), all address information can be assigned automatically.
- If the network does not support DHCP, or if the instrument is set to use alternate TCP/IP configuration, the addresses must be set manually.

By default, the instrument is configured to use dynamic TCP/IP configuration and obtain all address information automatically. This means that it is safe to establish a physical connection to the LAN without any previous instrument configuration.

NOTICE

Risk of network errors

Connection errors can affect the entire network. If your network does not support DHCP, or if you choose to disable dynamic TCP/IP configuration, you must assign valid address information before connecting the instrument to the LAN. Contact your network administrator to obtain a valid IP address.

Assigning the IP address on the instrument

1. Press the SETUP key and select the "System" tab.
2. Tap "Network".
3. Touch and hold (or right-click) "Local Area Connection" and select "Properties".
4. On the "Networking" tab, select "Internet Protocol Version 4 (TCP/IPv4)" and then select "Properties".
5. Select "Use the following IP address" and enter the address information as obtained from the network administrator.
6. If necessary, select "Use the following DNS server addresses" and enter your own DNS addresses.

19.2.3 Using Computer Names

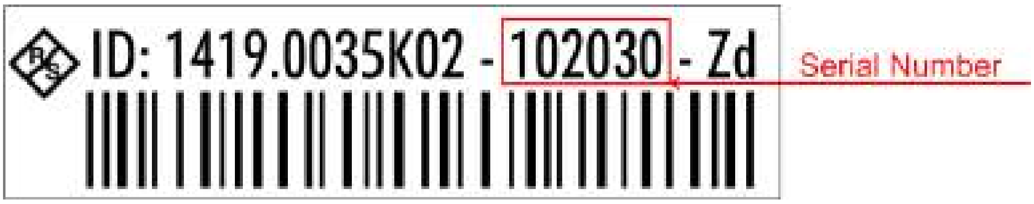
In a LAN that uses a DNS server (Domain Name System server), each PC or instrument connected in the LAN can be accessed via an unambiguous computer name instead of the IP address. The DNS server translates the host name to the IP address. This is especially useful when a DHCP server is used, as a new IP address may be assigned each time the instrument is restarted.

Each instrument is delivered with an assigned computer name, but this name can be changed.

The default instrument name is a non-case-sensitive string with the following syntax:

<Type><variant>-<serial_number>

The serial number can be found on the rear panel of the instrument. It is the third part of the device ID printed on the bar code sticker:



To change the computer name

1. Press the SETUP key and select the "System" tab or "LXI" tab.
   The current computer name is displayed and can be edited.
2. Alternatively, tap "System" on the "System" tab.
3. Select "Change", enter the new computer name and confirm the entry.

19.2.4 Changing the Windows Firewall Settings

A firewall protects an instrument by preventing unauthorized users from gaining access to it through a network. Rohde & Schwarz highly recommends the use of the firewall on your instrument. Rohde & Schwarz instruments are shipped with the Windows firewall enabled and preconfigured in such a way that all ports and connections for remote control are enabled.

For more details on firewall configuration, see the following Rohde & Schwarz White Paper:

- 1DC01: Malware Protection Windows 7

Note that changing firewall settings requires administrator rights.

19.3 Web Interface (LXI)

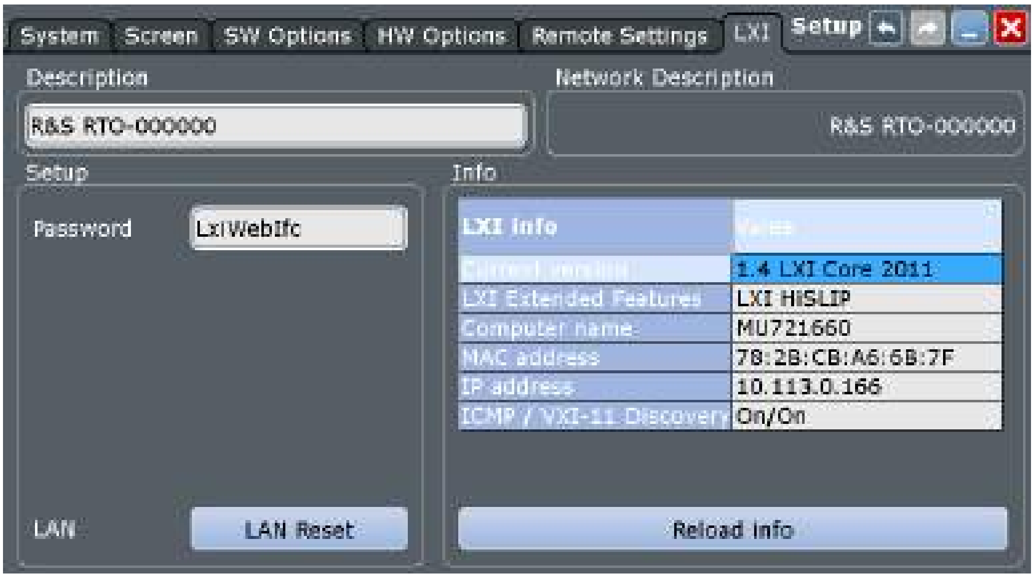
If the R&S RTO is connected to a computer via LAN, you can operate the instrument from a computer. No additional tools are required, you need only a web browser.

The R&S RTO supports the LXI core features. LAN extensions for instrumentation (LXI) is an instrumentation platform for measuring instruments and test systems that is based on standard Ethernet technology. LXI is intended to be the LAN-based successor to GPIB, combining the advantages of Ethernet with the simplicity and familiarity of GPIB. For information about the LXI standard, refer to the LXI website at http://www.lxistandard.org.

19.3.1 LXI Settings on the R&S RTO

The LXI status icon on the toolbar of the R&S RTO indicates the status of the LAN connection. A green icon indicates that the instrument is connected to the LAN; a red symbol indicates an error - mostly the LAN cable is not connected.

The "LXI" tab of the "Setup" dialog box provides network information required by LXI.



Description: R&S RTO-000000

Network Description: R&S RTO-000000

Password: LxiWebIfc

LAN

LXI info	Value
Current version	1.4 LXI Core 2011
LXI Extended Features	LXI HiSLIP
Computer name	MU721660
MAC address	78:2B:CB:A6:6B:7F
IP address	10.113.0.166
ICMP / VXI-11 Discovery	On/On

Description
Instrument description of the R&S RTO.

Password
Password for LAN configuration. The default password is *LxiWebIfc*.

LAN Reset
Resets the LAN configuration to its default settings using the network configuration reset mechanism (LCI) for the instrument. The following parameters are reset:

Parameter	Value
TCP/IP mode	DHCP + auto IP address
Dynamic DNS	Enabled
ICMP ping	Enabled
Password for LAN configuration	LxiWebIfc

The LAN settings are configured using the instrument's LXI web browser, see .

LXI Info

Displays the current LXI information from the R&S RTO.

"Current version"	Current LXI version
"LXI Extended Features"	List of extended LXI features that the instrument supports
"Computer name"	Name of the R&S RTO as defined in the operating system
"MAC address"	Media Access Control address (MAC address), a unique identifier for the network card in the R&S RTO
"IP address"	IP address of the R&S RTO as defined in the operating system.

Reload Info

Reloads LXI configuration

19.3.2 LXI Web Browser

The instrument's LXI web interface works with all W3C compliant browsers.

1. Open a web browser on the computer.
2. Type the instrument's host name or IP address in the address field of the browser on your PC, e.g. "http://10.113.10.203".

   The instrument home page opens.

Instrument Model	RTO2044
Manufacturer	Rohde & Schwarz GmbH & Co. KG
Serial Number	100032
Description	R&S RTO-100032
LXI Version	1.4 LXI Core 2011
LXI Extended Features	
DNS Host Name(s)	RTO-XXXXXX.local
MAC Address	00:E0:33:00:A2:E0
IP Address	10.113.0.255
Firmware Revision	3.40.11.22 Beta
Current Time	Tuesday, 2016/11/08, 11:27:43
Current Time source	Operating System
VISA resource string	TCPIP::10.113.0.255::inst0::INSTR
Device Indicator	INACTIVE (press to toggle)

Status

No error

The instrument home page displays the device information required by the LXI standard including the VISA resource string in read-only format.

► To update the "Host Name", press the "Device Indicator" button. The "Device Indicator" is not password-protected.

The most important items in the navigation menu of the browser interface are the following :

- "LAN Configuration" opens the menu with configuration pages.
- "Status" displays information about the LXI status of the instrument.
- "Utilities > Logging" shows log messages and provides buttons to download or clear the logfile.
- "Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.
- "Device Screenshot": creates a screenshot of the display.
- "Help" provides a glossary of terms related to the LXI standard, and a link to the Rohde & Schwarz Internet site.

19.3.2.1 LAN Configuration

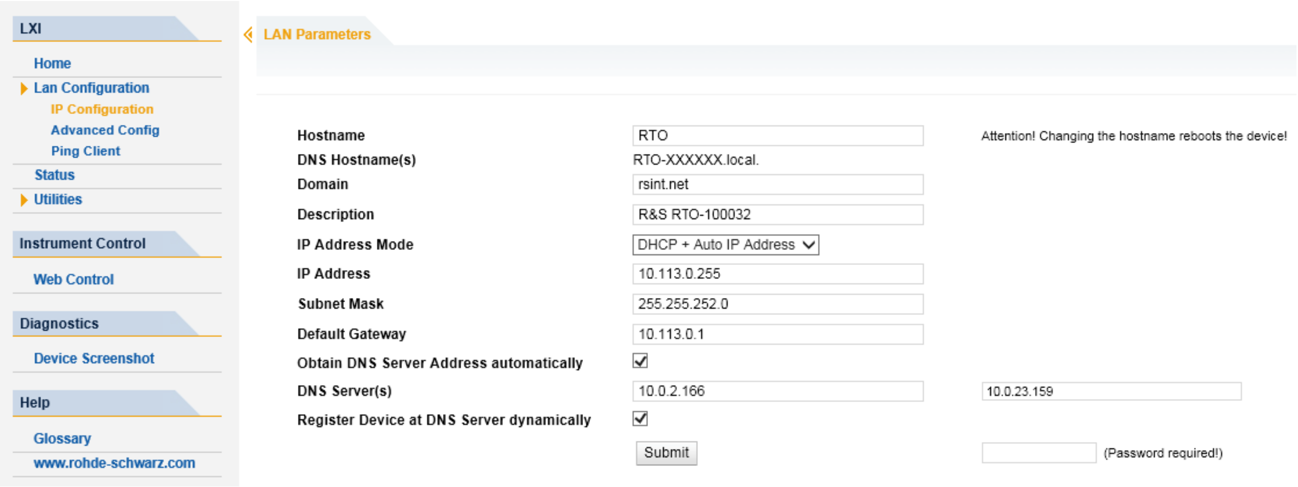
The LAN configuration consists of three parts:

- "IP configuration" provides all mandatory LAN parameters.
- "Advanced LAN Configuration" provides LAN settings that are not declared mandatory by the LXI standard.

- "Ping Client" provides the ping utility to verify the connection between the instrument and other devices.

IP Configuration

The "LAN Configuration > IP configuration" web page displays all mandatory LAN parameters and allows their modification.



Hostname	RTO	Attention! Changing the hostname reboots the device!
DNS Hostname(s)	RTO-XXXXXX.local.	
Domain	rsint.net	
Description	R&S RTO-100032	
IP Address Mode	DHCP + Auto IP Address	
IP Address	10.113.0.255	
Subnet Mask	255.255.252.0	
Default Gateway	10.113.0.1	
Obtain DNS Server Address automatically	☑	
DNS Server(s)	10.0.2.166	10.0.23.159
Register Device at DNS Server dynamically	☑	
	Submit	(Password required!)

The "TCP/IP Mode" configuration field controls how the IP address for the instrument gets assigned (see also Chapter 19.2.2, "Assigning the IP Address", on page 1137). For the manual configuration mode, the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses DHCP server or Dynamic Link Local Addressing (automatic IP) to obtain the instrument IP address.

Changing the LAN configuration is password-protected. The password is *LxiWebIfc* (notice upper and lower case characters). This password cannot be changed in the current firmware version.

Advanced Config

mDNS and DNS-SD	mDNS & DNS-SD	
ICMP Ping enabled	☑	
VXI-11 Discovery	☑	
	Submit	(Password required!)

The "LAN Configuration > Advanced Config" parameters are used as follows:

- mDNS and DNS-SD are two additional protocols: Multicast DNS and DNS Service Discovery. They are used for device communication in zero configuration networks working without DNS and DHCP
- "ICMP Ping" must be enabled to use the ping utility.

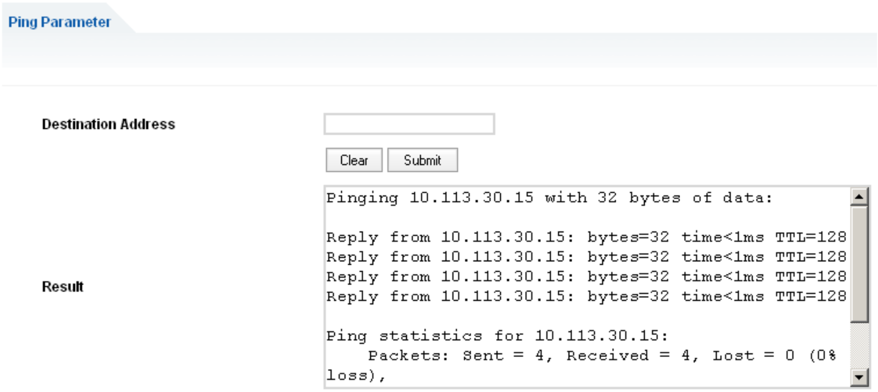
- "VXI-11" is the protocol that is used to detect the instrument in the LAN. According to the standard, LXI devices must use VXI-11 to provide a detection mechanism; other additional detection mechanisms are permitted.

Ping Client

Ping is a utility that verifies the connection between the LXI-compliant instrument and another device. The ping command uses the `ICMP` echo request and echo reply packets to determine whether the LAN connection is functional. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

To initiate a ping between the LXI-compliant instrument and a second connected device:

1. Enable "ICMP Ping" on the "Advanced Config" page (enabled by default).
2. On the "Ping Client" page, enter the IP address of the second device **without the ping command and without any further parameters** into the "Destination Address" field (e.g. *10.113.10.203*).
3. Click "Submit".



```
Pinging 10.113.30.15 with 32 bytes of data:

Reply from 10.113.30.15: bytes=32 time<1ms TTL=128
Reply from 10.113.30.15: bytes=32 time<1ms TTL=128
Reply from 10.113.30.15: bytes=32 time<1ms TTL=128
Reply from 10.113.30.15: bytes=32 time<1ms TTL=128

Ping statistics for 10.113.30.15:
    Packets: Sent = 4, Received = 4, Lost = 0 (0%
loss),
```

19.3.2.2 Web Control

"Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument. The Web control replaces VNC as control tool for remote operation.

Description: R&S RTO-100032

Password: LxiWebIfc

In the upper left corner of the emulated display, you see two arrows:

- The up/down arrow hides or shows the front panel.
- The left/right arrow hides or shows the menu.

19.3.2.3 Device Screenshot

If you click "Device Screenshot", a screenshot of the current instrument display is shown on the computer.

Add MetaData to Screenshot
Adds the instrument information to PNG and JPG files. Meta information is saved as EXIF information and can be read, for example, using the ExifTool, see "Meta information in screenshots" on page 468.

Update Screenshot
Updates the display.

Download
Saves the screenshot to the download directory of the computer. By default, JPG format is saved.

To save the screenshot in PNG format, select "Save as", select "All files" as type, and enter the filename with extension *.png*.

19.4 Remote Desktop Connection

Remote Desktop is a Windows application which can be used to access and control the instrument from a remote computer through a LAN connection. While the instrument is in operation, the instrument screen contents are displayed on the remote computer, and Remote Desktop provides access to all of the applications, files, and network resources of the instrument. Thus, remote operation of the instrument is possible.

NOTICE

Risk of unauthorized access

If you enable the Windows Remote Desktop application on the instrument, anyone using the network who knows the computer name and login data can access it. To prevent unauthorized access, make sure that the Remote Desktop application on the instrument is disabled: "Start" > "Settings" > "Control Panel" > "System"

To set up a Remote Desktop connection

1. Enable remote desktop control on the instrument.
2. Connect the instrument and the remote computer to a LAN, see Chapter 19.2.1, "Connecting the Instrument to the Network", on page 1136.
3. Set up the Remote Desktop connection between the remote computer and the instrument.

Remote Desktop Client

With Windows 7, Remote Desktop Client is part of the operating system and can be accessed via "Start > Programs > Accessories > [Communications >] Remote Desktop Connection.".

For other versions of Windows, Microsoft offers the Remote Desktop Client as an add-on.

Enabling remote desktop control on the instrument

1. Press the SETUP key and select the "System" tab.
2. Select "System" and switch to the "Remote" tab.
3. Under "Remote Desktop", activate the "Allow users to connect remotely to this computer" option.

Note: Remote Desktop access and firewall settings.
When you enable or disable the Windows Remote Desktop option (in the "System Properties"), the associated firewall settings are adapted automatically.

4. If necessary, click "Select Remote Users" and select users who are to be given access to the R&S RTO via Remote Desktop. The user account under which configuration is carried out is automatically enabled for Remote Desktop.

Setting up the Remote Desktop connection on the remote computer

1. On the remote computer, select "Start > Programs > Accessories > [Communications >] Remote Desktop Connection."
2. Enter the instrument's name or IP address in the dialog box
   See also Chapter 19.2.2, "Assigning the IP Address", on page 1137.
3. Enter the user ID and password for the instrument, see Chapter 19.1, "Operating System", on page 1133.
4. Click "Connect".

   When the connection has been set up, the instrument's screen appears on the remote computer.

For detailed information about Remote Desktop and the connection refer to the Windows Help.

Helpful settings for Remote Desktop

The following settings for the Remote Desktop connection can make working on the remote PC more convenient.

1. When setting up the connection to the instrument, you can configure the connection settings in the "Remote Desktop Connection" dialog box.
   Click the "Options >>" button.

   The dialog box is expanded to display the configuration data.
2. Customize the settings:
   - **On the "Experience" tab:**
     - Select the appropriate connection to optimize the connection speed.
     - To improve the performance, you can deactivate options you do not require under "Allow the following".
   - **On the "Local Resources" tab:**
     - If you need to access drives of the remote PC from the instrument (e.g. in order to store settings or to copy files from the PC to the instrument), activate the "Disk drives" option. Windows 7 will then map drives of the remote PC to the corresponding network drives. When a connection is established, a warning is displayed on the PC indicating that the drives are enabled for access from the instrument.

  - To use printers connected to the remote PC while accessing them from the instrument, activate the "Printers" options. Do not change the remaining settings.
- **On the "Display" tab:**
  - Under "Remote desktop size", set the size of the R&S RTO window on the desktop of the remote PC.
  - Activate the "Display the connection bar when in full screen mode" option. A bar showing the network address of the instrument is displayed on the screen which you can use to reduce, minimize or close the window.
- **On the "General" tab:**
  You can save the connection settings for later use using the "Save As" button.

Terminating Remote Desktop Control

A Remote Desktop connection can be terminated either on the R&S RTO or on the remote PC. The connection can be established again any time as long as remote control is enabled on the instrument. Consider the notice above concerning unauthorized access due to Remote Desktop!

► To terminate the connection on the remote PC, close the "Remote Desktop" window, or select "Start > Disconnect".

19.5 Remote Control Interfaces and Protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 19-1: Remote control interfaces and protocols

Interface	Protocols, VISA address string	Remarks

Local Area Network (LAN)	**Protocol HiSLIP**
	VISA address string:
	`TCPIP::<host address>::hislip0[,<port>][::INSTR]`
	Protocol VXI-11
	VISA address string:
	`TCPIP::<host address>[::inst0]::[INSTR]`
		The LAN connector is located on rear panel of the instrument.
		The interface is based on TCP/IP and supports various protocols.
		See also:
		• Chapter 19.5.2.2, "VXI-11 Protocol", on page 1149
		• Chapter 19.5.2.3, "HiSLIP Protocol", on page 1149
		• Chapter 19.5.1, "VISA Libraries", on page 1148

GPIB (IEC/IEEE Bus Interface)	VISA address string: GPIB::primary address[::INSTR] (no secondary address)	The optional GPIB bus interface according to standard IEC 625.1/IEEE 488.1 is located on the rear panel of the instrument. See also: Chapter 19.5.3, "GPIB Interface (IEC/IEEE Bus Interface)", on page 1150.

Within this interface description, the term GPIB is used as a synonym for the IEC/IEEE bus interface.

SCPI (Standard Commands for Programmable Instruments)

SCPI commands - messages - are used for remote control. Commands that are not taken from the SCPI standard follow the SCPI syntax rules. The instrument supports the SCPI version 1999. The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers. The tutorial "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00) offers detailed information on concepts and definitions of SCPI.

19.5.1 VISA Libraries

VISA is a standardized software interface library providing input and output functions to communicate with instruments. Instrument access via VXI11 protocol is usually achieved from high level programming platforms using VISA as an intermediate abstraction layer. VISA encapsulates the low level VXI or even GPIB function calls and thus makes the transport interface transparent for the user.

The I/O channel (LAN or TCP/IP, USB, GPIB,...) is selected at initialization time by means of the channel–specific address string ("VISA resource string") indicated in Table 19-1, or by an appropriately defined VISA alias (short name). A VISA installation is a prerequisite for remote control of R&S RTO.

For more information about VISA refer to the VISA user documentation.

19.5.2 LAN Interface

To be integrated in a LAN, the instrument is equipped with a LAN interface, consisting of a connector, a network interface card and protocols. For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ45 cable.The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library for specified protocols must be installed on the controller.

19.5.2.1 IP address

Only the address of the instrument is required to set up the connection. It is part of the "VISA resource string" used by programs to identify and control the instrument. The VISA resource string has the form:

`TCPIP::<host address>::hislip0[,<port>][::INSTR]` for HiSLIP protocol

`TCPIP::<host address>[::inst0][::INSTR]` for VXI-11 protocol

where:

- `host address` identifies the instrument in the network, usually the IP address. If the LAN is supported by a DNS server, the host name can be used instead of the IP address. The DNS server (Domain Name System server) translates the host name to the IP address.

- `hislip0` indicates the HiSLIP protocol
- `inst0` is the default LAN device name. VISA supports several devices running on the instrument. On R&S RTO, only one device is configured, so the LAN device name can be omitted.
- `INSTR` specifies a VISA resource of the type INSTR. By default, the VISA resource name control is set to the INSTR class.

Example: HiSLIP

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3::hislip0`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1::hislip0`.

DNS host name name is *RTO-123456*: the valid resource string is: `TCPIP::RTO-123456::hislip0`.

Example: VXI-11

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1`.

DNS host name name is *RTO-123456*: the valid resource string is: `TCPIP::RTO-123456`.

See also:

- Find IP address: SETUP > "System" tab, see "System" on page 101
- Chapter 19.2.2, "Assigning the IP Address", on page 1137

19.5.2.2 VXI-11 Protocol

The VXI-11 standard is based on the ONC RPC (Open Network Computing Remote Procedure Call) protocol which in turn relies on TCP/IP as the network/transport layer. The TCP/IP network protocol and the associated network services are preconfigured. TCP/IP ensures connection-oriented communication, where the order of the exchanged messages is adhered to and interrupted links are identified. With this protocol, messages cannot be lost.

19.5.2.3 HiSLIP Protocol

The HiSLIP (**Hi**gh **S**peed **L**AN **I**nstrument **P**rotocol) is the successor protocol for VXI-11 for TCP-based instruments specified by the IVI foundation. The protocol uses two TCP sockets for a single connection - one for fast data transfer, the other for non-sequential control commands (e.g. `Device Clear` or `SRQ`).

HiSLIP has the following characteristics:

- High performance as with raw socket network connections
- Compatible IEEE 488.2 support for Message Exchange Protocol, Device Clear, Serial Poll, Remote/Local, Trigger, and Service Request
- Uses a single IANA registered port (4880), which simplifies the configuration of firewalls

- Supports simultaneous access of multiple users by providing versatile locking mechanisms
- Usable for IPv6 or IPv4 networks

Using VXI-11, each operation is blocked until a VXI-11 device handshake returns. However, using HiSLIP, data is sent to the device using the "fire and forget" method with immediate return. Thus, a successful return of a VISA operation such as `viWrite()` does not guarantee that the instrument has finished or started the requested command, but is delivered to the TCP/IP buffers.

For more information see also the application note:

1MA208: Fast Remote Instrument Control with HiSLIP

19.5.3 GPIB Interface (IEC/IEEE Bus Interface)

To be able to control the instrument via the GPIB bus, the instrument and the controller must be linked by a GPIB bus cable. A GPIB bus card, the card drivers and the program libraries for the programming language used must be provided in the controller. The controller must address the instrument with the GPIB bus address.

Characteristics

- Up to 15 instruments can be connected
- The total cable length is restricted to a maximum of 15 m; the cable lenth between two instruments should not exceed 2m.
- A wired "OR"-connection is used if several instruments are connected in parallel.

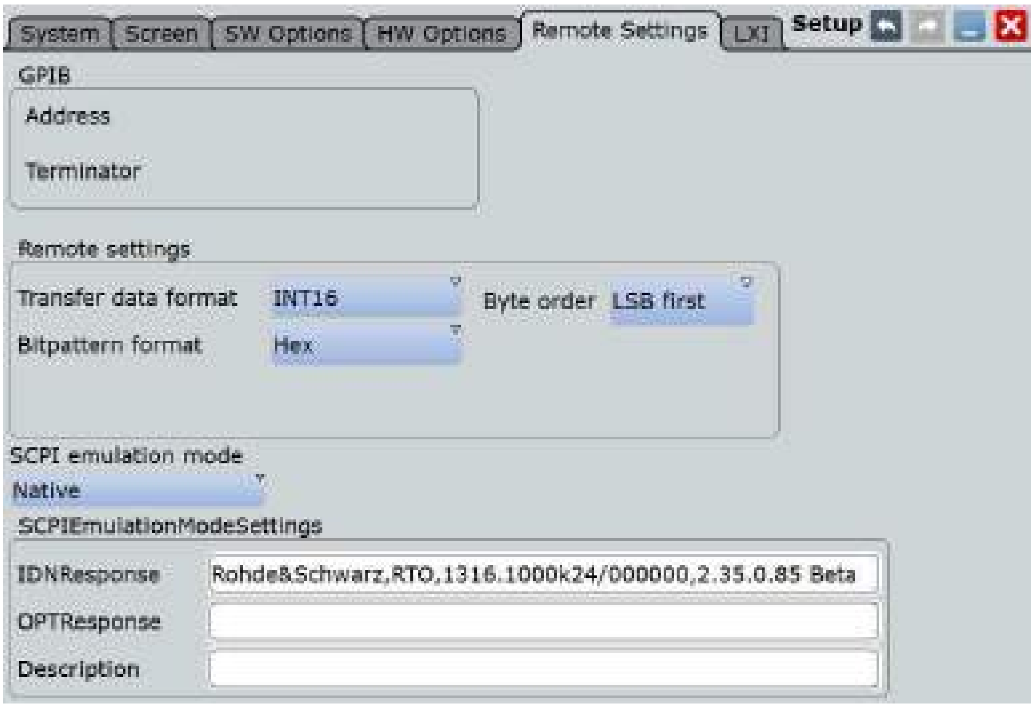
19.5.3.1 GPIB Instrument Address

In order to operate the instrument via remote control, it must be addressed using the GPIB address. The remote control address is factory-set to 20, but it can be changed in the network environment settings. For remote control, addresses 0 through 30 are allowed. The GPIB address is maintained after a reset of the instrument settings.

See also: "Address" on page 1151.

19.6 Remote Settings

The settings on this tab are required for remote control of the instrument via a connected computer.



GPIB

Address

Terminator

Remote settings

Transfer data format: INT16

Byte order: LSB first

Bitpattern format: Hex

SCPI emulation mode: Native

SCPIEmulationModeSettings

IDNResponse: Rohde&Schwarz,RTO,1316.1000k24/000000,2.35.0.85 Beta

OPTResponse

Description

Address

Indicates the GPIB address of the instrument if an optional GPIB bus card is installed.

The address can be edited here. Be aware that changing the address has major effects on the communication to the remote computer. See also: Chapter 19.5.3, "GPIB Interface (IEC/IEEE Bus Interface)", on page 1150.

Remote command:

`GPIB:ADDRess` on page 1183

Terminator

Specifies the symbol that is used as a terminator in GPIB communication.

Remote command:

`GPIB:TERMinator` on page 1184

Transfer data format

Selects the data format that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`
- `DIGital<m>:DATA[:VALues]?`

The content of the data stream can be defined with SAVE RECALL > "Save/Recall > Waveforms > Interleaved X/Y" (or `EXPort:WAVeform:INCXvalues`).

"Ascii"	Data values are returned in ASCII format as a list of comma separated values in floating point format.

"FLOAT"	Binary format. The data is stored as binary data (Definite Length Block Data according to IEEE 488.2).
"INT8"	Signed integer data with length 8 bit.
"INT16"	Signed integer data with length 16 bit. The Byte order can be set using . For details on the formats, refer to the description of the remote command.

Remote command:
`FORMat[:DATA]` on page 1181

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 1182

Bit pattern format
Sets the format for all bit pattern queries.

Remote command:
`FORMat:BPATtern` on page 1183

SCPI emulation mode
If option R&S RTO-K301 is installed, you can define the remote control behavior of the instrument.

"Tektronix DPO7000 / TDS540"	Emulated remote commands of these Tektronix oscilloscopes are used.
"Native"	By default, remote commands of R&S RTO are used.

Remote command:
`SYSTem:LANGuage` on page 1184

SCPI emulation mode settings
"IDN response" and "OPT response" define the responses to commands `IDN*?` and `OPT*?` which are expected by the remote control scripts. Instead of the actual RTO identification and options, these specified strings are returned. Use the "Description" field to add a comment to the response settings.

The settings are only relevant if the SCPI emulation mode is set to Tektronix emulation (requires option R&S RTO-K301).

19.7 Starting and Stopping Remote Control

19.7.1 Starting a Remote Control Session

When you switch on the instrument, it is always in manual operation state ("local" state) and can be operated via the front panel, the touch screen and external keyboard and/or mouse.

► To start remote control:
  - Send a command from the controller.
  - VXI-11 protocol (LAN or USB interface): Use `&GTR` interface message.

While remote control is active, the instrument settings are optimized for maximum measurement speed; the display is switched off. Operation via the front panel is disabled.

On the touch screen, two buttons appear in the upper left corner: "Local" and "View".

19.7.2 Using the display during remote control

You can observe the screen while a remote control script is executed. This is helpful for program test purposes but tends to slow down the measurement. Therefore it is recommended that you switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

► To switch on the display, do one of the following:
  - Tap the "View" button in the upper left corner of the touch screen.
  - Use the `SYSTem:DISPlay:UPDate ON` command.

► To switch off the display, do one of the following:
  - Tap the "View" button again.
  - Use the `SYSTem:DISPlay:UPDate OFF` command.

19.7.3 Returning to Manual Operation

The instrument switches back to manual operation when the remote connection is closed. Besides, you can return to manual operation manually or via remote control.

► To return to manual operation:
  - Tap the "Local" button in the upper left corner of the touch screen.
  - VXI-11 protocol: Use `&GTL` interface message.

20 Remote Control Commands

This chapter describes all remote commands available for R&S RTO and provides examples and information how to use the commands.

Further information on remote control:

- Chapter 19.5, "Remote Control Interfaces and Protocols", on page 1147
- Chapter 19.7, "Starting and Stopping Remote Control", on page 1153
- Chapter B, "Remote Control - Basics", on page 2218
- Chapter C, "Remote Control - Status Reporting System", on page 2232

20.1 Conventions used in Remote Command Description

Note the following conventions used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.

- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S RTO follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  This is the unit used for numeric values if no other unit is provided with the parameter.

20.2 Finding the Appropriate Command

In the following chapters, the commands are sorted according to the menu and dialog structure of the instrument.

A list of all commands in alphabetical order ist given in the "List of Commands" at the end of this documentation.

To find the appropriate command for a setting easily, you can use the context help:

1. Enable the "Tooltip" icon on the toolbar.

   ?

2. Tap the parameter for which you need information.

   The tooltip opens.

3. Tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command.

4. Tap the remote command link to open the command description.

20.3 Programming Examples

20.3.1 Display

20.3.1.1 Creating Zoom Diagrams

The example creates a zoom diagram, sets the relative size of the zoom area, and removes the zoom diagram.

Command description in: Chapter 20.10.1, "Zoom", on page 1296.

```
LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9, 20e-9, -0.1, 0.05, 'MyZoom1'
// Create an new zoom diagram for Diagram1
LAYout:ZOOM:HORZ:MODE? 'Diagram1', 'MyZoom1'
<--ABS
// Query the horizontal zoom mode - return value: ABS
```

```
LAYout:ZOOM:HORZ:MODE 'Diagram1', 'MyZoom1', REL
// Set horizontal zoom mode to relative
LAYout:ZOOM:HORZ:REL:SPAN 'Diagram1', 'MyZoom1', 10
// Set horizontal zoom span in percent
LAYout:ZOOM:HORZ:REL:POS 'Diagram1', 'MyZoom1', 15
// Set horizontal zoom position in percent
LAYout:ZOOM:REM 'Diagram1', 'MyZoom1'
// Remove zoom diagram
```

20.3.2 Automatic Measurements

20.3.2.1 Performing Amplitude/Time Measurements

Command description is given in Chapter 20.12.1, "General Settings", on page 1333 and Chapter 20.12.2, "Results", on page 1341

Simple Frequency and Amplitude Measurement

```
SING;*OPC?              //Asynchronous command
MEAS1:SOUR C1W1         // Configure frequency measurement
MEAS1:MAIN FREQ
MEAS1 ON
MEAS2:SOUR C1W1         // Configure amplitude measurement
MEAS2:MAIN AMPL
MEAS2 ON
*OPC?                  // Wait for operation complete - read result of *OPC?
MEAS1:RES:ACT?         // Get frequency result
MEAS2:RES:ACT?         // Get amplitude result
```

20.3.2.2 Setting Reference Levels

Command description in Chapter 20.12.13, "Reference Levels", on page 1387

Manual reference level definition using relative values

Reference levels are set to 15%, 50%, and 85% of the high signal level for waveform Ch2Wfm1 (= suffix 5).

```
REFLevel5:LDETection MANual
REFLevel5:LMODe REL
REFLevel5:RELative:MODE USER
REFLevel5:RELative:LOWer 15
REFLevel5:RELative:MIDDle 50
REFLevel5:RELative:UPPer 85
```

Manual reference level definition using absolute values

Set reference levels manually for waveform C1W1 (= suffix 2), defining high and low signal levels and the distances between signal and reference levels.

```
REFLevel2:LDETection MANual
REFLevel2:LMODe ABS
REFLevel2:ABSolute:HIGH 0.12
REFLevel2:ABSolute:TDIStance 0.03
REFLevel2:ABSolute:Low -0.12
REFLevel2:ABSolute:BDIStance 0.04
REFLevel2:ABSolute:MLEVel?
<-- 0
```

Set reference levels manually for waveform C1W1 (= suffix 2), defining upper and lower reference levels and the distances between signal and reference levels.

```
REFLevel2:LDETection MANual
REFLevel2:LMODe ABS
REFLevel2:USRLevel UREF
REFLevel2:ABSolute:LLEVel 0
REFLevel2:ABSolute:BDIStance 0.02
REFLevel2:ABSolute:ULEVel 0.2
REFLevel2:ABSolute:TDIStance 0.03
REFLevel2:ABSolute:MLEVel?
<-- 0.1
```

Automatic level detection, peak probability

Reference levels are set to the signal levels with the highest probability values for waveform C3W1 (= suffix 8).

```
REFLevel8:LDETection Auto
REFLevel8:AUTO:MODE PPRobability
```

20.3.2.3 Waveform Histograms

Creating and Reading Histograms

The example creates a histogram, activates two measurements (mean and standard deviation measurements of Histogram1), and queries the results of both measurements.

Command description in:

- Chapter 20.12.1, "General Settings", on page 1333
- Chapter 20.12.6.2, "Histogram Measurement", on page 1370
- Chapter 20.12.2, "Results", on page 1341

```
LAY:HIST:ADD 'Histogram1', C1W1, -2.5E-007, 2.5E-007, -1.32, 5.35, OFF, VERT

MEAS1 ON
```

```
MEAS1:HIST:SEL 'Histogram1'
MEAS1:CAT HIST
MEAS1:MAIN HME

MEAS2 ON
MEAS2:HIST:SEL 'Histogram1'
MEAS2:CAT HIST
MEAS2:MAIN HSTD

MEAS1:RES:ACT?

MEAS2:RES:ACT?
```

Exporting Histogram Data to File

The example writes the absolute data values of Histogram1 to `C:\Histograms\Hist1.xml` in XML format.

Command description in Chapter 20.16.5, "Waveform Histogram Export to File", on page 1484.

```
EXPort:HISTogram:SELect 'Histogram1'
EXPort:HISTogram:INCidence ABS
EXPort:HISTogram:NAME 'C:\Histograms\Hist1.xml'
EXPort:HISTogram:SAVE
```

Transferring Histogram Data

The example transfers the absolute values of Histogram1 to a controlling computer in ASCII format.

Command description in Chapter 20.16.5, "Waveform Histogram Export to File", on page 1484.

```
EXP:HIST:SEL 'Histogram1'
EXP:HIST:INC ABS
FRM ASC
EXP:HIST:DATA?
<--0,0,0,0,0,2037,5754804,4683496,3100169,2874565,...
```

20.3.2.4 Long Term Measurements

Exporting Long Term Measurement Data to File

The example writes the long term data of Meas1 to `C:\Measurements\Meas1.csv` in CSV format.

Command description in Chapter 20.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1485.

```
EXPort:MEASurement:SEL MEAS1
EXPort:MEASurement:TYPE LONGTERM
```

```
EXPort:MEASurement:NAME 'C:\Measurements\Meas1.csv'
EXPort:MEASurement:SAVE
```

Transferring Long Term Measurement Data

The example transfers the long term data of Meas1 to a controlling computer in ASCII format.

Command description in Chapter 20.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1485.

```
MEASurement:LTM ON
MEASurement:STAT ON
EXPort:MEASurement:SELect MEAS1
EXPort:MEASurement:TYPE LONGTERM
FORM ASC
EXPort:MEASurement:DATA?
<--50,0.24901185771,0.24731225296,0.24703557312,0.00069270717936,0,50,....
```

20.3.3 Mask Testing

20.3.3.1 Creating a user mask

Creates a new user mask "MyMask" with one inner segment, and turns the mask test on.

Command description in: Chapter 20.14, "Mask Testing", on page 1417.

```
MTEST:ADD 'MyMask'
MTEST:SEGM:ADD 'MyMask'
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 0, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 0, -0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 1, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 1, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 2, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 2, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 3, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 3, -0.1
MTEST:SEGM:REG 'MyMask', 0, INNER
MTEST:STAT 'MyMask', ON; *OPC?
```

20.3.4 Search

20.3.4.1 Searching for a pulse of specified width

Search for positive pulses with pulse width 12 ± 10 µs (2 µs to 22 µs).

Command description in: Chapter 20.15, "Search", on page 1432.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 2229.

```
SEAR:ADD 'MySearch'                  // Create a new search
SEAR:TRIG:WIDT:STAT 'MySearch',1     // Configure search type
SEAR:SOUR 'MySearch',M1              // Configure search source - here Math1
SEAR:TRIG:WIDT:RANG 'MySearch',WITH  // Configure search parameters
SEAR:TRIG:WIDT:WIDT 'MySearch',7e-6  // Configure search parameters
SEAR:TRIG:WIDT:DELT 'MySearch',1e-6  // Configure search parameters
SEAR:RES:LIM 'MySearch',1            // Set number of result lines in table to 1
SEAR:ALL 'MySearch'; *OPC?           // Initiate search for all events, asynchronous command
```

20.3.5 Data Management

20.3.5.1 Saving a Screenshot to File

Saves three display images in bmp format to the files `Print.bmp`, `Print_001.bmp`, and `Print_002.bmp` in the directory `C:\Temp`.

Command description in: Chapter 20.16.7, "Screenshots", on page 1487.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 2229.

```
HCOP:DEST 'MMEM'
HCOP:DEV:LANG BMP
MMEM:NAME 'C:\Temp\Print.bmp'
HCOP:IMMediate; *OPC?          \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
```

20.3.5.2 Exporting Waveform Data to File

Command description in:

- Chapter 20.16.4, "Waveform Data Export to File", on page 1478
- Chapter 20.16.1, "Instrument Settings", on page 1469

- Chapter 20.10.4, "History", on page 1317

Exporting a Single Waveform to XML File

Saves a single analog waveform completely to an XML file. Data logging is off.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 2229.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?               \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting Raw Data of a Single Waveform to BIN File

Saves the data of a single analog waveform in integer 8 bit format (raw data) to a BIN file. Data logging is off.

Data conversion is described in "Raw (ADC direct)" on page 460.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle; *OPC?             \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
```

```
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Raw Data of a Measurement Gate to BIN File

Saves the data of a measurement gate in integer 8 bit format (raw data) to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
MEASurement2:CATegory AMPT
MEASurement2:MAIN MEAN
MEASurement2:ENABle 1
MEASurement2:SOURce C1W1
MEASurement2:GATE:MODE ABS
MEASurement2:GATE:ABS:STARt -0.00012
MEASurement2:GATE:ABS:STOP -5e-06
MEASurement2:GATE:STATe On
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe GATE
EXPort:WAVeform:MEAS Meas2
RUNSingle;*OPC?                 \\Asynchronous command
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Interleaved x/y Data of a Single Waveform to CSV File

Saves the x- and y- values of a single analog waveform to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Interleaved x/y Data of a Zoom to CSV File

Saves the x- and y- values that is displayed in a zoom diagram to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
LAYout:ZOOM:ADD 'Diagram1',HORIZONTAL,OFF,-0.00012,-5e-06,0.308,-0.092,'ExportAreaZoom'
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe ZOOM
EXPort:WAVeform:ZOOM 'Diagram1', 'ExportAreaZoom'
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Multiple Running Acquisitions of a Single Waveform to XML File

Saves the data of 5 subsequent acquisitions of a single analog waveform to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
ACQuire:COUNt 5
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
RUNSingle;*OPC?                   \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting a Single Acquisition of the History to BIN File

Saves the oldest acquisition of the history to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW OFF
```

```
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
ACQuire:COUNt 5             \\Acquire 5 waveforms
RUNSingle;*OPC?             \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:CURRent -4;*OPC?  \\Oldest waveform of 5 has index -4
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Multiple Acquisition of the History to XML File

Saves the data of 5 subsequent acquisitions of the history to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
ACQuire:COUNt 5               \\Acquire 5 waveforms
RUNSingle;*OPC?               \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:STARt -4
CHANnel1:WAV1:HISTory:STOP 0
CHANnel1:WAV1:HISTory:REPLay OFF
CHANnel1:WAV1:HISTory:PLAY;*OPC? \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

20.3.5.3 Exporting Measurement Results to File

See:

- "Exporting Histogram Data to File" on page 1159
- "Transferring Histogram Data" on page 1159
- "Exporting Long Term Measurement Data to File" on page 1159
- "Transferring Long Term Measurement Data" on page 1160

20.3.6 Protocol Analysis

20.3.6.1 RFFE (Option R&S RTO-K40)

Configuring RFFE Bus

Example 1: 1.8 V bus

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 2229.

```
//Configure source and thresholds for 1.8 V bus
STOP;*OPC?
BUS1:TYPE RFFE
BUS1:LABel "RFFE Test 2"
BUS1:RFFE:CLOCk:SOUR C2W1
BUS1:RFFE:DATA:SOUR C1W1
BUS:RFFE:PRESet V18

//Load a label list and switch on
BUS1:NEWList 'C:\Protocols\RFFE.csv'
BUS1:SYMBols ON

//Initiate single sweep
CHANnel1:STATe ON
CHANnel2:STATe ON
BUS1 ON
RUNSingle;*OPC?              //asynchronous command
```

Example 2: User-defined thresholds with threshold coupling

```
//Configure source and user-defined thresholds
STOP;*OPC?
BUS1:TYPE RFFE
BUS1:LABel "RFFE Test 1"
BUS1:RFFE:CLOCk:SOUR C2W1
BUS1:RFFE:DATA:SOUR C1W1
BUS1:RFFE:COUPling ON
BUS1:RFFE:CLOCk:THReshold:HYSTeresis 0.2
BUS1:RFFE:CLOCk:THReshold:HIGH 0.72
BUS1:RFFE:CLOCk:THReshold:LOW  0.48
```

Triggering on RFFE Bus

Trigger on sequence start of sequences that have the slave address 0010, 0011, or 0100

```
//Set trigger source to serial bus
TRIGger1:SOURce SBUS
TRIGger:MODE NORMal
```

```
//Trigger on sequence start of all sequences with slave address range
TRIGger1:RFFE:TYPE STARt
TRIG1:RFFE:SADD:CONDition INR
TRIG1:RFFE:SADD:MIN #H2  //SAD = 0010
TRIG1:RFFE:SADD:MAX #H4  //SAD = 0100
```

Searching RFFE Data

Search for sequence ends of sequences if last bit of slave address is 1

```
STOP;*OPC?
SEARch:ADD 'RFFESearch1'
SEARch:SOURce 'RFFESearch1',SBUS1
SEARch:TRIGger:RFFE:TYPE 'RFFESearch1',STOP
SEARch:TRIGger:RFFE:SADD:COND 'RFFESearch1', EQU
SEARch:TRIGger:RFFE:SADD:MIN 'RFFESearch1', 'XXX1'
RUNSingle;*OPC?              //asynchronous command
SEARch:ALL 'RFFESearch1';*OPC?
SEARch:RESult:RFFE:FCOunt? 'RFFESearchCh1'

SEARch:RESult:RFFE:SEQuence1:STATe?  'RFFESearchCh1'
<--OK    //First sequence is valid
SEARch:RESult:RFFE:SEQuence1:TYPE?  'RFFESearchCh1'
<--ERRL  //Extended Register Read Long sequence
```

20.3.6.2 SENT (Option R&S RTO-K10)

Configuring SENT Bus

```
// Set protocol parameters
//*****************************************************
STOP;*OPC?
BUS:TYPE SENT
BUS:LABel "Bus 1 SENT"
BUS:SENT:DATA:SOURce C1W1
BUS:SENT:DATA:THReshold 2.0
BUS:SENT:CLKPeriod 0.000005
BUS:SENT:CLKTolerance 20.0
BUS:SENT:CRCVersion V2010
BUS:SENT:CRCMethod TLE
BUS:SENT:DNIBbles 5
BUS:SENT:PPULse NPP
BUS ON

//*****************************************************
// Load a label list and switch on
BUS:NEWList 'C:\Protocols\SENT_Labels.xml'
BUS:SYMBols ON
RUNSingle;*OPC?              //asynchronous command
```

```
//*****************************************************
// Display all results
BUS:SENT:RDSL ALL

//*****************************************************
// Display the fast channel transmission sequence
BUS:SENT:RDSL TRSQ

//*****************************************************
// Display the short serial message of slow channel
BUS:SENT:RDSL SMSG
```

Triggering on SENT Bus

```
//Set trigger source to serial bus
TRIGger1:SOURce SBUS
TRIGger:MODE NORMal

//Trigger on the fast channel transmission sequence
TRIGger1:SENT:TYPE TSEQ
TRIGger1:SENT:TTYPE STDA
TRIGger1:SENT:statbit #H2
TRIGger1:SENT:DCONdition INR
BUS1:SENT:DNibbles 5
TRIGger1:SENT:DMIN #H2 //Data MIN = 0010
TRIGger1:SENT:DMAX #H4 //Data MAX = 0100
```

Searching SENT Data

```
// Search for all frames with sync/calibration pulse
SEARch:TRIGger:SENT:CALibration 'Search1', ON
SEARch:ONLIne 'Search1',ON
SEARch:RESult:SORT:ASCending 'Search1', ON
SEARch:RESult:SENT:FCOunt? 'Search1'
SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:STARt? 'Search1'
SEARch:RESult:SENT:FRAMe1:STOP? 'Search1'
SEARch:RESult:SENT:FRAMe1:DATA? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:SCOM? 'Search1'
SEARch:TRIGger:SENT:CALibration 'Search1', OFF

//*****************************************************
// Search Short serial message
SEARch:TRIGger:SENT:SHORt 'Search1', ON
SEARch:RESult:SENT:FCOunt? 'Search1'
```

```
SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:IDValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'

SEARch:TRIGger:SENT:SHORt 'Search1', OFF

//*****************************************************
// Search Enhanced serial message
SEARch:TRIGger:SENT:ENHanced 'Search1', ON

SEARch:RESult:SENT:FCOunt? 'Search1'

SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:IDValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'

SEARch:TRIGger:SENT:ENHanced 'Search1', OFF
```

20.3.7 Power Analysis (Option R&S RTO-K31)

20.3.7.1 Auto Deskew

Configures the voltage and current probes for power measurements and executes the auto deskew.

Command description in Chapter 20.22.1, "General", on page 2156 and Chapter 20.22.2, "Deskew", on page 2157.

If the instrument refuses to accept `POWer` commands, activate the power mode using `:POWer:ENABle`.

```
*RST; *OPC?
STOP;*OPC?
//Activate two channels
:CHANnel1:STATe 1
:CHANnel2:STATe 1

//Activate power
:POWer:ENABle

//Select current and voltage sources
:POWer:SOURce:VOLTage1 CHANnel1
:POWer:SOURce:CURRent1 CHANnel2
```

```
//Configure voltage probe on CH1 manually
//Not necessary if you use an active R&S voltage probe that is recognized by the instrument
:PROBe1:SETup:ATTenuation:MODE Manual
:PROBe:SETup:ATTenuation:DEFProbe ZD01a100
//selected high voltage differential probe 1:100

//Configure current probe on CH2 manually
//Always required because R&S current probes are not recognized automatically
PROBe2:SETup:ATTenuation:MODE Manual
PROBe2:SETup:ATTenuation:DEFProbe ZC20
//select 20MHz current probe ZC10 also possible

//Start deskew
//Overwrites the skew offset of CH2 (current probe), because :POWer:DESKew:RESet? == 1
//writes a user-defined preset file (UserDefinedPreset_AutoDeskew.dfl) and
//activates the user defined preset, because :POWer:DESKew:UDPReset? == 1
:PoWer:DESKew:EXECute;*OPC?

//Check result
CHANnel2:SKEW:MAN?
CHANnel2:SKEW:TIMe?
POWer:DESKew:TIMe?
```

Effect of *RST and loading user-defined preset

Note that `*RST` resets the deskew values.

You can reload the deskew values as follows:

```
*RST;*OPC?
STOP;*OPC?
:POWer:ENABle
//Select voltage and current sources
:POWer:SOURce:VOLTage1 CHANnel1
:POWer:SOURce:CURRent1 CHANnel2
//Reload deskew values
:POWer:DESKew:CURRent
//Load default saveset after FW restart
MMEM:RCL 'C:\Users\Public\Documents\Rohde-Schwarz\RTx\SaveSets
\UserDefinedPreset_AutoDeskew.dfl'
```

20.3.7.2 Transient Response Measurement

Configures and executes a transient response measurement.

Command description in Chapter 20.22.15, "Transient Response", on page 2191.

Make sure to configure and deskew the probes before the measurement, see Chapter 20.3.7.1, "Auto Deskew", on page 1169.

```
//Activate power
*RST; *OPC?
:POWer:ENABle

//Expected smps frequency
:POW:TRANsient:FREQ         12500000

:POWer:TRANsient:AUToscale AUTO

:POWer:TRANsient:SIGHigh 0.1
:POWer:TRANsient:SIGLow    0.025
:POWer:TRANsient:HYSTeresis 20

//Trigger channel
:POWer:TRANsient:TRGC CHAN2

//Edge trigger slope
:POWer:TRANsient:TRGS POS

//Trigger level
:POWer:TRANsient:TRGL 0.08

//Run measurement
:POWer:TRANsient:EXECute;*OPC?

//Query results
:POWer:TRANsient:RESult? SETTling
:POWer:TRANsient:RESult? PEAKtime
:POWer:TRANsient:RESult? DELay
:POWer:TRANsient:RESult? RTIMe
:POWer:TRANsient:RESult? OVERshoot

//Add to report
:Power:TRANsient:REPort:Add
```

20.4 Frequently Used Parameters and Suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

20.4.1 Waveform Suffix

The numeric waveform suffix is used in some commands, for example, to indicate the source waveform number from which the reference level is taken, and to assign color tables to waveforms.

Depending on the command, not all suffix values are supported. For example, in REFLevel commands, only suffixes 2...21 are allowed. The range of supported suffix numbers is indicated in the description of the individual commands.

NOTICE

Suffix 1

Suffix 1 means that no waveform is assigned. The first waveform C1W1 corresponds to suffix number 2.

Waveform number	Description
1	None
2	C1W1 (channel 1, waveform 1)
3	C1W2 (channel 1, waveform 2)
4	C1W3 (channel 1, waveform 3)
5	C2W1 (channel 2, waveform 1)
6	C2W2 (channel 2, waveform 2)
7	C2W3 (channel 2, waveform 3)
8	C3W1 (channel 3, waveform 1)
9	C3W2 (channel 3, waveform 2)
10	C3W3 (channel 3, waveform 3)
11	C4W1 (channel 4, waveform 1)
12	C4W2 (channel 4, waveform 2)
13	C4W3 (channel 4, waveform 3)
14...17	Math waveforms: M1, M2, M3, M4
18...21	Reference waveforms: R1, R2, R3, R4
22...25	XY-waveforms: XY1, XY2, XY3, XY4
26...33	Measurement results: MRESult1, MRESult2, MRESult3, MRESult4, MRESult5, MRESult6, MRESult7, MRESult8
34...35	not used
36...39	Serial buses: SBUS1, SBUS2, SBUS3, SBUS4
40...55	Digital channels: D0...D15 (option R&S RTO-B1)
56...59	Digital buses: MSO1, MSO2, MSO3, MSO4 (option R&S RTO-B1)
60	not used
61...68	Track waveforms: TRK1, TRK2, TRK3, TRK4, TRK5, TRK6, TRK7, TRK8 Available for audio signals and jitter analysis (options R&S RTO-K5/K12)

Waveform number	Description
69...71	not used
72...75	Spectrograms: SG1, SG2, SG3, SG4 Available for spectrum analysis option R&S RTO-K18
76...83	Timeline spectrums: SG1TL1, SG1TL2, SG2TL1, SG2TL2, SG3TL1, SG3TL2, SG4TL1, SG4TL2 TL1 is timeline 1, TL2 is timeline 2 Available for spectrum analysis option R&S RTO-K18
84...87	not used
88...91	Voltage input channels of multi-channel probe R&S RT-ZVC (probe 1) R&S RT-ZVC04: Z1V1 | Z1V2 | Z1V3 | Z1V4 R&S RT-ZVC02: Z1V1 | Z1V2. Suffixes 90...91 are not available.
92...95	Current input channels of multi-channel probe R&S RT-ZVC (probe 1) R&S RT-ZVC04: Z1I1 | Z1I2 | Z1I3 | Z1I4 R&S RT-ZVC02: Z1I1 | Z1I2. Suffixes 94...95 are not available.
96...99	Voltage input channels of multi-channel probe R&S RT-ZVC (probe 2) R&S RT-ZVC04: Z2V1 | Z2V2 | Z2V3 | Z2V4 R&S RT-ZVC02: Z2V1 | Z2V2. Suffixes 98...99 are not available.
100...103	Current input channels of multi-channel probe R&S RT-ZVC (probe 2) R&S RT-ZVC04: Z2I1 | Z2I2 | Z2I3 | Z2I4 R&S RT-ZVC02: Z2I1 | Z2I2. Suffixes 102...103 are not available.

20.4.2 Waveform Parameter

Many commands requires one of the waveforms to be specified as source. The following table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified in the command description.

Waveform	Description
C1W1 | C1W2 | C1W3	Channel 1 waveforms
C2W1 | C2W2 | C2W3	Channel 2 waveforms
C3W1 | C3W2 | C3W3	Channel 3 waveforms
C4W1 | C4W2 | C4W3	Channel 4 waveforms
M1 | M2 | M3 | M4	Math waveforms
R1 | R2 | R3 | R4	Reference waveforms
XY1 | XY2 | XY3 | XY4	XY-waveforms
MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8	Measurement results
SBUS1 | SBUS2 | SBUS3 | SBUS4	Serial buses

Waveform	Description
D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15	Digital channels (option R&S RTO-B1)
MSOB1 | MSOB2 | MSOB3 | MSOB4	Digital buses (option R&S RTO-B1)
TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8	Track waveforms (option R&S RTO-K5 or K12)
CDRSW1 = CDRSw1, CDRSW2 = CDRSw2, CDRHW = CDRHw	Generated clock signals Track waveforms (option R&S RTO-K13)
SG1 | SG2 | SG3 | SG4	Spectrograms (option R&S RTO-K18)
Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Z1V1 | Z1V2 | Z1I1 | Z1I2 | Z2V1 | Z2V2 | Z2I1 | Z2I2	Input channels of multi-channel probe R&S RT-ZVC04 Input channels of multi-channel probe R&S RT-ZVC02

20.4.3 Slope Parameter

The slope parameter is used with several trigger and search condition commands.

Slope	Description
POSitive	Rising edge, that is a positive voltage change.
NEGative	Falling edge, that is a negative voltage change
EITHer	rising as well as the falling edge.

20.4.4 Polarity Parameter

The polarity parameter is used with several trigger and search condition commands.

Polarity	Description
POSitive	Positive going pulses.
NEGative	Negative going pulses.
EITHer	Both positive and negative going pulses.

20.4.5 Event Parameter

The event parameter is used with commands defining an action for mask testing, limit checks and margin checks.

Event	Description
NOACtion	The action is not initiated.
SUCCess	The action is initiated if the operation finished successfully: ● Limits or margins were not exceeded during the entire measurement ● Mask test passed
VIOLation	The action is initiated if the operation finished with error: ● Limits or margins were violated during the measurement ● Mask test failed

20.4.6 Bit Pattern Parameter

Bit pattern parameter are required with commands triggering on address, identifier, or data pattern.

To set the pattern value, you can use either a numeric parameter as defined in the SCPI standard, or a string parameter.

Bit pattern in numeric parameter

In a numeric parameter, the values are listed byte-by-byte, with bytes separated by commas and MSB first. The default numeral format is decimal, other formats can be indicated by a format identifier (#B = binary, #H = hexadecimal, #Q = octal). Currently, no format for signed values is available.

Example: Parameter with three bytes, decimal byte values are 10, 20, 30. The examples are given for CAN, the bit pattern in other commands is defined in the same way.

- `TRIGger:CAN:DMIN 10,20,30`
- `TRIGger:CAN:DMIN #B00001010,#B00010100,#B00011110`
- `TRIGger:CAN:DMIN #H0A,#H14,#H1E`
- `TRIGger:CAN:DMIN #Q012,#Q024,#Q036`

Bit pattern in string parameter

In a string, the complete binary pattern is written without separation of bytes, for example:

```
TRIGger:CAN:DMIN '000010100001010000011110'
```

Unlike a numeric parameter, the string parameter accepts wildcards for single bits (X = don't care). Whether wildcards can be used or not depends on the remote command. Usually, address and identifier parameter require unique patterns while data parameters may contain wildcards.

Mostly the length of the bit pattern is defined, for example, by the I²C address type, the CAN identifier type, or the data length code. In theses cases, it is recommended that you enter the complete bit pattern. If you enter a shorter pattern, the instrument fills up the pattern with X bits to the right of the defined pattern.

Example: You want to trigger on an 11 bit CAN address and enter the bit pattern '11100011' (8 bits only). The instrument uses the pattern '11100011XXX' for triggering.

Query for a pattern

The pattern format for the return value of a pattern is defined by the `FORMat:BPATtern` command.

20.5 Common Commands

Common commands are described in the IEEE 488.2 (IEC 625-2) standard. These commands have the same effect and are employed in the same way on different devices. The headers of these commands consist of "*" followed by three letters. Many common commands are related to the Status Reporting System.

Available common commands:

***CAL?**

Performs a self-alignment of the instrument and then generates a status response. Return values ≠ 0 indicate an error.

Return values:

<State>	0: no error 1: alignment failed 2: not aligned, e.g. init 3: device needs longer warmup time before selfalignment can start 4: input signal connected during selfalignment
Usage:	Query only

***CLS**

Clear status

Sets the status byte (STB), the standard event register (ESR) and the `EVENt` part of the `QUEStionable` and the `OPERation` registers to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

Usage:	Setting only

***ESE** <Value>

Event status enable

Sets the event status enable register to the specified value. The query returns the contents of the event status enable register in decimal form.

Parameters:

<Value>	Range:	0 to 255

***ESR?**

Event status read

Returns the contents of the event status register in decimal form and subsequently sets the register to zero.

Return values:

<Contents>	Range:	0 to 255
Usage:	Query only	

***IDN?**

Identification

Returns the instrument identification.

Return values:

<ID>	"Rohde&Schwarz,<device type>,<serial number>,<firmware version>"
Example:	`Rohde&Schwarz,RTO,1329.7002k24/200153,3.50.0.2`
Usage:	Query only

***IST?**

Individual status query

Returns the contents of the IST flag in decimal form. The IST flag is the status bit which is sent during a parallel poll.

Return values:

<ISTflag>	0 | 1
Usage:	Query only

***OPC**

Operation complete

Sets bit 0 in the event status register when all preceding commands have been executed. This bit can be used to initiate a service request. The query form writes a "1" into the output buffer as soon as all preceding commands have been executed. This is used for command synchronization.

***OPT?**

Option identification query

Queries the options included in the instrument. For a list of all available options and their description refer to the data sheet.

Return values:

<Options>	The query returns a list of options. The options are returned at fixed positions in a comma-separated string. A zero is returned for options that are not installed.
Usage:	Query only

***PCB** <Address>

Pass control back

Indicates the controller address to which remote control is returned after termination of the triggered action.

Setting parameters:

<Address>	Range: 0 to 30
Usage:	Setting only

***PRE** <Value>

Parallel poll register enable

Sets parallel poll enable register to the indicated value. The query returns the contents of the parallel poll enable register in decimal form.

Parameters:

<Value>	Range: 0 to 255

***PSC** <Action>

Power on status clear

Determines whether the contents of the `ENABle` registers are preserved or reset when the instrument is switched on. Thus a service request can be triggered when the instrument is switched on, if the status registers ESE and SRE are suitably configured. The query reads out the contents of the "power-on-status-clear" flag.

Parameters:

<Action>	0 | 1 **0** The contents of the status registers are preserved. **1** Resets the status registers.

***RCL** <Number>

Recall

Loads the instrument settings from an intermediate memory identified by the specified number. The instrument settings can be stored to this memory using the command `*SAV` with the associated number.

***RST**

Reset

Sets the instrument to a defined default status. The default settings are indicated in the description of commands.

Usage: Setting only

***SAV** <Number>

Save

Stores the current instrument settings under the specified number in an intermediate memory. The settings can be recalled using the command `*RCL` with the associated number.

***SRE** <Contents>

Service request enable

Sets the service request enable register to the indicated value. This command determines under which conditions a service request is triggered.

Parameters:

<Contents>	Contents of the service request enable register in decimal form. Bit 6 (MSS mask bit) is always 0. Range: 0 to 255

***STB?**

Status byte query

Reads the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers all actions waiting for a trigger event. In particular, *TRG generates a manual trigger signal. This common command complements the commands of the `TRIGger` subsystem.

Usage: Event

***TST?**

Self-test query

Initiates self-tests of the instrument and returns an error code

Return values:

<ErrorCode>	**integer > 0 (in decimal format)** An error occurred. (For details see the Service Manual supplied with the instrument). **0** No errors occurred.
Usage:	Query only

***WAI**

Wait to continue

Prevents servicing of the subsequent commands until all preceding commands have been executed and all signals have settled (see also command synchronization and `*OPC`).

Usage: Event

20.6 General Remote Settings

This chapter describes commands that have effect on many other remote commands in different applications of the instrument.

FORMat[:DATA] <Format>, [<Length>]

Selects the data type that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`
- `DIGital<m>:DATA[:VALues]?`

The content of the data stream can be defined with `EXPort:WAVeform:INCXvalues`
.

Parameters:

<Format>,[<Length>]	ASCii | REAL,32 | INT,8 | INT,16 **ASCii** Data values are returned in ASCII format as a list of comma separated values in floating point format. The length can be omitted. It is 0 which means that the instrument selects the number of digits to be returned. The query returns both values (`ASC,0`). **REAL,32** The data is stored as binary data (Definite Length Block Data according to IEEE 488.2). Each waveform value is formatted in 32 Bit IEEE 754 Floating Point Format. The schema of the result string is as follows: `#41024<value1><value2>…<value n>` with: `#4` = number of digits (= 4 in the example) of the following number `1024` = number of following data bytes (= 1024 in the example) `<value>` = 4-byte floating point values If the data exceeds 1 GB, the result string starts with header #0 (unknown length), followed by the data values. **INT,8 | INT,16** Signed integer data with length 8 bit or 16 bit. It defines that `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` returns the raw sample data of the ADC as integers. If format of the waveform data differs from the defined export format, the instrument converts the data to the required length. The result string has the same schema as the REAL format. Fot INT,16 you can set the byte order using the `FORMat:BORDer` command. Data conversion is described in "Raw (ADC direct)" on page 460. For digital channel data, math and histogram data, INT formats are not available. `EXPort:WAVeform:INCXvalues` must be set `OFF`. *RST: ASCii

Example:

```
FORMat:DATA REAL,32
FORMat:DATA?
REAL,32
```

Usage: SCPI confirmed

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:

<ByteOrder>	LSBFirst | MSBFirst LSB first: little endian, least significant byte first MSB first: big endian, most significant byte first *RST: LSBFirst

---

FORMat:BPATtern <BitPatternFormat>

Sets the number format for all remote bit pattern queries.

Parameters:

<BitPatternFormat>	DEC | HEX | OCT | BIN | ASCII | ASCii | STRG ASCII = ASCii *RST: HEX

Firmware/Software: V 1.25

SYSTem:DISPlay:UPDate <Enable>

Defines whether the display is updated while the instrument is in the remote state. If the display is switched off, the normal GUI is replaced by a static image while the instrument is in the remote state. Switching off the display can speed up the measurement. This is the recommended state.

See also: Chapter 19.7.2, "Using the display during remote control", on page 1153

Parameters:

<Enable>	**ON | 1:** Display is shown and updated during remote control **OFF | 0:** Display shows static image during remote control

Example: `SYSTem:DISPlay:UPDate 1`
Switch on the display update.

SYSTem:KLOCk <Enable>

Locks or unlocks the local controls of the instrument. This includes the front panel keys, the keyboard, or other local interfaces. except for the "View" button on the display.

Parameters:

<Enable>	**ON | 1:** Locks the local keys **OFF | 0:** Keys are unlocked

Usage: SCPI confirmed

GPIB:ADDRess <Address>

Sets the GPIB address of the instrument if an optional GPIB bus card is installed. Changing the address has major effects on the communication to the remote computer.

Parameters:

<Address>	Range:	0 to 30
	Increment:	1
	*RST:	20

GPIB:TERMinator <Terminator>

Specifies the symbol that is used as a terminator in GPIB communication.

Parameters:

<Terminator>	LFEoi | EOI	
	*RST:	EOI

SYSTem:DISPlay:MESSage:STATe <DispMessSt>

Enables and disables the display of an additonal text in remote control.

To define the text, use `SYSTem:DISPlay:MESSage[:TEXT]`.

Parameters:

<DispMessState>	ON | OFF	
	*RST:	OFF

Firmware/Software: Version 2.70

SYSTem:DISPlay:MESSage[:TEXT] <DisplayMessage>

Defines an additional text that is displayed during remote control operation.

To enable the text display, use `SYSTem:DISPlay:MESSage:STATe` on page 1184.

Parameters:

<DisplayMessage> String that contains the text.

Firmware/Software: Version 2.70

SYSTem:LANGuage <Language>

Defines the remote control behavior of the instrument and sets the remote control command set.

Parameters:

<Language>

String value. Available values:
'SCPI': R&S RTO remote command set is used.
"DPO7000" or 'TDS540': Compatible remote command set of Tektronix oscilloscopes DPO7000 or TDS540 is used. If one of these emulation modes is used, you can define alternative responses to the `IDN*?` and `OPT*?` commands on the SETUP > "Remote settings" tab.

Firmware/Software: V 1.35

Options:	R&S RTO-K301

20.7 Instrument Setup

This chapter describes commands related to Setup > "System" and "File" > "Exit". For commands related to Setup > "Remote Settings", see Chapter 20.6, "General Remote Settings", on page 1180.

20.7.1 System Setup

SYSTem:EXIT

Starts the shutdown of the firmware.

Usage:	Event

SYSTem:PRESet

Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After loading factory defaults, perform a self-aligment to synchronize the signal data.

Usage:	Event

SYSTem:RESet

Resets the instrument settings to defaults appropriate for remote control of the instrument. The last loaded user-defined preset is used. The command is equivalent to `*RST`.

Usage:	Event

SYSTem:DATE <Year>, <Month>, <Day>

Sets the date of the internal calendar.

Parameters:

<Year>	Year, to be entered as a four-digit number (including the century and millenium information)
<Month>	Month, 1 (January) to 12 (December)
<Day>	Day, 1 to the maximum number of days in the specified month *RST: does not affect the date settings

Example:	`SYSTem:DATE?` Returned value: `2011,09,13`
Usage:	SCPI confirmed

SYSTem:TIME? <Hour>, <Minute>, <Second>

Returns the UTC (Universal Time Coordinated) of the internal clock. To define the current local time, use the time zone setting of the operating system (Setup > "Time, date")

Example:	`SYSTem:TIME?` Returned value: `15,09,20`. UTC is 15:09:20.
Usage:	Query only SCPI confirmed

SYSTem:DEVice:ID?

Returns the instrument ID - that is the material number and the serial number

Return values:

<ID>	String containing the material number and the serial number
Example:	`1316.1000K24-001122-jT`
Usage:	Query only

DIAGnostic:SERVice:FWVersion?

Returns the firmware version that is currently installed on the instrument.

Return values:

<FirmwareVersion>	Version string
Usage:	Query only

DIAGnostic:SERVice:COMPutername <ComputerName>

The query returns the computer name that is currently defined. The computer name is required when configuring a network.

The setting command changes the computer name. The change takes effect after the next reboot of the computer.

Parameters:

<ComputerName>	Name string

DIAGnostic:SERVice:PARTnumber <MaterialNumber>

Returns the material number of your instrument. This number is required to order a new option, and in case of service.

Parameters:

<MaterialNumber>	Number string

DIAGnostic:SERVice:SERialnumber?

Returns the serial number of your instrument. This number is required to order a new option, and in case of service.

Return values:

<SerialNumber>	Number string

Usage: Query only

DIAGnostic:SERVice:CHANnelcount?

Queries the number of available channels.

Return values:

<ChannelCount>	Range:	0 to 4
	Increment:	1
	*RST:	0

Usage: Query only

Firmware/Software: V 2.00

SYSTem:VERSion?

Queries the SCPI version number to which the instrument complies. The instrument complies to the final SCPI version 1999.0.

Usage: Query only
SCPI confirmed

SYSTem:DFPRint [<Path>]

The device footprint contains the configuration of the instrument, installed modules, installed software and software licenses. This information is written in the device footprint xml file might be useful in case of maintenance or support request.

The query returns the information as block data. The setting command saves the device footprint xml file in the specified path.

It is also possible to access the device footprint xml file via the LXI web browser. Therefore, the directory containing the xml file must be enabled for sharing.

Setting parameters:

<Path>	String parameter, specifying the target path of the footprint file.

Return values:

<DeviceFootprint>	Content of the device footprint xml file as block data

---

SYSTem:ERRor:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error number and a short description of the error in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	List of: Error/event_number,"Error/event_description>[;Device-dependent info]" If the queue is empty, the response is 0,"No error"
Usage:	Query only SCPI confirmed

SYSTem:ERRor[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response consists of an error number and a short description of the error.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	Error/event_number,"Error/event_description>[;Device-dependent info]" If the queue is empty, the response is 0,"No error"
Usage:	Query only SCPI confirmed

SYSTem:ERRor:CODE:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error numbers in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	If the queue is empty, the response is 0
Usage:	Query only SCPI confirmed

SYSTem:ERRor:CODE[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response is the error number.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	If the queue is empty, the response is 0
Usage:	Query only SCPI confirmed

SYSTem:ERRor:COUNt?

Queries the number of entries in the error queue.

Return values:

<Count>	If the queue is empty, the response is 0
Usage:	Query only SCPI confirmed

20.7.2 Display Settings

20.7.2.1 Signal Colors / Persistence

DISPlay:PERSistence[:STATe] <State>

If enabled, each new data point in the diagram area remains on the screen for the duration defined using `DISPlay:PERSistence:TIME`, or as long as `DISPlay:PERSistence:INFinite` is enabled.

If disabled, the signal value is only displayed as long as it actually occurs.

Parameters:

<State>	ON | OFF *RST: ON

DISPlay:PERSistence:INFinite <State>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen infinitely until this command is set to "OFF".

Parameters:

<State>	ON | OFF	
	*RST:	OFF

DISPlay:PERSistence:TIME <Time>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen for the duration defined here.

Parameters:

<Time>	Range:	0.05 to 50
	Increment:	0.05
	*RST:	0.05
	Default unit:	s

DISPlay:PERSistence:RESet

Resets the display, removing persistent values.

Usage: Event

DISPlay:INTensity <Intensity>

This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (very strong).

The exact mapping of the cumulative value occurences according to the assigned color table is guaranteed only if the intensity is set to 50% (default). All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: Chapter 3.4.3.1, "Editing Waveform Colors", on page 122.

Parameters:

<Intensity>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

DISPlay:DIAGram:STYLe <Style>

Select the style in which the waveform is displayed.

Parameters:

<Style>	VECTors | DOTS **VECTors** The individual data points are connected by a line. **DOTS** Only the individual data points are displayed. *RST: VECTors

---

DISPlay:COLor:SIGNal<m>:COLor <Color>

Suffix:

<m>	1..103 Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<Color>	Decimal value of the ARGB color. Use the color dialog box on the instrument to get the hex value of the color, and convert the hex value to a decimal value. 0 is fully transparent black. 4278190080 (dec) = FF000000 (hex) is opaque black. 4294967295 (dec) = FFFFFFFF (hex) is opaque white. Range: 0 to 4294967295 Increment: 1 *RST: 0

DISPlay:COLor:SIGNal<m>:ASSign <ColorTable>

Assigns the color table to the specified signal.

Suffix:

<m>	1..103 Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<ColorTable>	Color table name to be assigned to the signal.

DISPlay:COLor:SIGNal<m>:USE <UseColorTable>

If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the default color table is used, i.e. the intensity of the specific signal color varies according to the cumulative occurance of the values.

Suffix:

<m>	1..103 Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<UseColorTable>	ON | OFF *RST: OFF

20.7.2.2 Color Tables

DISPlay:COLor:PALette:ADD <Name>

Adds a new color table with the specified name.

Setting parameters:

<Name>	color table
Usage:	Setting only

DISPlay:COLor:PALette:REMove <Name>

Removes the specified color table.

Setting parameters:

<Name>	color table
Usage:	Setting only

DISPlay:COLor:PALette:COUNt?

Queries the number of configured color maps.

Usage: Query only

DISPlay:COLor:PALette:POINt:ADD <PaletteName>

Appends a new row at the end of the color table.

Setting parameters:

<PaletteName>	color table
Usage:	Setting only

DISPlay:COLor:PALette:POINt:INSert <PaletteName>, <PointIndex>

Inserts the entry at the specified index in the color table.

Setting parameters:

<PaletteName>	color table
<PointIndex>	row number in the color table
Usage:	Setting only

DISPlay:COLor:PALette:POINt:REMove <PaletteName>, <PointIndex>

Removes the entry with the specified index from the color table.

Setting parameters:

<PaletteName>	color table
<PointIndex>	row number in the color table
Usage:	Setting only

DISPlay:COLor:PALette:POINt[:VALue] <ColorTableName>, <Index>,<Position>, <Color>
DISPlay:COLor:PALette:POINt[:VALue]? <ColorTableName>, <Index>

Inserts a new entry or queries the specified entry in the specified color table.

Parameters:

<Position>	Cumulative occurance value Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %
<Color>	ARGB value of the color to be used for the table entry. ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format. Range: 0 to 4294967295 Increment: 1 *RST: 0

Parameters for setting and query:

<ColorTableName>	Color table to be edited
<Index>	Index (row number) of the new entry in the color table

---

DISPlay:COLor:PALette:POINt:COUNt? <PaletteName>

Queries the number of entries in the color table.

Query parameters:

<PaletteName>	color table
Usage:	Query only

20.7.2.3 Diagram Layout

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using SAVE RECALL > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.

The settings for the signal bar are only relevant for R&S RTO1000 oscilloscopes.

DISPlay:DIAGram:GRID <Show>

If enabled, a grid is displayed in the diagram area.

Parameters:

<Show>	ON | OFF

DISPlay:DIAGram:CROSshair <Crosshair>

If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Parameters:

<Crosshair>	ON | OFF

DISPlay:DIAGram:FINegrid <ShowFineScale>

If ON, the crosshair is displayed as a ruler with scale markers. If OFF, the crosshair is shown as dashed lines.

Parameters:

<ShowFineScale>	ON | OFF

Firmware/Software: V 1.50

DISPlay:DIAGram:LABels <ShowLabels>

If enabled, labels mark values on the x- and y-axes in specified intervals in the diagram.

Parameters:

<ShowLabels>	ON | OFF

DISPlay:DIAGram:TITLe <DiagTitleSt>

If enabled, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If disabled, the tab titles are not shown except for those in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Parameters:

<DiagTitleSt>	ON | OFF

DISPlay:DIAGram:YFIXed <YGridFixed>

If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. This reflects the behavior of traditional oscilloscopes.

Parameters:

<YGridFixed>	ON | OFF

DISPlay:GATE:TRANsparency <Transparency>

Sets the transparency of the area that is defined as measurement or search gate.

Parameters:

<Transparency>	Range:	0 to 100
	Increment:	1
	*RST:	43
	Default unit:	%

Firmware/Software: FW 3.20

DISPlay:SIGBar[:STATe] <State>

If enabled, the signal bar is displayed in the diagram area.

Parameters:

<State>	ON | OFF

DISPlay:RESultboxes:DEFaultpos <State>

Defines where a new result box opens.

Parameters:

<State>	PREV | FLOA **PREV** Preview: The result box opens as a minimized result icon on the signal bar. It shows only two colums and a few rows of the results. **FLOA** Floating: The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.

LAYout:ADD <NodeName>, <ParentType>, <InsertBefore>, <FirstSource>, <DiagramName>

Adds a new diagram with a waveform on the screen, in relation to an existing diagram.

Setting parameters:

<NodeName>	String with the name of the existing diagram
<ParentType>	HORizontal | VERTical | TAB Position of the new diagram in relation to the existing one. **HORizontal** Besides the existing diagram **VERTical** Above or below the existing diagram **TAB** In a new tab in the existing diagram
<InsertBefore>	ON | OFF If on, the new diagram is inserted to the left (for HORizontal), above (for VERTical) or in a tab in front the existing diagram. HOR, ON = left to the existing diagram, defined in <NodeName> HOR, OFF = right to the existing diagram VERT, ON = above the existing diagram VERT, OFF = below the existing diagram

<FirstSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Waveform to be displayed in the new diagram, see Chapter 20.4.2, "Waveform Parameter", on page 1173. Spectrum analysis, option R&S RTO-K18: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.
<DiagramName>	String with the name of the new diagram.
Example:	`LAYout:ADD 'Diagram2',TAB,ON,C4W1,'MyDiagram3'` Creates a new diagram 'MyDiagram3' with waveform C4W1 in a new tab that is laid in front of 'Diagram2'.
Usage:	Setting only

LAYout:REMove <DiagramName>

Closes the specified diagram. The waveforms are displayed as minimized waveforms in their signal icons in the signal bar.

Setting parameters:

<DiagramName>	String with the name of the diagram
Usage:	Setting only

LAYout:SHOW <DiagramName>

Selects the specified diagram.

Setting parameters:

<DiagramName>	String with the name of the diagram
Usage:	Setting only

LAYout:SIGNal:ASSign <DiagramName>, <Source>

Shows the specified waveform in the selected diagram.

Setting parameters:

<DiagramName>	String with the diagram name

<Source>

C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform to be assigned, see Chapter 20.4.2, "Waveform Parameter", on page 1173
Spectrum analysis option R&S RTO-K18: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.

Usage: Setting only

LAYout:SIGNal:UNASsign <Source>

Removes the specified waveform from the diagram.

Setting parameters:

<Source>

C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

See Chapter 20.4.2, "Waveform Parameter", on page 1173

Usage: Setting only

DISPlay:SIGBar:POSition <Position>

The signal bar can be placed vertically at the right (default position) or at the left, or horizontally at the top, bottom or center of the diagram to ensure best visibility of the waveforms.

Parameters:

<Position> LEFT | RIGHt

DISPlay:SIGBar:HIDE[:AUTO] <AutoHide>

If enabled, the signal bar disappears automatically after some time, similar to the Windows task bar. With the commands `DISPlay:SIGBar:HIDE:TIME` and `DISPlay:SIGBar:HIDE:TRANsparency`, you can define when and how the signal bar hides.

The signal bar reappears if you tap it, or if an action changes the content of the bar.

Parameters:

<AutoHide>	ON | OFF

DISPlay:SIGBar:HIDE:TIME <AutoHideTime>

Sets the time when the signal bar is faded out if `DISPlay:SIGBar:HIDE[:AUTO]` is "ON".

Parameters:

<AutoHideTime>	Range: 0.03 to 86.4E+3 Increment: 0.5 Default unit: s

---

DISPlay:SIGBar:HIDE:HEAD <HideHeadAlso>

If enabled, the "Auto hide" function hides also the horizontal and trigger label at the top of the signal bar.

Parameters:

<HideHeadAlso>	ON | OFF

DISPlay:SIGBar:HIDE:TRANsparency <HidingTransp>

Sets the transparency of the signal bar when the signal bar is faded out with `DISPlay:SIGBar:HIDE[:AUTO]`.

Parameters:

<HidingTransp>	Range: 20 to 70 Increment: 5 Default unit: %

DISPlay:SIGBar:COLor:BORDer <BorderColor>

Defines the color of the signal bar border.

See also: "To change the colors" on page 125.

Parameters:

<BorderColor>	ARGB color value Range: 0 to 4294967295 Increment: 1

DISPlay:SIGBar:COLor:FILL <FillColor>

Define the fill color of the signal bar.

See also: "To change the colors" on page 125.

Parameters:

<FillColor>	ARGB color value Range: 0 to 4294967295 Increment: 1

20.7.2.4 Waveform Labels

To create a new waveform label, use `DISPlay:SIGNal:LABel:ADD`. Using the other `DISP:SIGN:LAB:...` commands, you can query the text and position of a label, and modify the initial settings. The <LabelID> and <Source> parameters identify each label uniquely. Note that it is not possible to query the <LabelID>, or to read it on the user interface.

DISPlay:SIGNal:LABel:ADD <LabelID>, <Source>, <LabelText>, <PositionMode>, <XPositon>, <YPositon>

Creates a new waveform label for the specified source waveform.

Setting parameters:

<LabelID>	String with the label identifier. The <LabelID> and <Source> parameters identify each label uniquely, so the label ID must be unique for the given waveform. Note the <LabelID> because it is not possible to query it, or to read it on the user interface.

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | QUICk | QUICK | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Waveform to that the label belongs, see Chapter 20.4.1, "Waveform Suffix", on page 1171.
<LabelText>	String with the label text that is shown on the display
<PositionMode>	ABS | REL **ABS** Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed. **REL** Fixed label position in percent of the screen counting from the upper left corner.
<XPositon>	Horizontal position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
<YPositon>	Vertical position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label1', C1W1, 'Label on C1W1', REL, 20, 20` Adds the label text 'Label on C1W1' to waveform1 of channel1 at relative position 20% from the upper left corner of the screen. The label ID is 'Label1'.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label1', C2W1, 'Label on C2W1', ABS, 10e-09, 0.1` Adds the label text 'Label on C2W1' to waveform1 of channel2 at absolute position 10 ns and 0.1 V. The label ID is 'Label1'.
Usage:	Setting only

DISPlay:SIGNal:LABel:REMove <LabelID>, <Source>

Deletes the specifies waveform label.

Setting parameters:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`
Example:	`DISPlay:SIGNal:LABel:REMove 'Label1', C1W1`
Usage:	Setting only

DISPlay:SIGNal:LABel:TEXT <LabelID>, <Source>, <LabelText>
DISPlay:SIGNal:LABel:TEXT? <LabelID>, <Source>

Modifies or queries the text of the specified label.

Parameters:

<LabelText>	String with the label text that is shown

Parameters for setting and query:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

DISPlay:SIGNal:LABel:POSMode <Source>, <PositionMode>
DISPlay:SIGNal:LABel:POSMode? <Source>

Modifies or queries the position mode: either relative to the diagram or with absolute values according to the units of the waveform. The position mode applies to all labels of the selected source. For different sources, different position modes can be selected.

Parameters:

<PositionMode>	ABS | REL **ABS** Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed. Use `DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition` and `DISPlay:SIGNal:LABel:HORizontal:RELative:POSition` to set the position. **REL** Fixed label position in percent of the screen counting from the upper left corner. Use `DISPlay:SIGNal:LABel:HORizontal:RELative:POSition` and `DISPlay:SIGNal:LABel:VERTical:RELative:POSition` to set the position.

Parameters for setting and query:

<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition? <LabelID>, <Source>

Modifies or queries the absolute horizontal and vertical positiions of the specified label if `DISPlay:SIGNal:LABel:POSMode` is set to `ABS`.

Parameters:

<Position>	Range: depends on waveform position and scaling Default unit: s and V, or in other units depending on the waveform character

Parameters for setting and query:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

Example:

```
DISPlay:SIGNal:LABel:HORizontal:ABSolute:
POSition 'Label1', C2W1, 5e-09
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition
'Label1', C2W1, -0.1
```

Move the label to 5 ns and -0.1 V.

DISPlay:SIGNal:LABel:HORizontal:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:RELative:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition? <LabelID>, <Source>

Modifies or queries the relative horizontal and vertical positiions of the specified label if `DISPlay:SIGNal:LABel:POSMode` is set to `REL`.

Parameters:

<Position>	Position in percent of the screen counting from the upper left corner. Range: 0 to 100 Default unit: %

Parameters for setting and query:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

Example:
```
DISPlay:SIGNal:LABel:HORizontal:RELative:
POSition 'Label1', C1W1, 30
DISPlay:SIGNal:LABel:VERTical:RELative:POSition
'Label1', C1W1, 70
```
Move the label to new relative position: horizontal at 30 % and vertical at 70 % of the screen.

20.8 Acquisition and Setup

20.8.1 Starting and Stopping Acquisition

RUNContinous
RUN

Starts the continuous acquisition.

Usage: Event
Asynchronous command

RUNSingle
SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACQuire:COUNt`.

Usage: Event
Asynchronous command

STOP

Stops the running acquistion.

Usage:	Event Asynchronous command

20.8.2 Time Base

TIMebase:SCALe <TimeScale>

Sets the horizontal scale - the time per division on the x-axis - for all channel and math waveforms.

The setting accuracy depends on the current resolution (sample rate).

- No interpolation:
  The resolution is an integer multiple of the ADC sample rate.
- With interpolation:
  Any value for the horizontal scale can be set.

Parameters:

<TimeScale>	Range:	25E-12 to 10000 (RTO) | 5000 (RTE)
	Increment:	1E-12
	*RST:	10E-9
	Default unit:	s/div

TIMebase:RANGe <AcquisitionTime>

Defines the time of one acquisition, that is the time across the 10 divisions of the diagram: *TimeScale*10*.

Parameters:

<AcquisitionTime>	Range: 250E-12 to 100E+3 (RTO) | 50E+3 (RTE) Increment: 1E-12 *RST: 0.5 Default unit: s

---

TIMebase:DIVisions?

Queries the number of horizontal divisions on the screen. The number cannot be changed.

Return values:

<HorizDivCnt>	Range: 4 to 20 Increment: 2 *RST: 10

Usage: Query only

TIMebase:HORizontal:POSition <RescaleCtrTime>

Defines the time distance between the reference point and the trigger point (the zero point of the diagram). The reference point marks the rescaling center of the time scale.

Parameters:

<RescaleCtrTime>	Range: -100E+24 to 100E+24 Increment: 1E-12 *RST: 0 Default unit: s

Firmware/Software: V 1.50

TIMebase:REFerence <RescaleCtrPos>

Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compresses to both sides of the reference point.

Parameters:

<RescaleCtrPos>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

TRIGger<m>:OFFSet:LIMited <State>

If ON, the horizontal position cannot be set outside the visible waveform diagram.

See also: `TIMebase:HORizontal:POSition` on page 1206

Suffix:

<m>	1..3 The numeric suffix is irrelevant.

Parameters:

<State>	ON | OFF *RST: OFF

AUToscale

Performs an autoset process: analyzes the enabled channel signals, and obtains appropriate horizontal, vertical, and trigger settings to display stable waveforms.

Usage:	Event Asynchronous command

ACQuire:POINts:AUTO <ReclgthManual>

Selection to keep constant either the resolution or the record length when you adjust the time scale (`TIMebase:SCALe`) or acquisition time (`TIMebase:RANGe`).

Parameters:

<ReclgthManual>	RESolution | RECLength **RESolution** Resolution is kept constant. Set the required resolution value with `ACQuire:RESolution`. **RECLength** The record length is kept constant. Set the required record length value with `ACQuire:POINts[:VALue]`. *RST: RESolution

---

ACQuire:POINts:AADJust <AutoAdjust>

Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the `ACQuire:POINts:AUTO` setting.

Parameters:

<AutoAdjust>	ON | OFF *RST: ON

ACQuire:POINts:MAXimum <ReclgthLim>

Sets a limit for the record length to prevent very large records. This value only takes effect if a constant resolution is selected with `ACQuire:POINts:AUTO`. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

Parameters:

<ReclgthLim>	Range:	1000 to 800 MSa. The actual maximum can be lower depending on the installed options, number of active channels, measurements and math waveforms.
	Increment:	2
	*RST:	10E+6
	Default unit:	Sa

ACQuire:POINts:ARATe?

Retrieves the sample rate of the ADC, that is the number of points that are sampled by the ADC in one second.

Return values:

<ADCSampleRate>	Range:	10E+9 and 20E+9
	*RST:	10E+9
	Default unit:	Sa/s

Usage: Query only

ACQuire:SRATe <SampleRate>

Defines the sample rate, that is the number of recorded waveform samples per second.

Parameters:

<SampleRate>	Range:	2 to 20E+12
	Increment:	1
	*RST:	10E+9
	Default unit:	Sa/s

ACQuire:SRReal <RealSampleRate>

Sets the number of captured waveform points per second. It considers the samples of the ADC, and the reduction of waveform points by decimation.

If interpolation is not active, the sample rate is the reciprocal value of the resolution and thus also depends on the acquisition time and the record length.

If interpolation is active, the sample rate is limited to the ADC sample rate.

Parameters:

<RealSampleRate>	Range: 2 to 20E+12 Increment: 1 *RST: 20E+3 Default unit: Sa/s
Firmware/Software:	FW 3.40

ACQuire:RESolution <Resolution>

Indicates the time between two waveform points in the record.

Parameters:

<Resolution>	A fine resolution with low values produces a more precise waveform record. Range: 1E-15 to 0.5 Increment: 10E-12 *RST: 100E-12 Default unit: s

---

ACQuire:POINts[:VALue] <RecordLength>

Indicates the record length, the number of recorded waveform points that build the waveform across the acquisition time. `[:VALue]` can be omitted.

Parameters:

<RecordLength>	Number of recorded waveform points. Range: 1000 to 1000000000 Increment: 2 *RST: 1000 Default unit: Sa

---

TIMebase:ROLL:ENABle <Mode>

Activates the automatic roll mode.

Parameters:

<Mode>	AUTO | OFF AUTO: the instrument activates the roll mode under specific conditions. See also "Roll mode" on page 150. *RST: AUTO

TIMebase:ROLL:STATe?

Returns the status of the roll mode.

Return values:

<State>	ON | OFF *RST: OFF
Usage:	Query only

TIMebase:ROLL:MTIMe <MinHorizGn>

The roll mode is enabled automatically if the acquisition time exceeds the given value, and if `TIMebase:ROLL:ENABle` is set to AUTO.

Parameters:

<MinHorizGn> Treshold value for roll mode enabling.

Range: 1 to 600
Increment: 1
*RST: 10
Default unit: s

20.8.3 Acquisition

ACQuire:MODE <EnhancementMode>

Selects the method of adding waveform points to the samples of the ADC in order to fill the record length.

See also: "Resolution enhancement" on page 155.

Parameters:

<EnhancementMode> **RTIMe**

Real Time Mode: The sampled points of the input signal are used to build the waveform, no waveform points are added.

ITIMe

Interpolated time: Interpolation of waveform points with the method set by the interpolation mode, see `ACQuire:INTerpolate` on page 1211.

*RST: ITIMe

ACQuire:INTerpolate <IntpolMd>

Selects the interpolation method.

See also: "Interpolation" on page 152.

Parameters:

<IntpolMd>	LINear | SINX | SMHD
	LINear Linear interpolation between two adjacent sample points
	SINX Interpolation by means of a sin(x)/x curve.
	SMHD Sample/Hold causes a histogram-like interpolation.
	*RST: SINX

CHANnel<m>[:WAVeform<n>][:STATe] <State>

Activates or deactivates a waveform. `[:STATe]` can be omitted.

Up to 3 waveforms per channel can be analyzed.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<State>	ON | OFF
	*RST: OFF

CHANnel<m>[:WAVeform<n>]:TYPE <DecimationMode>

Selects the method to reduce the data stream of the ADC to a stream of waveform points with lower sample rate.

Up to 3 waveforms per channel can be analyzed. You can select different decimation methods for the waveforms of one channel.

See also:"Mode" on page 153.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<DecimationMode>	SAMPle | PDETect | HRESolution | RMS **SAMPle** One of n samples in a sample interval of the ADC is recorded as waveform point. **PDETect** Peak Detect: the minimum and the maximum of n samples in a sample interval are recorded as waveform points. **HRESolution** High resolution: The average of n sample points is recorded as waveform point. **RMS** The waveform point is the root mean square of n sample values. *RST: SAMPle

---

ACQuire:CDTA <CoupleAcquSet>

Sets the acquisition mode and the waveform arithmetic of all channels to the last set value.

If the acquisition settings are coupled, `ACQuire:MUWaveform` is not relevant, only one waveform per channel can be used.

Parameters:

<CoupleAcquSet>	ON | OFF *RST: ON

Firmware/Software: FW 3.30
Substitutes `ACQuire:CMODode`

ACQuire:MUWaveform <MultiWaveform>

For each channel, up to three waveforms can be shown and analyzed. The decimation mode and the waveform arithmetic are specific for each waveform. So you can analyze several aspects of the signal: For example, waveform1 shows the peaks, and waveform2 shows the average of the signal.

Parameters:

<MultiWaveform>	ON | OFF *RST: OFF

Firmware/Software: FW 3.20

CHANnel<m>[:WAVeform<n>]:ARIThmetics <Arithmetics>

Selects the method to build the resulting waveform from several consecutive acquisitions of the signal. To define the number of acquisitions, use `ACQuire:COUNt`.

Up to 3 waveforms per channel can be analyzed. You can select different arithmetic methods for the waveforms of one channel.

See also: "Wfm Arithmetic" on page 154.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<Arithmetics> OFF | ENVelope | AVERage

OFF
The data of the current acquisition is recorded according to the decimation settings.

ENVelope
Detects the minimum and maximum values in an sample interval over a number of acquisitions. To define the reset method, use ...

AVERage
Calculates the average from the data of the current acquisition and a number of acquisitions before.

*RST: OFF

ACQuire:COUNt <MaxAcqCnt>

The acquisition and average count has a double effect:

- It sets the number of waveforms acquired with `RUNSingle`.
- It defines the number of waveforms used to calculate the average waveform.

Parameters:

<MaxAcqCnt>	Range:	1 to 16777215
	Increment:	10
	*RST:	1

ACQuire:ARESet:IMMediate

Forces the immediate restart of the envelope and average calculation for all waveforms.

Usage: Event

Firmware/Software: V 1.36

ACQuire:ARESet:MODE <ArtmRst>

Defines when the envelope and average evaluation restarts.

Parameters:

<ArtmRst>	NONE | TIME | WFMS **TIME** Restarts the envelope and average calculation after the time defined with ACQuire:ARESet:TIME. **WFMS** Restarts the envelope and average calculation after a number of acquired waveforms defined with ACQuire:ARESet:COUNt on page 1214. *RST: NONE

Firmware/Software: V 1.36

ACQuire:ARESet:TIME <EnvelopeTimeout>

Defines the time after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `TIME`.

Parameters:

<EnvelopeTimeout>	Range:	0.1 to 10000
	Increment:	0.01
	*RST:	0.1
	Default unit:	s

Firmware/Software: V 1.36

ACQuire:ARESet:COUNt <NofWaveforms>

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `WFMS`.

Parameters:

<NofWaveforms>	Range:	2 to 16777215
	Increment:	10
	*RST:	1000

Firmware/Software: V 2.70
Replaces the command `ACQuire:ARESet:WFMCount`

20.8.4 Ultra Segmentation

ACQuire:SEGMented:STATe <State>

Switches the Ultra Segmentation mode on and off.

See also: Chapter 4.2.3, "Ultra Segmentation", on page 156.

Parameters:

<State>	ON | OFF *RST: OFF

ACQuire:SEGMented:MAX <MaxAcquisitions>

The number of acquisitions in a Ultra Segmentation acquisition series depends on the record length.

Parameters:

<MaxAcquisitions>	ON | OFF **ON** The maximum possible number of acquisitions in a series is used. **OFF** Acquires the number of acquisitions defined using `ACQuire:COUNt`. *RST: OFF

ACQuire:SEGMented:AUToreplay <ReplayAfterAcq>

If enabled, the instrument starts processing and displaying the data as soon as the acquisition series is captured completely. Depending on the number of acquisitions, it may take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Parameters:

<ReplayAfterAcq>	ON | OFF *RST: ON

Firmware/Software: FW 1.40

20.8.5 Vertical

CHANnel<m>:STATe <State>

Switches the channel signal on or off.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<State>	ON | OFF *RST: OFF

CHANnel<m>:COUPling <Coupling>

Selects the connection of the indicated channel signal.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Coupling>	DC | DCLimit | AC **DC** Direct connection with 50 Ωtermination. **DCLimit** Direct connection with 1 MΩ termination. **AC** Connection through DC capacitor. *RST: DCLimit

---

CHANnel<m>:GND <State>

Connects the signal to the ground.

Suffix:

<m>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

CHANnel<m>:SCALe <Scale>

Sets the vertical scale for the indicated channel.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Scale> Scale value, given in Volts per division.

Range:	Depends on attenuation factors, coupling, and instrument model. With 1:1 probe and external attenuations and 50 Ω input coupling, the vertical scale (input sensitivity) is minimum 1 mV/div (RTO, RTE 1317.2500) or 0.5 mV/div (RTE 1326.2000) to maximum 1 V/div. For 1 MΩ input coupling, the upper limit is 10 V/div. If the probe and/or external attenuation is changed, multiply the values by the attenuation factors to get the actual scale range.
Increment:	Depends on vertical and probe settings
*RST:	0.05
Default unit:	V/div

CHANnel<m>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. Use the command alternativly instead of `CHANnel<m>:SCALe`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Range> Voltage range value

Range:	Depends on attenuation factors and coupling. With 1:1 probe and external attenuations and 50 Ω input coupling, the range is 10 mV to 10 V. For 1 MΩ input coupling, it is 10 mV to 100 V. If the probe and/or external attenuation is changed, multiply the range values by the attenuation factors.
Increment:	Depends on vertical and probe settings
*RST:	0.5
Default unit:	V/div

CHANnel<m>:POSition <Position>

Sets the vertical position of the indicated channel as a graphical value.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Position>	Positive values move the waveform up, negative values move it down. Range: -5 to 5 Increment: 0.01 *RST: 0 Default unit: div

---

CHANnel<m>:OFFSet <Offset>

The offset voltage is subtracted to correct an offset-affected signal. The offset of a signal is determined and set by the autoset procedure.

See also: "Offset" on page 160

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Offset>	Negative values move the waveform up, positive values move it down. Range: Depends on attenuation factors, input coupling, and the offset compensation range of active probes. The nominal offset range for 1:1 attenuation and probe offset compensation = 0 is specified in the data sheet. Increment: Depends on vertical and probe settings *RST: 0 Default unit: V

CHANnel<m>:INVert <InvertChannel>

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<InvertChannel>	ON | OFF *RST: OFF

Firmware/Software: FW 3.30

CHANnel<m>:BANDwidth <BandwidthLimit>

Selects the bandwidth limit for the indicated channel.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<BandwidthLimit> FULL | B800 | B200 | B20

FULL
Use full bandwidth.

B200 | B20
Limit to 200 MHz or 20 MHz.

B800
Limit to 800 MHz. Available for 50 Ω coupling on scopes with ≥ 1 GHz instrument bandwith.

*RST: FULL

CHANnel<m>:IMPedance <Impedance>

Sets the impedance of the channel for power calculations and measurements.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Impedance>
Range: 1 to 100E+3
Increment: 1
*RST: 50
Default unit: Ohm

CHANnel<m>:OVERload <Overload>

Retrieves the overload status of the specified channel from the status bit. When the overload problem is solved, the command resets the status bit.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Overload> ON | OFF

Use OFF to reset the overload status bit.

*RST: OFF

Example:

```
CHANnel2:OVERload?
```
Queries the overload status of channel 2.
```
CHANnel2:OVERload OFF
```
Resets the overload status bit.

20.8.6 Waveform Data

To set the export data format, see `FORMat[:DATA]` on page 1181.

CHANNel<m>[:WAVeform<n>]:DATA:HEADer?

Returns the header of channel waveform data.

Table 20-1: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of one waveform	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

If multichannel export is enabled, the number of returned samples is *Record length * Number of exported waveforms*. See also `EXPort:WAVeform:MULTichannel`.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Example:

```
CHAN1:WAV1:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only

CHANNel<m>[:WAVeform<n>]:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values (usually voltage values), or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

If multichannel export is active (`EXPort:WAVeform:MULTichannel`), the channel suffix is ignored. To select the channels to be exported, use `CHANNel<m>:EXPortstate`. The Y-values are written in interleaved order, for example, $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$... for a 2-channel instrument.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:

<Data>	List of values according to the format and content settings.

Example:

```
FORM ASC
EXP:WAV:INCX OFF
CHAN1:WAV1:DATA?
-0.125000,-0.123016,-0.123016,-0.123016,
-0.123016,-0.123016,...
```

Usage: Query only

20.8.7 Probes

`TRPRobe:...` command are dedicated commands for the external trigger input.

They are only available on R&S RTO2000 instruments.

20.8.7.1 Common Probe Settings

PROBe<m>:SETup:STATe?

Queries if the probe at the specified input channel is active (detected) or not active (not detected). To switch the probe on, use `CHANnel<m>:STATe`.

Suffix:

<m>	1..4

Return values:

<State>	DETected | NDETected	
	*RST:	NDETected

Usage:	Query only

PROBe<m>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Type> String containing one of the following values:
- None (no probe detected)
- Passive Probe
- active single-ended

Usage:	Query only

PROBe<m>:SETup:NAME?

Queries the name of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Name>	Name string

Usage:	Query only

PROBe<m>:SETup:BANDwidth?

Queries the bandwidth of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Bandwidth>	Range:	10000 to 20E+9
	*RST:	1E+9
	Default unit:	Hz

Usage:	Query only

PROBe<m>:SETup:ATTenuation[:AUTO]?

Queries the attenuation of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<AutoAttenuation>	Range: 1E-3 to 1000 *RST: 1 Default unit: V/V

Usage: Query only

PROBe<m>:SETup:OFFSet:AZERo

Performs an automatic correction of the zero error. If the DUT is ground-referenced, the AutoZero function can improve the measurement results.

See also: "Detect AutoZero, Use AutoZero" on page 168

Suffix:

<m>	1..4 Selects the input channel.

Usage: Event

PROBe<m>:SETup:OFFSet:USEautozero <AutoZeroOffset>

Includes the AutoZero offset in measurement results. The auto zero error is detected with `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AutoZeroOffset>	ON | OFF *RST: OFF

Firmware/Software: Version 2.70

CHANnel<m>:EATScale <ExtAttScl>

Sets the attenuation scale for an external divider.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExtAttScl>	LIN | LOG *RST: LIN

CHANnel<m>:EATTenuation <ExtAtt>

Sets the attenuation of an external voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExtAtt>	Values and unit depend on the selected scale (`CHANnel<m>:EATScale`).

Range:	Linear scale: 1E-3 to 1E+6, logarithmic scale: -60 dB to 120 dB
Increment:	0.01
*RST:	1

20.8.7.2 Micro Button and R&S ProbeMeter

PROBe<m>:SETup:MODE <Mode>

Select the action that is started when you press the micro button on the probe head.

See also: "Micro button action" on page 169.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Mode>	RCONtinuous | RSINgle | AUToset | AZERo | SEToffsettomean | PRINt | SITFile | NOACtion | FINDtriglevel | REPort | PRObemode | PRSetup **RCONtinuous** Run continuous: The acquisition is running as long as the probe button is pressed. **RSINgle** Run single: Starts a defined number of acquisitions (same as SINGLE key). **AUTOSET** Starts the autoset procedure. **AZero** AutoZero: performs an automatic correction of the zero error. **SEToffsettomean** Set offset to mean: performs an automatic compensation for a DC component of the input signal. **PRINt** Prints the current display according to the printer set with `SYSTem:COMMunicate:PRINter:SELect<1..2>`. **SITFile** Save Image To File: Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`. **NOACtion** Nothing is started on pressing the micro button. **FINDtriglevel** Sets the trigger level automatically to*0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source. **REPort** Creates and saves a report of the current results. **PROBemode** Only available for R&S RT-ZM probes. Changes the measurement mode of the probe. **PRSetup** Opens the "Probes Setup" dialog box. *RST: RCONtinuous

---

PROBe<m>:SETup:DISPlaydiff <DisplayDiff>

Selects the input voltages to be measured by the ProbeMeter of an R&S differential active probe.

See also: "Differential Active Probes" on page 146.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<DisplayDiff>	DIFFerential | SINGleended **DIFFerential** Measures differential and common mode voltages **SINGleended** Measures the voltage between the positive/negative signal socket and the ground. *RST: DIFFerential

---

PROBe<m>:PMETer:VISibility <Visibility>

Activates the integrated R&S ProbeMeter of active R&S probes.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Visibility>	ON | OFF *RST: OFF

Firmware/Software: FW 2.25

PROBe<m>:PMETer:RESults:SINGle?

Returns the ProbeMeter measurement result of single-ended active R&S probes, the voltage measured between the probe tip and the ground.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

PROBe<m>:PMETer:RESults:COMMon?

Returns the ProbeMeter measurement result of differential active R&S probes: the common mode voltage, which is the mean voltage between the signal sockets and the ground socket.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range:	-100E+24 to 100E+24
	Increment:	1E-3
	*RST:	0
	Default unit:	V

Usage: Query only

Firmware/Software: FW 2.25

PROBe<m>:PMETer:RESults:DIFFerential?

Returns the ProbeMeter measurement result of differential active R&S probes, the differential voltage - the voltage between the positive and negative signal sockets.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range:	-100E+24 to 100E+24
	Increment:	1E-3
	*RST:	0
	Default unit:	V

Usage: Query only

Firmware/Software: FW 2.25

PROBe<m>:PMETer:RESults:NEGative?

Returns the ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range:	-100E+24 to 100E+24
	Increment:	1E-3
	*RST:	0
	Default unit:	V

Usage: Query only

Firmware/Software: FW 2.25

PROBe<m>:PMETer:RESults:POSitive?

Returns the ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

20.8.7.3 Passive Probes

PROBe<m>:SETup:ATTenuation:MODE <AttenuationMode>

Set the mode to MANual if the instrument does not detect the probe.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AttenuationMode>	AUTO | MANual *RST: AUTO

PROBe<m>:SETup:ATTenuation:UNIT <AttenuationUnit>

Sets the unit for the connected probe type if `PROBe<m>:SETup:ATTenuation:MODE` on page 1228 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AttenuationUnit>	V | A | W Voltage probe (V), current probe (A), power probe (W) *RST: V

PROBe<m>:SETup:ATTenuation:MANual <ManualAttenuation>

Sets the attenuation for the connected probe if `PROBe<m>:SETup:ATTenuation:MODE` on page 1228 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ManualAttenuation>	Range:	100E-6 to 10000
	Increment:	0.1
	*RST:	1
	Default unit:	Depends on the selected unit

PROBe<m>:SETup:GAIN:MANual <GainManual>

Sets the gain of a current probe.

Suffix:

<m>	1..4 Selects the input channel. The number of channels depends on the instrument.

Parameters:

<GainManual>	Range:	100E-6 to 10000
	Increment:	100E-6
	*RST:	1
	Default unit:	V/A

20.8.7.4 Active Voltage Probes

PROBe<m>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset. The setting is only available for differential probes.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<CMOffset>	Range:	-100E+24 to 100E+24
	Increment:	1E-3
	*RST:	0
	Default unit:	V

PROBe<m>:SETup:ZAXV <ExtAttRTZA15>

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable it to include the external attenuation in the measurements.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExtAttRTZA15>	ON | OFF *RST: OFF

PROBe<m>:SETup:ACCoupling <ProbeCouplingAC>

Enables AC coupling in the R&S RT-ZPR20 probe, which removes DC and very low-frequency components. The R&S RT-ZPR20 probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ProbeCouplingAC>	ON | OFF *RST: OFF

20.8.7.5 Modular Probes

The commands of this chapter are relevant for R&S RT-ZM modular probes. The commands are available in firmware version 3.40 and higher.

The suffix <m> selects the input channel to which the probe is connected.

PROBe<m>:SETup:PRMode <MeasMode>

Sets the measurement mode of the modular probe.

Suffix:

<m>	1..4

Parameters:

<MeasMode>	DMODe | CMODe | PMODe | NMODe **DMODe** Differential mode input voltage (V_{dm}), the voltage between the positive and negative input terminal. **CMODe** Common mode input voltage (V_{cm}) , the mean voltage between the positive and negative input terminal vs. ground. **PMODe** Positive single-ended input voltage (V_p). the voltage between the positive input terminal and ground. **NMODe** Negative single-ended input voltage (V_N). the voltage between the negative input terminal and ground. *RST: DMODe

---

PROBe<m>:SETup:DMOFfset <DMOffset>

Sets the differential offset to compensate a DC voltage applied to the positive and the negative input terminal.

Suffix:

<m>	1..4

Parameters:

<DMOffset>	In "DM" probe mode (`DMODe`), this offset is used as channel offset and considered automatically for correction. Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

PROBe<m>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset. The setting is only available for differential probes.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<CMOffset>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

PROBe<m>:SETup:NOFFset <NOffset>

Sets the negative offset to compensate a DC voltage applied to the negative input terminal (Vp) referenced to ground.

Suffix:

<m>	1..4

Parameters:

<NOffset>
In "N" probe mode (`NMODe`), this offset is used as channel offset and considered automatically for correction.

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:POFFset <POffset>

Sets the positive offset to compensate a DC voltage applied to the positive input terminal (Vp) referenced to ground.

Suffix:

<m>	1..4

Parameters:

<POffset>
In "P" probe mode (`PMODe`), this offset is used as channel offset and considered automatically for correction.

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:TERM:STATe <VoltageState>

Activates the instrument control of the termination voltage.

Suffix:

<m>	1..4

Parameters:

<VoltageState>
ON | OFF

*RST: OFF

PROBe<m>:SETup:TERM:MODE <Mode>

Setting the termination voltage is relevant if you use the R&S RT-ZMA40 SMA module.

You can set a termination voltage to correct the internal 50 Ω termination of the SMA module by the common mode voltage. To control the termination voltage by the instrument, connect the VT terminal of the R&S RT-ZM probe amplifier to the VT terminal of the SMA module using the red DC lead (see R&S RT-ZM User Manual).

Suffix:

<m>	1..4

Parameters:

<Mode> AUTO | MANual

AUTO
The instrument uses the measured common mode voltage to control the termination.

MANual
Enter the voltage to be used for termination.

*RST: AUTO

PROBe<m>:SETup:TERM:MEASure?

Returns the measured common mode voltage.

Suffix:

<m>	1..4

Return values:

<VoltageMeas> Common mode voltage

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

PROBe<m>:SETup:TERM:ADJust <VoltageAdjust>

Sets the voltage to be used for termination correction.

Suffix:

<m>	1..4

Parameters:

<VoltageAdjust> Correction voltage

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

20.8.7.6 Predefined Probes

PROBe<m>:SETup:ATTenuation:DEFProbe <PredefinedProbe>

Selects a predefined probe. These are probes that are not recognized automatically but the parameters of the probe are known to the instrument.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<PredefinedProbe>	ZC10 | ZC20 | ZC30 | ZD01A100 | ZD01A1000 | ZZ80 | FREE | ZS10L | ZD02 | ZD08 | ZC02100 | ZC021000 | ZC03 **ZC10 | ZC20 | ZC30 | ZZ80 | ZS10L | ZD02 | ZD08 | ZC03** Type of the probe **ZD01A100 | ZD01A1000** High voltage differential probe R&S RT-ZD01, attenuation ratio 100:1 or 1000:1 according to the setting on the probe control box. **ZC02100 | ZC021000** Current probes 100 A or 1000 A according to the setting on the probe. **FREE** Any other probe that is not recognized by the instrument. *RST: FREE

Firmware/Software: V 1.27

PROBe<m>:SETup:OFFSet:TOMean

Performs an automatic compensation for a DC component of the specified input signal using the result of a background mean measurement.

Suffix:

<m>	1..4 Selects the input channel.

Usage: Event

20.8.7.7 Current Probes

To set up R&S RT-ZC10 and R&S RT-ZC20, use `PROBe<m>:SETup:ATTenuation:DEFProbe`.

PROBe<m>:SETup:DEGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement. The demagnetizing process takes about one second.

Suffix:

<m>	1..4 Selects the input channel.
Usage:	Event
Firmware/Software:	FW 2.50

PROBe<m>:SETup:OFFSet:STPRobe

Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again.

Suffix:

<m>	1..4 Selects the input channel.
Usage:	Event

PROBe<m>:SETup:OFFSet:ZADJust <ZeroAdjustValue>

set the waveform to zero position. It corrects the effect of a voltage offset or temperature drift. To set the value by the instrument, use `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ZeroAdjustValue>	Range:	-100 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Firmware/Software: FW 2.50

20.8.7.8 Probe Attributes

PROBe<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Softwareversion>	Version number in a string.
Usage:	Query only

PROBe<m>:ID:PRDate?

Queries the production date of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<ProductionDate>	Date in a string.
Usage:	Query only

PROBe<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<PartNumber>	Part number in a string.
Usage:	Query only

PROBe<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<SerialNo>	Serial number in a string.
Usage:	Query only

PROBe<m>:SETup:CAPacitance?

Queries the input capacitance of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<InputCapacity>	Range: 100E-15 to 1E-9 *RST: 10E-12 Default unit: F

Usage: Query only

PROBe<m>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<InputImpedance>	Range: 100E-15 to 1E+9 *RST: 50 Default unit: Ω

Usage: Query only

20.8.8 R&S RT-ZVC Probe

20.8.8.1 Probe Setup

In the `ZVC:Z<m>:` commands, the following suffixes are used:

- `<m>` selects the multi-channel probe. The available range is `1..2`
- `<n>` selects the voltage or current channel. The available range depends on the probe characteristics and is `1..2` /`1..4`

ZVC:BANDwidth <Bandwidth>

Sets the bandwidth limit of the probe. The bandwidth specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 89 % (0.1 dB) of its amplitude.

Parameters:

<Bandwidth>	Range: 5000 to 1E+6 Increment: 5000 *RST: 1E+6 Default unit: Hz

ZVC:TYPE <DecimationMode>

Sets the decimation mode for the R&S RT-ZVC probe. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution.

Parameters:

<DecimationMode>	SAMPle | PDETect | HRESolution *RST: SAMPle

ZVC:Z<m>:I<n>:BANDwidth?

Queries the bandwidth of the current channel. You can set the probe bandwidth with `ZVC:BANDwidth`.

The bandwidth of some current channels is restricted to 300KHz due to their vertical settings.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Bandwidth>	Range: 5000 to 1E+6 Increment: 5000 *RST: 1E+6 Default unit: Hz

Usage:	Query only

ZVC:Z<m>:I<n>:IMPedance <MeasImp>

Sets the current impedance of the probe channel for power calculations and measurements.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<MeasImp>	Range: 1 to 100E+3 Increment: 1 *RST: 50 Default unit: Ω

ZVC:Z<m>:I<n>:OFFSet <VerticalOffset>

Sets the offset current for the current channel.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VerticalOffset>	Range: -1 to 1 Increment: 0.01 *RST: 0 Default unit: V

ZVC:Z<m>:I<n>:OVERload:RSTO <Settings>

Resets the overload indication at the probe and chooses the operation range for the given current channel.

Suffix:

<m>	1..2
<n>	1..4

Setting parameters:

<Settings>	ADJusted | ORIGinal **ADJusted** In internal shunt mode (`ZVC:Z<m>:I<n>:SHUNt:MODE` is set to `INTShunt`) , an operation range with a higher maximum current is chosen, so that no overload happens. If the last operation range (± 10A) doesn't reach out, the mode is modified to external shunt. **ORIGinal** The original operation range is restored.
Usage:	Setting only

ZVC:Z<m>:I<n>:OVERload:VALue?

Queries if an overload of the current channel was detected.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Overload>	ON | OFF *RST: OFF
Usage:	Query only

ZVC:Z<m>:I<n>:POSition <VertPosi>

Sets the vertical position of the indicated current channel as a graphical value.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VertPosi>	Range: -5 to 5 Increment: 0.02 *RST: 0 Default unit: div

---

ZVC:Z<m>:I<n>:SCALe <VerticalScale>

Sets the vertical scale for the current channel in Volts per division. Increasing the scale compresses the display of the signal.

Suffix:

<m>	1..2
<n>	1..4

Parameters:
<VerticalScale> Range: 1E-15 to 10E+24
Increment: 10E-6
*RST: 3
Default unit: V/div

ZVC:Z<m>:I<n>:SHUNt:EVALue <ExtShuntVal>

Defines the value of the external shunt resistor to calculate the correct current values.

Suffix:
<m> 1..2

<n> 1..4

Parameters:
<ExtShuntVal> Range: 10E-6 to 10000
Increment: 0.02
*RST: 1
Default unit: Ω

ZVC:Z<m>:I<n>:SHUNt:MODE <ShuntMode>

Sets the internal or external shunt mode.

Suffix:
<m> 1..2

<n> 1..4

Parameters:
<ShuntMode> INTShunt | EXTShunt

*RST: INTShunt

ZVC:Z<m>:I<n>:SHUNt:MAXCurrent <IntShuntMeasRg>

Sets the maximum current and the internal shunt value.

The internal shunt and maximum current parameter pairs are defined as described in the table below.

Parameter	Internal shunt	Maximum current
`A100r01`	10 A	10 mΩ
`A40R01`	4.5 A	10 mΩ
`A45M10r`	45 mA	10 Ω
`A4M510r`	4.5 mA	10 Ω
`A45u10k`	45 µA	10 KΩ
`A4U510k`	4.5 µA	10 KΩ

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<IntShuntMeasRg> A100r01 | A40R01 | A45M10r | A4M510r | A45u10k | A4U510k

*RST: A100r01

ZVC:Z<m>:I<n>:SHUNt:MXCValue?

Queries the maximum current.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<MaxCurrentValue> Default unit: A

Usage: Query only

ZVC:Z<m>:I<n>:SHUNt:MAXVoltage <ExtShuntMeasRg>

Sets the maximum voltage for the external shunt.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<ExtShuntMeasRg> V450m | V045m

`V450m`: 450 mV
`V045m`: 45 mV

*RST: V450m

ZVC:Z<m>:I<n>:SKEW <DeskewOffset>

Sets the skew offset value for the current probe channel. This is a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<DeskewOffset>
Range: -6E-6 to 6E-6
Increment: 200E-9
*RST: 0
Default unit: s

ZVC:Z<m>:I<n>[:STATe] <State>

Enables the corresponding current channel of the probe.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

ZVC:Z<m>:V<n>:BANDwidth?

Queries the bandwidth of the voltage channel. You can set the probe bandwidth with `ZVC:BANDwidth`.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Bandwidth>	Range: 5000 to 1E+6 Increment: 5000 *RST: 1E+6 Default unit: Hz

Usage: Query only

ZVC:Z<m>:V<n>:IMPedance <MeasImp>

Sets the voltage impedance of the probe channel for power calculations and measurements.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<MeasImp>	Range: 1 to 100E+3 Increment: 1 *RST: 50 Default unit: Ω

ZVC:Z<m>:V<n>:OFFSet <VerticalOffset>

Sets the vertical offset for the voltage channel.

Suffix:

<m>	1..2

<n>	1..4

Parameters:

<VerticalOffset>	Range: -1 to 1 Increment: 0.01 *RST: 0 Default unit: V

ZVC:Z<m>:V<n>:OVERload:RSTO <Settings>

Resets the overload indication at the probe and chooses the operation range for the given voltage channel.

Suffix:

<m>	1..2
<n>	1..4

Setting parameters:

<Settings> ADJusted | ORIGinal

ADJusted
The next operation range with a higher maximum voltage is chosen.

ORIGinal
The original operation range is restored.

Usage: Setting only

ZVC:Z<m>:V<n>:OVERload:VALue?

Queries if an overload of the voltage channel was detected.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Overload>	ON | OFF *RST: OFF

Usage: Query only

ZVC:Z<m>:V<n>:POSition <VertPosi>

Sets the vertical position of the indicated voltage channel as a graphical value.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VertPosi>	Range: -5 to 5 Increment: 0.02 *RST: 0 Default unit: div

---

ZVC:Z<m>:V<n>:SCALe <VerticalScale>

Sets the vertical scale for the voltage channel in Volts per division. Increasing the scale compresses the display of the signal.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VerticalScale>	Range: 1E-15 to 10E+24 Increment: 10E-6 *RST: 3 Default unit: V/div

---

ZVC:Z<m>:V<n>:SKEW <DeskewOffset>

Sets the skew offset value for the voltage probe channel. This is a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<DeskewOffset>	Range: -6E-6 to 6E-6 Increment: 200E-9 *RST: 0 Default unit: s

---

ZVC:Z<m>:V<n>[:STATe] <State>

Enables the corresponding voltage channel of the probe.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

ZVC:Z<m>:ID:NAME?

Queries the name of the probe.

Suffix:

<m>	1..2

Return values:

<Name>

Usage: Query only

ZVC:Z<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m>	1..2

Return values:

<PartNumber>

Usage: Query only

ZVC:Z<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m>	1..2

Return values:

<SerialNo>

Usage: Query only

ZVC:Z<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<m>	1..2

Return values:

<Softwareversion>

Usage: Query only

20.8.9 Digital Filter

CHANnel<m>:DIGFilter:STATe <State>

Enables the DSP filter for input channels.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<State>	ON | OFF	
	*RST:	OFF

CHANnel<m>:DIGFilter:CUToff <CutOffLP>

Sets the limit frequency of the lowpass filter for input channels.

Suffix:

<m>	1..4 Selects the input channel. One filter is applied to a pair of channels - one filter for channels 1 and 2 and another filter for channels 3 and 4 (only 4-channel models).

Parameters:

<CutOffLP>	Range:	100E+3 to 2 GHz for R&S RTO2064, all others to 1 GHz
	Increment:	1000
	*RST:	1E+6
	Default unit:	Hz

TRIGger<m>:COUPling <DigTrigCpl>

Selects the filter for the trigger channel(s). Other channels must use the same filter, or proceed unfiltered.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<DigTrigCpl> OFF | RFReject

OFF
The trigger signal is not filtered.

RFReject
Frequencies higher a given limit are rejected, lower frequencies pass the filter. The limit is set with `TRIGger<m>:RFReject`.

*RST: OFF

TRIGger<m>:RFReject <Bandwidth>

Sets the limit frequency, if the trigger coupling is set to RFReject, see `TRIGger<m>:COUPling`. This limit is applied to the trigger channel and to the input channels enabled for filtering.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Bandwidth>	Range:	100E+3 to 4E+9
	Increment:	1000
	*RST:	1E+6
	Default unit:	Hz

20.8.10 Skew

CHANnel<m>:SKEW:MANual <ManualCompens>

If enabled, the skew offset value (`CHANnel<m>:SKEW:TIME`) is used for compensation. This improves horizontal and trigger accuracy.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ManualCompens>	ON | OFF	
	*RST:	ON

CHANnel<m>:SKEW:TIME <Offset>

Sets an delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Offset>	Range:	-100E-9 to 100E-9
	Increment:	1E-12
	*RST:	0
	Default unit:	s

20.8.11 AUX OUT

CALibration:SOURce:FREQuency <Frequency>

Frequency value and waveform type of the internal calibration source.

Parameters:

<Frequency>	GHZ1 **GHZ1** 1 GHz sine wave generated by the mainboard. *RST: GHZ1

Example:

```
CAL:SOUR:FREQ GHZ1
CAL:SOUR:STAT ON
```

The commands activate the 1 GHz reference frequency.

CALibration:SOURce:STATe <State>

Defines the state of the internal calibration source.

Parameters:

<State>	ON | OFF *RST: OFF

20.8.12 High Definition (Option R&S RTO-K17)

HDEFinition:STATe <State>

Activates the high definition mode of the instrument.

Parameters:

<State>	ON | OFF ON: high definition mode, up to 16 bit digital resolution OFF: normal oscilloscope mode *RST: OFF

HDEFinition:BWIDth <Bandwidth>

Sets the filter bandwidth for the high definition mode.

Parameters:

<Bandwidth>	Range:	10000 to max. 2 GHz, depending on the instrument bandwidth.
	Increment:	1000
	*RST:	1E+6
	Default unit:	Hz

See "Bandwidth" on page 163 for bandwidth limits.

HDEFinition:RESolution?

Returns the resulting digital resolution in high definition mode.

Return values:

<Resolution>	Range:	0 to 16
	Increment:	0.1
	*RST:	0

Usage: Query only

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:

<ByteOrder> LSBFirst | MSBFirst

LSB first: little endian, least significant byte first
MSB first: big endian, most significant byte first

*RST: LSBFirst

20.8.13 Reference Clock

Reference settings require OCXO option R&S RTO)-B4.

SENSe[:ROSCillator]:SOURce <RefOsciltrSrc>

Enables the use of the external reference signal instead of the internal OCXO reference.

Parameters:

<RefOsciltrSrc> INTernal | EXTernal

*RST: INTernal

SENSe[:ROSCillator]:EXTernal:FREQuency <ExternalRef>

Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel.

Parameters:

<ExternalRef>	Range:	RTO: 1E+6 to 20E+6. RTE: 10E+6
	Increment:	RTO: 1E+6. RTE: none
	*RST:	10E+6
	Default unit:	Hz

20.9 Trigger

20.9.1 Basic Trigger Settings

DISPlay:TRIGger:LINes <State>

Hides or shows the trigger levels in the diagrams.

Parameters:

<State>	ON | OFF *RST: OFF

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured. For all other trigger sources, only suffix 1 is allowed. See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed>	CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4 **CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4** Input channels **EXTernanalog** External analog signal connected to the External Trigger Input. For this source, only the analog edge trigger is available. **SBUS** Serial bus **D0...D15** Digital channels (option R&S RTO-B1) See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 2103 **LOGIc** Logic combination of digital channels, used as trigger source (option R&S RTO-B1) **MSOB1 | MSOB2 | MSOB3 | MSOB4** Parallel bus (option R&S RTO-B1) *RST: CHAN1

TRIGger<m>:TYPE <Type>

Selects the trigger type to trigger on analog channels or the external trigger input.

See also: Chapter 5.3, "Trigger Types", on page 206.

To trigger on digital channels and parallel buses, use `TRIGger<m>:PARallel:TYPE`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event For suffix 2, only the EDGE trigger type is available. For suffix 3, the following trigger types are availabe: GLITch, WIDTh, RUNT, WINDow, TIMeout, INTerval, SLEWrate.

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | DATatoclock | STATe | PATTern | ANEDge | SERPattern | NFC | TV | CDR

Most of the type values are self-explanatory.

DATatoclock
Data2Clock: analyzes the relative timimg between a data signal and the synchronous clock signal. For trigger settings, see Chapter 20.9.10, "Data2Clock Trigger", on page 1269.

ANEDge
Edge trigger for external trigger input. Only available if the trigger source is the EXT TRIGGER INPUT on the rear panel. This trigger type uses the analog input signal. For trigger settings, see Chapter 20.9.2, "Edge Trigger", on page 1255.
See also: "External trigger input" on page 203

SERPattern
Serial Pattern for signals with serial data patterns in relation to a clock signal. For trigger settings, see Chapter 20.9.13, "Serial Pattern Trigger", on page 1274

NFC
Specific trigger for Near Field Communication testing, requires option R&S RTO-K11. For NFC trigger settings, see Chapter 20.20.3, "NFC Trigger", on page 2139.

CDR
Trigger on the edges of a recovered clock signal, requires option R&S RTO-K13. The CDR also uses the trigger level as threshold to detect signal edges. For CDR trigger settings, see Chapter 20.21.4, "CDR Trigger", on page 2150.

*RST: EDGE

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event
<n>	1..27 Indicates the trigger source: 1...4 = channel 1 to 4 5 = external trigger input 6...11 = not available 12...27 = R&S RT-ZVC input channels (R&S RTO2000 only)

Parameters:

<Level> Voltage for the trigger level.

Range:	Depends on vertical scale, channel offset and other settings. The trigger level must be within the current display range.
Increment:	1E-3
*RST:	0
Default unit:	V

Example:

```
TRIG:LEV5 0.01
```

Sets the trigger level for the external trigger signal to 10 mV.

```
TRIG2:LEV3 0.2
```

Sets the trigger level for the B-event and B-trigger source channel 3 to 200 mV.

TRIGger<m>:FINDlevel

Sets the trigger level automatically. The command is only relevant if the trigger source is an analog channel CHAN1...4.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Usage: Event
Asynchronous command

TRIGger<m>:ROBust <Robust>

The "robust trigger" setting is relevant for all trigger types with an event condition that is based on the time difference between a rising and a falling edge. These trigger types are: glitch, width, runt, timeout, window, data2clock, pattern, and serial pattern. It avoids an undefined state of the trigger system that might occur due to hysteresis, for example, when triggering on the envelope of a modulated signal.

See also: "Robust trigger" on page 209

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:

<Robust>	ON | OFF *RST: OFF

20.9.2 Edge Trigger

TRIGger<m>:EDGE:SLOPe <Slope>

Defines the edge for the edge trigger event.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:

<Slope>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:ANEDge:COUPling <Coupling>

Sets the coupling for the external trigger signal.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Coupling>	DC | DCLimit | AC **DC** Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal. **DCLimit** Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal. **AC** Connection through DC capacitor, removes DC and very low-frequency components. *RST: DCLimit

---

TRIGger<m>:ANEDge:FILTer <Filter>

Sets a filter for the external trigger signal to reject high or low frequencies.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Filter> OFF | LFReject | RFReject

OFF
The trigger signal is not filtered.

LFReject
Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:LOWPass` command, the default is 50 kHz.

RFReject
Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:HIGHpass` command, the default is 50 kHz.

*RST: OFF

TRIGger<m>:ANEDge:CUToff:HIGHpass <AnalogCutOffHP>

Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AnalogCutOffHP> KHZ5 | KHZ50 | MHZ50

Cut-off frequency

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:CUToff:LOWPass <AnalogCutOffLP>

Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AnalogCutOffLP>	KHZ5 | KHZ50 | MHZ50 **KHZ5** 5 kHz **KHZ50** 50 kHz **MHZ50** 50 MHz *RST: KHZ50

TRIGger<m>:ANEDge:GND <Ground>

Connects the analog signal to the ground.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Ground>	ON | OFF *RST: OFF

TRIGger<m>:ANEDge:SLOPe <Slope>

Sets the edge for the trigger event.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Slope>	POSitive | NEGative See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

20.9.3 Glitch Trigger

The glitch trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:GLITch:POLarity <Polarity>

Defines the polarity of a pulse, that is the direction of the first pulse slope.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:GLITch:RANGe <RangeMode>

Selects which glitches are identified: shorter or longer than the width specified using `TRIGger<m>:GLITch:WIDTh`.

Suffix:

<m>	1 | 3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode>	SHORter | LONGer **SHORter** Glitches shorter than the specified width are identified. **LONGer** Glitches longer than the specified width are identified. *RST: SHORter

---

TRIGger<m>:GLITch:WIDTh <Width>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depnding on the `TRIGger<m>:GLITch:RANGe` command.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Suffix:

<m>	1 | 3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-6 *RST: 1E-9 Default unit: s

20.9.4 Width Trigger

The width trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:WIDTh:POLarity <Polarity>

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Polarity>	POSitive | NEGative See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:WIDTh:RANGe <RangeMode>

Defines how the range of a pulse width is defined in relation to the width and delta specified using `TRIGger<m>:WIDTh:WIDTh` and `TRIGger<m>:WIDTh:DELTa`, respectively.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers on pulses inside a given range. The range is defined by the width ±delta. **OUTSide** Triggers on pulses outside a given range. The range is defined by the width ±delta. **SHORter** Triggers on pulses shorter than the given width. **LONGer** Triggers on pulses longer than the given width. *RST: WITHin

---

TRIGger<m>:WIDTh:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WIDTh:RANGe`), the width defines the center of a range which is defined by the limits "±Delta" (see `TRIGger<m>:WIDTh:DELTa` on page 1260).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using `TRIGger<m>:WIDTh:WIDTh`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

20.9.5 Runt Trigger

The runt trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:RUNT:POLarity <Polarity>

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:LEVel<n>:RUNT:LOWer <Level>
TRIGger<m>:LEVel<n>:RUNT:UPPer <Level>

Set the lower and upper voltage thresholds.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger
<n>	1..27 Indicates the trigger source: 1...4 = channel 1...4 5...27 = not available

Parameters:

<Level>	Range:	-10 to 10
	Increment:	1E-3
	*RST:	Lower = -0.1, upper =0.1
	Default unit:	V

TRIGger<m>:RUNT:RANGe <Mode>

Defines the time limit of the runt pulse in relation to the `TRIGger<m>:RUNT:WIDTh` and `TRIGger<m>:RUNT:DELTa` settings.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given "Runt width".

SHORter
Triggers on runts shorter than the given "Runt width".

WITHin
Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

OUTSide
Triggers if the runt length is outside a given time range. The range is defined by "Runt width" and "±Delta".

*RST: ANY

TRIGger<m>:RUNT:WIDTh <Width>

Defines the upper or lower voltage threshold. This command is not available if `TRIGger<m>:RUNT:RANGe` is set to "ANY".

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:RUNT:DELTa <WidthDelta>

Defines a range around the runt width specified using `TRIGger<m>:RUNT:WIDTh`. This command is only available if `TRIGger<m>:RUNT:RANGe` is set to "WITHin" or "OUTSide".

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 100E-12 Default unit: s

20.9.6 Window Trigger

The window trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:LEVel<n>:WINDow:LOWer <Level>
TRIGger<m>:LEVel<n>:WINDow:UPPer <Level>

Set the lower and upper voltage limits for the window.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger
<n>	1..27 Indicates the trigger source: 1...4 = channel 1...4 5...27 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: Lower = -0.1, upper =0.1 Default unit: V

TRIGger<m>:WINDow:RANGe <RangeMode>

Defines the signal run in relation to the window:

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

*RST: ENTer

TRIGger<m>:WINDow:TIME <TimeRangeMode>

Defines the limit of the window in relation to the time specified using `TRIGger<m>:WINDow:WIDTh` and `TRIGger<m>:WINDow:DELTa`. Time conditioning is available for `TRIGger<m>:WINDow:RANGe`= "WITHin" and "OUTSide".

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeRangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most. **OUTSide** "Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*. **SHORter** Triggers if the signal crosses vertical limits before the specified "Width" time is reached. **LONGer** Triggers if the signal crosses vertical limits before the specified "Width" time is reached. *RST: WITHin

---

TRIGger<m>:WINDow:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WINDow:RANGe`), the width defines the center of a time range which is defined by the limits "±Delta" (see `TRIGger<m>:WINDow:DELTa` on page 1264).

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:WINDow:DELTa <WidthDelta>

Defines a range around the "Width" value specified using `TRIGger<m>:WINDow:WIDTh`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

20.9.7 Timeout Trigger

The timeout trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:TIMeout:RANGe <TimeoutMode>

Defines the relation of the signal level to the trigger level.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

TRIGger<m>:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-9 Default unit: s

20.9.8 Interval Trigger

The interval trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:INTerval:SLOPe <Slope>

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Slope>	POSitive | NEGative See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

Firmware/Software:	Version 2.70 The command replaces `TRIGger<m>:INTerval:POLarity`.

TRIGger<m>:INTerval:RANGe <RangeMode>

Defines the range of an interval in relation to the interval width specified using `TRIGger<m>:INTerval:WIDTh` and `TRIGger<m>:INTerval:DELTa`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers on pulses inside a given range. The range is defined by the interval width ±delta. **OUTSide** Triggers on pulses outside a given range. The range is defined by the interval width ±delta. **SHORter** Triggers on pulses shorter than the given interval width. **LONGer** Triggers on pulses longer than the given interval width. *RST: OUTSide

---

TRIGger<m>:INTerval:WIDTh <Width>

Defines the time between two pulses.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:INTerval:DELTa <WidthDelta>

Defines a range around the "Interval width" value specified using `TRIGger<m>:INTerval:WIDTh` on page 1266.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

20.9.9 Slew Rate Trigger

The slew rate trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:SLEW:SLOPe <Slope>

Selects the edge type for the trigger event.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Slope>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:LEVel<n>:SLEW:LOWer <Level>
TRIGger<m>:LEVel<n>:SLEW:UPPer <Level>

Set the lower and upper voltage thresholds. When the signal crosses a level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger
<n>	1..27 Indicates the trigger source: 1...4 = channel 1...4 5...27 = not available

Parameters:

<Level>

Range:	-10 to 10
Increment:	1E-3
*RST:	Lower = -0.1, upper =0.1
Default unit:	V

TRIGger<m>:SLEW:RANGe <RangeMode>

Defines the time limit for the slew rate in relation to the upper or lower trigger level (see `TRIGger<m>:SLEW:RATE` on page 1269 and `TRIGger<m>:SLEW:DELTa` on page 1269). The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTRange
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

LTHan
Triggers on pulses shorter than the given slew rate.

GTHan
Triggers on pulses longer than the given slew rate.

*RST: GTHan

TRIGger<m>:SLEW:RATE <Time>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope (see `TRIGger<m>:SLEW:SLOPe` on page 1267).

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-12 Default unit: s

---

TRIGger<m>:SLEW:DELTa <TimeDelta>

Defines a time range around the slew rate specified using `TRIGger<m>:SLEW:RATE`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

20.9.10 Data2Clock Trigger

The Data2Clock trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:DATatoclock:CSOurce[:VALue] <ClockSource>

Selects the source of the clock signal.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockSource>	CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4 Input channel of the clock signal *RST: CHAN1

TRIGger<m>:DATatoclock:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:DATatoclock:CSOurce:LEVel <ClockLevel>

Sets the voltage level for the clock signal. Both this command and `TRIGger<m>:DATatoclock:CSOurce:EDGE` define the starting point for calculation of the setup and hold time.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockLevel>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

TRIGger<m>:SCOupling <TrigLevSrcCpl>

Sets the trigger levels of all channels to the value of channel 1 for the indicated trigger event.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:

<TrigLevSrcCpl>	ON | OFF *RST: OFF

TRIGger<m>:DATatoclock:HTIMe <HoldTime>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<HoldTime>	Range:	-99.999E-9 to 100E-9
	Increment:	1E-9
	*RST:	0
	Default unit:	s

TRIGger<m>:DATatoclock:STIMe <SetupTime>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the instrument.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<SetupTime>	Range:	-99.999E-9 to 100E-9
	Increment:	1E-9
	*RST:	0
	Default unit:	s

20.9.11 State Trigger

The state trigger combines the edge trigger settings with trigger qualification. It is not available for the B-event (Suffix = 2).

Use the following commands:

- `TRIGger<m>:EDGE:SLOPe` on page 1255
- `TRIGger<m>:LEVel<n>[:VALue]` on page 1253
- `TRIGger<m>:SCOupling` on page 1270

- To define the state, use the `TRIG:QUAL...[ENABle]` and `TRIG:QUAL...LOGic` commands, which are described in Chapter 20.9.15, "Trigger Qualification", on page 1280.

20.9.12 Pattern Trigger

The pattern trigger is only available for the A-event (Suffix = 1).

The pattern is defined using the commands:

- `TRIGger<m>:QUALify<n>:A[:ENABle]` on page 1282
- `TRIGger<m>:QUALify<n>:A:LOGic` on page 1282
- `TRIGger<m>:QUALify<n>:AB:LOGic` on page 1283

These are the commands for channel 1, use the similar commands for channels 2, 3, and 4.

TRIGger<m>:PATTern:MODE <Mode>

Adds additional time limitation to the pattern definition.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No time limitation. The event occurs if the pattern condition is fulfilled.

TIMeout
Defines how long the result of the pattern condition must be true or false. The duration of the timeout is defined using `TRIGger<m>:PATTern:TIMeout[:TIME]`.

WIDTh
Defines a time range for keeping up the true result of the pattern condition. The range is defined using `TRIGger<m>:PATTern:WIDTh:RANGe`.

*RST: OFF

TRIGger<m>:PATTern:TIMeout:MODE <TimeoutMode>

Defines the condition for the timeout.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<TimeoutMode> HIGH | LOW

HIGH
The result stays high.

LOW
The result stays low.

*RST: HIGH

TRIGger<m>:PATTern:TIMeout[:TIME] <Time>

Defines how long the result of the pattern condition must be true or false.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Time>

Range:	100E-12 to 10000
Increment:	100E-9
*RST:	100E-9
Default unit:	s

TRIGger<m>:PATTern:WIDTh:RANGe <WidthRangeMode>

Defines how the range of a pulse width is defined for keeping up the true result of the pattern condition. The width and delta are specified using `TRIGger<m>:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PATTern:WIDTh:DELTa`, respectively.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the width ±delta.

SHORter
Triggers on pulses shorter than the given width.

LONGer
Triggers on pulses longer than the given width.

*RST: WITHin

TRIGger<m>:PATTern:WIDTh[:WIDTh] <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:PATTern:WIDTh:RANGe`), the width defines the center of a range which is defined by the limits "±Delta" (see `TRIGger<m>:PATTern:WIDTh:DELTa` on page 1274).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using `TRIGger<m>:PATTern:WIDTh[:WIDTh]`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

20.9.13 Serial Pattern Trigger

The serial pattern trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:SPATtern:CSOurce[:VALue] <ClockSource>

Defines the source of the clock signal.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockSource>	CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4 Input channel of the clock signal *RST: CHAN1

TRIGger<m>:SPATtern:CSOurce:EDGE <ClockEdge>

Together with the clock level (see `TRIGger<m>:SPATtern:CSOurce:LEVel` on page 1275), the clock edge defines the point in time when the state of the data signal is checked.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

---

TRIGger<m>:SPATtern:CSOurce:LEVel <ClockLevel>

Defines the voltage level for the clock signal.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockLevel>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

TRIGger<m>:SPATtern:PATTern <Pattern>

The pattern contains the bits of the serial data to be found in the data stream. The maximum length of the pattern is 128 bit.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Pattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

20.9.14 TV/Video Trigger

The TV or video trigger requires a channel input as trigger source (`TRIGger<m>:SOURce`). It is only available for the A-event (Suffix = 1).

Make sure to set the trigger level - the threshold of the sync pulse - with `TRIGger<m>:LEVel<n>[:VALue]`.

TRIGger<m>:TV:STANdard <Standard>

Sets the TV standard.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Standard> CUSTom | PAL | PALM | NTSC | SECam | P480L60HZ | P720L30HZ | P720L50HZ | P720L60HZ | I1080L50HZ | I1080L60HZ | P1080L24HZ | P1080L24HZSF | P1080L25HZ | P1080L30HZ | P1080L50HZ | P1080L60HZ

CUSTom
User-defined signal. Configure the signal using:
`TRIGger<m>:TV:CUSTom:SCANmode`
`TRIGger<m>:TV:CUSTom:STYPe`
`TRIGger<m>:TV:CUSTom:LDURation`
`TRIGger<m>:TV:CUSTom:SDURation`

PAL | PALM | NTSC | SECam
SDTV standards. PALM = PAL-M

PxxxxLyyHZ
HDTV standards using progressive scanning (P). xxxx indicates the number of active lines, yy is the frame rate.

IxxxxLxxHZ
HDTV standards using interlaced scanning (I). xxxx indicates the number of active lines, yy is the field rate.

P1080L24HZSF
1080p/24sF is a HDTV standard using progressive segmented frame scanning.

*RST: PAL

Firmware/Software: FW 1.40

TRIGger<m>:TV:MODE <Mode>

Selects the lines or fields on which the instrument can trigger. Available modes depend on the scanning system.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> ALL | ODD | EVEN | ALINe | LINE

ALL
All fields, triggers on the frame start (progressive scanning) or field start (interlaced and progressive segmented frame scanning)

ODD | EVEN
Only available for interlaced scanning and progressive segmented frame scanning. Triggers on the field start of the odd or even field.

ALINe
All lines, triggers on all line starts.

LINE
Triggers on a specified line. To set the line number, use `TRIGger<m>:TV:LINE`. For NTSC signals, set also the field with `TRIGger<m>:TV:LFIeld`.

*RST: ALL

Firmware/Software: FW 1.40

TRIGger<m>:TV:POLarity <Polarity>

Sets the polarity of the *signal*. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Polarity> POSitive | NEGative

*RST: POSitive

Firmware/Software: FW 1.40

TRIGger<m>:TV:LINE <LineNumber>

Specifies the line number to trigger on. The command is relevant if `TRIGger<m>:TV:MODE` is set to `LINe`.

Usually the lines of the frame are counted beginning from the frame start. For NTSC signals, the lines are counted per field, not per frame. For these signals, set also the field with `TRIGger<m>:TV:LFIeld`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<LineNumber>	Range:	Depends on the standard, see table below
	Increment:	1
	*RST:	1

Firmware/Software: FW 1.40

Standard	Minimum value	Maximum value
PAL	1	625
PAL-M	1	525
NTSC	1	263 in odd field 262 in even field
SECAM	1	625
480p/60 (`P480L60HZ`)	1	525
720p/30 (`P720L30HZ`) 720p/50 (`P720L50HZ`) 720p/60 (`P720L60HZ`)	1	750
1080i/50 (`I1080L50HZ`) 1080i/60 (`I1080L60HZ`) 1080p/24 (`P1080L24HZ`) 1080p/24sF (`P1080L24HZSF`) 1080p/25 (`P1080L25HZ`) 1080p/30 (`P1080L30HZ`) 1080p/50 (`P1080L50HZ`) 1080p/60 (`P1080L60HZ`)	1	1125

TRIGger<m>:TV:LFIeld <LineField>

The commands is only relevant for NTSC signals and sets the field in which the line number is counted.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<LineField>	FIELD1 | FIELd1 | FIELD2 | FIELd2 FIELD1 = FIELd1 = odd field FIELD2 = FIELd2 = even field *RST: FIELD1

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SCANmode <ScanMode>

Sets the scanning system. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

See also: "Scan" on page 232.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ScanMode>	INTerlaced | PROGressive | SEGMented SEGMented: Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display. *RST: INTerlaced

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:LDURation <LinePeriod>

Sets the duration of a line, the time between two successive sync pulses. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<LinePeriod>	Range: 1E-6 to 500E-6 Increment: 100E-9 *RST: 64E-6 Default unit: s

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:STYPe <SyncPulseType>

Sets the type of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<SyncPulseType> BILevel | TRILevel

BILevel
Bi-level sync pulse, usually used in SDTV signals

TRILevel
Tri-level sync pulse, used in HDTV signals

*RST: BILevel

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SDURation <SyncPlsDur>

Sets the width of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<SyncPlsDur>
Range: 100E-9 to 100E-6
Increment: 100E-9
*RST: 4.7E-6
Default unit: s

Firmware/Software: FW 1.40

20.9.15 Trigger Qualification

The A-event can have its own trigger qualification. Qualification is not available for B- and R-events (event suffix m = 2 | 3) and some trigger types.

The trigger type to which the qualification belongs is defined by a suffix.

Table 20-2: Trigger type suffixes

Suffix	Trigger type
1	EDGE
2	GLITch
3	WIDTh
4	RUNT
5	WINDow
6	TIMeout
7	INTerval

Suffix	Trigger type
8	qualification is not supported (SLEWrate)
9	qualification is not supported (DATatoclock)
10	STATe
11	PATTern
12	qualification is not supported (ANEDge)
13	currently not used
14	qualification is not supported (SERPattern)
15	qualification is not supported (NFC)
16	qualification is not supported (TV)
17	qualification is not supported (CDR)

TRIGger<m>:QUALify<n>:STATe <AddTrigLogi>

Enables the use of the qualification definition for the selected trigger event.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Defines the trigger type, see Table 20-2.

Parameters:

<AddTrigLogi> ON | OFF

ON
The qualification expression is considered for the trigger event.

OFF
The qualification expression is ignored for the trigger event.

*RST: OFF

TRIGger<m>:QUALify<n>:A[:ENABle] <State>
TRIGger<m>:QUALify<n>:B[:ENABle] <State>
TRIGger<m>:QUALify<n>:C[:ENABle] <State>
TRIGger<m>:QUALify<n>:D[:ENABle] <State>

The command is relevant for qualification, for pattern trigger and for state trigger.

Select the channels to be considered:

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

The trigger source cannot be enabled.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type, see Table 20-2.

Parameters:

<State> ON | OFF

ON
The qualification expression is considered.

OFF
The qualification expression is ignored.

*RST: OFF

TRIGger<m>:QUALify<n>:A:LOGic <Operator>
TRIGger<m>:QUALify<n>:B:LOGic <Operator>
TRIGger<m>:QUALify<n>:C:LOGic <Operator>
TRIGger<m>:QUALify<n>:D:LOGic <Operator>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type, see Table 20-2.

Parameters:

<Operator>	DIRect | NOT **DIRect** Input value remains unchanged **NOT** Input value is inverted *RST: DIRect

---

TRIGger<m>:QUALify<n>:AB:LOGic <Operator>
TRIGger<m>:QUALify<n>:CD:LOGic <Operator>
TRIGger<m>:QUALify<n>:ABCD:LOGic <Operator>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type, see Table 20-2.

Parameters:

<Operator>	AND | NAND | OR | NOR **AND** logical AND, conjunctive combination **NAND** logical NOT AND **OR** logical OR, disjunctive combination **NOR** logical NOT OR *RST: AND

20.9.16 Holdoff

TRIGger<m>:HOLDoff:MODE <Mode>

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> TIME | EVENts | RANDom | AUTO | OFF

TIME
Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed (defined using `TRIGger<m>:HOLDoff:TIME`).

EVENts
Defines the holdoff as a number of trigger events. The next trigger occurs only when this number of events is reached. The number of triggers to be skipped is defined using `TRIGger<m>:HOLDoff:EVENts`.

RANDom
Defines the holdoff as a random time limited by `TRIGger<m>:HOLDoff:MIN` on page 1285 and `TRIGger<m>:HOLDoff:MAX` on page 1286. For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.

AUTO
The holdoff time is calculated automatically based on the current horizontal scale.

OFF
No holdoff

*RST: OFF

TRIGger<m>:HOLDoff:TIME <Time>

Defines the holdoff time period. The next trigger occurs only after this time has passed. The setting is relevant if the holdoff mode is set to TIME.

See also:

- `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Time>	Range: 100E-9 to 10 Increment: 200E-6 *RST: 1E-3 Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE TIME
TRIGger<m>:HOLDoff:TIME 1ms
```

The holdoff time is set to 1 ms.

TRIGger<m>:HOLDoff:EVENts <Events>

Defines the number of triggers to be skipped. The next trigger only occurs when this number of events is reached. The setting is relevant if the holdoff mode is set to EVENts.

See also:

- `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Events>	Range: 1 to 2147483647 Increment: 1 *RST: 1

Example:

```
TRIGger1:HOLDoff:MODE EVENts
TRIGger<m>:HOLDoff:EVENts 5
```

TRIGger<m>:HOLDoff:MIN <RandomMinTime>

Defines the lower limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- `TRIGger<m>:HOLDoff:MODE`
- `TRIGger<m>:HOLDoff:MAX`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMinTime>	Range: 100E-9 to 5 Increment: 200E-6 *RST: 1E-3 Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE RANDom
TRIGger<m>:HOLDoff:MIN 1ms
TRIGger<m>:HOLDoff:MAX 2ms
```

The holdoff time is set randomly between 1 ms and 2 ms.

TRIGger<m>:HOLDoff:MAX <RandomMaxTime>

Defines the upper limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- `TRIGger<m>:HOLDoff:MODE`
- `TRIGger<m>:HOLDoff:MIN`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMaxTime>

Range: 100E-9 to 10
Increment: 200E-6
*RST: 2E-3
Default unit: s

TRIGger<m>:HOLDoff:AUTotime?

Returns the resulting holdoff time if the holdoff mode is set to AUTO: *Auto time* = *Auto time scaling* * *Horizontal scale*. The auto time scaling factor is defined with `TRIGger<m>:HOLDoff:SCALing`.

See also: `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Return values:

<AutoTime>

Holdoff time

Range: 100E-9 to 10
*RST: 1E-3
Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE AUTO
TRIGger1:HOLDoff:SCALing 0.5
TRIGger<m>:HOLDoff:AUTotime?
1ms
```

Result if the horizontal scale is 1 ns/div

Usage: Query only

TRIGger<m>:HOLDoff:SCALing <AutoTimeScaling>

Sets the auto time scaling factor the horizontal scale is multipied with: *Auto time* = *Auto time scaling* * *Horizontal scale*. The setting is relevant if the holdoff mode is set to AUTO.

See also:

- `TRIGger<m>:HOLDoff:MODE`
- `TRIGger<m>:HOLDoff:AUTotime?` on page 1286

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AutoTimeScaling>	Range:	1E-3 to 1000
	Increment:	1
	*RST:	0.5

20.9.17 Noise Reject

TRIGger<m>:LEVel<n>:NOISe[:STATe] <HysteresisMode>

Selects how the hysteresis is set.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.
<n>	1..27 Indicates the trigger source: 1...4 = channel 1 to 4 5 = external trigger input 6...11 = not available 12...27 = R&S RT-ZVC input channels (R&S RTO2000 only)

Parameters:

<HysteresisMode>	AUTO | MANual **AUTO** This is the recommended mode. The hysteresis is set by the instrument to reject at least the internal noise of the instrument. You can define a higher minimum value using `TRIGger<m>:LEVel<n>:NOISe:ABSolute`. **MANual** The hysteresis is defined directly with `TRIGger<m>:LEVel<n>:NOISe:ABSolute`. *RST: AUTO

TRIGger<m>:LEVel<n>:NOISe:MODE <HystSizeMd>

Selects how the hysteresis is set.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.
<n>	1..27 Indicates the trigger source: 1...4 = channel 1 to 4 5 = external trigger input 6...10 = not available 11 = Waveform generator

Parameters:

<HystSizeMd>	ABS | REL **ABS** The hysteresis is set in absolute values (voltage). **REL** The hysteresis is defined in relative values (div). *RST: ABS

TRIGger<m>:LEVel<n>:NOISe:ABSolute <HystAbs>

Defines a range in absolute values around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.
<n>	1..27 Indicates the trigger source: see `TRIGger<m>:LEVel<n>:NOISe[:STATe]` on page 1287.

Parameters:

<HystAbs>	Range:	0 to The value corresponding to full division range. The exact maximum value depends on the selected vertical scale.
	Increment:	1E-3
	*RST:	0
	Default unit:	V

TRIGger<m>:LEVel<n>:NOISe:RELative <HystRel>

Defines a range in percent around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.
<n>	1..27 Indicates the trigger source: see `TRIGger<m>:LEVel<n>:NOISe[:STATe]` on page 1287.

Parameters:

<HystRel>	Range:	0 to 50
	Increment:	1
	*RST:	0
	Default unit:	%

TRIGger<m>:ANEDge:NREJect <NoiseReject>

Enables the noise reject for the external trigger input.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<NoiseReject>	ON | OFF	
	*RST:	OFF

Firmware/Software: FW 2.25

20.9.18 Trigger Sequence

TRIGger<m>:SEQuence:MODE <Type>

Selects the type of the sequence.

See also: Chapter 5.8, "Sequence", on page 241.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Type> AONLy | ABR | AZ | ABRZ

AONLy
Triggers only on A-events. Additionally, a holdoff condition can be set. if AONLy sequence is set, all inputs (input channels, serial and parallel buses, digital channels etc.) can be used as trigger source.

ABR
Triggers if all conditions of A- and B-events, as well as additional delay and reset timeout or R-event (reset) conditions are fulfilled. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.

AZ
Triggers if the conditions of the A-event and the zone trigger are fulfilled. Additionally, a holdoff condition can be set. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.
Available for R&S RTO2000, requires option R&S RTO-K19.

ABRZ
Triggers if all conditions of A- and B-events, reset timeout or R-event (reset) conditions are fulfilled for the defined zone. Additionally, a holdoff condition can be set. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.
Available for R&S RTO2000, requires option R&S RTO-K19.

*RST: AONLy

TRIGger<m>:ECOupling <TrigLevEvtCpl>

Event coupling of trigger levels: Sets the trigger levels to the values of the indicated event. Thus, channel 1 has one trigger level for all events, channel 2 has one trigger level and so on.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:

<TrigLevEvtCpl> ON | OFF

*RST: ON

TRIGger<m>:SEQuence:DELay <Delay>

Sets the time the instrument waits after an A-event until it recognizes B-events.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Delay>	Range:	0 to 50
	Increment:	1E-12
	*RST:	0
	Default unit:	s

TRIGger<m>:SEQuence:COUNt <Events>

Sets the number of B-events to be fulfilled after an A-event. The last B-event causes the trigger.

The waiting time for B-events can be restricted with a reset condition: timeout or reset event.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Events>	Range:	1 to 2147483647
	Increment:	1
	*RST:	1

TRIGger<m>:SEQuence:RESet:EVENt <EnabRstEvt>

If set to ON, the trigger sequence is restarted by the R-event if the specified number of B-event does not occur.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<EnabRstEvt>	ON | OFF	
	*RST:	OFF

TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle] <State>

If set to ON, the instrument waits for the time defined using `TRIGger<m>:SEQuence:RESet:TIMeout:TIME` for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<State>	ON | OFF	
	*RST:	OFF

TRIGger<m>:SEQuence:RESet:TIMeout:TIME <ResetTimeout>

The time the instrument waits for the number of B-events specified using `TRIGger<m>:SEQuence:COUNt` before the sequence is restarted with the A-event.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<ResetTimeout>	Range:	0 to 50
	Increment:	1E-12
	*RST:	0
	Default unit:	s

20.9.19 Trigger Control

TRIGger<m>:MODE <TriggerMode>

Sets the trigger mode which determines the behaviour of the instrument if no trigger occurs.

See also: "Trigger mode" on page 238

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<TriggerMode>	AUTO | NORMal | FREerun **AUTO** The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base. **NORMal** The instrument acquires a waveform only if a trigger occurs. **FREerun** The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored *RST: AUTO

TRIGger<m>:FORCe

If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Usage: Event

TRIGger<m>:OUT:STATe <State>

Enables/disbales the trigger out signal that is provided to the TRIGGER OUT connector on the rear panel when a trigger occurs.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<State>	ON | OFF *RST: OFF

TRIGger<m>:OUT:POLarity <Polarity>

Sets the polarity of the trigger out pulse.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Polarity>	POSitive | NEGative *RST: POSitive

TRIGger<m>:OUT:PLENgth <PulseLength>

Sets the length of the trigger out pulse.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<PulseLength>	Range:	4E-9 to 0.06
	Increment:	20E-9
	*RST:	100E-9
	Default unit:	s

TRIGger<m>:OUT:DELay <Delay>

Sets the delay of the first pulse edge to the trigger point.

The settin gis not available if a mask test or measurement is running and the on-violation event is set to trigger out pulse.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Delay>	Range:	800E-9 to 1
	Increment:	1E-9
	*RST:	800E-9
	Default unit:	s

20.9.20 Actions on Trigger

TRIGger<m>:EVENt:BEEP <Beep>

Generates a beep sound if the command is set to `TRIGger`.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<Beep>	NOACtion | TRIGger	
	*RST:	NOACtion

TRIGger<m>:EVENt:PRINt <Print>

Saves a screenshot at each trigger if the command is set to `TRIGger`.

For screenshot settings, see Chapter 20.16.7, "Screenshots", on page 1487.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<Print>	NOACtion | TRIGger *RST: NOACtion

TRIGger<m>:EVENt:WFMSave <SaveWfm>

Saves the waveform data to file at each trigger if the command is set to `TRIGger`.

For data export settings, see Chapter 20.16.4, "Waveform Data Export to File", on page 1478.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<SaveWfm>	NOACtion | TRIGger *RST: NOACtion

20.9.21 Zone Trigger (Option R&S RTO-K19)

TRIGger<m>:ZONE:EXPRession[:DEFine] <LogicalExpr>

Defines the zone trigger.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<LogicalExpr>	String with the logical expression

Example:

```
TRIGger:ZONE:EXPRession 'MT1 and MT2 and Zone1'
TRIGger:ZONE:EXPRession?
<-- MT1 and MT2 and Zone1
```

Firmware/Software: FW 3.20

20.9.22 Acquisition Info

ACQuire:CURRent?

Shows the current number of acquisitions that have been acquired.

Return values:

<CurrAcqCnt>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

20.10 Waveform Analysis

20.10.1 Zoom

LAYout:ZOOM:ADD <NodeName>, <ParentType>, <InsertBefore>, <XStart>, <XStop>, <YStart>, <YStop>, <NewZoomName>

Adds a new zoom diagram based on the specified waveform.

Setting parameters:

<NodeName>	String with the name of diagram to be zoomed
<ParentType>	VERTical, OFF The new zoom diagram is displayed below the original one.
<InsertBefore>	OFF Position of the zoom diagram, depending on `ParentType`
<XStart>	Defines the x-value at the beginning of the zoom area.
<XStop>	Defines the x-value at the end of the zoom area.
<YStart>	Defines the y-value at the beginning of the zoom area.
<YStop>	Defines the y-value at the end of the zoom area.
<NewZoomName>	String with the name of the new zoom diagram.

Example:

```
LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9,
20e-9, -0.1, 0.05, 'MyZoom1'
```

Creates the zoom diagram 'MyZoom1' for 'Diagram1'.

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 1156

Usage: Setting only

LAYout:ZOOM:ADDCoupled <ZoomName>, <XOffset>, <YOffset>, <NewZoomName>

Creates a new zoom diagram based on the settings of an existing zoom area for the same source.

Parameters:

<NewZoomName>	Defines the name of the new zoom diagram.

Setting parameters:

<ZoomName>	Defines the name of the zoom diagram to be copied.
<XOffset>	Defines an offset to the existing zoom area in x direction.
<YOffset>	Defines an offset to the existing zoom area in y direction.

LAYout:ZOOM:ONEDiagram <ShowInOne>

Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The command takes effect on all zoom diagrams.

Parameters:

<ShowInOne>	ON | OFF *RST: OFF

LAYout:ZOOM:POSCoupling <DiagramName>, <ZoomName>,<PositionCoupl>
LAYout:ZOOM:POSCoupling? <DiagramName>, <ZoomName>

Enables or disables the position coupling of coupled zooms. If position coupling is enabled and one zoom area is moved, the other coupled zoom areas are moved, too, and keep their distance.

Parameters:

<PositionCoupl>	ON | OFF *RST: OFF

Parameters for setting and query:

<DiagramName>	String with the name of the diagram on which the zoom is based
<ZoomName>	String with the name of the zoom diagram

LAYout:ZOOM:HORZ:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:HORZ:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the x-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode>	ABS | REL Mode used to specify the x-axis values of the zoom area. *RST: ABS

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 1156

LAYout:ZOOM:HORZ:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:HORZ:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.

<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:HORZ:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:HORZ:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:HORZ:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:POSition <DiagramName>, <ZoomName>,<RelPosi>
LAYout:ZOOM:HORZ:RELative:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Relative position of the centerpoint (x-value) Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram
Example:	See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 1156

LAYout:ZOOM:HORZ:RELative:SPAN <DiagramName>,
<ZoomName>,<RelativeSpan>
LAYout:ZOOM:HORZ:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram
Example:	See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 1156

LAYout:ZOOM:HORZ:RELative:STARt <DiagramName>,
<ZoomName>,<RelativeStart>
LAYout:ZOOM:HORZ:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<RelativeStart>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:HORZ:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:VERTical:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the y-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode>	ABS | REL Mode used to specify the y-axis values of the zoom area. *RST: ABS

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:VERTical:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:VERTical:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:VERTical:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:VERTical:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:POSition <DiagramName>,
<ZoomName>,<RelPosi>
LAYout:ZOOM:VERTical:RELative:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Relative position of the centerpoint (y-value) Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:SPAN <DiagramName>, <ZoomName>,<RelativeSpan>
LAYout:ZOOM:VERTical:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STARt <DiagramName>, <ZoomName>,<RelativeStart>
LAYout:ZOOM:VERTical:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<RelativeStart>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:VERTical:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:REMove <DiagramName>, <ZoomName>

Removes the specified zoom diagram.

Setting parameters:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram
Example:	See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 1156
Usage:	Setting only

20.10.2 Reference Waveforms

20.10.2.1 Reference

REFCurve<m>:SOURce <Source>

Selects the source waveform to be used as a reference.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the reference waveform, see Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1

REFCurve<m>:STATe <State>

If enabled, the reference waveform is displayed in the diagram.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<State>	ON | OFF *RST: OFF

REFCurve<m>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<Name>	Path and name of the file that contains the reference waveform or to which the reference waveform is to be stored (`.xml` or `.bin` format), enclosed in single quotes.

REFCurve<m>:OPEN

Loads the reference waveform file selected by `REFCurve<m>:NAME` on page 1305.

Suffix:

<m>	1..4 Reference waveform
Usage:	Event

REFCurve<m>:UPDate

Copies the selected source waveform (see `REFCurve<m>:SOURce` on page 1304) with all its settings to the memory of the reference waveform.

Suffix:	
<m>	1..4 Reference waveform
Usage:	Event

REFCurve<m>:SAVE

Saves the reference waveform to the file selected by `REFCurve<m>:NAME` on page 1305.

Suffix:	
<m>	1..4 Reference waveform
Usage:	Event

REFCurve<m>:DELete

Deletes the reference waveform file selected by `REFCurve<m>:NAME` on page 1305.

Suffix:	
<m>	1..4 Reference waveform
Usage:	Event

REFCurve<m>:CLEar

The selected reference waveform is no longer displayed, its memory is deleted.

Suffix:	
<m>	1..4 Reference waveform
Usage:	Event

20.10.2.2 Scaling

REFCurve<m>:RESTore

Restores the settings of the source waveform, if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 1307).

Suffix:

<m>	1..4 Reference waveform

Usage:	Event

REFCurve<m>:VMODe <VerticalMode>

Selects the coupling of vertical settings.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.

*RST: INDependent

REFCurve<m>:SCALe <VerticalScale>

Sets the scale factor for the reference waveform if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 1307).

Suffix:

<m>	1..4 Reference waveform

Parameters:

<VerticalScale>
Range: 1E-15 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

REFCurve<m>:POSition <VertPosi>

Moves the reference waveform and its horizontal axis up or down in the diagram, if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 1307).

Suffix:

<m>	1..4 Reference waveform

Parameters:

<VertPosi>	Range: -100E+24 to 100E+24 Increment: 0.02 *RST: 0 Default unit: div

---

REFCurve<m>:RESCale:VERTical:STATe <State>

Enables and disables the vertical stretching. Stretching changes the display of the waveform independent of the vertical scale and position.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<State>	ON | OFF *RST: OFF

REFCurve<m>:RESCale:VERTical:FACTor <ScaleFactor>

Defines the vertical stretching factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<ScaleFactor>	Range: -1E+6 to 1E+6 Increment: 0.1 *RST: 1

REFCurve<m>:RESCale:VERTical:OFFSet <Offset>

Moves the reference waveform vertically. Like vertical offset of channel waveforms, the offset of a reference waveform is subtracted from the measured value.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<Offset>	Negative values shift the waveform up, positive values shift it down. Range: -100E+24 to 100E+24 Increment: 1E-6 *RST: 0 Default unit: V

REFCurve<m>:HMODe <HorizontalMode>

Selects the coupling of horizontal settings.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<HorizontalMode>	ORIGinal | COUPled **ORIGinal** Horizontal scaling and reference point of the source waveform are used. **COUPled** The current horizontal settings of the diagram are used. *RST: ORIGinal

---

REFCurve<m>:RESCale:HORizontal:STATe <State>

Enables and disables the horizontal stretching.

Stretching changes the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<State>	ON | OFF *RST: OFF

REFCurve<m>:RESCale:HORizontal:FACTor <ScaleFactor>

A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<ScaleFactor>	Range: 1E-6 to 1E+6 Increment: 0.1 *RST: 1

REFCurve<m>:RESCale:HORizontal:OFFSet <Offset>

Moves the waveform horizontally. Positive values shift the waveform to the right, negative values shift it to the left.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<Offset>

Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0
Default unit: s

20.10.2.3 Waveform Data Export

Commands for saving waveform data to file are described in Chapter 20.16.4, "Waveform Data Export to File", on page 1478.Commands for reference waveforms are listed below.

REFCurve<m>:DATA:STYPe?

Returns the signal type of the source of the reference waveform.

Suffix:

<m>	1..4 Reference waveform

Return values:

<SignalType>

SOUR | SPEC | CORR | NONE

SOURce = normal signal
SPECtrum = FFT spectrum, specific math signal
CORRelation = correlated signal, specific math signal
NONE = undefined

Usage: Query only

REFCurve<m>:DATA:HEADer?

Returns information on the reference waveform.

Table 20-3: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For reference waveforms the number is always 1.	1

Suffix:	
<m>	1..4 Reference waveform
Example:	`REFC:DATA:HEAD?` `-9.477E-008,9.477E-008,200000,1`
Usage:	Query only

REFCurve<m>:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:	
<m>	1..4 Reference waveform
Return values:	
<Data>	List of values according to the format and content settings.
Usage:	Query only

20.10.2.4 Import of Multichannel Waveform Data

Commands for saving waveform data to file are described in Chapter 20.16.4, "Waveform Data Export to File", on page 1478.Commands for reference waveforms are listed below.

REFCurve<m>:MULTichannel:NAME <MultiChImportPath>

Defines the path and the file to be imported. If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

Suffix:	
<m>	1..4 The suffix is irrelevant.
Parameters:	
<MultiChImportPath>	String with path and filename
Example:	See `REFCurve<m>:MULTichannel:IMPort` on page 1312.

REFCurve<m>:MULTichannel:IMPort <WfmSelect>

Assigns a waveform from the multichannel file to a reference waveform. To import all waveforms that are in the file, you must assign each waveform to another reference waveform.

Suffix:

<m>	1..4 Selects the reference waveform.

Parameters:

<WfmSelect>	NONE | NONE | WF1 | WAFEFORM1 | WF2 | WAFEFORM2 | WF3 | WAFEFORM3 | WF4 | WAFEFORM4 WF1 = WAFEFORM1, WF2 = WAFEFORM2, WF3 = WAFEFORM3, WF4 = WAFEFORM4 Selects the waveform in the export file. *RST: NONE

Example:

```
REFCurve:MULTichannel:NAME
RefCurve_2016-02-16_01.bin
REFCurve1:MULTichannel:IMPort WF1
REFCurve2:MULTichannel:IMPort WF3
REFCurve3:MULTichannel:IMPort WF4
REFCurve:MULTichannel:OPEN
```

Firmware/Software: FW 3.20

REFCurve<m>:MULTichannel:OPEN

Loads the waveform data to the reference waveforms.

Suffix:

<m>	1..4 The suffix is irrelevant.

Example: See `REFCurve<m>:MULTichannel:IMPort` on page 1312.

Usage: Event
Asynchronous command

20.10.3 Mathematics

CALCulate:MATH<m>[:EXPRession][:DEFine] <RemComplExpr>

Defines the math expression to be calculated for the specified math channel.

For an overview of corresponding expressions for the available keys in the formula editor, see Chapter 6.3.3, "Advanced Expressions", on page 271.

Suffix:

<m>	1..4 Selects the math waveform.

Parameters:

<RemComplExpr>	String with regular expression for calculation

Example: `CALC:MATH 'Ch1Wfm1*Ch2Wfm1'`
Defines the multiplication of waveforms Ch1Wfm1 and Ch2Wfm1.

CALCulate:MATH<m>:STATe <State>

Enables the math waveform display.

Suffix:

<m>	1..4 math waveform

Parameters:

<State>	ON | OFF *RST: OFF

CALCulate:MATH<m>:ENVSelection <EnvelopeCurve>

Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

Suffix:

<m>	1..4 Selects the math waveform.

Parameters:

<EnvelopeCurve>	MIN | MAX | BOTH *RST: BOTH

Firmware/Software: FW 2.25

CALCulate:MATH<m>:ARIThmetics <Arithmetics>

Selects the method to build the resulting math waveform from consecutive acquisitions. The processing is similar to the waveform arithmetics - instead of the acquired waveforms the results of the mathematic formula are used to create envelope, average and RMS.

To define the reset condition for arithmetics calculation, use `ACQuire:ARESet:MODE`.

Suffix:

<m>	1..4 Selects the math waveform.

Parameters:

<Arithmetics>

OFF | ENVelope | AVERage | RMS | MINHold | MAXHold

waveform arithmetic mode

OFF
The math waveform is built according to the mathematic formula.

ENVelope
Detects the minimum and maximum math values in a sample interval over a number of acquisitions.

AVERage
Calculates the average from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

RMS
The resulting math waveform is the root mean square of the current acquisition and a number of acquisitions before. The result is the average power spectrum. Number of acquisitions: `ACQuire:COUNt`

MAXHold
Determines the maximum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

MINHold
Determines the minimum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

*RST: OFF

CALCulate:MATH<m>:VERTical:OFFSet <VerticalOffset>

Sets a voltage offset to adjust the vertical position of the math function on the screen.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalOffset> Negative values move the waveform au, positive values move it down.

Range:	-100E+12 to 100E+12
Increment:	0.01
*RST:	0
Default unit:	div

CALCulate:MATH<m>:VERTical:RANGe <VerticalRange>

Defines the range of FFT values to be displayed.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalRange>

Range:	0 to 1E+15
Increment:	0.01
*RST:	0
Default unit:	div

CALCulate:MATH<m>:VERTical:SCALe <VerticalScale>

Defines the scale of the y-axis in the math function diagram. The value is defined as "V per division", e.g. *50V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 V.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalScale>

Range:	1E-12 to 100E+12
Increment:	10E-6
*RST:	0.5
Default unit:	V/div

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<SignalType>	SOUR | SPEC | CORR | MEAS | NONE SOURce = normal signal SPECtrum = FFT spectrum, specific math signal CORRelation = correlated signal, specific math signal MEAsurement = result of a measurement NONE = undefined Im GUI nicht vorhanden: XY = XY-signal SBUS = Serial bus
Usage:	Query only

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 20-4: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:

<m>	1..4 Selects the math waveform.
Example:	`CALC:MATH4:DATA:HEAD` `-9.477E-008,9.477E-008,200000,1`
Usage:	Query only

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:	
<Data>	List of values according to the format and content settings.
Usage:	Query only

20.10.4 History

CHANNel<m>[:WAVeform<n>]:HISTory[:STATe] <State>

Enables or disables the history display.

Suffix:	
<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.
Parameters:	
<State>	ON | OFF *RST: OFF

ACQuire:AVAilable?

Returns the number of acquisitions currently saved in the memory. This number of acquisitions is available for history viewing. It is also the number of acquisitions in an Ultra Segmentation acquisition series.

Return values:	
<AcqCnt>	Range: 0 to 4294967295
Usage:	Query only
Firmware/Software:	V 1.25

CHANnel<m>[:WAVeform<n>]:HISTory:CURRent <CurrAcqIdx>

Accesses a particular acquisition in the memory to display it. The query returns the index of the segment that is shown.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<CurrAcqIdx>	History index: the newest segment has the index "0", older segments have a negative index: -(n-1), ... -1 , 0 where n is the number of acquired segments. Range: 0 to -(n-1) Increment: 1

Example:

```
CHAN2:HIST:CURR -1
*OPC
```

Displays the acquisition before last from the history.

CHANnel<m>[:WAVeform<n>]:HISTory:STARt <StrtAcqIdx>

Sets the index of the oldest history acquisition for the history viewing.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<StrtAcqIdx>	The start index is always negative. Range: 0 to -(n-1) Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:STOP <StpAcqIdx>

Sets the index of the latest segment to be displayed in the history viewer.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<StpAcqIdx>	Index of the stop acquisition. The newest acquisition always has the index "0". Range: 0 to -(n-1) Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:TPACq <TimePerAcq>

Sets the display time for one acquisition. The shorter the time, the faster is the replay.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<TimePerAcq>	Range: 40E-6 to 10 Increment: 1 *RST: 0.05 Default unit: s

---

CHANnel<m>[:WAVeform<n>]:HISTory:PLAY

Starts and stops the replay of the history waveforms.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.
Usage:	Event Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:REPLay <AutoRepeat>

If ON, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the stop index set with `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:	
<AutoRepeat>	ON | OFF *RST: OFF
Usage:	Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?

Returns the date of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:	
<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.
Return values:	
<DateAbsString>	String with date of the current acquisition (absolute time)
Usage:	Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?

Returns the abolsute daytime of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:	
<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.
Return values:	
<TimeAbsString>	String containing the time and unit
Usage:	Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?

Returns the relative time of the current acquisition - the time difference to the newest acquisition (index = 0).

See also: (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:	
<m>	1..4 Selects the input channel.

<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:

<TimeRelative>	Range: -100E+24 to 100E+24 Default unit: s

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?

Returns the relative time of the currently selected acquisition and the internal reference time (horizontal alignment) in history view with respect to the acquisition with index 0.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:

<TimeRelIntRef>	Range: -100E+24 to 100E+24 Increment: 1 *RST: 0 Default unit: s

Usage: Query only

Firmware/Software: Version 2.70

20.10.5 XY-Diagram

WAVeform<m>:XYCurve:RATio <ConstantXYRatio>

If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<ConstantXYRatio>	ON | OFF *RST: ON

WAVeform<m>:XYCurve:STATe <State>

Activates an XY-waveform.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<State>	ON | OFF *RST: OFF

WAVeform<m>:XYCurve:SWAP

Replaces the source of the x-axis with the source of the y-axis and vice versa.

Suffix:

<m>	1..4 XY-diagram
Usage:	Event

LAYout:SIGNal:AXIS <DiagramName>, <Source>, <XSource>

Creates an XY-diagram by adding a second waveform to a diagram with a channel, math or reference waveform.

Setting parameters:

<DiagramName>	String with the name of the diagram where the waveform is added.
<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Waveform to be added, see Chapter 20.4.2, "Waveform Parameter", on page 1173
<XSource>	ON | OFF If on, the added waveform is assigned to the x-axis. If off, it is assigned to the y-axis.
Usage:	Setting only

WAVeform<m>:XYCurve:XSOurce <XSource>

Defines the signal source that supplies the x-values of the XY-diagram.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<XSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of x-values, see Chapter 20.4.2, "Waveform Parameter", on page 1173

WAVeform<m>:XYCurve:YSOurce <YSource>

Defines the signal source that supplies the y-values of the XY-diagram.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<YSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of y-values, see Chapter 20.4.2, "Waveform Parameter", on page 1173

20.11 Cursor Measurements

CURSor<m>:AOFF

This command switches all cursors off.

Suffix:

<m>	1..* The numeric suffix is ignored.

Usage: Event

CURSor<m>:STATe <State>

Switches the indicated cursor on or off.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<State>	ON | OFF *RST: OFF

CURSor<m>:FUNCtion <Type>

Defines the type of the indicated cursor set.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<Type>	HORizontal | VERTical | PAIRed **HORizontal** A pair of horizontal cursor lines. **VERTical** A pair of vertical cursor lines. **PAIRed** Both vertical and horizontal cursor line pairs. *RST: PAIRed

---

CURSor<m>:TRACking[:STATe] <TrackCurve>

If set to `ON`, the horizontal cursor lines follow the waveform.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<TrackCurve>	ON | OFF *RST: OFF

CURSor<m>:SOURce <Source>

Defines the source of the cursor measurement.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the cursor measurement, see Chapter 20.4.2, "Waveform Parameter", on page 1173

CURSor<m>:SSOurce <Source2>

Selects the second cursor source.

Suffix:

<m>	1..4

Parameters:

<Source2>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the cursor measurement, see Chapter 20.4.2, "Waveform Parameter", on page 1173

Firmware/Software: FW 3.60

CURSor<m>:USSource <UseSource2>

Enables the second cursor source. To select the second source, use `CURSor<m>:SSOurce` on page 1325.

If enabled, the second corsor lines Cx.2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Suffix:

<m>	1..4

Parameters:

<UseSource2>	ON | OFF *RST: OFF

Firmware/Software: FW 3.60

CURSor<m>:X1Position <XPosition1>

Defines the position of the left vertical cursor line.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<XPosition1>	Range: 0 to 500 Increment: 0.1 *RST: 0 Default unit: s

CURSor<m>:X2Position <XPosition2>

Defines the position of the right vertical cursor line.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<XPosition2>

Range: 0 to 500
Increment: 0.1
*RST: 0
Default unit: s

CURSor<m>:XCOupling <Coupling>

Defines the positioning mode of the vertical cursor.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<Coupling>

ON | OFF

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

CURSor<m>:Y1Position <YPosition1>

Defines the position of the lower horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the lower vertical value of the waveform.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<YPosition1>

Range: -50 to 50
Increment: 0.01
*RST: 0
Default unit: The unit depends on the type of the waveform.

CURSor<m>:Y2Position <YPosition2>

Defines the position of the upper horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the upper vertical value of the waveform.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<YPosition2>	Range: -50 to 50 Increment: 0.01 *RST: 0 Default unit: The unit depends on the type of the waveform.

CURSor<m>:YCOupling <Coupling>

Defines the positioning mode of the horizontal cursor. If the horizontal cursor lines track the waveform, the y-coupling is irrelevant (CURSor<m>:MODE TRACk).

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<Coupling>	ON | OFF **ON** Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance. **OFF** Each cursor line is positioned independently. *RST: OFF

CURSor<m>:X1ENvelope <EnvelopeCurve1>

If the waveform arithmetics are set to envelope curve (see `CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 1212) and `CURSor<m>:TRACking[:STATe]` is set to "ON", this setting defines how the first horizontal cursor is positioned.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<EnvelopeCurve1>	MIN | MAX **MIN** The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope. **MAX** The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope. *RST: MAX

CURSor<m>:X2ENvelope <EnvelopeCurve2>

If the waveform arithmetics are set to envelope curve (see `CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 1212) and `CURSor<m>:TRACking[:STATe]` is set to "ON", this setting defines how the second horizontal cursor is positioned.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<EnvelopeCurve2>	MIN | MAX **MIN** The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope. **MAX** The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope. *RST: MIN

CURSor<m>:XDELta[:VALue]?

Queries the delta value (distance) of two vertical cursor lines.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Return values:

<Delta>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

CURSor<m>:XDELta:INVerse?

Queries the inverse value of the delta value (distance) of the two vertical cursor lines.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Return values:

<DeltaInverse>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: Hz

Usage: Query only

CURSor<m>:YDELta[:VALue]?

Queries the delta value (distance) of the two horizontal cursor lines.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Return values:

<Delta>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

CURSor<m>:YDELta:SLOPe <DeltaSlope>

Returns the inverse value of the voltage difference - the reciprocal of the vertical distance of two horizontal cursor lines: *1/ΔV*.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<DeltaSlope>	Range:	-100E+24 to 100E+24
	Increment:	0
	*RST:	0

CURSor<m>:FFT:SETCenter

Sets the center frequency to the frequency value that is measured at cursor line c1.

Suffix:

<m>	1..* The suffix is irrelevant.

Usage: Event

CURSor<m>:FFT:TOCenter

Sets the vertical cursor line c1 to the center frequency.

Suffix:

<m>	1..* The suffix is irrelevant.

Usage: Event

CURSor<m>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.
Usage:	Event

CURSor<m>:MAXimum:LEFT

Sets cursor 2 to the next maximum to the left of the current position.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.
Usage:	Event

CURSor<m>:MAXimum:RIGHt

Sets cursor 2 to the next peak to the right (from the current position).

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.
Usage:	Event

CURSor<m>:MAXimum:NEXT

Sets cursor 2 to the next smaller peak (from the current position).

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.
Usage:	Event

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<m>	1..* The suffix is irrelevant.

Parameters:

<Value>	Threshold in dBm
Firmware/Software:	Version 2.70

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:

<m>	1..* The suffix is irrelevant

Parameters:

<Value>	Range:	0 to 100
	Increment:	1
	*RST:	5
	Default unit:	dB

CURSor<m>:STYLe <Style>

Defines how the cursor is displayed in the diagram.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:

<Style>

LINes | LRHombus | VLRHombus | RHOMbus

LINes
The cursors are displayed as lines.

LRHombus
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

VLRHombus
The cursors are displayed only as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

RHOMbus
The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

*RST: LINes

CURSor<m>:LABel <ShowLabel>

Shows the cursor labels in the diagram.

Suffix:

<m>	1..* Selects the cursor set. 4 cursor sets are available.

Parameters:		
<ShowLabel>	ON | OFF	
	*RST:	ON

20.12 Automatic Measurements

This chapter contains all remote commands to set up automatic measurements and to analyze the measurement results.

Measurement selection: MEASurement<m>

With R&S RTO you can configure up to eight simultaneous measurements. In manual operation, these eight measurements are represented as subtabs "Meas 1" to "Meas 8" in the "Measurements" dialog box. For remote operation, the measurement is indicated by the suffix MEAS<m>, containing the number of the measurement.

Measurement suffix	Measurement
1 to 8	"Meas 1" to "Meas 8"
9 and 10	Not used

20.12.1 General Settings

MEASurement<m>[:ENABle] <State>

Switches the indicated measurement on or off.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF *RST: OFF

Example: See "Simple Frequency and Amplitude Measurement" on page 1157.

MEASurement<m>:SOURce <SignalSource>, [<SignalSource2>]

Defines the source of the measurement. Depending on the selected source type, only suitable measurement types are available.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 1173 Digital channels are provided with option R&S RTO-B1. Serial bus SBUS1 | SBUS2 | SBUS3 | SBUS4 is available as measurement source if an audio bus is configured (option R&S RTO-K5) SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2: Spectrograms require option R&S RTO-K18. Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4: input channels of multi-channel high accuracy power probe R&S RT-ZVC.

<SignalSource2>

C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Digital channels are only available if <SignalSource> is a digital channel.

Example: See "Simple Frequency and Amplitude Measurement" on page 1157.

MEASurement<m>:FSRC <Source>

Defines the first measurement source.

The command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m>

1..10

See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Source>

C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 1173

SBUS1 ... SBUS4

Serial bus is available as measurement source if an audio bus is configured (option R&S RTO-K5)

D0 ... D15

Digital channels are provided with option R&S RTO-B1.

SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Spectrograms require option R&S RTO-K18.

Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Input channels of multi-channel high accuracy power probe R&S RT-ZVC.

Firmware/Software: FW 2.00

MEASurement<m>:SSRC <Source2>

Defines the second measurement source.

the command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Source2>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Second source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 1173 Digital channels are only available if a digital channel is set as first measurement source using `MEASurement<m>:FSRC`.

Firmware/Software: V 2.00

MEASurement<m>:CATegory <Category>

Defines the measurement category.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:	
<Category>	AMPTime | JITTer | EYEJitter | SPECtrum | HISTogram | PROTocol **AMPTime** Amplitude and time measurements **JITTer** Jitter measurements, only available isf option R&S RTO-K12 is installed **EYEJitter** Eye diagram mesurements **SPECtrum** Spectrum measurements **HISTogram** Histogram measurements **PROTocol** Protocol measurements (track and trend) *RST: AMPTime
Example:	See "Creating and Reading Histograms" on page 1158

MEASurement<m>:MAIN <MeasType>

Defines the measurement type of the main measurement. The main measurement is referred to if the measurement is used as a source for math calculations.

Suffix:	
<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<MeasType>

Amplitude/time measurements
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SHT | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling
See Chapter 20.12.3, "Amplitude/Time Measurement", on page 1346.
*RST value for amplitude/time measurements: `AMPLitude`.

Jitter measurements
CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase
Only available isf option R&S RTO-K12 is installed. See Chapter 20.21.1, "Jitter Measurements (Option R&S RTO-K12)", on page 2140.

Eye diagram measurements
ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter
See Chapter 20.12.4, "Eye Diagram Measurements", on page 1355
*RST value for eye/jitter measurements: `ERPercent`.

Spectrum measurements
CPOWer | OBWidth | SBWidth | THD | THDPCT | THDA | THDU | THDR | HAR | PLISt
See Chapter 20.12.5, "Spectrum", on page 1358.
*RST value for spectrum measurements: `CPOWer`.

Histogram measurements
WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative
See Chapter 20.12.6.2, "Histogram Measurement", on page 1370.
*RST value for histogram measurements: `WCOunt`.

Example:
See "Simple Frequency and Amplitude Measurement" on page 1157.
See "Creating and Reading Histograms" on page 1158

MEASurement<m>:ADDitional <MeasType>, <State>
MEASurement<m>:ADDitional? <MeasType>

Enables or disables an additional measurement type. Only one measurement type can be enabled or disabled per command. The query returns the state of the specified measurement type.

Note that each measurement can only perform measurements from the same category. For example, if the main measurement type of measurement 1 is amplitude, then you cannot enable an eye width measurement for measurement 1.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF Enables or disables the measurement type.

Parameters for setting and query:

<MeasType>

Amplitude/time measurements
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SHT | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling
See Chapter 20.12.3, "Amplitude/Time Measurement", on page 1346.

Jitter measurements
CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase
Only available isf option R&S RTO-K12 is installed. See Chapter 20.21.1, "Jitter Measurements (Option R&S RTO-K12)", on page 2140.

Eye diagram measurements
ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter
See Chapter 20.12.4, "Eye Diagram Measurements", on page 1355.

Spectrum measurements
CPOWer | OBWidth | SBWidth | THD | THDPCT | HAR | THDA | THDU | THDR | PLISt
See Chapter 20.12.5, "Spectrum", on page 1358.

Histogram measurements
WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative
See Chapter 20.12.6.2, "Histogram Measurement", on page 1370.

MEASurement<m>:AON

Enables all additional measurements in all categories of the indicated measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Event

MEASurement<m>:AOFF

Disables all additional measurements in all categories of the indicated measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Event

MEASurement<m>:CLEar

Deletes the statistic results of the indicated mesurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Event

MEASurement<m>:MULTiple <MultiMeas>

The measurement is performed repeatedly if the measured parameter occurs several times inside the defined gate.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<MultiMeas>	ON | OFF *RST: OFF

MEASurement<m>:MNOMeas <MaxMeasPerAcq>

Sets the maximum number of measurements per acquisition if multiple measurement is enabled (`MEASurement<m>:MULTiple` is `ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<MaxMeasPerAcq>	Range:	2 to 1000000
	Increment:	1
	*RST:	1000

20.12.2 Results

MEASurement<m>:ARES?

Returns the results of all active measurement types for the selected measurement. If statistics are enabled, the instrument returns also statistical results.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<Data>	Result string

Example:

```
:MEASurement:ARES?
2.351778656126e-001,1.343873517787e-001,
-1.343873517787e-001
```

Example:

```
:MEASurement:ARNames 1
:MEASurement:ARES?
Amplitude: 2.351778656126e-001,Max:
1.343873517787e-001,Min: -1.343873517787e-001
```

Example:

```
:MEASurement:ARNames 1
:MEASurement:STATistics:ENABle 1
:MEASurement:ARES?
Amplitude:
2.312252964427e-001,2.608695652174e-001,
2.292490118577e-001,2.391822576775e-001,
2.392462568683e-001,5.533663458383e-003,12447,
12447,Max: 1.343873517787e-001,
1.343873517787e-001,1.324110671937e-001,
1.340297640714e-001, 1.340319233732e-001,
7.608360495310e-004,12447,12447, Min:
-1.324110671937e-001,-1.324110671937e-001,
-1.343873517787e-001,-1.340169449387e-001,
1.340191641476e-001,7.712812700636e-004,12447,12447
Results: current, peak+, peak-, average, RMS,
standard deviation, event count, waveform count
```

Usage: Query only

MEASurement<m>:ARNames <Identifier>

Enables a prefix that indicates the measurement type in the result string of the `MEASurement<m>:ARES?` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Identifier>	ON | OFF *RST: OFF

Example:

```
:MEASurement:ARNames 1
:MEASurement:ARES?
Low: -1.185770750988e-001,Amplitude:
2.371541501976e-001,Max: 1.343873517787e-001
```

Firmware/Software: FW 2.25

MEASurement<m>:RESult[:ACTual]? [<MeasType>]
MEASurement<m>:RESult:AVG? [<MeasType>]
MEASurement<m>:RESult:EVTCount? [<MeasType>]
MEASurement<m>:RESult:NPEak? [<MeasType>]
MEASurement<m>:RESult:PPEak? [<MeasType>]
MEASurement<m>:RESult:RELiability? [<MeasType>]
MEASurement<m>:RESult:RMS? [<MeasType>]

MEASurement<m>:RESult:WFMCount? [<MeasType>]
MEASurement<m>:RESult:STDDev? [<MeasType>]

Return the statistic results of the specified measurement type. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<m>:MAIN`.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RELiability: reliability of the measurement result
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

For a detailed description of the results see "Measurement selection: MEASurement<m>" on page 1333.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Query parameters:	
<MeasType>	**Amplitude/time measurements** HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SETup | HOLD | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling See Chapter 20.12.3, "Amplitude/Time Measurement", on page 1346. **Jitter measurements (option R&S RTO-K12)** CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase See Chapter 20.21.1, "Jitter Measurements (Option R&S RTO-K12)", on page 2140 **Eye diagram measurements** ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter See Chapter 20.12.4, "Eye Diagram Measurements", on page 1355. **Spectrum measurements** CPOWer | OBWidth | SBWidth | THD | THDPCT | HAR | THDA | THDU | THDR | PLISt See Chapter 20.12.5, "Spectrum", on page 1358. **Histogram measurements** WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative See Chapter 20.12.6.2, "Histogram Measurement", on page 1370.
Example:	See "Simple Frequency and Amplitude Measurement" on page 1157. See "Creating and Reading Histograms" on page 1158
Usage:	Query only

MEASurement<m>:RESult:STARt? [<MeasType>]
MEASurement<m>:RESult:STOP? [<MeasType>]

Return the start and stop times of the specified measurement. The parameter defines the measurement type. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<m>:MAIN`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Query parameters:

<MeasType>

Amplitude/time measurements

HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SETup | HOLD | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling

See Chapter 20.12.3, "Amplitude/Time Measurement", on page 1346.

Jitter measurements (option R&S RTO-K12)

CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase

See Chapter 20.21.1, "Jitter Measurements (Option R&S RTO-K12)", on page 2140

Eye diagram measurements

ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter

See Chapter 20.12.4, "Eye Diagram Measurements", on page 1355.

Spectrum measurements

CPOWer | OBWidth | SBWidth | THD | THDPCT | HAR | THDA | THDU | THDR | PLISt

See Chapter 20.12.5, "Spectrum", on page 1358.

Histogram measurements

WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative

See Chapter 20.12.6.2, "Histogram Measurement", on page 1370.

Usage: Query only

MEASurement<m>:RESult:COUNt?

Returns the number of result groups that are returned by MEASurement:RESult:ACTual? HAR.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<MeasType> HAR

The command is only relevant for harmonic search.

Example:

```
:MEASurement:RESult:ACTual? HAR
99.9;-6.000139236;199.8;-80.701713562;299.7;-15.528377533;
:MEASurement:RESult:COUNt? HAR
4
```

Usage: Query only

Firmware/Software: Version 2.70

20.12.3 Amplitude/Time Measurement

The following table lists the <MeasType> parameter values with a short description.

In addition, the meas type suffixes are listed, which are required in limit check remote commands.

For a detailed description, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 328.

Table 20-5: Amplitude and time measurement types

<MeasType> parameter value	Meas. type	Description, result	Type suffix
HIGH	High	High signal level	1
LOW	Low	Low signal level	2
AMPLitude	Amplitude	Amplitude of the signal	3
MAXimum	Max	Maximum value of the waveform	4
MINimum	Min	Minimum value of the waveform	5
PDELta	Peak to peak	Peak-to-peak value of the waveform	6
MEAN	Mean	Mean value of the waveform	7
RMS	RMS	RMS (Root Mean Square) value of the voltage	8
STDDev	σ (S-dev)	Standard deviation of the waveform	9
POVershoot	Pos. overshoot	Positive overshoot of a square wave	10
NOVershoot	Neg. overshoot	Negative overshoot of a square wave	11
AREA	Area	Area beneath the waveform (integral)	12
RTIMe	Rise time	Rise time of the left-most rising edge of the waveform.	13
FTIMe	Fall time	Falling time of the left-most falling edge of the waveform.	14
PPULse	Pos. pulse	Width of a positive pulse – a rising edge followed by a falling edge. The measurement requires at least one complete period of a triggered signal.	15

<MeasType> parameter value	Meas. type	Description, result	Type suffix
NPULse	Neg. pulse	Width of a negative pulse – a falling edge followed by a rising edge. The measurement requires at least one complete period of a triggered signal.	16
PERiod	Period	Length of the left-most signal period of the waveform	17
FREQuency	Frequency	Frequency of the signal. The result is based on the period measurement.	18
PDCYcle	Pos. duty cycle	Positive duty cycle. The measurement requires at least one complete period of a triggered signal.	19
NDCYcle	Neg. duty cycle	Negative duty cycle. The measurement requires at least one complete period of a triggered signal.	20
CYCarea	Cycle area	Area (integral) beneath one cycle	21
CYCMean	Cycle mean	Mean value of one cycle	22
CYCRms	Cycle RMS	The RMS (Root Mean Square) value of one cycle	23
CYCStddev	Cycle σ (S-dev)	Standard deviation of one cycle	24
PULCnt	Pulse count	Number of positive or negative pulses of the waveform, or both	25
DELay	Delay	Time difference between the any edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source.	26
PHASe	Phase	Phase difference between two waveforms	27
BWIDth	Burst width	Duration of one burst, measured from the first edge to the last	28
PSWitching	Pos. switching	Settling time at rising edges	29
NSWitching	Neg. switching	Settling time at falling edges	30
PULSetrain	Pulse train	Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. N has to be configured.	31
EDGecount	Edge count	Number of positive or negative edges of the waveform, or both	32
SETup	Setup time	Parameters to query the setup and hold times. Use these parameters only in following queries: ● `MEASurement<m>:ARES?` ● MEASurement<n>:RESult:.. commands	33
HOLD	Hold time		
SHT	Setup/Hold time	Setting parameter to enable Setup/Hold time measurements. Use this parameter only as setting in: ● `MEASurement<m>:MAIN` on page 1337 ● `MEASurement<m>:ADDitional` on page 1338	35

<MeasType> parameter value	Meas. type	Description, result	Type suffix
SHR	Setup/Hold ratio	Setup/Hold ratio measurement. Setup/Hold ratio is the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$ Use this parameter as setting to activate the Setup/Hold ratio measurement in: ● `MEASurement<m>:MAIN` on page 1337 ● `MEASurement<m>:ADDitional` on page 1338 It is also used in the following queries: ● `MEASurement<m>:ARES?` ● MEASurement<n>:RESult:.. Used also in queries with and commands.	36
Used for jitter measurements (limit checks) see Chapter 20.21.1, "Jitter Measurements (Option R&S RTO-K12)", on page 2140.			37 to 45
DTOTrigger	Delay to trigger	Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data.	46
PROBemeter	Trig. ProbeMeter	DC voltage measured by the connected active R&S probe	47
SLERising	Slew rate on rising edge	Steepness of the rising edge: voltage difference between the lower and higher reference level, divided by the rise time.	48
SLEFalling	Slew rate on falling edge	Steepness of the falling edge: voltage difference between the higher and lower reference level, divided by the fall time.	49

MEASurement<m>:ENVSelect <EnvelopeCurve>

The command is only relevant for measurements on envelope waveforms. It selects the envelope to be used for measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<EnvelopeCurve>	MIN | MAX | BOTH MIN: measures on the lower envelope MAX: measures on the upper envelope BOTH: the envelope is ignored and the waveform measured as usual *RST: BOTH

Firmware/Software: V 1.25

MEASurement<m>:DETThreshold <SignDetectThres>

Defines the value above which measurement results are displayed. Values beneath the threshold are considered to be noise and they are ignored.

Suffix:

<m>	1..10 irrelevant

Parameters:

<SignDetectThres>	Range:	0 to 50
	Increment:	1
	*RST:	5
	Default unit:	%

MEASurement<m>:AMPTime:ALEVel <AreaLevel>

Defines the reference level used to integrate the waveform.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<AreaLevel>	Range:	-100E+24 to 100E+24
	Increment:	0
	*RST:	0
	Default unit:	V

MEASurement<m>:AMPTime:PFSLope <PeriodSlope>

Selects the slope direction for frequency and period measurements.

Suffix:

<m>	1..9 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<PeriodSlope>	FIRSt | POSitive | NEGative | EITHer **POSitive | NEGative** Measures the time between rising or falling edges, respectively. **EITHer** In multiple measurements, the time is measured both between rising edges and between falling edges. In single measurements. the first edge is taken for the measurement. **FIRSt** Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either". Only available for analog measurement sources. *RST: FIRSt (analog source), POSitive (digital source)

MEASurement<m>:AMPTime:PSLope <PulsesSlope>

Sets the first slope of the pulses to be counted. The setting is only relevant for pulse count measurement (`MEASurement<m>:MAIN PULCnt` or `MEASurement<m>:ADDitional PULCnt,ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<PulsesSlope>	POSitive | NEGative | EITHer Count either positive or negative pulses, or both. *RST: POSitive

MEASurement<m>:AMPTime:DELay<n>:DIRection <EdgeCntDirct>

Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

<n>	1..2 Selects the source number.

Parameters:

<EdgeCntDirct>	FRFI | FRLA FRFI - FRom FIrst, counting starts with the first edge of the waveform. FRLA - FRom LAst, counting starts with the last edge of the waveform. *RST: FRFI

MEASurement<m>:AMPTime:DELay<n>:ECOunt <EdgeIndex>

Sets the number of the edge that is relevant for delay measurement for each source.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 Selects the source number.

Parameters:

<EdgeIndex>	Edge number Range: 1 to 100000 Increment: 1 *RST: 1

MEASurement<m>:AMPTime:DELay<n>:LSELect <DelayLevelSelect>

Selects the reference level on which the time is measured for each source.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 Selects the source number.

Parameters:

<DelayLevelSelect>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DELay<n>:SLOPe <Slope>

Sets the edge of each source, between which the delay is measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 Selects the source number.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:PTCount <PulseCount>

Sets the number of positive pulses for the pulse train measurement. It measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<PulseCount>	Range: 1 to 2147483647 Increment: 1 *RST: 1

MEASurement<m>:AMPTime:ESLope <EdgesSlope>

Sets the edge direction to be counted: rising edges, falling edges, or both. The setting is only relevant for edge count measurement (`MEASurement<m>:MAIN EDGecount` or `MEASurement<m>:ADDitional EDGecount,ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<EdgesSlope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:CSLope <SetupHoldClkSlope>

Sets the edge of the clock from which the setup and hold times are measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<SetupHoldClkSlope>	POSitive | NEGative | EITHer **EITHer** The clock edges next to the data edge are considered regardless of the clock slope. *RST: POSitive

---

MEASurement<m>:AMPTime:CLCK<n>:LSELect <ClockLevel>

Selects the reference level of the clock on which the time is measured. Reference level and clock slope define the time point for setup and hold measurements.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 The suffix is irrelevant, omit it.

Parameters:

<ClockLevel>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DATA<n>:LSELect <DataLevel>

Selects the reference level of the data on which the setup and hold time are measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 The suffix is irrelevant, omit it.

Parameters:

<DataLevel>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe <DelaySlope>

Sets the edge direction to be used for delay measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 The suffix is irrelevant.

Parameters:

<DelaySlope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect <RefLevel>

Selects the reference level of the measurement source on which the delay is measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 The suffix is irrelevant.

Parameters:

<RefLevel>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for amplitude vs. time measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..49 Number of the amplitude/time measurement type, see Table 20-5.

Parameters:

<ValidRange>	ILIMit | ULIMit | LLIMit | OLIMit **ILIMit** Inside (within) limit; between the upper and lower limit values **ULIMit** Upper limit; above the upper limit value **LLIMit** Lower limit; below the lower limit value **OLIMit** Outside limit; above the upper limit or below the lower limit values *RST: ILIMit

---

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit <Limit>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit <Limit>

Define the lower and upper limit for limit checking, respectiveley. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..49 Number of the amplitude/time measurement type, see Table 20-5.

Parameters:

<Limit>	Range:	-100 to 100
	Increment:	10E-6
	*RST:	0

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin <Margin>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin <Margin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..49 Number of the amplitude/time measurement type, see Table 20-5.

Parameters:

<Margin>	Range:	-100 to 100
	Increment:	10E-6
	*RST:	0

20.12.4 Eye Diagram Measurements

The following table lists the <MeasType> parameter values with a short description.

In addition, the meas type suffixes are listed, which are required in limit check remote commands.

For a detailed description, see Chapter 7.2.6.1, "Eye Diagram Measurement Types", on page 340.

Table 20-6: Eye diagram measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
		not used	1
ERPercent	Extinction ratio (%)	Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0	2
ERDB	Extinction ratio (dB)	10*log (Eye top / Eye base)	3
EHEight	Eye height	Vertical eye opening	4
EWIDth	Eye width	Horizontal eye opening	5
ETOP	Eye top	Mean of the upper vertical histogram	6
EBASe	Eye base	Mean of the lower vertical histogram	7
		not used	8...9
QFACtor	Q factor	(Eye top – Eye base) / (σtop + σbase)	10
		not used	11...13
RMSNoise	Noise (RMS)	Quadratic mean of the noise of eye top and eye base	14
SNRatio	S/N ratio	Signal-to-noise ratio 10 * log (Eye amplitude / Noise RMS)	15
DCDistortion	Duty cycle distortion	20 * log (Eye amplitude / Noise RMS)	16
ERTime	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level	17
EFTime	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level	18
EBRate	Eye bit rate	Frequency between two crossings	19
EAMPlitude	Eye amplitude	Eye top - Eye base	20
		not used	21...27
PPJitter	Jitter (peak to peak)	Average of the jitter for both crossing points (σcrossing1 + σcrossing2) / 2	28
STDJitter	Jitter (6*σ)	Jitter *6	29
RMSJitter	Jitter (RMS)	Quadratic mean of the jitter at both crossing points	30

MEASurement<m>:EYEJitter:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for eye/jitter measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..30 Number of eye/jitter measurement type, see Table 20-6.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limit for the limit check, respectively. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..30 Number of eye/jitter measurement type, see Table 20-6.

Parameters:

<UpperLimit>

Range:	-100 to 100
Increment:	10E-6
*RST:	0

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin <UpperMargin>

Defines the upper margin for the limit check. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

<n>	1..30 Number of eye/jitter measurement type, see Table 20-6.

Parameters:

<UpperMargin>	Range:	-100 to 100
	Increment:	10E-6
	*RST:	0

20.12.5 Spectrum

The following table lists the <MeasType> parameter values with a short description.

In addition, the meas type suffixes are listed, which are required in limit check remote commands.

For a detailed description, see Chapter 7.2.7.1, "Spectrum Measurement Types", on page 342.

Table 20-7: Spectrum measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
CPOWer	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in mW	1
		not used	2
OBWidth	Occupied bandwidth	From the defined center frequency, symmetric sample value pairs to the left and right are integrated until a user-defined percentage of the total power is reached	3
SBWidth	Bandwidth	n dB down Bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded; the frequencies at which the threshold is exceeded define the limits of the requested bandwidth	4
		not used	5
		not used	6
THD	Total harmonic distortion in dB	Power sum of the harmonic waves divided by the power of the fundamental wave.	7
THDPCT	Total harmonic distortion in %	Power sum of the harmonic waves divided by the power of the fundamental wave.	8
THD_A	Total harmonic distortion of amplitudes	Sum of all amplitudes of the harmonic waves in relation to the amplitude of the fundamental waveform	9
THD_U	Total harmonic distortion in relation to fundamental waveform	Root mean square of the power sum of harmonic waves in relation to the power of the fundamental waveform	10
THD_R	Total harmonic distortion in relation to all waveforms	Root mean square of the power sum of harmonic waves in relation to the power of all waveforms	11

<MeasType> parameter value	**Meas. type**	**Description/Result**	**Type suffix**
PLISt	Peak list	List of frequency and peak power value pairs	12
HAR	Harmonic search	Returns the measured harmonics. For each harmonic, the frequency and the value is listed. To get the number of result pairs (= harmonics), use `MEASurement<m>:RESult:COUNt?`.	13

MEASurement<m>:SPECtrum:CPOWer:BANDwidth <ChPowBw>

Defines the bandwidth over which the channel power is calculated.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ChPowBw>	Range: 0 to 4E+9 Increment: 1 *RST: 0 Default unit: Hz

---

MEASurement<m>:SPECtrum:OBANdwidth <OccupiedBW>

Defines the percentage of the total power used to determine the occupied bandwidth.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<OccupiedBW>	Range: 0.1 to 99.9 Increment: 1 *RST: 20 Default unit: %

MEASurement<m>:SPECtrum:CPOWer:CFRequency <CenterFreq>

Defines the center frequency from which the channel power is calculated over the specified bandwidth.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<CenterFreq>	Range: 0 to 6E+9 Increment: 1 *RST: 0 Default unit: Hz

---

MEASurement<m>:SPECtrum:NDBDown <NDbDown>

Defines the threshold until which the samples to the left and right of the peak value are analyzed in order to determine the "N dB down bandwidth".

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<NDbDown>	Range: 0 to 100 Increment: 1 *RST: 20 Default unit: dB

MEASurement<m>:SPECtrum:PEXCursion <Value>

Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<Value>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

Firmware/Software: Version 2.70

MEASurement<m>:SPECtrum:ATHReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Value>	numeric value Default unit: dBm

Firmware/Software: Version 3.30
The command replaces `MEASurement<m>:SPECtrum:THReshold`.

MEASurement<m>:RESult:MAXCount <MeasType>,<Number>
MEASurement<m>:RESult:MAXCount? <MeasType>

Defines the maximum number of results that are returned for the specified measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Number>

Parameters for setting and query:

<MeasType>	CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR For other measurement types, this command returns an error. **PLISt** Defines the maximum number of peaks that are listed in the peak list and labeled in the diagram. **HAR** Defines the maximum number of harmonics to be measured.

MEASurement<m>:RESult:INVerse <MeasType>, <State>
MEASurement<m>:RESult:INVerse? <MeasType>

Displays labels with black font on white background using the "Full frame" label type (if `MEASurement<m>:RESult:LABorder`=`ON`).).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<MeasType>	CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR For other measurement types, this command returns an error. **PLISt** Peaklist

Example:

Display labels.
`MEAS:RES:SHL PLIS,ON`
Select inverted labels.
`MEAS:RES:INV PLIS,ON`
Query the type of labels for peak lists.
`MEAS:RES:INV? PLIS`
`//Result: ON`

MEASurement<m>:RESult:LABorder <MeasType>, <FrameType>
MEASurement<m>:RESult:LABorder? <MeasType>

Defines the layout of the labels.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<FrameType>	NOFRAME | UNDERLINE | FULL **NOFRAME** No frame **UNDERLINE** The label is underlined. **FULL** The label is surrounded by a frame.

Parameters for setting and query:

<MeasType>	CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR For other measurement types, this command returns an error. **PLISt** Peaklist

---

MEASurement<m>:RESult:SHFRequency <MeasType>, <State>
MEASurement<m>:RESult:SHFRequency? <MeasType>

Includes the frequency of the detected peak in the diagram labels (if `MEASurement<m>:RESult:LABorder`=`ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<MeasType>	CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR For other measurement types, this command returns an error. **PLISt** Peaklist

Example:

Display labels.
```
MEAS:RES:SHL PLIS,ON
```
Show frequency in labels.
```
MEAS:RES:SHFR PLIS,ON
```
Query the type of labels for peak lists.
```
MEAS:RES:SHFR? PLIS
//Result: ON
```

MEASurement<m>:RESult:SHLabels <MeasType>, <State>
MEASurement<m>:RESult:SHLabels? <MeasType>

Defines whether a description (label) is displayed for each detected peak in the spectrum diagram.

The layout of the label is defined by `MEASurement<m>:RESult:LABorder`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<MeasType>	CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR For other measurement types, this command returns an error. **PLISt** Peaklist

Example: Display labels.

```
MEAS:RES:SHL PLIS,ON
```

MEASurement<m>:SPECtrum:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for spectrum measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..10 Number of spectrum measurement type, see Table 20-7.

Parameters:

<ValidRange>	ILIMit | ULIMit | LLIMit | OLIMit **ILIMit** Inside (within) limit; between the upper and lower limit values **ULIMit** Upper limit; above the upper limit value **LLIMit** Lower limit; below the lower limit value **OLIMit** Outside limit; above the upper limit or below the lower limit values *RST: ILIMit

---

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..10 Number of spectrum measurement type, see Table 20-7.

Parameters:

<LowerLimit>	Range:	-100 to 100
<UpperLimit>	Increment:	10E-6
	*RST:	0

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..10 Number of spectrum measurement type, see Table 20-7.

Parameters:

<LowerMargin>	Range:	-100 to 100
<UpperMargin>	Increment:	10E-6
	*RST:	0

20.12.6 Histograms

See also: Chapter 20.16.5, "Waveform Histogram Export to File", on page 1484

20.12.6.1 Histogram Display

LAYout:HISTogram:ADD <HistogramName>, <Source>, <XStart>, <XStop>, <YStart>, <YStop>, <Relative>, <Orientation>

Defines and displays a new histogram for the specified source.

Note: To define the mode of the histogram (vertical or horizontal), use the `LAYout:HISTogram:MODE` command.

Setting parameters:

<HistogramName>	String defining the histogram name which is used to refer to the histogram by other functions.
<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Data source of the histogram, see Chapter 20.4.2, "Waveform Parameter", on page 1173
<XStart>	Defines the start value of the x-value range.
<XStop>	Defines the stop value of the x-value range.
<YStart>	Defines the start value of the y-value range.
<YStop>	Defines the stop value of the y-value range.
<Relative>	ON | OFF Defines whether relative or absolute values are used for the value range definition.
<Orientation>	VERTical | HORizontal
Example:	See "Creating and Reading Histograms" on page 1158
Usage:	Setting only

LAYout:HISTogram:SOURce <HistogramName>,<Source>
LAYout:HISTogram:SOURce? <HistogramName>

Defines the source of the histogram. Any analog input signal, math or reference waveform and measurement can be selected.

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Waveform source of the histogram, see Chapter 20.4.2, "Waveform Parameter", on page 1173. If a measurement is the histogram source, the density distribution of the results of the main measurement is displayed.

Parameters for setting and query:

<HistogramName>	String parameter

LAYout:HISTogram:MODE <HistogramName>,<Mode>
LAYout:HISTogram:MODE? <HistogramName>

Defines or queries the type of histogram.

Parameters:

<Mode>	VERTical | HORizontal **VERTical** Amplitude histogram (horizontal bars across amplitude) **HORizontal** Time or frequency histogram (vertical bars over time/frequencies) *RST: VERTical

Parameters for setting and query:

<HistogramName>	The name of the histogram as defined using `LAYout:HISTogram:ADD` on page 1366.

LAYout:HISTogram:HORZ:MODE <HistogramName>,<Mode>
LAYout:HISTogram:HORZ:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode>	ABS | REL *RST: ABS

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:HORZ:ABSolute:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:HORZ:ABSolute:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:HORZ:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:HORZ:RELative:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:HORZ:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:HORZ:RELative:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:MODE <HistogramName>,<Mode>
LAYout:HISTogram:VERTical:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:VERTical:ABSolute:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:VERTical:ABSolute:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:VERTical:RELative:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<RelativeStart>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:VERTical:RELative:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:RESet <HistogramName>

Resets the values to begin a new histogram.

Setting parameters:
<HistogramName>

Usage: Setting only

LAYout:HISTogram:REMove <Name>

Removes the specified histogram.

Setting parameters:
<Name>

Usage: Setting only

20.12.6.2 Histogram Measurement

This chapter lists commands to set up measurements on histograms.

Note that the R&S RTO performs histogram measurements on the main measurement type. Additional measurement types are not considered.

See also: "Creating and Reading Histograms" on page 1158.

The following table lists the <MeasType> parameter values with a short description.

In addition, the meas type suffixes are listed, which are required in limit check remote commands.

For a detailed description, see Table 7-7.

Table 20-8: Histogram measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
WCOunt	Waveform count	Number of acquisitions (waveforms) the histogram is based on	1
WSAMples	Waveform samples	Number of samples from the most recent acquisition included in the current histogram	2
HSAMples	Histogram samples	Number of samples from all acquisitions included in the current histogram	3
HPEak	Histogram peak	Maximum sample value in the histogram	4
PEAK	Peak value	Signal value at the histogram peak	5
UPEakvalue	Upper peak value	Signal value at the maximum sample value in the upper half of the histogram	6
LPEakvalue	Lower peak value	Signal value at the maximum sample value in the lower half of the histogram	7
HMAXimum	Maximum	Highest signal value with a probability > 0	8
HMINimum	Minimum	Lowest signal value with a probability > 0	9
MEDian	Median	Signal value for which half the samples lie above, the other half below in the histogram	10
MAXMin	Max - Min	Range of signal values with a probability > 0	11
HMEan	Mean	Weighted arithmetic average of the histogram	12
HSTDdev	σ (S-dev)	Standard deviation of the sample numbers	13
M1STddev	Mean ±σ	Range between (mean value + standard deviation) and (mean value - standard deviation)	14
M2STddev	Mean ±2*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	15
M3STddev	Mean ±3*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	16
MKPositive	Marker + Probability %	Marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.	17
MKNegative	Marker - Probability %	Marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.	18

MEASurement<m>:HISTogram:SELect <HistogramName>

Selects the histogram on which the measurement is based.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<HistogramName>	String with the name of the histogram

Example:	See "Creating and Reading Histograms" on page 1158

MEASurement<m>:HISTogram:PROBability:TYPE <Marker>

Defines the marker reference in the probability domain.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Marker> PEAK | UPPK | LWPK | MAXimum | MINimum | MEDian | MEAN

PEAK
The y-value with the maximum sample value in the histogram

UPPK
The y-value at the maximum sample value in the upper half of the histogram

LWPK
The y-value at the maximum sample value in the lower half of the histogram

MAXimum
The highest y-value with a probability > 0

MINimum
The lowest y-value with a probability > 0

MEDian
The y-value for which half the samples lie above, the other half below in the histogram

MEAN
The weighted arithmetic average of the histogram

*RST: PEAK

MEASurement<m>:HISTogram:PROBability:LIMit <Limit>

Defines a range around the probability marker.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Limit>	Range: 0 to 100 Increment: 10 *RST: 10 Default unit: %

MEASurement<m>:HISTogram:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for histogram measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..18 Number of histogram measurement type, see Table 20-8.

Parameters:

<ValidRange>	ILIMit | ULIMit | LLIMit | OLIMit **ILIMit** Inside (within) limit; between the upper and lower limit values **ULIMit** Upper limit; above the upper limit value **LLIMit** Lower limit; below the lower limit value **OLIMit** Outside limit; above the upper limit or below the lower limit values *RST: ILIMit

---

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

<n>	1..18 Number of histogram measurement type, see Table 20-8.

Parameters:

<UpperLimit>	Range: -100 to 100 Increment: 10E-6 *RST: 0

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..18 Number of histogram measurement type, see Table 20-8.

Parameters:

<UpperMargin>	Range: -100 to 100 Increment: 10E-6 *RST: 0

20.12.7 Display

MEASurement<m>:DISPlay:LEVels <DisplayLevels>

If enabled, the reference levels used for the measurement are displayed in the diagram.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<DisplayLevels>	ON | OFF *RST: OFF

MEASurement<m>:DISPlay:RESults <DisplayResult>

If enabled, the intermediate result lines required to obtain the measurement result (e.g. signal thresholds) are displayed in the measurement diagram.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<DisplayResult>	ON | OFF *RST: OFF

MEASurement<m>:DISPlay:STYLe <DisplayStyle>

Selects the style in which the measurement waveform is displayed.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<DisplayStyle>	LINE | MARKer **LINE** The individual data points are connected by a line. **MARKer** Only the individual data points are displayed as markers. *RST: LINE

MEASurement<m>:DISPlay:HISTogram <DispHistg>

Displays a histogram for the source of the selected measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<DispHistg>	ON | OFF *RST: OFF

20.12.8 Limit check

MEASurement<m>:LCHeck <LimitCheckState>

Defines the type of the limit check that can run together with the measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<LimitCheckState> OFF | LIMit | LMARgin

OFF
No limit check.

LIMit
Only limits are checked.

LMARgin
Limits and margins are checked.

*RST: OFF

20.12.9 Statistics and Long-term Measurements

See also: Chapter 20.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1485.

MEASurement<m>:STATistics[:ENABle] <StatisticsState>

Enables statistics calculation for the measurement.

For details on the statistics results, see "Statistics" on page 355.

Suffix:

<m>	See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<StatisticsState>	ON | OFF *RST: OFF

MEASurement<m>:STATistics:HISTogram <ShowHistogram>

Displays a histogram of the statistical results. Enabling the histogram enables also the calculation and display of statistics for the measurement results if statistics were disabled. the histogram shows the cumulative occurence distribution of mean measurement results in a graphic.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ShowHistogram>	ON | OFF *RST: OFF

MEASurement<m>:STATistics:HBINs <HistogramBins>

Sets the number of bins - the number of vertical bars that build the histogram.

If `MEASurement<m>:VERTical:CONT` is ON, the instrument determines the number of bins automatically based on the time base, the current measurements, and other settings.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<HistogramBins>	Range: 2 to 1000 Increment: 10 *RST: 1000

Options: FW 2.50

MEASurement<m>:STATistics:MODE <ResetMode>

Defines when the statistics for long term measurements are reset.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ResetMode>	TIME | WFMS | MEAS **TIME** Sets one long term measurement point after the time defined using `MEASurement<m>:STATistics:RTIMe`. **WFMS - Waveforms** Sets one long term measurement point after a number of acquired waveforms defined using `MEASurement<m>:STATistics:RCOunt`. **MEAS** Sets one long term measurement point after a number of measurement results. *RST: TIME

MEASurement<m>:STATistics:RCOunt <RstWfmCnt>

Defines the number of measured waveforms from which one point of the long term measurement is created (reset of statistics).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<RstWfmCnt>	Range:	1 to 65535
	Increment:	10
	*RST:	1000

MEASurement<m>:STATistics:RMEascount <RstMeasCnt>

Defines the number of measurement results from which one point of the long term measurement is created.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to `MEAS`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<RstMeasCnt>	Range:	1 to 65535
	Increment:	10
	*RST:	1000

MEASurement<m>:STATistics:RTIMe <ResetTime>

Defines the time or period after which the statistics are reset.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ResetTime>

Range: 0.1 to 2.14748E+9
Increment: 1E-3
*RST: 0.2
Default unit: s

MEASurement<m>:STATistics:RESet

Resets the histogram, the long term measurement and the statistics.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Event

MEASurement<m>:VERTical:CONT <AutoScale>

If enabled, automatic vertical scaling is performed whenever the waveform does not fit in the diagram during the long term measurement period.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<AutoScale> ON | OFF

*RST: ON

Firmware/Software: V 1.50

MEASurement<m>:VERTical:AUTO

Performs an automatic scaling once so that the scaling is adapted to the current measurement results. Available only for long term measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Event

MEASurement<m>:VERTical:OFFSet <VerticalOffset>

Defines a vertical offset for the long term measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<VerticalOffset>	Range:	-100E+24 to 100E+24
	Increment:	1E-6
	*RST:	0
	Default unit:	div

MEASurement<m>:VERTical:SCALe <VerticalScale>

Defines the vertical scaling per division, so that the scaling can be adapted automatically during the long term measurement period.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<VerticalScale>	Range:	10E-24 to 100E+24
	Increment:	10E-6
	*RST:	0.5
	Default unit:	V/div

MEASurement<m>:LTMeas[:STATe] <ShowDiagram>

Enables long term measurement for a defined number of measurement points (see `MEASurement<m>:LTMeas:COUNt` on page 1380) or a specified time (see`MEASurement<m>:LTMeas:TIME` on page 1381).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ShowDiagram>	ON | OFF	
	*RST:	OFF

MEASurement<m>:LTMeas:COUNt <MeasCount>

Defines the total number of points to be measured during the long term measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<MeasCount>	Range:	1000 to 200000
	Increment:	10
	*RST:	1000

MEASurement<m>:LTMeas:TIME <MeasurementTime>

Defines the total duration of the long term measurement.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to "Time".

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<MeasurementTime>	Range:	0.01 to 2.14748E+9
	Increment:	1
	*RST:	200
	Default unit:	s

20.12.10 Track and Trend

MEASurement<m>:TRACk[:STATe] <State>

Enables the track functionality and displays the track.

The track functionality requires at least one option, see "Enable (Track)" on page 359.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF	
	*RST:	OFF

MEASurement<m>:TRACk:DATA:HEADer?

Returns the header of the track.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
Usage:	Query only

MEASurement<m>:TRACk:DATA:STYPe?

Returns the data type: TRK (track).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
Usage:	Query only

MEASurement<m>:TRACk:DATA[:VALues]?

Returns the data of track points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
Usage:	Query only

20.12.11 Gating

MEASurement<m>:GATE[:STATe] <State>

Considers the gating settings of the source waveform for the measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF	
	*RST:	OFF

MEASurement<m>:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

MEASurement<m>:GATE:ABSolute:STARt <Start>
MEASurement<m>:GATE:ABSolute:STOP <Stop>

Define the absolute start and end values for the gate.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Start> <Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

MEASurement<m>:GATE:RELative:STARt <RelativeStart>
MEASurement<m>:GATE:RELative:STOP <RelativeStop>

Define the relative start and end values for the gate, respectively.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<RelativeStart> <RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

MEASurement<m>:GATE:NOISe <NoiseEvalArea>

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<NoiseEvalArea>	UPPer | LOWer *RST: LOWer

MEASurement<m>:GATE:CURSor <Cursorset>

Selects the cursor set to be used for measurement gating. The gate area is defined by the cursor lines.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Cursorset>	CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4 CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4 *RST: CURSOR1

MEASurement<m>:GATE:CCOupling <CursorCoupling>

Enables the cursor coupling for automatic measurements.

Select the cursor set to be used with `MEASurement<m>:GATE:CURSor`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<CursorCoupling>	ON | OFF *RST: OFF

MEASurement<m>:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

If enabled, define the zoom area to be used as gate with `MEASurement<m>:GATE:ZDIagram`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

MEASurement<m>:GATE:ZDIagram <ZoomDiagram>

If `MEASurement<m>:GATE:ZCOupling` is enabled, the gate area is defined identically to the zoom area for the selected zoom diagram.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<ZoomName>	String with the name of the zoom diagram

Parameters for setting and query:

<DiagramName>	String with the name of the diagram on which the zoom is based

Example:

```
:MEASurement:GATE:ZDIagram "Diagram1","Zoom1"
```

20.12.12 Event Actions

MEASurement<m>:ONViolation:BEEP <Beep>

Generates a beep sound for the specified event.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Beep>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOACtion

---

MEASurement<m>:ONViolation:ACQStop <StopAcq>

Stops data acquisition for the specified event.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<StopAcq>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOACtion

---

MEASurement<m>:ONViolation:PRINt <Print>

Prints a screenshot including the measurement results to the printer defined using `SYSTem:COMMunicate:PRINter:SELect<1..2>` for the specified event.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Print>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOACtion

---

MEASurement<m>:ONViolation:WFMSave <SaveWfm>

Saves the waveform data.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<SaveWfm>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOACtion

---

MEASurement<m>:ONViolation:REPort <Report>

Creates and saves a report of the current settings and results.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<Report>	NOACtion | SUCCess | VIOLation	
	See Chapter 20.4.5, "Event Parameter", on page 1174	
	*RST:	NOACtion

MEASurement<m>:ONViolation:TRIGgerout <TriggerOutPulse>

Creates a trigger out pulse on limit or margin violation or on successful completion of themeasurement.

Suffix:

<m>	1..10

Parameters:

<TriggerOutPulse>	NOACtion | SUCCess | VIOLation	
	*RST:	NOACtion

20.12.13 Reference Levels

20.12.13.1 General Reference Level Settings

REFLevel<m>:LDETection <LevelDetection>

Defines whether the reference level is configured manually or automatically.

For automatic configuration, select the signal level to be used (see `REFLevel<m>:AUTO:MODE` on page 1390).

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<LevelDetection>	AUTO | MANual *RST: AUTO

Example: `REFLevel2:LDETection MANual`
Sets manual level configuration for Ch1Wfm1. C1W1 corresponds to suffix number 2.

Example: See: Chapter 20.3.2.2, "Setting Reference Levels", on page 1157

REFLevel<m>:LMODe <LevelMode>

Defines whether the reference is configured using absolute or relative values.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<LevelMode>	ABS | REL *RST: REL

Example: `REFLevel2:LMODe ABS`
Sets definition of reference levels to absolute values for Ch1Wfm1. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using relative values" on page 1157

REFLevel<m>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:	
<RelativeLevels>	FIVE | TEN | TWENty | USER **FIVE** 5/50/95 **TEN** 10/50/90 **TWENty** 20/50/80 **USER** Set the reference levels to individual values with `REFLevel<m>:RELative:LOWer`, `REFLevel<m>:RELative:MIDDle`, and `REFLevel<m>:RELative:UPPer`. *RST: TEN
Example:	`REFL2:REL:MODE FIVE` Reference levels for Ch1Wfm1: Lower reference level = 5% of high signal level, middle reference level = 50% of high signal level, upper reference level = 95% of high signal level
Example:	See: "Manual reference level definition using relative values" on page 1157

REFLevel<m>:USRLevel <UserLevel>

Defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

Suffix:	
<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:	
<UserLevel>	USIGnal | UREF **USIGnal** The high and low signal levels are defined by the user. **UREF** The reference levels are defined by the user. *RST: USIGnal
Example:	`REFLevel2:USRLevel UREF` Sets user-defined reference levels to be used for Ch1Wfm1. C1W1 corresponds to suffix number 2.
Example:	See: "Manual reference level definition using absolute values" on page 1158

20.12.13.2 Automatic Configuration

REFLevel<m>:AUTO:MODE <AutoLevelMode>

Defines the high and low signal levels from which the reference levels are derived.

This setting is only available for automatic reference level mode (see `REFLevel<m>:LDETection` on page 1387).

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:	
<AutoLevelMode>	AUTO | PPRobability | MPRobability | ABSolutepeak | UPLM | UMLP | UALM | UMLA **AUTO** Auto select absolute probability: most suitable signal levels for the selected measurement **PPRobability** Peak probability: signal levels with the highest probability value **MPRobability** Mean probability: signal levels with mean probability **ABSolutepeak** Absolute peak: absolute peak signal levels **UPLM** Upper absolute peak, lower mean probability: high signal level is the upper absolute peak, low signal level is the level with the mean probability in the lower half of the histogram. **UMLP** Upper mean probability, lower absolute peak: high signal level is the level with mean probability in the upper half of the histogram, low signal level is the lower absolute peak. **UALM** Upper absolute peak, lower manual value: high signal level is the maximum result value of the amplitude measurement; low signal level is manually set using `REFLevel<m>:RELative:LOWer`. **UMLA** Upper manual, lower absolute peak: The upper signal level is set manually using `REFLevel<m>:RELative:UPPer`. The lower level is the minimum result value of the amplitude measurement. *RST: AUTO
Example:	`REFLevel5:AUTO:MODE PPRobability` Sets the automatic reference level mode for Ch2Wfm1 to "Peak probability". C2W1 corresponds to suffix number 5.
Example:	See: "Automatic level detection, peak probability" on page 1158

REFLevel<m>:AUTO[:STATe] <HistgAveraging>

Enables averaging over several histograms to determine the reference levels. The number of histograms to consider is defined using `REFLevel<m>:AUTO:COUNt`.

This function is only available in automatic reference level mode (see `REFLevel<m>:LDETection` on page 1387).

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<HistgAveraging>	ON | OFF *RST: OFF

REFLevel<m>:AUTO:COUNt <Weight>

Defines the number of histograms from which the average is calculated.

Prerequisites:

- `REFLevel<m>:AUTO[:STATe]` is set to `ON`
- `REFLevel<m>:LDETection` on page 1387 is set to `AUTO`

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<Weight>	Range: 2 to 128 Increment: 2 *RST: 128

20.12.13.3 Manual Configuration

REFLevel<m>:ABSolute:HIGH <SignalHigh>

The signal value that represents a high level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<SignalHigh>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example: `REFLevel2:ABSolute:HIGH 0.015`
Sets the high signal level for Ch1Wfm1 to 15 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:LOW <SignalLow>

The signal value that represents a low level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<SignalLow>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example: `REFLevel2:ABSolute:Low 0.0015`
Sets the low signal level forCh1Wfm1 to 1.5 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:TDIStance <TopDistance>

The distance between the high signal level and the upper reference level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<TopDistance>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example: `REFLevel2:ABSolute:TDIStance 0.0002`
Sets the top distance for Ch1Wfm1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 1158

REFLevel<m>:ABSolute:BDIStance <BottomDistance>

The distance between the lower reference level and the low signal value.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<BottomDistance>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example: `REFLevel2:ABSolute:BDIStance 0.0002`
Sets the bottom distance for Ch1Wfm1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 1158

REFLevel<m>:ABSolute:MLEVel <MiddleLevel>

For user signal level selection, the level is the middle level between high and low signal level. The value is adjusted automatically if you change the high or low signal levels. Vice versa, if you change the middle level, the high and low signal levels are adjusted.

For user reference level selection, the level is the middle level between upper and lower reference level. The value is adjusted automatically if you change the upper or lower reference levels. Vice versa, if you change the middle level, the upper and lower reference levels are adjusted.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the reference level, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<MiddleLevel>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example: `REFLevel2:ABSolute:MLEVel 0.05`
Sets the middle signal level for Ch1Wfm1 to 50 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 1158

REFLevel<m>:ABSolute:ULEVel <UpperLevel>

The upper reference level, required e.g. to determine a rise.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<UpperLevel>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example:

`REFLevel2:ABSolute:ULEVel 0.01`

Sets the upper reference level for Ch1Wfm1 to 10 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 1158

REFLevel<m>:ABSolute:LLEVel <LowerLevel>

The lower reference level, required e.g. to determine a fall.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<LowerLevel>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Example:

`REFLevel2:ABSolute:LLEVel 0.001`

Sets the lower reference level for Ch1Wfm1 to 1 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 1158

REFLevel<m>:RELative:UPPer <UppRefLevRel>

Sets the upper relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<UppRefLevRel>	Percentage of the high signal level. Range: -100 to 200 Increment: 1 *RST: 90 Default unit: %

Example: `REFLevel8:RELative:LOWer 85`

Sets the upper reference level for Ch3Wfm1 to 85 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 1157

REFLevel<m>:RELative:MIDDle <MidRefLevRel>

Sets the middle relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<MidRefLevRel>	Percentage of the high signal level. Range: -100 to 200 Increment: 1 *RST: 50 Default unit: %

Example: `REFLevel8:RELative:MIDDle 50`

Sets the middle reference level for Ch3Wfm1 to 50 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 1157

REFLevel<m>:RELative:LOWer <LowRefLevRel>

Sets the lower relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<LowRefLevRel>	Percentage of the high signal level. Range: -100 to 200 Increment: 1 *RST: 10 Default unit: %

Example: `REFLevel8:RELative:LOWer 15`
Sets the lower reference level for Ch3Wfm1 to 15 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 1157

20.12.13.4 Hysteresis

REFLevel<m>:RELative:HYSTeresis <Hysteresis>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<Hysteresis>	Range: 0 to 50 Increment: 1 *RST: 10 Default unit: %

20.12.13.5 Tube

REFLevel<m>:RELative:OTUBe <OuterDist>

Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<OuterDist>	Range: 0 to 100 Increment: 1 *RST: 10 Default unit: %

REFLevel<m>:RELative:ITUBe <InnerDist>

Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<InnerDist>	Range: 0 to 50 Increment: 1 *RST: 0 Default unit: %

REFLevel<m>:ABSolute:TOTube <TopOuterDist>

Defines an area above the high signal level which is still considered to be high level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<TopOuterDist>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

REFLevel<m>:ABSolute:TITube <TopInnerDist>

Defines an area beneath the high signal level which is still considered to be high level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<TopInnerDist>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

REFLevel<m>:ABSolute:BITube <BottomInnerDist>

Defines an area above the low signal level which is still considered to be low level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<BottomInnerDist>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

REFLevel<m>:ABSolute:BOTube <BottomOuterDist>

Defines an area beneath the low signal level which is still considered to be low level.

Suffix:

<m>	1..103 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 1171.

Parameters:

<BottomOuterDist>	Range: 0 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

20.12.13.6 Results

MEASurement<m>:REFLevel:RESult:LOWer?
MEASurement<m>:REFLevel:RESult:MIDDle?
MEASurement<m>:REFLevel:RESult:UPPer?

Return the lower, middle, and upper reference level, respectively.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<Lower> <Middle>	Range:	-100E+24 to 100E+24
<Upper>	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:SIGLow?
MEASurement<m>:REFLevel:RESult:SIGHigh?

Return the signal value that represents a low or high level, respectively.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<SignalLow>	Range:	-100E+24 to 100E+24
<SignalHigh>	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:BINNer?

Returns the area above the low signal level which is still considered to be low level.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<BottomInner>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:BOUTer?

Returns the area beneath the low signal level which is still considered to be low level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<BottomOuter>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:TINNer?

Returns the area beneath the high signal level which is still considered to be high level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<TopInner>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:TOUTer?

Returns the area above the high signal level which is still considered to be high level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1333.

Return values:

<TopOuter>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

20.13 Spectrum Analysis

20.13.1 Basic FFT

CALCulate:MATH<m>:FFT:LOGScale <XAxisMode>

Defines the scaling method for the frequency (x-)axis of the spectrogram.

This command is only available if the R&S RTO-K18 option is installed.

Suffix:

<m>	1..4

Parameters:

<XAxisMode>	LIN | LOG **LOG** Logarithmic scaling **LIN** Linear scaling *RST: LIN

CALCulate:MATH<m>:FFT:STARt <StartFreq>

Defines the start frequency of the displayed frequency span.

Suffix:

<m>	1..4 math waveform

Parameters:

<StartFreq>	start frequency Range: 0 to 5E+9 Increment: 1 *RST: 2E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:STOP <StopFreq>

Defines the stop frequency of the displayed frequency span.

Suffix:

<m>	1..4 math waveform

Parameters:

<StopFreq>	stop frequency Range: 0 to 5E+9 Increment: 1 *RST: 2E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:CFRequency <CenterFreq>

Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the `CALCulate:MATH<m>:FFT:SPAN` command.

Suffix:

<m>	1..4 math waveform

Parameters:

<CenterFreq>	center frequency Range: 0 to 2E+12 Increment: 1 *RST: 2.5E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:FULLspan

Performs FFT calculation for the full frequency span.

Suffix:

<m>	1..4 math waveform

Usage: Event

CALCulate:MATH<m>:FFT:SPAN <FreqSpan>

The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the `CALCulate:MATH<m>:FFT:CFRequency` command.

Suffix:

<m>	1..4 Math waveform

Parameters:

<FreqSpan>	Frequency span Range: 1 to 4E+12 Increment: 1 *RST: 5E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted?

Queries the effective resolution bandwidth.

Suffix:

<m>	1..4 Math waveform

Return values:

<AdjResBW>	effective resolution bandwidth Range: 0.01 to 2E+12 *RST: 0 Default unit: Hz

Usage: Query only

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO <State>

Couples the frequency span to the RBW.

Suffix:

<m>	1..4 math waveform

Parameters:

<State>	ON | OFF *RST: ON

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

This command defines the ratio of span (Hz) / resolution bandwidth (Hz).

Suffix:

<m>	1..4 math waveform

Parameters:

<SpanRBWRatio>	ratio span / resolution bandwidth Range: 1 to 1000 Increment: 1 *RST: 100

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] <ResolutionBW>

This command defines the resolution bandwidth.

Suffix:

<m>	1..4 math waveform

Parameters:

<ResolutionBW>	resolution bandwidth Range: 0.01 to 2E+6 Increment: 0.01 *RST: 2E+6 Default unit: Hz

---

CALCulate:MATH<m>:FFT:WINDow:TYPE <WindowType>

Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTO to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Suffix:

<m>	1..4 math waveform

Parameters:

<WindowType> RECTangular | HAMMing | HANN | BLACkharris | GAUSsian | FLATTOP2 | FLATtop2 | KAISerbessel

RECTangular
The rectangular window has the best frequency resolution, but a poor amplitude accuracy and is recommended for separating two tones with almost equal amplitudes and a small frequency distance.

HAMMing
The Hamming window is bell shaped and has a good frequency resolution and fair amplitude accuracy. It is recommended for frequency response measurements as well as sine waves, periodic signals and narrow-band noise

HANN
The Hann window is bell shaped and has a slightly worse frequency resolution but smaller sidelobe level than the Hamming window. The applications are the same.

BLACkharris
The Blackman window is bell shaped and has a poor frequency resolution, but very good amplitude accuracy. It is recommended mainly for signals with single frequencies to detect harmonics.

GAUSsian
Good frequiency resolution and best magnitude resolution, recommended for weak signals and short duration

FLATTOP2 = FLATtop2
The flattop window has a poor frequency resolution, but the best amplitude accuracy and the sharpest side lobe. It is recommended for accurate single-tone amplitude measurements.

KAISerbessel
The Kaiser-Bessel window has a fair frequency resolution and good amplitude accuracy, and a very high sidelobe level. It is recommended for separating two tones with differing amplitudes and a small frequency distance.

*RST: BLACkharris

Firmware/Software: Version 3.35 and higher: Use FLATTOP2 or FLATtop2 instead of FLAT2

CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics <Arithmetics>

The arithmetic mode defines how the final FFT result is calculated from the individual frame results.

Suffix:

<m>	1..4 Selects the math waveform.

Parameters:

<Arithmetics>	OFF | ENVelope | AVERage | RMS | MINHold | MAXHold See "FFT Segment Arithmetics" on page 383 *RST: OFF

CALCulate:MATH<m>:FFT:FRAMe:COVerage?

Due to the restriction of the number of frames (see `CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1407), the waveform may only be analyzed partially. This command queries the percentage of the trace that was analyzed, i.e. which part of the trace was included in the frame calculation.

Suffix:

<m>	1..4 math waveform

Return values:

<FrameCoverage>	Range: 0 to 100 *RST: 100 Default unit: %

Usage: Query only

CALCulate:MATH<m>:FFT:FRAMe:MAXCount <MaxFrameCount>

Restricts the maximum number of frames to be calculated. Due to the other parameter settings, the required number of frames may become very high, thus slowing performance. By restricting the number of frames, you can avoid performance loss without changing the other parameters.

Suffix:

<m>	1..4 math waveform

Parameters:

<MaxFrameCount>	Range: 1 to 10000 Increment: 10 *RST: 1000

CALCulate:MATH<m>:FFT:FRAMe:OFACtor <OverlapFactor>

Defines the minimum factor by which two neighboring frames overlap. If the required number of frames to cover the input values allows for more overlap, the factor is increased.

The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Suffix:

<m>	1..4 math waveform

Parameters:

<OverlapFactor>	Range:	0 to 90
	Increment:	1
	*RST:	50
	Default unit:	%

CALCulate:MATH<m>:FFT:GATE:COUPling <GateRBWCoupling>

Defines the behaviour of the record length or RBW value in dependancy to the other FFT parameters.

See also:

- "Record Length/RBW Coupling" on page 386
- Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 371

Suffix:

<m>	1..4 math waveform

Parameters:

<GateRBWCoupling> LENGth | RBW

LENGth
The record length remains constant. If not enough samples are available for the selected RBW, the RBW will be decreased.

RBW
The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

*RST: RBW

TIMebase:RACTime?

Queries the required acquisition time. If FFT gating is used and the resolution BW is set to constant, record length can be extended to acquire the required number of samples. In this case, the required acquisition time differs from the adjusted acquisition time (`TIMebase:RANGe`).

Return values:

<RqrdAcqTime>	Required acquisition time for FFT Range: 125E-12 to 100E+3 *RST: 0.5 Default unit: s

Usage: Query only

CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt <Start>

Defines the starting value for the gate.

Suffix:

<m>	1..4 math waveform

Parameters:

<Start>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01

CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP <Stop>

Defines the end value for the gate.

Suffix:

<m>	1..4 math waveform

Parameters:

<Stop>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01

CALCulate:MATH<m>:FFT:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m>	1..4 math waveform

Parameters:

<Mode>	ABS | REL *RST: ABS

CALCulate:MATH<m>:FFT:GATE:RELative:STARt <RelativeStart>

Defines the starting value for the gate in percent.

Suffix:

<m>	1..4 math waveform

Parameters:

<RelativeStart>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %

CALCulate:MATH<m>:FFT:GATE:RELative:STOP <RelativeStop>

Defines the end value for the gate in percent.

Suffix:

<m>	1..4 math waveform

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

CALCulate:MATH<m>:FFT:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

Suffix:

<m>	1..4 math waveform

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:GATE[:STATe] <State>

Enables FFT gating.

Suffix:

<m>	1..4 math waveform

Parameters:

<State>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:MAGNitude:LEVel <VerticalMax>

Defines the reference level for dB scaling.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalMax>	Range: -100E+24 to 1E+15 Increment: 0.01 *RST: 0 Default unit: div

---

CALCulate:MATH<m>:FFT:MAGNitude:RANGe <Range>

Defines the vertical value range in spectrum mode.

Suffix:

<m>	1..4 math waveform

Parameters:

<Range>	Range: 1 to 500 Increment: 1 *RST: 100 Default unit: dB

CALCulate:MATH<m>:FFT:MAGNitude:SCALe <MagnitudeScale>

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impendance.

For details on the available scaling modes, see "Magnitude unit" on page 387.

Suffix:

<m>	1..4 math waveform

Parameters:

<MagnitudeScale>

LINear | DBM | DB | DBUV | DBMV | DBV | DBPS | DBNS | DBUS | DBMS | DBS | DBHZ | DBKHZ | DBKHz | DBMHZ | DBMHz | DBGHZ | DBGHz | DBA | DBMA | DBUA

LINear
Linear scaling; displays the RMS value of the voltage

*RST: DBM

Table 20-9: Logarithmic scaling values

DBM	dBm
DB	dB (related to reference level)
DBUV	dBµV
DBMV	dBmV
DBV	dBV

DBPS	dBps
DBNS	dBns
DBUS	dBµs
DBMS	dBms
DBS	dBs
DBHZ	dBHz
DBKHZ = DBKHz	dBkHz
DBMHZ = DBMHz	dBMHz
DBGHZ = DBGHz	dBGHz
DBA	dBA
DBMA	dBmA
DBUA	dBµA

CALCulate:MATH<m>:FFT:PHASe:SCALe <PhaseScale>

Defines the scaling unit for phase display.

Suffix:

<m>	1..4 math waveform

Parameters:

<PhaseScale>	DEGRees | RADians	
	*RST:	DEGRees

CALCulate:MATH<m>:FFT:PHASe:SUPPression <Suppression>

Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value (see `CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 1412).

Suffix:

<m>	1..4 math waveform

Parameters:

<Suppression>	ON | OFF	
	*RST:	OFF

CALCulate:MATH<m>:FFT:PHASe:THReshold <SupprThres>

Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if `CALCulate:MATH<m>:FFT:PHASe:SUPPression` is set to "ON".

Suffix:

<m>	1..4 math waveform

Parameters:

<SupprThres>

Range: -180 to 180
Increment: 0.1
*RST: 0
Default unit: dBm

CALCulate:MATH<m>:FFT:PHASe:UNWRap <Unwrap>

If enabled, phase shifts due to a limitation of the value range are eliminated.

Suffix:

<m>	1..4 math waveform

Parameters:

<Unwrap> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:COUPled:WITH<m2> <MathIndex>

Copies the current FFT settings of the selected math waveform (m) to the other selected math waveform (m2), and couples the two waveforms. This can be repeated for all math waveforms.

If any FFT setting for any of the coupled spectrums is changed, it is changed for all coupled spectrums.

Suffix:

<m>, <m2>	1..4 Math waveforms to be coupled. <m>, <m2> must be distinct

Parameters:

<MathIndex> ON | OFF

*RST: OFF

Example:

```
CALC:MATH1:FFT:COUP:WITH2 ON
```

Couples the math waveforms m1 and m2.

20.13.2 Waveform Data

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<SignalType>	SOUR | SPEC | CORR | MEAS | NONE SOURce = normal signal SPECtrum = FFT spectrum, specific math signal CORRelation = correlated signal, specific math signal MEAsurement = result of a measurement NONE = undefined Im GUI nicht vorhanden: XY = XY-signal SBUS = Serial bus

Usage: Query only

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 20-10: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:

<m>	1..4 Selects the math waveform.

Example:

```
CALC:MATH4:DATA:HEAD
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<Data>	List of values according to the format and content settings.

Usage: Query only

20.13.3 Spectrum Analysis (Option R&S RTO-K18)

In all `CALC:MATH<m>:FFT` commands, the suffix <m> selects the math waveform.

In all `CALC:MATH<m>:FFT:SPEC:TIM` commands, the suffix <m> selects the timeline.

CALCulate:MATH<m>:FFT:SPECtrogram:CMODe <ColorTableMode>

Selects the color table mode for the frequency analysis display.

Suffix:

<m>	1..4

Parameters:

<ColorTableMode>	INCI | AMPL **INCI** ("Incidence") The display color is set depending on the frequency of occurrence of a value. **AMPL** ("Amplitude") In the spectrogram and the frequency analysis display, the color is used to indicate the magnitude of the FFT signal. The higher the amplitude the higher the color in the assigned color table. *RST: INCI

CALCulate:MATH<m>:FFT:USEColtab <UseColorTable>

If enabled, the selected waveform is displayed according to its assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 113.

If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Suffix:

<m>	1..4

Parameters:

<UseColorTable>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:STATe <State>

Enables the spectrogram display for a math waveform.

Suffix:

<m>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition <Position>

Defines the position of one of the two possible time lines in a spectrogram. The time line must be enabled first, using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` command.

Suffix:

<m>	1..4
<n>	1..2

Parameters:

<Position>	The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings. Range: 0 to 4294967295 Increment: 1 *RST: 0

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe <State>

Enables one of two possible time lines in a spectrogram diagram. A time line marks a single waveform in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram.

The position of the time line is defined using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` command.

Suffix:

<m>	1..4
<n>	1..2

Parameters:

<State>	ON | OFF *RST: OFF

20.14 Mask Testing

20.14.1 Mask Test Definition

MTESt:ADD <MaskTestName>

Creates a new mask test definition with the specified name.

Setting parameters:

<MaskTestName>	String with the name of the mask test

Example: See Chapter 20.3.3.1, "Creating a user mask", on page 1160

Usage: Setting only

MTESt:REMove <MaskTestName>

Deletes the mask test definition with the specified name.

Setting parameters:

<MaskTestName>	String with the name of the mask test

Usage: Setting only

MTESt[:STATe] <MaskTestName>,<State>
MTESt[:STATe]? <MaskTestName>

Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, also due to the `MTESt:ONViolation:STOP` command, or if `MASK[:STATe]` is set to "OFF".

The coommand needs `*OPC` command synchronisation, see Chapter B.3, "Command Sequence and Synchronization", on page 2229.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

Example: `MTEST:STAT 'MyMask', ON; *OPC?`

See Chapter 20.3.3.1, "Creating a user mask", on page 1160

MTESt:RST

Clears all totals and results in all "Mask Test" result boxes.

Usage: Event

Firmware/Software: FW 1.35

MTESt:SOURce <MaskTestName>,<Source>
MTESt:SOURce? <MaskTestName>

Selects the waveform to be tested against the mask.

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Waveform to be tested, see Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:CONDition <MaskTestName>,<PassFailMode>
MTESt:CONDition? <MaskTestName>

Sets the first criteria for a failed test, the kind of hits to be considered for test evaluation. A test has failed if the number of sample hits or acquisition hits exceeds the limit defined by `MTESt:TOLerance`.

Parameters:

<PassFailMode>	SAMPles | ACQuisitions **SAMPles** Considers the number of samples that hit the mask. **ACQuisitions** Considers the number of acquisitions that contain at least one sample hit. How many samples hit the mask in that acquisition is not relevant. *RST: SAMPles

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:TOLerance <MaskTestName>,<ViolationCount>
MTESt:TOLerance? <MaskTestName>

Sets the second criteria for a failed test, the number of tolerable sample hits or acquisition hits. Use `MTESt:CONDition` to define which hits are considered for test evaluation.

Parameters:

<ViolationCount>	Range: 0 to 4000000000 Increment: 1 *RST: 0

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:CTYPe <MaskTestName>,<DefinitionType>
MTESt:CTYPe? <MaskTestName>

Sets the method of mask definition.

Parameters:

<DefinitionType>	USER | WFML | EYEMask | PROTocol **USER** The mask segments are created by entering the numerical x- and y-values of the mask points. See: Chapter 20.14.2, "Mask Definition: User Mask", on page 1420 **WFML** The mask is created from the envelope of an existing waveform. See: Chapter 20.14.3, "Mask Definition: Waveform Mask", on page 1426 **EYEMask** Mask for eye diagram testing. See: Chapter 20.21.6, "Eye Mask Testing", on page 2152. Requires jitter option R&S RTO-K12 *RST: USER

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:FILE:NAME <MaskTestName>, <Path>
MTESt:FILE:NAME? <MaskTestName>

Specifies a file to save the mask test.

Parameters:

<Path>	String containing path and file name, format .xml

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:FILE:SAVE <MaskTestName>

Saves the specified mask test. It contains the mask definition, defined actions and fail conditions.

Setting parameters:

<MaskTestName>	String with the name of the mask test
Usage:	Setting only

MTESt:FILE:OPEN <MaskTestName>

Loads the specified mask test to the instrument.

Setting parameters:

<MaskTestName>	String with the name of the mask test
Usage:	Setting only

MTESt:FILE:DELete <MaskTestName>

Deletes the specified mask test.

Setting parameters:

<MaskTestName>	String with the name of the mask test
Usage:	Setting only

20.14.2 Mask Definition: User Mask

The chapter contains commands required for the definition of user masks - `MTESt:CTYPe` is set to `USER`.

Segment and point indices

In remote control, the numbering of segments and points starts from 0. But in manual operation, the numbering starts from 1.

MTESt:SEGMent:STATe <MaskTestName>, <MaskSegmIdx>,<State>
MTESt:SEGMent:STATe? <MaskTestName>, <MaskSegmIdx>

Enables and disables the mask segment. Disabled segments are not considered by running tests.

Parameters:

<State>	ON | OFF *RST: ON

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

MTESt:SEGMent:ADD <MaskTestName>

Creates a new segment in the mask definition.

Setting parameters:

<MaskTestName>	String with the name of the mask test
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 1160
Usage:	Setting only

MTESt:SEGMent:COUNt? <MaskTestName>

Returns the number of segments in the mask definition

Query parameters:	
<MaskTestName>	String with the name of the mask test
Return values:	
<Count>	Number of segments
Usage:	Query only

MTESt:SEGMent:INSert <MaskTestName>, <MaskSegmIdx>

Inserts a new segment before the specified index in the mask definition.

Setting parameters:	
<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:REMove <MaskTestName>, <MaskSegmIdx>

Removes the specified segment from the mask definition.

Setting parameters:	
<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:REGion <MaskTestName>, <MaskSegmIdx>,<Region>
MTESt:SEGMent:REGion? <MaskTestName>, <MaskSegmIdx>

Defines the region of the segment that builds the mask.

Parameters:	
<Region>	UPPer | LOWer | INNer **UPPer** the segment points are connected to a line, the display area above this line is the mask segment **LOWer** the segment points are connected to a line, the display area below this line is the mask segment **INNer** the segment points form a closed geometrical shape, which is the mask segment *RST: INNer
Parameters for setting and query:	
<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 1160

MTESt:SEGMent:POINt:ADD <MaskTestName>, <MaskSegmIdx>

Adds a new point to the segment definition.

Setting parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 1160
Usage:	Setting only

MTESt:SEGMent:POINt:INSert <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Inserts a new point before the specified mask segment point.

Setting parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:POINt:REMove <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Removes the specified point from the mask segment.

Setting parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:POINt:COUNt? <MaskTestName>, <MaskSegmIdx>

Returns the number of defined points for the specified mask segment.

Query parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Usage:	Query only

MTESt:SEGMent:POINt:X <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>,<X>
MTESt:SEGMent:POINt:X? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Defines the x-value of the mask segment point.

Parameters:

<X>	Range: -100E+24 to 100E+24 Increment: 1E-6 *RST: 0 Default unit: s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 1160

MTESt:SEGMent:POINt:Y <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>,<Y>
MTESt:SEGMent:POINt:Y? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Defines the y-value of the mask segment point.

Parameters:

<Y>	Range: -100E+24 to 100E+24 Increment: 1E-6 *RST: 0 Default unit: V

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 1160

MTESt:SEGMent:RESCale:RECalculate <MaskTestName>, <MaskSegmIdx>

Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Setting parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:RESCale:XFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactor>
MTESt:SEGMent:RESCale:XFACtor? <MaskTestName>, <MaskSegmIdx>
MTESt:SEGMent:RESCale:YFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactor>
MTESt:SEGMent:RESCale:YFACtor? <MaskTestName>, <MaskSegmIdx>

Stretches or compresses the selected mask segment in horizontal (XFACtor) or vertical direction (YFACtor). The x- or y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<ExpansionFactor>	Range:	-100 to 100
	Increment:	1
	*RST:	1

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

MTESt:SEGMent:RESCale:XOFFset <MaskTestName>, <MaskSegmIdx>,<OffsetX>
MTESt:SEGMent:RESCale:XOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<OffsetX>	Range:	-50 to 50
	Increment:	1E-9
	*RST:	0
	Default unit:	s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

Firmware/Software: V 1.25

MTESt:SEGMent:RESCale:YOFFset <MaskTestName>, <MaskSegmIdx>,<OffsetY>
MTESt:SEGMent:RESCale:YOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<OffsetY>	Range: -1000 to 1000 Increment: 1E-6 *RST: 0 Default unit: V

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

20.14.3 Mask Definition: Waveform Mask

The chapter contains commands required for the definition of waveform masks - `MTESt:CTYPe` is set to `WFML`.

MTESt:REFWfm <MaskTestName>,<Source>
MTESt:REFWfm? <MaskTestName>

Sets the reference waveform from which the mask is created.

The reference waveform can be created before, or loaded from a file with REFCurve commands, see Chapter 20.10.2, "Reference Waveforms", on page 1304.

Parameters:

<Source>	REF1 | REFerence1 | REF2 | REFerence2 | REF3 | REFerence3 | REF4 | REFerence4 REF1 = REFerence1, REF2 = REFerence2, REF3 = REFerence3, REF4 = REFerence4: reference waveforms *RST: REF1

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:WFMLupdate <MaskTestName>

Creates the upper and lower mask limit from the envelope of the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test source waveform which is set wtih `MTESt:SOURce`.

Setting parameters:

<MaskTestName>	String containing the name of the mask test

Usage: Setting only

MTESt:WFMRescale:XWIDth <MaskTestName>,<HorizontalWidth>
MTESt:WFMRescale:XWIDth? <MaskTestName>

Sets the width of the mask in horizontal direction. The specified factor in divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask.

Parameters:

<HorizontalWidth>	Range: 0 to 1000 Increment: 0.01 *RST: 0 Default unit: div

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:WFMRescale:YWIDth <MaskTestName>,<VerticalWidth>
MTESt:WFMRescale:YWIDth? <MaskTestName>

Sets the width of the waveform mask in vertical direction. The specified factor in divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down.

Parameters:

<VerticalWidth>	Vertical mask width in divisions Range: 0 to 1000 Increment: 0.01 *RST: 0 Default unit: div

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:WFMRescale:YPOSition <MaskTestName>,<VertPosi>
MTESt:WFMRescale:YPOSition? <MaskTestName>

Moves the mask vertically within the display.

Parameters:

<VertPosi>	Range: -1000 to 1000 Increment: 0.01 *RST: 0 Default unit: div

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:WFMRescale:YSTRetch <MaskTestName>,<VerticalStretch>
MTESt:WFMRescale:YSTRetch? <MaskTestName>

Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit.

Parameters:

<VerticalStretch>	Scale factor in % Range: 10 to 1000 Increment: 1 *RST: 100 Default unit: %

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

20.14.4 Event Actions

MTESt:ONViolation:BEEP <MaskTestName>,<Beep>
MTESt:ONViolation:BEEP? <MaskTestName>

Generates a beep sound for the specified event.

Parameters:

<Beep>	NOAction | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOAction

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:STOP <MaskTestName>,<StopAcq>
MTESt:ONViolation:STOP? <MaskTestName>

Stops data acquisition for the specified event.

Parameters:

<StopAcq>	NOAction | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOAction

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:PRINt <MaskTestName>,<Print>
MTESt:ONViolation:PRINt? <MaskTestName>

Prints a screenshot including the measurement results to the printer defined using `SYSTem:COMMunicate:PRINter:SELect<1..2>` for the specified event.

Parameters:

<Print>	NOACtion | SUCCess | VIOLation See Event Parameter *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:SAVewaveform <MaskTestName>,<SaveWfm>
MTESt:ONViolation:SAVewaveform? <MaskTestName>

Saves the waveform data.

Parameters:

<SaveWfm>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 1174 *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:REPort <MaskTestName>,<Report>
MTESt:ONViolation:REPort? <MaskTestName>

Creates and saves a report of the current settings and results.

Parameters:

<Report>	NOACtion | SUCCess | VIOLation **NOACtion** The action is not initiated. **SUCCess** The action is initiated if the limits or margins were not exceeded during the entire measurement. **VIOLation** The action is initiated if the limits or margins are exceeded during the measurement. *RST: NOACtion

Parameters for setting and query:

<MaskTestName>

MTESt:ONViolation:TRIGgerout <MaskTestName>,<TriggerOutPulse>
MTESt:ONViolation:TRIGgerout? <MaskTestName>

Creates a trigger out pulse on mask violation or successful completion of the test cycle.

Parameters:

<TriggerOutPulse>	NOAction | SUCCess | VIOLation	
	*RST:	NOAction

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

20.14.5 Mask Display

MTESt:LABel <LabelState>

Switches the display of the mask test name on or off.

To change the name of the mask test, use `MTESt:REName` on page 1430.

Parameters:

<LabelState>	ON | OFF	
	*RST:	ON

MTESt:REName <MaskTestName>, <NewName>
MTESt:REName? <MaskTestName>

Changes the name of the mask test.

Parameters:

<NewName>	String with the new mask test name.

Parameters for setting and query:

<MaskTestName>	String with the existing mask test name.

20.14.6 Results

MTESt:RESult:STATe? <MaskTestName>

Shows if the test is running or has finished. The state is set to "Finished" if no acquisitions remain (see `MTESt:RESult:COUNt:REMaining?` on page 1431).

Query parameters:
<MaskTestName>

Return values:

<State>	RUNNing | FINished	
	*RST:	RUNNing
Usage:	Query only	

MTESt:RESult[:RESult]? <MaskTestName>

Returns the test result.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits (see `MTESt:TOLerance` on page 1419, `MTESt:RESult:COUNt:FAILures?` on page 1432 and `MTESt:RESult:COUNt:FWAVeforms?` on page 1432).

Query parameters:
<MaskTestName>

Return values:

<TestResult>	PASS | FAIL	
	*RST:	PASS
Usage:	Query only	

MTESt:RESult:COUNt:WAVeforms? <MaskTestName>

Returns the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<AcqsCompleted>	Range:	0 to 100E+24
	*RST:	0
Usage:	Query only	

MTESt:RESult:COUNt:REMaining? <MaskTestName>

Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation, or if the acquisition has been stopped manually.

See also: Chapter 9.3.4, "Running a Mask Test", on page 416.

Query parameters:
<MaskTestName>

Return values:

<AcqsRemaining>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FWAVeforms? <MaskTestName>

Returns the number of acquisitions that contained at least one sample hit.

Query parameters:
<MaskTestName>

Return values:

<AcquisitionHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FAILures? <MaskTestName>

Returns the number of sample hits that violated the mask.

Query parameters:
<MaskTestName>

Return values:

<SampleHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:FRATe? <MaskTestName>

Ratio of acquisition hits to the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<FailRate>	Range:	-100E+24 to 100E+24
	*RST:	0
	Default unit:	%

Usage: Query only

20.15 Search

20.15.1 General Search Settings

SEARch:ADD <SearchName>

Creates a new search definition with the specified name.

Setting parameters:

<SearchName>	String with the name of the search
Example:	See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161
Usage:	Setting only

SEARch:CLEar <SearchName>

Clears the search results once to start a new search.

Setting parameters:

<SearchName>	Search definition
Usage:	Setting only

SEARch:REMove <SearchName>

Deletes the specified search definition.

Setting parameters:

<SearchName>	String with the name of the search

Usage:	Setting only

SEARch:SOURce <SearchName>,<Source>
SEARch:SOURce? <SearchName>

Defines the source on which the search conditions are applied. The source can be any analog or digital channel, math or reference waveform as well as a serial bus configured for a supported protocol.

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

Parameters for setting and query:

<SearchName>	String with the name of the search
Example:	See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161

SEARch:ONLine <SearchName>,<OnlineState>
SEARch:ONLine? <SearchName>

If enabled, a search is performed repeatedly for each new data acquisition.

Parameters:

<OnlineState>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:ALL <SearchName>

Performs a search for all results on the existing data from the selected source.

Setting parameters:

<SearchName>	Search definition
Example:	See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161
Usage:	Setting only Asynchronous command

20.15.2 Basic Trigger Search Conditions

SEARch:TRIGger:DATatoclock[:STATe] <SearchName>,<State>
SEARch:TRIGger:DATatoclock[:STATe]? <SearchName>
SEARch:TRIGger:EDGE[:STATe] <SearchName>,<State>
SEARch:TRIGger:EDGE[:STATe]? <SearchName>
SEARch:TRIGger:GLITch[:STATe] <SearchName>,<State>
SEARch:TRIGger:GLITch[:STATe]? <SearchName>
SEARch:TRIGger:INTerval[:STATe] <SearchName>,<State>
SEARch:TRIGger:INTerval[:STATe]? <SearchName>
SEARch:TRIGger:PATTern[:STATe] <SearchName>,<State>
SEARch:TRIGger:PATTern[:STATe]? <SearchName>
SEARch:TRIGger:RUNT[:STATe] <SearchName>,<State>
SEARch:TRIGger:RUNT[:STATe]? <SearchName>
SEARch:TRIGger:SLEWrate[:STATe] <SearchName>,<State>
SEARch:TRIGger:SLEWrate[:STATe]? <SearchName>
SEARch:TRIGger:STATe[:STATe] <SearchName>,<State>
SEARch:TRIGger:STATe[:STATe]? <SearchName>
SEARch:TRIGger:TIMeout[:STATe] <SearchName>,<State>
SEARch:TRIGger:TIMeout[:STATe]? <SearchName>

SEARch:TRIGger:WIDTh[:STATe] <SearchName>,<State>
SEARch:TRIGger:WIDTh[:STATe]? <SearchName>
SEARch:TRIGger:WINDow[:STATe] <SearchName>,<State>
SEARch:TRIGger:WINDow[:STATe]? <SearchName>

Includes the search conditions for the selected trigger event type in the next search.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:LEVel[:VALue] <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel[:VALue]? <SearchName>, <SignalSource>

Sets the voltage of the trigger level that is used to determine other parameters.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

SEARch:TRIGger:DATatoclock:ACOPy <SearchName>
SEARch:TRIGger:EDGE:ACOPy <SearchName>
SEARch:TRIGger:GLITch:ACOPy <SearchName>
SEARch:TRIGger:INTerval:ACOPy <SearchName>
SEARch:TRIGger:PATTern:ACOPy <SearchName>
SEARch:TRIGger:RUNT:ACOPy <SearchName>
SEARch:TRIGger:SLEWrate:ACOPy <SearchName>
SEARch:TRIGger:STATe:ACOPy <SearchName>
SEARch:TRIGger:TIMeout:ACOPy <SearchName>
SEARch:TRIGger:WIDTh:ACOPy <SearchName>
SEARch:TRIGger:WINDow:ACOPy <SearchName>

Copies the trigger event configuration from Trigger A for the selected channel source to the search condition settings.

See Chapter 5.3, "Trigger Types", on page 206.

Setting parameters:

<SearchName>	Search definition
Usage:	Setting only

SEARch:TRIGger:EDGE:BCOPy <SearchName>

Copies the trigger event configuration from trigger B for the selected channel source to the search condition settings.

Setting parameters:

<SearchName>	String with name of the search
Usage:	Setting only

20.15.3 Edge Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:EDGE:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:EDGE:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

20.15.4 Glitch Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:GLITch:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:GLITch:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:GLITch:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:GLITch:RANGe? <SearchName>

Selects which glitches are identified: shorter or longer than the specified width (see `SEARch:TRIGger:GLITch:WIDTh` on page 1438).

Parameters:

<RangeMode>	SHORter | LONGer *RST: SHORter

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:GLITch:WIDTh <SearchName>,<Width>
SEARch:TRIGger:GLITch:WIDTh? <SearchName>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value (see also `SEARch:TRIGger:GLITch:RANGe` on page 1438).

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Parameters:

<Width>	Range: 100E-12 to 1E-3 Increment: 100E-6 *RST: 1E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

20.15.5 Interval Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:INTerval:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:INTerval:SLOPe? <SearchName>

Sets the edge for the search.

Parameters:

<Slope>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	String parameter, name of the search definition

Firmware/Software:	Version 2.70 The command replaces `SEARch:TRIGger:INTerval:POLarity`.

SEARch:TRIGger:INTerval:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:INTerval:DELTa? <SearchName>

Defines a range around the "Interval width" value (see `SEARch:TRIGger:INTerval:WIDTh` on page 1440).

Parameters:

<WidthDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:INTerval:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:INTerval:RANGe? <SearchName>

Selects how the range of an interval is defined based on the interval width and delta (see `SEARch:TRIGger:INTerval:WIDTh` on page 1440 and `SEARch:TRIGger:INTerval:DELTa` on page 1439).

Parameters:

<RangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta". **OUTSide** Triggers on intervals outside a given range. The range definition is the same as for "Within" range. **SHORter** Triggers on intervals shorter than the given "Interv. width". **LONGer** Triggers on intervals longer than the given "Interv. width". *RST: OUTSide

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:INTerval:WIDTh <SearchName>,<Width>
SEARch:TRIGger:INTerval:WIDTh? <SearchName>

Defines the time between two pulses.

Parameters:

<Width>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 5E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

20.15.6 Runt Search Conditions

SEARch:TRIGger:RUNT:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:RUNT:DELTa? <SearchName>

Defines a range around the given runt width.

Parameters:

<WidthDelta>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 100E-12 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:RUNT:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:RUNT:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:RUNT:RANGe <SearchName>,<Mode>
SEARch:TRIGger:RUNT:RANGe? <SearchName>

Selects how the time limit of the runt pulse is defined based on the runt width and delta (see `SEARch:TRIGger:RUNT:WIDTh` on page 1442 and `SEARch:TRIGger:RUNT:DELTa` on page 1440).

Parameters:

<Mode>	ANY | LONGer | SHORter | WITHin | OUTSide **ANY** Triggers on all runts fulfilling the level condition, without time limitation. **LONGer** Triggers on runts longer than the given "Runt width". **SHORter** Triggers on runts shorter than the given "Runt width". **WITHin** Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta". **OUTSide** Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range. *RST: ANY

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:RUNT:WIDTh <SearchName>,<Width>
SEARch:TRIGger:RUNT:WIDTh? <SearchName>

For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

The range is defined using `SEARch:TRIGger:RUNT:RANGe` on page 1441.

Parameters:

<Width>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 5E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:LEVel:RUNT:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:RUNT:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage threshold, respectively.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

20.15.7 Slew Rate Search Conditions

SEARch:TRIGger:SLEWrate:DELTa <SearchName>,<TimeDelta>
SEARch:TRIGger:SLEWrate:DELTa? <SearchName>

Defines a time range around the given slew rate.

Parameters:

<TimeDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:TRIGger:SLEWrate:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:SLEWrate:RANGe? <SearchName>

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

OUTRange
Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

LTHan
Triggers on slew rates shorter than the given "Slew rate" limit.

GTHan
Triggers on slew rates longer than the given "Slew rate" limit.

*RST: GTHan

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:TRIGger:SLEWrate:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:SLEWrate:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 1174.

*RST: POSitive

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:TRIGger:SLEWrate:TIME <SearchName>,<Time>
SEARch:TRIGger:SLEWrate:TIME? <SearchName>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

The range is defined using `SEARch:TRIGger:SLEWrate:RANGe`.

Parameters:

<Time>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 100E-12 Default unit: s

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:TRIGger:LEVel:TRANsition:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:TRANsition:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage thresholds, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

20.15.8 Timeout Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:TIMeout:RANGe <SearchName>,<TimeoutMode>
SEARch:TRIGger:TIMeout:RANGe? <SearchName>

Selects the relation of the signal level to the trigger level:

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:TIMeout:TIME <SearchName>,<Time>
SEARch:TRIGger:TIMeout:TIME? <SearchName>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

20.15.9 Width Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WIDTh:DELTa? <SearchName>

Defines a range around the given width value (see also `SEARch:TRIGger:WIDTh:WIDTh` on page 1447).

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161

SEARch:TRIGger:WIDTh:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:WIDTh:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 20.4.4, "Polarity Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:WIDTh:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WIDTh:RANGe? <SearchName>

Selects how the range of a pulse width is defined in relation to the width and delta (see `SEARch:TRIGger:WIDTh:WIDTh` on page 1447 and `SEARch:TRIGger:WIDTh:DELTa` on page 1445).

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range of the pulse width is defined by "Width" and "±Delta".

OUTSide
Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

SHORter
Triggers on pulses shorter than the given "Width".

LONGer
Triggers on pulses longer than the given "Width".

*RST: WITHin

Parameters for setting and query:

<SearchName>	Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161

SEARch:TRIGger:WIDTh:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WIDTh:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

The range is defined using `SEARch:TRIGger:WIDTh:RANGe`.

Parameters:

<Width>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 5E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161

20.15.10 Window Search Conditions

SEARch:TRIGger:WINDow:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WINDow:DELTa? <SearchName>

Defines a range around the "Width" value (see `SEARch:TRIGger:WINDow:WIDTh` on page 1449).

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:WINDow:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WINDow:RANGe? <SearchName>

Selects how the signal run is compared with the window.

Parameters:

<RangeMode>	ENTer | EXIT | WITHin | OUTSide **ENTer** Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels. **EXIT** Triggers when the signal leaves the window. **WITHin** Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the `SEARch:TRIGger:WINDow:TIMerange` command. **OUTSide** Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the `SEARch:TRIGger:WINDow:TIMerange` command. *RST: ENTer

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:WINDow:TIMerange <SearchName>,<TimeRangeMode>
SEARch:TRIGger:WINDow:TIMerange? <SearchName>

Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "WITHin" and "OUTSide" (see `SEARch:TRIGger:WINDow:RANGe` on page 1447).

Parameters:

<TimeRangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most. **OUTSide** "Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*. **SHORter** Triggers if the signal crosses vertical limits before the specified "Width" time is reached. **LONGer** Triggers if the signal crosses vertical limits before the specified "Width" time is reached. *RST: WITHin

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:WINDow:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WINDow:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

The range is defined using `SEARch:TRIGger:WINDow:RANGe`.

Parameters:

<Width>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 5E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:LEVel:WINDow:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:WINDow:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage limits for the window.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

20.15.11 Data2Clock Search Conditions

Data level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1436

SEARch:TRIGger:DATatoclock:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:DATatoclock:CEDGe? <SearchName>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 1174. *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:DATatoclock:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:DATatoclock:CLEVel? <SearchName>

Sets the voltage level for the clock signal. Both this command and `SEARch:TRIGger:DATatoclock:CEDGe` define the starting point for calculation of the setup and hold time.

Parameters:

<ClockLevel>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:DATatoclock:CSOurce <SearchName>,<ClockSource>
SEARch:TRIGger:DATatoclock:CSOurce? <SearchName>

Selects the waveform used for the clock signal.

Parameters:

<ClockSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 Source of the clock signal, see Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1

Parameters for setting and query:

<SearchName>	Search definition name

SEARch:TRIGger:DATatoclock:HTIMe <SearchName>,<HoldTime>
SEARch:TRIGger:DATatoclock:HTIMe? <SearchName>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Parameters:

<HoldTime>	Range: -99.999E-9 to 0.1 Increment: 1E-9 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:DATatoclock:STIMe <SearchName>,<SetupTime>
SEARch:TRIGger:DATatoclock:STIMe? <SearchName>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the intrument.

Parameters:

<SetupTime>	Range: -99.999E-9 to 0.1 Increment: 1E-9 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

20.15.12 Pattern Search Conditions

SEARch:TRIGger:PATTern:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:A[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:B[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:C[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:D[:ENABle]? <Searchname>

Enables the channel to be considered in the pattern search. The trigger source channel is selected by default.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<Searchname>	String with name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:A:LOGic? <Searchname>
SEARch:TRIGger:PATTern:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:B:LOGic? <Searchname>
SEARch:TRIGger:PATTern:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:C:LOGic? <Searchname>
SEARch:TRIGger:PATTern:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:

<Operator>	DIRect | NOT **DIRect** Input value remains unchanged **NOT** Input value is inverted

Parameters for setting and query:

<Searchname>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:AB:LOGic? <Searchname>
SEARch:TRIGger:PATTern:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:CD:LOGic? <Searchname>
SEARch:TRIGger:PATTern:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:

<Operator>	AND | NAND | OR | NOR AND: logical AND, conjunctive combination NAND:logical NOT AND OR:logical OR, disjunctive combination NOR: logical NOT OR

Parameters for setting and query:

<Searchname>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:MODE <SearchName>,<Mode>
SEARch:TRIGger:PATTern:MODE? <SearchName>

Adds additional time limitation to the pattern definition.

Parameters:

<Mode>	OFF | TIMeout | WIDTh **OFF** No time limitation. The event is found if the pattern condition is fulfilled. **TIMeout** Defines how long the result of the pattern condition stays high or low. The duration of the timeout is defined using `SEARch:TRIGger:PATTern:TIMeout[:TIME]` The result state is defined using `SEARch:TRIGger:PATTern:TIMeout:MODE`. **WIDTh** Defines a time range for keeping up the true result of the pattern condition. The range is defined using `SEARch:TRIGger:PATTern:WIDTh:RANGe`. *RST: OFF

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout:MODE <SearchName>,<TimeoutMode>
SEARch:TRIGger:PATTern:TIMeout:MODE? <SearchName>

Defines the condition for the timeout.

Parameters:

<TimeoutMode>	HIGH | LOW | EITHer **EITHer** High or low, the pattern remains unchanged for the given time. *RST: HIGH

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout[:TIME] <SearchName>, <Time>
SEARch:TRIGger:PATTern:TIMeout[:TIME]? <SearchName>

Defines how long the result of the pattern condition must keep the given state.

Parameters:

<Time>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 100E-9 Default unit: s

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:RANGe <SearchName>, <WidthRangeMode>
SEARch:TRIGger:PATTern:WIDTh:RANGe? <SearchName>

Defines the time range of a pulse width for keeping up the true result of the pattern condition. The width and delta are specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]` and `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:

<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin | OUTSide
Triggers on pulses inside or outside a given range. The range is defined by the width ±delta.

SHORter | LONGer
Triggers on pulses shorter or longer than the given width.

*RST: WITHin

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh[:WIDTh] <SearchName>, <Width>
SEARch:TRIGger:PATTern:WIDTh[:WIDTh]? <SearchName>

For the ranges WITHin and OUTSide, the width defines the center of a range that is defined by the limits ±delta.

For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.

To set the range mode, use `SEARch:TRIGger:PATTern:WIDTh:RANGe`. To set the delta value, use `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:

<Width>
Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:PATTern:WIDTh:DELTa? <SearchName>

Defines a range around the width value specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]`.

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

20.15.13 State Search Conditions

SEARch:TRIGger:STATe:CSOurce <SearchName>,<Source>
SEARch:TRIGger:STATe:CSOurce? <SearchName>

Sets the source of the clock signal.

Parameters:

<Source>	C1W1 | C2W1 | C3W1 | C4W1

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:STATe:CEDGe? <SearchName>

Sets the trigger edge of the clock signal.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer *RST: POSitive

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:STATe:CLEVel? <SearchName>

Sets the trigger level of the clock signal.

The command has the same effect as with `SEARch:TRIGger:LEVel[:VALue]`.

Parameters:

<ClockLevel>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

Parameters for setting and query:

<SearchName>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:A[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:B[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:C[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:D[:ENABle]? <Searchname>

Enables the channel to be considered in the state search. You can enable all channel signals except for the trigger source.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<Searchname>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:A:LOGic? <Searchname>
SEARch:TRIGger:STATe:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:B:LOGic? <Searchname>

SEARch:TRIGger:STATe:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:C:LOGic? <Searchname>
SEARch:TRIGger:STATe:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:

<Operator>	DIRect | NOT **DIRect** Input value remains unchanged **NOT** Input value is inverted

Parameters for setting and query:

<Searchname>	String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:AB:LOGic? <Searchname>
SEARch:TRIGger:STATe:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:CD:LOGic? <Searchname>
SEARch:TRIGger:STATe:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:

<Operator>	AND | NAND | OR | NOR AND: logical AND, conjunctive combination NAND:logical NOT AND OR:logical OR, disjunctive combination NOR: logical NOT OR

Parameters for setting and query:

<Searchname>	String with the name of the search

Firmware/Software: FW 1.40

20.15.14 Search on Spectrum

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:

<m>	1..* The suffix is irrelevant

Parameters:

<Value>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<m>	1..* The suffix is irrelevant.

Parameters:

<Value>	Threshold in dBm

Firmware/Software: Version 2.70

20.15.15 Search Scope Settings

SEARch:GATE[:STATe] <SearchName>,<State>
SEARch:GATE[:STATe]? <SearchName>

Performs the search only on the defined gate area of the source waveform.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:MODE <SearchName>,<Mode>
SEARch:GATE:MODE? <SearchName>

Defines whether the gate settings are configured using absolute or relative values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:ABSolute:STARt <SearchName>,<Start>
SEARch:GATE:ABSolute:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:ABSolute:STOP <SearchName>,<Stop>
SEARch:GATE:ABSolute:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:RELative:STARt <SearchName>,<RelativeStart>
SEARch:GATE:RELative:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:RELative:STOP <SearchName>,<RelativeStop>
SEARch:GATE:RELative:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:ZCOupling <SearchName>,<ZoomCoupling>
SEARch:GATE:ZCOupling? <SearchName>

If enabled, the gate area is set to the limits of a zoom area.

The zoom diagramm is selected using `SEARch:GATE:ZDIagram`.

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:GATE:ZDIagram <SearchName>,<ZoomDiagram>
SEARch:GATE:ZDIagram? <SearchName>

Selects the zoom to which the gate area is set if `SEARch:GATE:ZCOupling` is set to "ON".

Parameters:
<ZoomDiagram>

Parameters for setting and query:

<SearchName>	String with the name of the search

Example:

```
SEARch:GATE:ZCOupling 'Search1',ON
SEARch:GATE:ZDIagram 'Search1','Diagram1',
'Zoom2'
SEARch:GATE:ZDIagram? 'Search1'
<-- Diagram1;Zoom2
```

Enables the zoom coupling to define the gate,and selects Zoom2 as gate area. Zoom2 is based on Diagram1.

20.15.16 Noise Rejection

SEARch:TRIGger:LEVel:NOISe:ABSolute <SearchName>, <SignalSource>, <Value>

Defines the trigger hysteresis, a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value>	Hysteresis value

Setting parameters:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

SEARch:TRIGger:LEVel:NOISe:MODE <SearchName>, <SignalSource>, <Mode>
SEARch:TRIGger:LEVel:NOISe:MODE? <SearchName>, <SignalSource>

Defines whether absolute values or relative values to the vertical scaling are used as a hysteresis for noise rejection.

Parameters:

<Mode>	ABS | REL

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the trigger waveform, see Chapter 20.4.2, "Waveform Parameter", on page 1173

SEARch:TRIGger:LEVel:NOISe:RELative <SearchName>, <SignalSource>, <Value>

Defines a range around the trigger level in relative values. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value>	Hysteresis value in %

Setting parameters:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

SEARch:TRIGger:LEVel:NOISe[:STATe] <SearchName>, <SignalSource>, <State>
SEARch:TRIGger:LEVel:NOISe[:STATe]? <SearchName>, <SignalSource>

If enabled, the noise reject settings for the waveform are considered for the search.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 1173

20.15.17 Search Results

SEARch:RESDiagram:HORZ:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:HORZ:ABSolute:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:HORZ:ABSolute:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:MODE <SearchName>,<Mode>
SEARch:RESDiagram:HORZ:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the x-axis values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:HORZ:RELative:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:HORZ:RELative:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:SHOW <SearchName>,<ShwSearchWind>
SEARch:RESDiagram:SHOW? <SearchName>

If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Parameters:

<ShwSearchWind>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:VERT:ABSolute:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:VERT:ABSolute:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:MODE <SearchName>,<Mode>
SEARch:RESDiagram:VERT:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the y-axis values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:VERT:RELative:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:VERT:RELative:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESult:LIMit <SearchName>,<ResultListLimit>
SEARch:RESult:LIMit? <SearchName>

Defines the maximum number of entries in the search result table.

Parameters:

<ResultListLimit>	Range: 1 to 1000 Increment: 1 *RST: 100

Parameters for setting and query:

<SearchName>	Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 1161

SEARch:RESult:SHOW <SearchName>,<ShowResultTable>
SEARch:RESult:SHOW? <SearchName>

Displays or hides the search result table.

Parameters:

<ShowResultTable>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESult:SORT:ASCending <SearchName>,<SortAscending>
SEARch:RESult:SORT:ASCending? <SearchName>

If enabled, the results are listed in asscending order, i.e. the smallest value at the top.

Parameters:

<SortAscending>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESult:SORT[:MODE] <SearchName>,<SortMode>
SEARch:RESult:SORT[:MODE]? <SearchName>

Sorts the search result table by x-value position or value of the result.

Parameters:

<SortMode>	POSition | VALue **POSition** Sorts the search result table by the x-value position. **VALue** Sorts the search result table by the value of the result. *RST: POSition

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESult[:ALL]? <SearchName>

Returns all search results.

Query parameters:

<SearchName>	Search definition

Return values:

<Data>	List of search results, separated by commas. For each result, six values are returned: 1. Acquisition index, currently always 0. 2. X-position of the search result 3. Y-position of the search result, currently not relevant 4. Type of the search result (Edge, Glitch, ...) 5. Slope or polarity of the search result 6. For runt, glitch, width, and window searches, the value contains the width. For timeout and interval searches, it contains the timeout. For transition searches, it contains the slew rate. For all other searches, the value is not relevant. If a value is not relevant, 9.91E+37 is returned.

Example:

```
SEAR:RES? 'Search1'
0,1.5375e-007,-84,Edge,Positive,9.91E+37,
0,5.3e-008,-84,Edge,Positive,9.91E+37
```

The query returns two search results for edge search on rising edges at X-position 153,75 ns and 53 ns.

Usage: Query only

20.16 Data Management

20.16.1 Instrument Settings

The Mass MEMory subsystem provides commands to access the storage media and to save and reload instrument settings.

File and directory names

The <file_name> and <directory_name> parameters are strings. Some commands use a fixed directory; for others the <file_name> can contain the complete path including the drive name and all subdirectories, e.g. '`C:\TEMP\TRASH\test.txt`' for the file named test.txt in the TEMP\TRASH subdirectory of the internal hard disk drive C:\. If no complete path is specified, the file location is relative to the current directory, queried with `MMEMory:CDIRectory?`. The file name itself may contain the period as a separator for extensions.

File and directory names can be chosen according to Windows™ conventions; the restrictions placed on file names known from DOS systems do not apply. All letters and numbers are allowed, as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved file names are CON, AUX, COM1, ..., COM4, LPT1, ..., LPT3, NUL and PRN.

The use of wildcards ? and * is not allowed.

MMEMory:DRIVes?

Returns a list of the logical drives of the instrument as configured in the operating system.

Return values:

<Drive>	List of strings, for example, `"C:\","F:\","H:\"`
Usage:	Query only

MMEMory:MSIS [<msus>]

Changes the default storage device to the indicated drive or network server.

Parameters:

<msus>	String parameter. Drives are indicated with their drive letter, network servers require the UNC format.
Example:	`MMEM:MSIS 'C:'`
Example:	`MMEM:MSIS '\\server1\share1'`

MMEMory:DCATalog? [<PathName>]

Returns the subdirectories of the current or of a specified directory.

Query parameters:

<PathName>	String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntry>	Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Example:

```
MMEM:DCAT?
".","..","Documents and Settings","Program
Files","temp"
```

Usage: Query only

MMEMory:DCATalog:LENGth? [<PathName>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." and corresponds to the number of strings returned by the `MMEMory:DCATalog?` command.

Query parameters:

<PathName>	String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntryCount>	Number of parent and subdirectories.

Example:	`MMEM:DCAT:LENG?` `5`
Usage:	Query only

MMEMory:CDIRectory [<DirectoryName>]

Changes the default directory for file access.

Parameters:

<DirectoryName>	String parameter to specify the directory. If the string also contains a drive letter or network server name, the command `MMEMory:MSIS` is executed implicitely. *RST: "\"
Example:	`MMEM:CDIR 'C:\USER\DATA'`
Usage:	SCPI confirmed

MMEMory:MDIRectory <DirectoryName>

Creates a new directory with the specified name.

Setting parameters:

<DirectoryName>	String parameter to specify the new directory. If the path consists of several subdirectories, the complete tree will be created if necessary. If no drive letter or server name is indicated, the directory is created on the default soreage device specified with `MMEMory:MSIS`.
Example:	`MMEM:MDIR 'C:\USER\DATA'`
Usage:	Setting only

MMEMory:RDIRectory <DirectoryName>

Deletes the specified directory.

Setting parameters:

<DirectoryName>	String parameter to specify the directory to be deleted.
Example:	`MMEM:RDIR 'C:\USER\TEST'`
Usage:	Setting only

MMEMory:CATalog? [<PathName>][, <Format>]

Returns the a list of files contained in the specified directory. The result corresponds to the number of files returned by the MMEMory:CATalog:LENgth command.

Query parameters:

<PathName>	String parameter to specify the directory. If the directory is omitted, the command queries directory specified with `MMEMory:CDIRectory`.
<Format>	ALL | WTIMe ALL: Extended result including file, date, time and attributes WTIMe: Extended result including file, date, time

Return values:

<UsedMemory>	Total amount of storage currently used in the directory, in bytes.
<FreeMemory>	Total amount of storage available in the directory, in bytes.
<FileEntry>	All files and subdirectories of the directory are listed with their file name, format and size in bytes. The first two strings are related to the parent directory.

Example:

```
MMEM:CAT 'C:\USER\DATA'?
529479,1831777894400,".,DIR,0","..,DIR,0",
"Backup,DIR,0","CSS,DIR,0","DATEN,DIR,0",
"Commands.jar,BIN,529479","FAVORITES,DIR,0",
"LOG,DIR,0","DATA,DIR,0","test,DIR,0",
"TotalCMD,DIR,0"
```

Usage: Query only
SCPI confirmed

MMEMory:CATalog:LENGth? [<PathName>]

Returns the number of files and subdirectories of the current or specified directory. The number includes the parent directory strings "." and ".." and it corresponds to the number of <FileEntry> strings returned by the `MMEMory:CATalog?` command.

Query parameters:

<PathName>	String parameter, directory to be queried. If the directory is omitted, the current directory is queried, specified with `MMEMory:CDIRectory`.

Return values:

<Count>	Number of files and subdirectories including parent directory entries.

Example:

```
MMEM:CAT:LENG?
11
```

Usage: Query only

MMEMory:COPY <FileSource>[, <FileDestination>]

Copies an existing file to a new file.

Setting parameters:

<FileSource>	String parameter, contains name and path of the file to be copied. Wildcards (* and ?) are allowed.
<FileDestination>	String parameter, contains name and path of the new file. If the file already exists, it is overwritten without notice. If no file destination is specified, the source file is written to the current directory specified with `MMEMory:CDIRectory`.

Example:

```
MMEM:COPY 'C:\Users\Public\Documents
\Rohde-Schwarz\RTx\RefWaveforms
\RefCurve_2011-03-16*.bin','E:'
```

Copies all reference waveforms saved on March 16, 2011 to an external storage medium, mapped to drive `E:\`.

Usage: Setting only
SCPI confirmed

MMEMory:MOVE <FileSource>, <FileDestination>

Moves the specified file to a new location on the same drive and renames it.

Setting parameters:

<FileSource>	String parameter, contains name and path of the file to be copied. Wildcards (* and ?) are allowed. Therefore, specify a directory for <FileDestination>. Renaming is not possible.
<FileDestination>	String parameter, contains name and path of the new file. If no path is specified, the <FileSource> directory is used - the file is renamed.

Example:

```
MMEM:MOVE 'C:\USER\DATA\SETUP.CFG','C:\STORE'
```

Moves the file "Setup.cfg" from the directory `C:\USER\DATA` to `C:\STORE`.

Usage: Setting only
SCPI confirmed

MMEMory:DELete <FileName>

Removes the specified file(s). To delete directories, use `MMEMory:RDIRectory`.

Setting parameters:

<FileName>	String parameter to specify the name and directory of the file to be removed. Wildcards (* and ?) are allowed. If no path is defined, the current directory is used, specified with `MMEMory:CDIRectory`.

Example:

```
MMEM:DEL '*.CFG'
```

Deletes all cfg files from the current directory.

Usage: Setting only
SCPI confirmed

MMEMory:DATA <FileName>, <Data>
MMEMory:DATA? <FileName>

Stores data in the specified file to the storage location specified using `MMEMory:CDIRectory`.

Parameters:

<Data>	<block> 488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer. The block begins with character '#'. The next digit is the length of the length information, followed by this given number of digits providing the number of bytes in the following binary data.

Parameters for setting and query:

<FileName>	String parameter, the name of the file the data is stored to.
Example:	`MMEM:DATA 'abc.txt' #216This is the file` #2: the length infomation has two digits 16: the binary data has 16 bytes

---

MMEMory:ATTRibute <FileName>, <Attributes>
MMEMory:ATTRibute? <FileName>

Sets file attributes for the specified file(s). The command can be used for files only.

Setting parameters:

<Attributes>	String with attributes and setting information. '+' before the attribute: sets the attribute '-' before the attribute: deletes the attribute 'R': read only 'A': archive file 'S': system file 'H': hidden file

Parameters for setting and query:

<FileName>	String parameter, contains name and path of the file. Wildcards (* and ?) are allowed.

Return values:

<FileEntry>	String containing: "<file_name>,<file_attributes>"
Example:	`MMEM:ATTR 'C:\USER\DATA\*.LOG', '-R -A'` Deletes the read-only and archive attributes from all LOG files in the directory`C:\USER\DATA\*.LOG`.

Example:	`MMEM:ATTR? 'C:\USER\DATA\*.*'`
	`"Datei1.LOG,A", "Datei2.LOG,A",`
	`"Datei3.LOG,ASH", "Datei4.DLL,RSH",`
	`"Datei5.INI,SH"`

MMEMory:SAV <FileDestination>

Stores the current instrument settings to the specified file.

This command has the same effect as the combination of `*SAV` and `MMEMory:STORe:STATe`.

Parameters:

<FileDestination>	String parameter specifying path and filename of the target file. Wildcards are not allowed.
Example:	`MMEM:SAV 'C:\mysavefile.dfl'` Saves the current instrument settings to the file `mysavefile.dfl` located in the directory C:\.
Usage:	Event

MMEMory:RCL <FileSource>

Restores the instrument settings from the specified file.

This command has the same effect as the combination of `MMEMory:LOAD:STATe` and `*RCL`.

Parameters:

'<FileSource>'	String parameter specifying the path and filename of the source file. Wildcards are not allowed.
Example:	`MMEM:RCL 'C:\mysavefile.dfl'` Loads and activates the instrument settings from the file `mysavefile.dfl` located in the directory C:\.
Usage:	Event

MMEMory:STORe:STATe <MemoryNumber>, <FileName>

Stores the instrument settings from the specified internal memory to the specified file. To store the current instrument settings to the internal memory, use `*SAV` first.

Setting parameters:

<MemoryNumber>	Number of the internal memory Range: 1 to 99
<FileName>	String parameter specifying the complete path and filename of the source file.

Example:	`*SAV 4`
	`MMEM:STORe:STATe 4,'C:\Settings\Settings_1051.dfl'`
	Saves current instrument settings to the internal memory number 4. Then stores the settings from the internal memory number 4 to the file `C:\Settings\Settings_1051.dfl`.

Usage:	Setting only

MMEMory:LOAD:STATe <MemoryNumber>, <FileName>

Loads the instrument settings from the specified file to the specified internal memory. After the file has been loaded, the settings must be activated using a `*RCL` command.

Setting parameters:

<MemoryNumber>	Number of the internal memory Range: 1 to 99
<FileName>	String parameter specifying the complete path and filename of the source file.

Example:

```
MMEM:LOAD:STATe 4,'C:
\Settings\Settings_1051.dfl'
*RCL 4
```

Loads instrument settings from the file `C:\Settings\Settings_1051.dfl` to the internal memory number 4, and then activates the settings in internal memory number 4.

Usage: Setting only

SAVeset:CONFig:PREView <Include>

If set to OFF, the saveset is stored without the preview image to reduce the file size.

Use the command each time before you save a saveset.

Parameters:

<Include>	ON | OFF *RST: ON

20.16.2 Autonaming

MMEMory:AUTonaming:PREFix <State>
MMEMory:AUTonaming:USERtext <State>
MMEMory:AUTonaming:DATE <State>

MMEMory:AUTonaming:INDex <State>
MMEMory:AUTonaming:TIME <State>

Includes or excludes the name part in the file name pattern for automatic file name generation. This name is used as the default file name.

The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

To define a user text, use `MMEMory:AUTonaming:TEXT`.

Parameters:

<State>	ON | OFF	
	*RST:	ON

MMEMory:AUTonaming:TEXT <NameString>

Defines a text, that can be included in the autonaming pattern.

Parameters:

<NameString>	String parameter

MMEMory:AUTonaming:DEFaultpath <Path>

Sets the path where data and settings files will be stored. The default path is `C:\Users\Public\Documents\Rohde-Schwarz\RTx`.

Parameters:

<Path>	String parameter

MMEMory:AUTonaming:RESPath

Resets the path for file operations to the default path.

Usage: Event

MMEMory:AUTonaming:RESall

Resets all autonaming settings to the default value, including the path.

Usage: Event

20.16.3 Waveform Data Transmission

The R&S RTO provides specific data export commands for the various waveform types. The commands transmit the data of the waveform points from the instrument to the controlling computer. The data can be used in MATLAB, for example.

The commands are described in the relevant chapters:

- Analog waveforms: Chapter 20.8.6, "Waveform Data", on page 1220
- Reference waveforms: Chapter 20.10.2.3, "Waveform Data Export", on page 1310

- Math waveforms: Chapter 20.10.3, "Mathematics", on page 1312
- Spectrum waveforms: Chapter 20.13.2, "Waveform Data", on page 1413
- Logic channels: Chapter 20.18.5, "MSO Data ", on page 2112
- I/Q data: Chapter 20.20.2, "I/Q Data Output", on page 2138

20.16.4 Waveform Data Export to File

The resulting files of waveforms exports are described in Chapter 11.2.1, "Waveform Export Files", on page 449.

The export settings for manual operation are explained in Chapter 11.2.2, "Waveforms - Export Settings", on page 456.

EXPort:WAVeform:SOURce <Source>

Selects the waveform to be exported to file.

The commands takes effect if `EXPort:WAVeform:MULTichannel` is `OFF`.

Parameters:

<Source>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4
Example:	See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 1161
Firmware/Software:	V 1.25

EXPort:WAVeform:MULTichannel <MltChXpt>

Enables or disables the multichannel export.

If you enable the multichannel export, all active channels are included to the export data. You can change the export state using the `CHANnel<m>:EXPortstate` command.

If multichannel export is disabled, select the waveform to be exported using the `EXPort:WAVeform:SOURce` command.

Note that `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` returns the data of all channels that are selected for export, no matter of the channel suffix.

Parameters:

<MltChXpt>	ON | OFF *RST: OFF

CHANnel<m>:EXPortstate <ExportState>

Includes or excludes the indicated channel in waveform export. The data of channel waveform 1 is exported.

The commands takes effect if `EXPort:WAVeform:MULTichannel` is `ON`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExportState>	ON | OFF If you enable the multichannel export, the export state of all active channels is automatically set ON. *RST: OFF

EXPort:WAVeform:NAME <FileName>

Sets the file name, file format and path to save the waveform to.

See also: Chapter 11.2.1, "Waveform Export Files", on page 449

Parameters:

<FileName> String with path and file name with extension .xml, .bin, or .csv

Example:

```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch11.xml'
EXPort:WAVeform:SAVE
```

Saves the waveform data in XML format to `C:\temp\Export_Ch1.xml`.

Example:

```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch2.bin'
EXPort:WAVeform:SAVE
```

Saves the waveform data in binary format to `C:\temp\Export_Ch2.bin`.

Firmware/Software: V 1.25

EXPort:WAVeform:SAVE

Saves the waveform(s) to the file specified with `EXPort:WAVeform:NAME`. The file format is also set using the `...NAME` command.

Example:	See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 1161
Usage:	Event
Firmware/Software:	V 1.25

EXPort:WAVeform:SCOPe <Scope>

Defines the part of the waveform record that has to be stored.

Parameters:

<Scope> WFM | ZOOM | CURSor | GATE | MANual

WFM
Complete waveform

ZOOM
Data included in the zoom area if a zoom is defined for the source waveform.

CURSor
Data between the cursor lines if a cursor measurement is defined for the source waveform.

GATE
data included in the measurement gate if a gated measurement is defined for the source waveform.

MANual
Saves the data between user-defined start and stop values to be set with `EXPort:WAVeform:STARt` and `EXPort:WAVeform:STOP`.

*RST: WFM

Example:	See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 1161
Firmware/Software:	V 1.25

EXPort:WAVeform:STARt <Start>

Sets the start value of the waveform section for export, if `EXPort:WAVeform:SCOPe` is set to `Manual`.

Parameters:

<Start>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01 Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:STOP <Stop>

Sets the end value of the waveform section for export, if `EXPort:WAVeform:SCOPe` is set to `Manual`.

Parameters:

<Stop>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0.01 Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:ZOOM <ZoomDiagram>

Sets the zoom area to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `ZOOM`.

Parameters:

<ZoomName> Name of the zoom diagram

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

Example: See "Exporting Interleaved x/y Data of a Zoom to CSV File" on page 1164

Firmware/Software: V 1.25

EXPort:WAVeform:CURSorset <Cursorset>

Sets the cursor set to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `CURSor`.

Parameters:

<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4

CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4

Firmware/Software: V 1.25

EXPort:WAVeform:MEAS <MeasGate>

Sets the gate to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `GATE`.

Parameters:

<MeasGate>	MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8 Measurement for which the gate is defined.
Example:	See "Exporting Raw Data of a Measurement Gate to BIN File" on page 1163
Firmware/Software:	V 1.25

EXPort:WAVeform:DLOGging <DataLogging>

The command enables the export of subsequent acquisitions of the selected waveforms. The waveforms are taken from a running Nx Single acquisition (data logging, history is disabled), or from the history (multiple waveforms, history is enabled).

If the history is disabled (`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]`) and data logging is enabled, a specified number of waveforms is transferred to file directly during RUN Nx SINGLE acquisition. Enabling data logging stops a running acquisition. Set the number of acquisitions to be acquired and stored with `ACQuire:COUNt` and start export using `RUNSingle`.

If the history is enabled, the subsequent waveforms are taken from the history. Specify the range with `CHANnel<m>[:WAVeform<n>]:HISTory:STARt` and `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`. Then play the history with `CHANnel<m>[:WAVeform<n>]:HISTory:PLAY`.

The commands `EXPort:WAVeform:SAVE`, `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` and `CHANnel<m>[:WAVeform<n>]:DATA:HEADer?` are not available if data logging is enabled. The `RUNContinous` command disables data logging.

If data logging is off, and the history is enabled, one waveform out of the history is written to file. Specify the waveform using `CHANnel<m>[:WAVeform<n>]:HISTory:CURRent` and save it using `EXPort:WAVeform:SAVE`.

Parameters:

<DataLogging>	ON | OFF *RST: OFF
Example:	See: "Exporting Multiple Running Acquisitions of a Single Waveform to XML File" on page 1164 "Exporting Multiple Acquisition of the History to XML File" on page 1165 "Exporting a Single Acquisition of the History to BIN File" on page 1164
Firmware/Software:	V 1.25

EXPort:WAVeform:TIMestamps <UseTimestamps>

Exports the relative timestamps of all history waveforms to the waveform data file. The time is written at the beginning of each waveform record.

Parameters:

<UseTimestamps>	ON | OFF *RST: OFF

EXPort:WAVeform:INCXvalues <IncHorValues>

Includes horizontal values in the retrieved data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written. The X-values are always returned in 64 bit real format, regardless of the defined data format.

The setting is not available for the export of raw data.

The command affects the content of export files as well as data retrieved with:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`

Parameters:

<IncHorValues>	ON | OFF *RST: OFF
Example:	See: "Exporting Interleaved x/y Data of a Single Waveform to CSV File" on page 1163 "Exporting Interleaved x/y Data of a Zoom to CSV File" on page 1164
Firmware/Software:	FW 1.40

EXPort:WAVeform:RAW <RawValues>

Enables the export of raw sample data, and sets the data format to integer 8 bit. In high definition acquisition mode, the data format is integer 16 bit (requires option R&S RTO-K17). Fot INT16, you can set the byte order using the `FORMat:BORDer` command.

The raw format reduces the file size but changes also the precision of the values.

The setting is not available for the export of digital channel data and for the export of interleaved X/Y values.

Parameters:

<RawValues>	ON | OFF *RST: OFF

Example:	See: "Exporting Raw Data of a Single Waveform to BIN File" on page 1162 "Exporting Raw Data of a Measurement Gate to BIN File" on page 1163
Firmware/Software:	FW 1.40

EXPort:WAVeform:FASTexport <Enable>

To improve the performance of data export to file, the measurements are performed slower while the data export speeds up.

Setting parameters:

<Enable>	ON | OFF
Example:	See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 1161
Usage:	Setting only
Firmware/Software:	V 1.47

20.16.5 Waveform Histogram Export to File

EXPort:HISTogram:SELect <Name>

Selects the histogram to be exported.

Parameters:

<Name>	String with the histogram name.
Example:	See "Exporting Histogram Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:HISTogram:INCidence <Incidence>

Sets the mode of exported data: relative or absolute frequency of amplitude values.

Parameters:

<Incidence>	ABS | REL *RST: REL
Example:	See "Exporting Histogram Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:HISTogram:NAME <Path>

Sets the file name and path to save the histogram to.

Parameters:

<Path>	String with path and file name. The file extension defines the file format: XML, CSV, or BIN.
Example:	See "Exporting Histogram Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:HISTogram:SAVE

Saves the histogram to the file specified with `EXPort:HISTogram:NAME`.

Example:	See "Exporting Histogram Data to File" on page 1159
Usage:	Event
Firmware/Software:	V 1.47

EXPort:HISTogram:DATA?

Transfers the histogram data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data>	List of values according to the format settings and `EXPort:HISTogram:INCidence`. See also: Chapter 11.2.3, "Waveform Histograms", on page 461
Example:	See "Transferring Histogram Data" on page 1159
Usage:	Query only
Firmware/Software:	V 1.47

20.16.6 Long Term Measurement Results and Measurement Histogram Export to File

---

EXPort:MEASurement:SELect <SelcMeas>

Selects the measurement for export of long term or measurement histogram data.

Parameters:

<SelcMeas>	MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8 *RST: MEAS1
Example:	See "Exporting Long Term Measurement Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:MEASurement:TYPE <ExportType>

You can export the result data of the long term measurement, or the measurement histogram.

To export the measurement histogram, it must be enabled using `MEASurement<m>:STATistics:HISTogram`.

To export the long term results, the long term measurement must be enabled using `MEASurement<m>:LTMeas[:STATe]`.

Parameters:

<ExportType>	LONGTERM | LONGterm | HISTOGRAM | HISTogram LONGTERM = LONGterm, HISTOGRAM = HISTogram *RST: HISTOGRAM
Example:	See "Exporting Long Term Measurement Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:MEASurement:NAME <Path>

Sets the file name and path to save the long term or measurement histogram data to.

Parameters:

<Path>	String with path and file name. The file extension defines the file format: XML, CSV, or BIN.
Example:	See "Exporting Long Term Measurement Data to File" on page 1159
Firmware/Software:	V 1.47

EXPort:MEASurement:SAVE

Saves the long term or measurement histogram results to the file specified using `EXPort:MEASurement:NAME`.

The measurement data can be exported as absolute or relative values, which is defined using `EXPort:HISTogram:INCidence`.

Example:	See "Exporting Long Term Measurement Data to File" on page 1159
Usage:	Event
Firmware/Software:	V 1.47

EXPort:MEASurement:DATA?

Transfers the long term measurement data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data>	List of values according to the format settings Long term data: If statistics are enabled (`MEASurement<m>:STATistics[:ENABle]`), six values for each long term point are returned: maximum, minimum, average, standard deviation, number of measured results per long term point, number of waveforms per long term point. If statistics are disabled, the current value of each long term point is returned. For measurement histograms, absolute values are returned. See also: Chapter 11.2.5, "Long Term / Meas Histograms", on page 464
Example:	See "Transferring Long Term Measurement Data" on page 1160
Usage:	Query only
Firmware/Software:	V 1.47

20.16.7 Screenshots

The HCOPy subsystem and some other commands control the output of display information for documentation purposes on output devices (printer and clipboard) or files (also for report files). The instrument allows two independent output configurations which can be set separately with the suffix.

HCOPy:DESTination<1..2> <Medium>

Selects the output medium: file, printer or clipboard.

Suffix:

<1..2>	Selects the output configuration.

Parameters:

<Medium>
MMEM | SYST:COMM:PRIN | SYST:COMM:CLIP

String parameter

MMEM
Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`.

SYST:COMM:PRIN
Directs the display image to the printer. The printer is selected with the `SYSTem:COMMunicate:PRINter:SELect<1..2>` command. The `HCOPy:DESTination` command should always be sent after setting the printer.

SYST:COMM:CLIP
Directs the hardcopy to the clipboard.

*RST: SYST:COMM:CLIP

Example:
`HCOP:DEST 'SYST:COMM:PRIN'`
See also Chapter 20.3.5.1, "Saving a Screenshot to File", on page 1161

MMEMory:NAME <FileName>

Defines the file name when an image of the display is stored to a file rather than printed to a printer using the `HCOPy:IMMediate<m>[:DUM]` command.

Setting parameters:

<FileName>	String parameter specifiying path and file name of the screenshot

Example:
See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 1161

Usage:
Setting only
SCPI confirmed

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for output of the display image to file.

To set the output to file, use `HCOPy:DESTination<1..2>` with parameter `'MMEM'`.

Suffix:	
<m>	1..2 Selects the output configuration.

Parameters:	
<FileFormat>	PNG | JPG | BMP | TIFF | PDF *RST: PNG

Example: See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 1161

HCOPy:PAGE:ORIentation<1..2> <Orientation>

Defines the page orientation for output of the display image to a printer.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:	
1..2	Selects the output configuration.

Parameters:	
<Orientation>	PORTrait | LANDscape *RST: LANDscape

HCOPy:DEVice<m>:COLor <Color>

Selects between color and monochrome printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:	
<m>	1..2 Selects the output configuration.

Parameters:	
<Color>	ON | OFF ON: Color output OFF: Black and white output *RST: ON

HCOPy:DEVice<m>:INVerse <InverseColor>

Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

Suffix:	
<m>	1..2 Selects the output configuration.

Parameters:

<InverseColor>	ON | OFF *RST: ON

Firmware/Software: V 1.27

HCOPy:WBKG <WhiteBackground>

Inverts the background color. So you can print waveforms with normal waveform colors on white background.

Parameters:

<WhiteBackground>	ON | OFF *RST: OFF

HCOPy:CMAP<m>:DEFault <PrintColorSet>

Defines the default color set for printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:

<m>	1..2 Selects the output configuration.

Parameters:

<PrintColorSet>	DEF1 | DEF4 **DEF1** Current screen colors with white background and black grid. **DEF4** Current screen colors without any changes (black background). *RST: DEF1

HCOPy:SSD <ShowSetupDialog>

Enables or disables the display of open dialog boxes in screenshots. Use this command if you want to document settings in screenshots.

Parameters:

<ShowSetupDialog>	ON | OFF *RST: OFF

Firmware/Software: FW 3.20

HCOPy:IMMediate<m>[:DUM]

Starts the immediate output of the display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

Suffix:	
<m>	1..2 Selects the output configuration.
Example:	See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 1161
Usage:	Event Asynchronous command

HCOPy:IMMediate<m>:NEXT

Starts the output of the next display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

If the output is printed to a file, the file name used in the last saving process is automatically counted up to the next unused name.

Suffix:	
<m>	1..2 Selects the output configuration.
Example:	See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 1161
Usage:	Event Asynchronous command

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

Queries the name of the first printer in the list of printers that is configured in the Windows operating system.

To query the names of other installed printers, use the `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?` command.

Return values:	
<PrinterName>	If no printer is configured an empty string is returned.
Usage:	Query only

SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?

Queries the name of the next printer that is configured in the Windows operating system.

Before you send the ...NEXT command, send `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` to return to the beginning of the printer list and query the name of the first printer.

Return values:	
<PrinterName>	After all available printer names have been returned, an empty string enclosed by quotation marks (") is returned for the next query. Further queries are answered by a query error.

Usage:	Query only

SYSTem:COMMunicate:PRINter:SELect<1..2> <PrinterName>

Selects a configured printer.

Parameters:

<PrinterName>	Enter the string as it is returned with `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` or `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?`.

20.16.8 Reports

The following commands configure and save report files. To configure the screenshot that is included in the report, use the commands explained in Chapter 20.16.7, "Screenshots", on page 1487.

REPort:LANGuage <Language>

Sets the language to be used in the report. Available languages are listed in the data sheet.

Parameters:

<Language>	String with the english language name, upper case.
Example:	`REPort:LANGuage 'Spanish'`

REPort:PAPersize <PaperSize>

Selects the paper size: A4 or US Letter.

Parameters:

<PaperSize>	A4 | USL *RST: A4

REPort:LOGType <Logo>

By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown.

Parameters:

<Logo>	RS | CUST | NONE **CUST** Select the logo file using `REPort:LOGO`. *RST: RS

REPort:LOGO <LogoFile>

Defines the logo file that is used on the report if `REPort:LOGType` is set to `CUSTom`.

Parameters:

<LogoFile>	String with the path and filename of the logo image.

Example:
```
REPort:LOGO 'C:\Company files\logo.jpg'
```

REPort:USER <User>

Enter the user name that appears in the general information section at the beginning of the report.

Parameters:

<User>	String parameter

REPort:COMMent <Comment>

Enter a comment that appears in the general information section at the beginning of the report.

Parameters:

<Comment>	String parameter

REPort:FILE:NAME <ReportFile>

Sets the file name and path to save the report to.

Parameters:

<ReportFile>	String with path and file name. The file extension defines the file format: PDF, HTML, or DOC.

REPort:FILE:SAVE

Saves the report to the specified file.

Usage:	Event Asynchronous command

20.17 Protocols

20.17.1 Configuration Settings for all Serial Protocols

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Type> I2C | SPI | UART | CAN | CANFd | LIN | FLXRay | I2S | MILS1553 | MILStd1553 | ARIN429 | ARINc429 | MDIO | USB | USBPD | ETHernet | HBTO | CXPI | CMSB | SENT | RFFE | EBTB | DPHY | SWIRe | MPHY | USB3 | PCIE

MILS1553 = MILStd1553: specification MIL-STD-1553 (option R&S RTO-K6)
ARIN429 = ARINc429: specification ARINC 429 (option R&S RTO-K7)
HBTO: Ethernet 100BASE-T1 (BroadR-Reach, option R&S RTO-K57)
CXPI: Clock extension peripheral interface (option R&S RTO-K76)
CMSB: custom decode serial bus (option R&S RTO-K50)
EBTB: 8b/10b general decoding (option R&S RTO-K52)
SWIRe: SpaceWire (option R&S RTO-K65)

*RST: I2C

Usage: Asynchronous command

BUS<m>[:STATe] <State>

Enables the decoding of the specified bus.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

BUS<m>:SETReflevels

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Suffix:

<m>	1..4 Selects the serial bus.

Usage: Event
Asynchronous command

Firmware/Software: FW 1.45

BUS<m>:LABel <Label>

Defines a label to be displayed with the bus.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Label>	String containing the label text.

Usage: Asynchronous command

BUS<m>:RESult <ShowResultTable>

Opens a table with decoded data of the serial signal. The function affects all protocol types and requires the option for the analyzed protocol.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ShowResultTable>	ON | OFF *RST: OFF

Usage: Asynchronous command

BUS<m>:THReshold <ShwThresLines>

If ON, the threshold levels are displayed in the diagram.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ShwThresLines>	ON | OFF *RST: OFF

Usage: Asynchronous command

BUS<m>:RESDetail <ShwResDetails>

Shows detailed information for the frames.

The command is relevant for FlexRay, D-PHY, M-PHY, Ethernet, CXPI, and Custom protocols.

Suffix:

<m>	1..4

Parameters:

<ShwResDetails>	ON | OFF *RST: OFF
Usage:	Asynchronous command
Firmware/Software:	FW 3.40

BUS<m>:FORMat <DataFormat>

Sets the number format for decoded data values of the indicated bus. It defines the format in the "Decode table" and in the combs of the decoded signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataFormat>	HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG ASCII = ASCii SYMB = Symbolic, only available for CAN and CAN FD if a DBC label list is applied. *RST: HEX

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:

<DataFormat>	HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG ASCII = ASCii *RST: HEX
Usage:	Asynchronous command
Firmware/Software:	FW 1.45

BUS<m>:NEWList <FileName>

Loads a label list file.

Suffix:

<m>	1..4 Selects the serial bus.

Setting parameters:

<FileName>	String parameter with path and file name.
Example:	`BUS1:NEWList 'C:\Protocols\CAN.csv'` `BUS1:SYMBols ON`
Usage:	Setting only

BUS<m>:SYMBols <UseTranslation>

Activates the lable list to be used for decoding.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<UseTranslation>	ON | OFF *RST: OFF
Usage:	Asynchronous command
Firmware/Software:	FW 1.36

20.17.2 Trigger Settings for all Serial Protocols

The following commands are available for all serial protocols that have a protocol trigger.

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured. For all other trigger sources, only suffix 1 is allowed. See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed>	CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4 **CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4** Input channels **EXTernanalog** External analog signal connected to the External Trigger Input. For this source, only the analog edge trigger is available. **SBUS** Serial bus **D0...D15** Digital channels (option R&S RTO-B1) See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 2103 **LOGIc** Logic combination of digital channels, used as trigger source (option R&S RTO-B1) **MSOB1 | MSOB2 | MSOB3 | MSOB4** Parallel bus (option R&S RTO-B1) *RST: CHAN1

TRIGger<m>:SOURce:SBSelect <SerialBus>

Selects the serial bus to be triggered on.

Suffix:

<m>	1..3 Event in a trigger sequence: 1 = A-event only

Parameters:

<SerialBus>	SBUS1 | SBUS2 | SBUS3 | SBUS4

Firmware/Software: Version 2.70

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Type>	I2C | SPI | UART | CAN | CANFd | LIN | FLXRay | I2S | MILS1553 | MILStd1553 | ARIN429 | ARINc429 | MDIO | USB | USBPD | ETHernet | HBTO | CXPI | CMSB | SENT | RFFE | EBTB | DPHY | SWIRe | MPHY | USB3 | PCIE MILS1553 = MILStd1553: specification MIL-STD-1553 (option R&S RTO-K6) ARIN429 = ARINc429: specification ARINC 429 (option R&S RTO-K7) HBTO: Ethernet 100BASE-T1 (BroadR-Reach, option R&S RTO-K57) CXPI: Clock extension peripheral interface (option R&S RTO-K76) CMSB: custom decode serial bus (option R&S RTO-K50) EBTB: 8b/10b general decoding (option R&S RTO-K52) SWIRe: SpaceWire (option R&S RTO-K65) *RST: I2C
Usage:	Asynchronous command

20.17.3 I²C

20.17.3.1 Configuration

BUS<m>:I2C:SCL:SOURce <SCLSource>

Sets the waveform of the clock line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:	
<SCLSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data and clock lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1
Usage:	Asynchronous command

BUS<m>:I2C:SDA:SOURce <SDASource>

Sets the waveform of the data line.

Suffix:	
<m>	1..4 Selects the serial bus.
Parameters:	
<SDASource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data and clock lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1
Usage:	Asynchronous command

BUS<m>:I2C:SCL:THReshold <SCLThreshold>

Sets a user-defined threshold value for the clock line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:I2C:TECHnology`.

Suffix:	
<m>	1..4 Selects the serial bus.
Parameters:	
<SCLThreshold>	User-defined clock threshold Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:I2C:SDA:THReshold <SDAThreshold>

Sets a user-defined threshold value for the data line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:I2C:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SDAThreshold> User-defined data threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:I2C:TECHnology <Technology>

Sets the threshold voltage clock and data lines as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with `BUS<m>:I2C:SCL:THReshold` and `BUS<m>:I2C:SDA:THReshold`.

*RST: V165

BUS<m>:I2C:RWBit <BusConfig>

Defines if the R/W bit of a 7-bit address is considered separately or as part of the address. 10-bit addresses are not affected. The setting defines which address lengths are available with `TRIGger<m>:I2C:AMODe`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:	
<BusConfig>	SEParate | INADdress **SEParate** 7-bit address and separate R/W bit. **INADdress** 8-bit address with R/W bit included. *RST: SEParate
Firmware/Software:	FW 1.35

20.17.3.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:I2C:MODE <Type>

Selects the trigger type for I²C analysis.

See: "Trigger type" on page 494

Parameters:

<Type>	STARt | REPStart | STOP | NACK | ADDRess | ADOR | ADAT **STARt** Start condition **REPStart** Repeated start - the start condition occurs without previous stop condition. **STOP** Stop condition, end of frame **NACK** Missing acknowledge bit. To localize specific missing acknowledge bits, use `TRIGger<m>:I2C:ADNack`, `TRIGger<m>:I2C:DWNack`, and `TRIGger<m>:I2C:DRNack`. **ADDRess** Triggers on one specific address **ADOR** Triggers on an OR combination with up to four four address conditions. **ADAT** Triggers on a combination of address and data condition. *RST: STARt

Usage: Asynchronous command

TRIGger<m>:I2C:ACCess <RWBitAddress>

Sets the trigger condition for the R/W bit - the transfer direction of the data.

Parameters:

<RWBitAddress>	READ | WRITe | EITHer **EITHer** Transfer direction is not relevant. *RST: EITHer

Usage: Asynchronous command

TRIGger<m>:I2C:ADNack <AddressNack>

Triggers if the address acknowledge bit is missing - no slave recognizes the address.

Parameters:

<AddressNack>	ON | OFF *RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:DWNack <DataWriteNack>

Triggers if a date acknowledge bit is missing - the addressed slave does not accept the data.

Parameters:

<DataWriteNack>	ON | OFF *RST: ON
Usage:	Asynchronous command

TRIGger<m>:I2C:DRNack <DataReadNack>

Triggers on the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack>	ON | OFF *RST: ON
Usage:	Asynchronous command

TRIGger<m>:I2C:AMODe <AddressType>

Sets the address length. The setting affects the address input with `TRIGger<m>:I2C:ADDRess` and `TRIGger<m>:I2C:ADDTo`.

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

BIT7
Enter the 7 address bits. Only available if `BUS<m>:I2C:RWBit` SEParate is set.

BIT7_RW
Enter 7 address bits and the R/W bit. Only available if `BUS<m>:I2C:RWBit`INADdress is set.

BIT10
10-bit address

ANY
Only available for trigger type "Address + data" (`TRIGger<m>:I2C:MODE` ADAT). Used to trigger on data only, regardless of the address.

*RST: BIT7

Usage: Asynchronous command

TRIGger<m>:I2C:ACONdition <AddressOperator>

Sets the operator to set a specific address or an address range. The address values are set with `TRIGger<m>:I2C:ADDRess` and `TRIGger<m>:I2C:ADDTo`.

Parameters:

<AddressOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal
Firmware/Software:	V 1.25

TRIGger<m>:I2C:ADDRess <Address>

Triggers on the specified slave address, or sets the the start value of an address range depending on the condition set with `TRIGger<m>:I2C:ACONdition`.

Parameters:

<Address>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:I2C:ADDTo <AddressTo>

Sets the the end value of an address range if the condition is set to an address range with `TRIGger<m>:I2C:ACONdition`.

Parameters:

<AddressTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.
Usage:	Asynchronous command

TRIGger<m>:I2C:ADOR<n>:ENABle <UseAddress>

Includes the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<UseAddress>	ON | OFF *RST: OFF

TRIGger<m>:I2C:ADOR<n>:ADRType <AddressType>

Sets the address type for the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<AddressType>	BIT7 | BIT7_RW | BIT10 *RST: BIT7

TRIGger<m>:I2C:ADOR<n>[:VALue] <Address>

Defines the address pattern of the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<Address>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:I2C:ADOR<n>:RWBit <RWBit>

Defines the R/W bit of the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<RWBit> UNDefined | READ | WRITe | EITHer

UNDefined
Return value only

*RST: EITHer

TRIGger<m>:I2C:DPOPerator <DataPosOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:I2C:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:I2C:DPOSition` and `TRIGger<m>:I2C:DPTO`.

*RST: ANY

TRIGger<m>:I2C:DPOSition <DataPosition>

Sets the number of data bytes before the first byte of interest. These bytes are ignored.

Parameters:

<DataPosition>	The index 0 is associated with the first data byte. Range: 0 to 4095 Increment: 1 *RST: 0

TRIGger<m>:I2C:DPTO <DataPositionTo>

Defines the last byte of interest, if `TRIGger<m>:I2C:DPOPerator` is set to `RANGe`.

Parameters:

<DataPositionTo>	Range: 0 to 4095 Increment: 1 *RST: 0

TRIGger<m>:I2C:DCONdition <DataOperator>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

---

TRIGger<m>:I2C:DMIN <Data>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command
Firmware/Software:	V 1.30

TRIGger<m>:I2C:DMAX <DataTo>

Sets the the end value of an data range if `TRIGger<m>:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

Firmware/Software: V 1.30

20.17.3.3 Decode Results (Option R&S RTO-K1)

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:I2C:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Data>	Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example:

```
BUS:I2C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only

BUS<m>:I2C:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames.
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:AACCess?

Returns the address acknowledge bit value for the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressAckBit>	INComplete | ACK | NACK | EITHer *RST: INComplete
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:ACCess?

Returns the value of the R/W bit of the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<RWBit>	UNDefined | READ | WRITe | EITHer *RST: UNDefined
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:ACOMplete?

Returns if the address is completely contained in the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.

<n>	* Selects the frame.

Return values:

<AddressComplete>	ON | OFF *RST: OFF
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:ADBStart?

Returns the start time of the address acknowledge bit.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddrAckBtStrt>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:ADDRess?

Returns the device address value of the indicated frame, that is, the address value that is shown in the decoded cells and in the decode results table.

If the frame has a 7-bit address, the command considers the status of `BUS<m>:I2C:RWBit`. If `BUS<m>:I2C:RWBit INADdress` is set, the returned address includes the R/W bit (8 bit). Otherwise, the pure address without the R/W bit is returned (7 bit, same result as returned with `BUS<m>:I2C:FRAMe<n>:ADEVice?`).

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and default – are decimal values. Range: 0 to 1023 *RST: 0
Usage:	Query only

BUS<m>:I2C:FRAMe<n>:ADEVice?

Returns the pure device address of the indicated frame *without* the R/W bit.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DeviceAddress>
To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and default – are decimal values.
Range: 0 to 1023
*RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AMODe?

Returns the address length.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressType>
BIT7 | BIT7_RW | BIT10 | AUTO | ANY
*RST: BIT7

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AStart?

Returns the start time of the address for the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressStart>
Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:RWBStart?

Returns the start time of the R/W bit

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<RWBitStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STATus?

Returns the overall state of the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState> INComplete | OK | UNEXpstop | INSufficient | ADDifferent

INComplete
The stop bit is missing.

OK
The frame is valid.

UNEXpstop
A stop bit was detected but clock and data are continued.

INSufficient
The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

ADDifferent
Error in 10 bit address. In case of a read access on a 10 bit address, the first address byte is sent twice, first as write, the second as read. The first seven bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

*RST: OK

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic name of the address

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:I2C:FRAMe<n>:BCOunt?

Returns the number of bytes in the specified frame

Suffix:

<m>	1..4 Selects the input channel.
<n>	* Selects the frame.

Return values:

<Count>	Byte count

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACCess?

Returns the acknowledge bit value of the specified data byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ByteAckBit>	INComplete | ACK | NACK | EITHer *RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACKStart?

Returns the start time of the acknowledge bit of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<AckBitStart>	To set the value format, use FORMat:BPATtern. The values below – range, increment and reset – are decimal values. Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete?

Returns if the indicated byte is completely contained in the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ValueComplete>	ON | OFF *RST: OFF

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:STARt?

Returns the start time of the specified data byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ByteStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:VALue?

Returns the data value of the specified byte.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.
Return values:	
<ByteData>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and default – are decimal values. Range: 0 to 255 *RST: 0
Usage:	Query only

20.17.3.4 I²C Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to I²C trigger commands.

SEARch:TRIGger:I2C:SCONdition <SearchName>,<Start>
SEARch:TRIGger:I2C:SCONdition? <SearchName>

Enables the search for the start of the message.

Parameters:

<Start>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:RCONdition <SearchName>,<RepeatedStart>
SEARch:TRIGger:I2C:RCONdition? <SearchName>

Enables the search for a start condition without previous stop condition.

Parameters:

<RepeatedStart>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:STCNdition <SearchName>,<Stop>
SEARch:TRIGger:I2C:STCNdition? <SearchName>

Enables the search for the start of the message.

Parameters:

<Stop>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:NACKnowledge <SearchName>,<NoAcknowledge>
SEARch:TRIGger:I2C:NACKnowledge? <SearchName>

Searches for missing address acknowledge bits.

Parameters:

<NoAcknowledge>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:SADDress <SearchName>,<Address>
SEARch:TRIGger:I2C:SADDress? <SearchName>

Enables the search for one specific address condition or for a combination of address conditions.

To define the address condition, use the following commands:

- `SEARch:TRIGger:I2C:ACONdition` on page 1520
- `SEARch:TRIGger:I2C:ADDRess` on page 1521
- `SEARch:TRIGger:I2C:ADDTo` on page 1521
- `SEARch:TRIGger:I2C:AMODe` on page 1520
- `SEARch:TRIGger:I2C:ACCess` on page 1521

Parameters:

<Address>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADOR <SearchName>,<AddressOr>
SEARch:TRIGger:I2C:ADOR? <SearchName>

Enables the search for one to four address conditions.

- `SEARch:TRIGger:I2C:ADDO<m>:ENABle` on page 1521
- `SEARch:TRIGger:I2C:ADDO<m>:ADRType` on page 1522
- `SEARch:TRIGger:I2C:ADDO<m>[:VALue]` on page 1522
- `SEARch:TRIGger:I2C:ADDO<m>:RWBit` on page 1523

Parameters:

<AddressOr>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADData <SearchName>,<AddressData>
SEARch:TRIGger:I2C:ADData? <SearchName>

Enables the search for a combination of address and data conditions.

Parameters:

<AddressData>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ACONdition <SearchName>,<AddressOperator>
SEARch:TRIGger:I2C:ACONdition? <SearchName>

Sets the operator to set a specific address or an address range.

Parameters:

<AddressOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `SEARch:TRIGger:I2C:ADDRess` on page 1521.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:I2C:ADDRess` on page 1521 and `SEARch:TRIGger:I2C:ADDTo` on page 1521.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:AMODe <SearchName>,<AddressType>
SEARch:TRIGger:I2C:AMODe? <SearchName>

Sets the address length.

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

BIT7 | BIT10
Enter only address bits in the address pattern.

BIT7_RW
Enter seven address bits and also the R/W bit in the address pattern.

ANY
Only available for search criteria "Address and data" (`SEARch:TRIGger:I2C:ADData` is set `ON`). Used to search for data only, regardless of the address.

*RST: BIT7

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDRess <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDRess? <SearchName>

Specifies an address pattern, or sets the the start value of an address range.

Parameters:

<Address>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDTo <SearchName>,<AddressTo>
SEARch:TRIGger:I2C:ADDTo? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:ACONdition` is set to `INRange` or `OORange`.

Parameters:

<AddressTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ACCess <SearchName>,<RWBitAddress>
SEARch:TRIGger:I2C:ACCess? <SearchName>

Sets the transfer direction of the data.

Parameters:

<RWBitAddress>	READ | WRITe | EITHer *RST: EITHer

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDO<m>:ENABle <SearchName>,<UseAddress>
SEARch:TRIGger:I2C:ADDO<m>:ENABle? <SearchName>

Includes the indicated ADOR address in the "address OR" search condition.

Suffix:

<m>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<UseAddress>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:ADRType <SearchName>,<AddressType>
SEARch:TRIGger:I2C:ADDO<m>:ADRType? <SearchName>

Sets the address type for the indicated ADOR address in the "address OR" search condition.

Suffix:

<m>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<AddressType>	BIT7 | BIT7_RW | BIT10 **BIT7 | BIT10** Enter only address bits in the address pattern. **BIT7_RW** Enter seven address bits and also the R/W bit in the address pattern. *RST: BIT7

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>[:VALue] <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDO<m>[:VALue]? <SearchName>

Defines the address pattern of the indicated ADOR address in the "address OR" search condition.

Suffix:

<m>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<Address>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The pattern length is defined with `SEARch:TRIGger:I2C:ADDO<m>:ADRType`.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:RWBit <SearchName>,<RWBit>
SEARch:TRIGger:I2C:ADDO<m>:RWBit? <SearchName>

Defines the R/W bit of the indicated ADOR address in the "address OR" search condition.

Suffix:

<m>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<RWBit> UNDefined | READ | WRITe | EITHer

UNDefined
Only return value

*RST: EITHer

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DPOPerator <SearchName>,<DataPosOperator>
SEARch:TRIGger:I2C:DPOPerator? <SearchName>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:I2C:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:I2C:DPOSition` and `SEARch:TRIGger:I2C:DPTO`.

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:I2C:DPOSition? <SearchName>

Defines the first byte of interest. All bytes before that byte are ignored.

Parameters:

<DataPosition>	The index 0 is associated with the first data byte. Range: 0 to 4095 Increment: 1 *RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:I2C:DPTO? <SearchName>

Defines the last byte of interest, if `SEARch:TRIGger:I2C:DPOPerator` defines a range.

Parameters:

<DataPositionTo>	Range: 0 to 4095 Increment: 1 *RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:I2C:DCONdition? <SearchName>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DMIN <SearchName>,<Data>
SEARch:TRIGger:I2C:DMIN? <SearchName>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DMAX <SearchName>,<DataTo>
SEARch:TRIGger:I2C:DMAX? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADNack <SearchName>,<AddressNack>
SEARch:TRIGger:I2C:ADNack? <SearchName>

Parameters:

<AddressNack>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DRNack <SearchName>,<DataReadNack>
SEARch:TRIGger:I2C:DRNack? <SearchName>

Searches for the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DWNack <SearchName>,<DataWriteNack>
SEARch:TRIGger:I2C:DWNack? <SearchName>

Searches for missing data write acknowledge bits.

Parameters:

<DataWriteNack>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

Usage:	Asynchronous command

20.17.3.5 I²C Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.3.3, "Decode Results (Option R&S RTO-K1)", on page 1509.

SEARch:RESult:I2C:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage:	Query only

SEARch:RESult:I2C:FRAMe<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameState>	INComplete | OK | UNEXpstop | INSufficient | ADDifferent
	*RST: OK

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AACCess? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<AddressAckBit>	INComplete | ACK | NACK | EITHer
	*RST: INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACCess? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<RWBit>	UNDefined | READ | WRITe | EITHer	
	*RST:	UNDefined

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACOMplete? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<AddressComplete>	ON | OFF	
	*RST:	OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADBStart? <SearchName>

Returns the start time of the address acknowledge bit.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<AddrAckBtStrt>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADDRess? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<AddressValue>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADEVice? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<DeviceAddress>	Range:	0 to 1023
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AMODe? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY

*RST: BIT7

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ASTart? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<AddressStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:DATA? <SearchName>

Returns the data bytes of the indicated frame.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Data>	Data value

Usage:	Query only

SEARch:RESult:I2C:FRAMe<m>:RWBStart? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<RWBitStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage:	Query only

SEARch:RESult:I2C:FRAMe<m>:SYMBol? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Translation>

Usage:	Query only

SEARch:RESult:I2C:FRAMe<m>:BCOunt?

Suffix:

<m>	*

Return values:

<Count>

Usage:	Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteAckBit>	INComplete | ACK | NACK | EITHer	
	*RST:	INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart? <SearchName>

Returns the start time of the acknowledge bit of the indicated data byte.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrmBteAckBtStrt>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrmBteComplete>	ON | OFF	
	*RST:	OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteData>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

20.17.4 SPI

20.17.4.1 SPI Bus Configuration

BUS<m>:SPI:BORDer <BitOrder>

Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit).

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<BitOrder>	LSBF | MSBF *RST: MSBF

Usage: Asynchronous command

BUS<m>:SPI:WSIZe <WordLength>

Sets the number of bits in a message.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WordLength>	Number of bits Range: 4 to 32 Increment: 1 *RST: 8

Usage: Asynchronous command

BUS<m>:SPI:SCLK:SOURce <SCLKSource>

Sets the input channel of the clock line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SCLKSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data, clock and slave select lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1

Usage: Asynchronous command

BUS<m>:SPI:SSELect:SOURce <SlaveSelectSource>

Sets the input channel of the slave select line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SlaveSelectSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data, clock and slave select lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173

Usage: Asynchronous command

BUS<m>:SPI:SSELect:POLarity <SSPolarity>

Selects whether transmitted slave select signal is high active (high = 1) or low active (low = 1).

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SSPolarity>	ACTLow | ACTHigh *RST: ACTLow

Usage: Asynchronous command

BUS<m>:SPI:MISO:SOURce <MISOSource>

Sets the input channel of the MISO line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:	
<MISOSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data, clock and slave select lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173
Usage:	Asynchronous command

BUS<m>:SPI:MISO:POLarity <MISOPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:	
<m>	1..4 Selects the serial bus.
Parameters:	
<MISOPolarity>	ACTLow | ACTHigh *RST: ACTHigh
Usage:	Asynchronous command

BUS<m>:SPI:MOSI:SOURce <MOSISource>

Sets the input channel of the MOSI line.

Suffix:	
<m>	1..4 Selects the serial bus.
Parameters:	
<MOSISource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data, clock and slave select lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173
Usage:	Asynchronous command

BUS<m>:SPI:MOSI:POLarity <MOSIPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:	
<m>	1..4 Selects the serial bus.

Parameters:

<MOSIPolarity>	ACTLow | ACTHigh *RST: ACTHigh
Usage:	Asynchronous command

BUS<m>:SPI:TECHnology <Technology>

Sets the threshold voltage clock, slave select and data lines as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology>	V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN **V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0** 1.5 V, 2.5 V, 1.65 V ... respectively **VM13** -1.3 V (negative value) **MAN** Manual setting of user-defined values with `BUS<m>:SPI:SCLK|SSEL|MISO|MOSI:THReshold`. *RST: V165

BUS<m>:SPI:SCLK:THReshold <SCLKThreshold>
BUS<m>:SPI:MISO:THReshold <MISOThreshold>
BUS<m>:SPI:MOSI:THReshold <MOSIThreshold>
BUS<m>:SPI:SSELect:THReshold <SSThreshold>

Set user-defined threshold values for the clock, MISO, MOSI and slave select lines.

Alternatively, you can set the thresholds according to the signal technology with `BUS<m>:SPI:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SSThreshold>	User-defined value Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:SPI:FRCondition <FrameCondition>

Defines the start of a frame. A frame contains a number of successive words, at least one word.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<FrameCondition> SS | CLKTimeout

SS
Start and end of the frame is defined by the active state of the slave select signal, see `BUS<m>:SPI:SSELect:POLarity`.

CLKTimeout
Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

*RST: SS

BUS<m>:SPI:TIMeout <ClockTimeout>

Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ClockTimeout>	Range:	50E-9 to 10
	Increment:	1E-6
	*RST:	1E-3
	Default unit:	s

20.17.4.2 SPI Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:SPI:MODE <Type>

Selects the trigger type for SPI analysis.

Parameters:

<Type> SSACtive | TIMeout | MOSI | MISO | MOMI

SSACtive
Start of the message: slave select signal SS changes to the active state.

TIMeout
Triggers on the next message start after the "Timeout" time.

MOSI
Triggers on a specified data pattern in that is expected on the MOSI line. Define the pattern with `TRIGger<m>:SPI:MOSipattern`.

MISO
Triggers on a specified data pattern in that is expected on the MISO line. Define the pattern with `TRIGger<m>:SPI:MISopattern`

MOMI
Triggers on a specified data patterns on the MISO and MISO lines.

*RST: SSACtive

Usage: Asynchronous command

TRIGger<m>:SPI:PALignment <DataAlignment>

Defines how the specified data pattern is searched.

Parameters:

<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by bit: the pattern can be at any position in the data word.

*RST: WORD

Usage: Asynchronous command

TRIGger<m>:SPI:DPOPerator <DatPosiOptor>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DatPosiOptor>	ANY | OFF | EQUal | GETHan | INRange | RANGe **ANY = OFF** The position of the required pattern is not relevant. **EQUal | GETHan** Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:SPI:DPOSition`. **INRange = RANGe** Set the minimum and maximum value of the range with `TRIGger<m>:SPI:DPOSition` and `TRIGger<m>:SPI:DPTO`. *RST: ANY

TRIGger<m>:SPI:DPOSition <DataPosition>

Sets the number of bits or words to be ignored before the first bit or word od interest. The effect is defined by `TRIGger<m>:SPI:PALignment`.

Parameters:

<DataPosition>	The index 0 is associated with the first data byte.	
	Range:	0 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
	Increment:	1
	*RST:	0

TRIGger<m>:SPI:DPTO <DataPositionTo>

Defines the last bit or word of interest, if `TRIGger<m>:SPI:DPOPerator` is set to `INRange`.

Parameters:

<DataPositionTo>	Range:	1 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
	Increment:	1
	*RST:	1

TRIGger<m>:SPI:FCONdition <DataOperator>

Selects the operator for the MISO and MOSI pattern.

Parameters:

<DataOperator>	EQUal | NEQual *RST: EQUal

Firmware/Software: V 1.25

TRIGger<m>:SPI:MISopattern <MISOPattern>

Specifies the pattern to be triggered on the MOSI line.

Parameters:

<MISOPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

TRIGger<m>:SPI:MOSipattern <MOSIPattern>

Specifies the pattern to be triggered on the MOSI line.

Parameters:

<MOSIPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

20.17.4.3 SPI Decode Results (Option R&S RTO-K1)

BUS<m>:SPI:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Parameters:

<Data>	Comma-separated sequence of integer values (N, L1, R1,…, LN, RN). N is the number of word pairs in the frame, and {L1,R1}…{LN,RN} are the value pairs. The values Lx and Rx are associated with the MOSI and the MISO channel, respectively. If a channel is disabled, an empty value is returned.

Example:	`BUS:SPI:FRAMe3:DATA?` `<-- 2,10,108,35,70` (MOSI+MISO) `2,10,,35,` (MOSI only) `2,,108,,70` (MISO only)
Usage:	Query only Asynchronous command

BUS<m>:SPI:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames.
Usage:	Query only
Firmware/Software:	V 1.27

BUS<m>:SPI:FRAMe<n>:STATus?

Returns the overall state of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | VOID | INCFirst | INCLast | INSufficient OK: the frame is valid. VOID: the frame is empty. INCFirst: INComplete First word. The first word does not have the expected word length. INCLast: INComplete Last word. The last word does not have the expected word length. INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. *RST: OK
Usage:	Query only

BUS<m>:SPI:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WCOunt?

Returns the number of words in the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<WordCount>	Range: 0 to 4096 *RST: 0

Usage: Query only

Firmware/Software: V 1.27

BUS<m>:SPI:FRAMe<n>:WORD<o>:STARt?

Returns the start time of the specified data word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<WordStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:STOP?

Returns the end time of the specified data word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<WordStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MISO?

Returns the data value of the specified word on the MISO line.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<MISOValue>	To set the value format, use FORMat:BPATtern. The values below – range, increment and reset – are decimal values. Range: 0 to 4294967295 *RST: 0

Usage:	Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MOSI?

Returns the data value of the specified word on the MOSI line.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<MOSIValue>	To set the value format, use FORMat:BPATtern. The values below – range, increment and reset – are decimal values. Range: 0 to 4294967295 *RST: 0

Usage:	Query only

20.17.4.4 SPI Search Settings

In search setup commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name. All commands are similar to SPI trigger commands.

SEARch:TRIGger:SPI:MODE <SearchName>,<Type>
SEARch:TRIGger:SPI:MODE? <SearchName>

Sets the event to be searched for.

Parameters:

<Type>	SSACtive | TIMeout | MOSI | MISO | MOMI **SSACtive** Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `SS`. **TIMeout** Searches for the start of the frame when the clock idle time exceeds the timeout. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `CLKTimeout`. **MOSI | MISO** Searches for a specified data pattern expected on the MOSI line or on the MISO line, respectively. **MOMI** Searches in parallel for specified data patterns expected on the MOSI and MISO lines. *RST: SSACtive

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:FCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:SPI:FCONdition? <SearchName>

Selects the operator for the data pattern: equal or not equal.

Parameters:

<DataOperator>	EQUal | NEQual *RST: EQUal

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:MISopattern <SearchName>,<PATTern>
SEARch:TRIGger:SPI:MISopattern? <SearchName>
SEARch:TRIGger:SPI:MOSipattern <SearchName>,<PATTern>
SEARch:TRIGger:SPI:MOSipattern? <SearchName>

Specifies a data pattern for the MISO or MOSI line, respectively.

Parameters:

<PATTern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

Usage:	Asynchronous command
Firmware/Software:	FW 3.30

SEARch:TRIGger:SPI:DPOPerator <SearchName>,<DatPosiOptor>
SEARch:TRIGger:SPI:DPOPerator? <SearchName>

Operator for the data position. You can define an exact position, a position range, or let the position undefined (ANY).

Parameters:

<DatPosiOptor>	ANY | OFF | EQUal | GETHan | INRange | RANGe ANY = OFF, INRange = RANGe *RST: ANY

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:SPI:DPOSition? <SearchName>

Sets the number of bits or words before the first word of interest, see also `SEARch:TRIGger:SPI:PALignment`. These offset bits/words are skipped. The index 0 is associated with the first data bit or word.

If the position operator defines a range, also define the last bit/word of interest using `SEARch:TRIGger:SPI:DPTO`

Parameters:

<DataPosition>	Range:	0 to 32767
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:SPI:DPTO? <SearchName>

Sets the the end value of a data postion range.

Parameters:

<DataPositionTo>	Range:	1 to 32767
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:PALignment <SearchName>,<DataAlignment>
SEARch:TRIGger:SPI:PALignment? <SearchName>

Defines how the specified data pattern is searched.

Parameters:

<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by-bit: the pattern can start at any position in the message.

*RST: WORD

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

20.17.4.5 SPI Search Results

The search on decoded SPI data returns the same results as the queries for decode results.

In search result commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

The suffix FRAMe<m> indicates the frame index. The suffix WORD<n> indicates the word index inside a frame-

For a description of the returned values, see the corresponding commands in Chapter 20.17.4.3, "SPI Decode Results (Option R&S RTO-K1)", on page 1540. All SPI search commands are first implemented in firmware version 3.30.

SEARch:RESult:SPI:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:COUNt?

Returns the number of frames that have matched the search criteria. In the search result table on the display, the number of rows is the number of frames that match the search criteria.

Suffix:
<m> *

Return values:
<Count>

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameState>	OK | VOID | INCFirst | INCLast | INSufficient	
	*RST:	OK

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STOP? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WCOunt? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameWordCount>	Range:	0 to 4096
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MISO? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrmWordMOSIVal>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MOSI? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrmWordMOSIVal>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STARt? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameWordStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STOP? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameWordStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

20.17.5 UART

20.17.5.1 Configuration

BUS<m>:UART:RX:SOURce <RxSource>

Selects the input channel for the receiver signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<RxSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for RX and TX lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173
Usage:	Asynchronous command

BUS<m>:UART:TX:SOURce <TxSource>

Selects the input channel for the transmitter signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<TxSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for RX and TX lines. See Chapter 20.4.2, "Waveform Parameter", on page 1173

Usage: Asynchronous command

BUS<m>:UART:RX:THReshold <RxThreshold>

Sets a user-defined threshold value for the Rx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<RxThreshold> User-defined clock threshold

Range: -15 to 15
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TX:THReshold <TxThreshold>

Sets a user-defined threshold value for the Tx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<TxThreshold> User-defined clock threshold

Range: -15 to 15
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TECHnology <Technology>

Sets the threshold voltage Tx and Rx lines as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with `BUS<m>:UART:RX:THReshold` and `BUS<m>:UART:TX:THReshold`.

*RST: V165

BUS<m>:UART:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m> 1..4

Parameters:

<Bitrate>
Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:BAUDrate <Bitrate>

Same as `BUS<m>:UART:BITRate`.

Suffix:

<m> 1..4

Parameters:

<Bitrate>
Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

See also: "Parity" on page 522.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Parity>	NONE | ODD | EVEN | MARK | SPC | DC **MARK** The parity bit is always a logic 1. **SPC** SPaCe: The parity bit is always a logic 0. **DC** Don't Care: the parity is ignored. *RST: NONE

Usage: Asynchronous command

BUS<m>:UART:POLarity <Polarity>

Defines the idle state of the bus. The idle state corresponds to a logic 1. The transmitted data on the bus is high (high = 1) or low (low = 1) active.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Polarity>	IDLLow | IDLHigh *RST: IDLHigh

Usage: Asynchronous command

BUS<m>:UART:SBIT <StopBits>

Sets the number of stop bits: 1; 1.5 or 2 stop bits are possible.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<StopBits>	B1 | B15 | B2 *RST: B1

Usage: Asynchronous command

BUS<m>:UART:SSIZe <DataBits>

Sets the number of data bits in a message.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataBits>	Number of data bits Range: 5 to 8 Increment: 1 *RST: 8

Usage:	Asynchronous command

BUS<m>:UART:PACKets <Packets>

Defines the method of packet separation. A packet is a number of subsequent words in a date stream.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Packets> NONE | EWORd | TOUT

NONE
Packets are not considered.

EWORd
End word, the end condition of a packet is a pattern. To define the end word, use `BUS<m>:UART:EWORd`

TOUT
Defines a timeout between the packets. To set the timeout, use `BUS<m>:UART:TOUT`

*RST: NONE

Firmware/Software:	FW 2.25

BUS<m>:UART:TOUT <InterframeTime>

Sets the timeout between packets in a UART data stream. A new packet starts with the first start bit after the timeout.

The command is relevant if `BUS<m>:UART:PACKets` is set to `TOUT`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<InterframeTime>	Range: 1E-6 to 1 Increment: 1 *RST: 1E-3 Default unit: s

Usage: Asynchronous command

Firmware/Software: FW 2.25

BUS<m>:UART:EWORd <EndOfFrame>

Sets the end pattern of the packets. A new packet starts with the first start bit after the defined end pattern.

The command is relevant if `BUS<m>:UART:PACKets` is set to `EWORd`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<EndOfFrame>	End word value in decimal format (range 0 to 255) or hexadecimal format (prefix #H). The query always returns hexadecimal values.

Example:

```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR 10 // Decimal value
:BUS:UART:EWOR?
#H0A // Query returns hex
```

Example:

```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR #Hff // Hexadecimal, prefix #H
:BUS:UART:EWOR?
#HFF
```

Usage: Asynchronous command

Firmware/Software: FW 2.25

20.17.5.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:UART:TYPE <Type>

Selects the trigger type for UART analysis.

See also: "Type" on page 524

Parameters:

<Type>	STBT | PCKS | DATA | PRER | BRKC | STPerror STBT: Start bit PCKS: Packet start DATA: Serial pattern PRER: Parity error BRKC: Break condition STPerror: Stop error *RST: STBT
Usage:	Asynchronous command

TRIGger<m>:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Parameters:

<Source>	TX | RX *RST: TX
Usage:	Asynchronous command

TRIGger<m>:UART:DPOPerator <DatPosiOptor>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DatPosiOptor>	EQUal | GETHan | INRange | RANGe INRange = RANGe *RST: GETHan
Usage:	Asynchronous command

TRIGger<m>:UART:DPOSition <DataPosition>

Sets the number of words before the first word of interest. These offset words are ignored.

Parameters:

<DataPosition>	Number of words Range: 0 to 32767 Increment: 1 *RST: 0
Usage:	Asynchronous command

TRIGger<m>:UART:DPTO <DataPositionTo>

Defines the last word of interest, if `TRIGger<m>:UART:DPOPerator` defines a position range.

Parameters:

<DataPositionTo>	Range: 0 to 32767 Increment: 1 *RST: 0
Usage:	Asynchronous command

TRIGger<m>:UART:FCONdition <DataOperator>

Selects the operator for the data pattern (`TRIGger<m>:UART:DATA`).

Parameters:

<DataOperator>	EQUal | NEQual *RST: EQUal

TRIGger<m>:UART:DATA <Data>

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order.

Parameters:

<Data>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

20.17.5.3 Decode Results (Option R&S RTO-K2)

BUS<m>:UART:WORD<n>:RXValue?
BUS<m>:UART:WORD<n>:TXValue?

Returns the value of the specified word on the Rx line or Tx line, respectively.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<RxValue> <TxValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 255 *RST: 0

Usage: Query only

BUS<m>:UART:WORD<n>:COUNt?

Returns the number of words in the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* The suffix is irrelevant.

Return values:

<Count>	Number of words

Usage: Query only

BUS<m>:UART:WORD<n>:SOURce?

Returns the line on which the specified word was transferred.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:	
<WordSource>	TX | RX *RST: TX
Usage:	Query only

BUS<m>:UART:WORD<n>:STARt?

Returns the start time of the specified word.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the word.
Return values:	
<WordStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:UART:WORD<n>:STATe?

Returns the status of the specified word.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the word.
Return values:	
<WordState>	OK | FRSTart | FRENd | FRME | BREak | STERror | SPERror | PRERror | INSufficient OK: the frame is valid. BREak:stop bit error with 0x00 word STERror: StarT ERror, incorrect start bit SPERror: StoP ERror, incorrect stop bit PRERror:PaRity ERror, incorrect parity bit. INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. *RST: OK
Usage:	Query only

20.17.6 CAN (Option R&S RTO-K3/R&S RTO-K9)

20.17.6.1 Configuration

BUS<m>:CAN:DATA:SOURce <DataSource>

Sets the source of the data line that is selected with `BUS<m>:CAN:TYPE`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

Usage: Asynchronous command

BUS<m>:CAN:TYPE <SignalType>

Selects the CAN-High or CAN-Low line. Both lines are required for differential signal transmission used by CAN.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SignalType>	CANH | CANL *RST: CANL

BUS<m>:CAN:FDATa:PSTandard <ProtStd>

Only available for CAN FD buses. Selects whether the tested signal is an ISO CAN FD signal or not.

Suffix:

<m>	1..4

Parameters:

<ProtStd>	ISO | NISO **ISO** Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence. **NISO** Non-ISO. Signals are decoded according to the the Bosch CAN FD protocol. *RST: ISO

Firmware/Software: FW 3.35

BUS<m>:CAN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:CAN:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Threshold>	Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:CAN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology> V25 | V3 | V2 | V0 | MAN

V25
2.5 Volt (CMOS 5.0 V)

V3
3.0 Volt (CAN_H HS / CAN_L LS)

V2
2.0 Volt (CAN_L HS / CAN_H LS)

V0
Ground

MAN
Manual setting of user-defined values with `BUS<m>:CAN:DATA:THReshold`.

*RST: V25

BUS<m>:CAN:BITRate <Bitrate>

For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum bit rate for High Speed CAN is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Bitrate>	Range:	100 to 5E+6
	Increment:	1
	*RST:	100E+3
	Default unit:	bps

BUS<m>:CAN:FDATa:ENABle <CANFDEnabled>

Enables the CAN FD protocol configuration.

The setting is available in CAN FD option R&S RTO-K9.

Suffix:

<m>	1..4

Parameters:

<CANFDEnabled> ON | OFF

*RST: ON

BUS<m>:CAN:FDATa:DBITrate <FlexDatBitrate>

Sets the bit rate of the data phase. The data rate can be higher than the arbitration rate, but it is uniform and fixed for a given CAN FD bus.

The setting is available in CAN FD option R&S RTO-K9.

Suffix:

<m>	1..4

Parameters:

<FlexDatBitrate>	Range:	100 to 15E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	bps

BUS<m>:CAN:SAMPlepoint <SamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Alternatively, you can set the sample point with `BUS<m>:CAN:T1Segment` and `BUS<m>:CAN:T2Segment`.

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SamplePoint>	Range:	12 to 96 if number of segments is 25. The range reduces if the signal has fewer segments.
	Increment:	5
	*RST:	50
	Default unit:	%

BUS<m>:CAN:T1Segment <TimeSeg1>

Sets the number of time quanta before the sample point (T1Segment). T1Segment comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard.

Make sure to set also `BUS<m>:CAN:T2Segment` for correct definition of the sample point. Alternatively, you can use `BUS<m>:CAN:SAMPlepoint`.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 530

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4

Parameters:

<TimeSeg1>	Time quanta
	Range: 3 to 24
	Increment: 1
	*RST: 5

BUS<m>:CAN:T2Segment <TimeSeg2>

Sets the number of time quanta after the sample point (T2Segment). T2Segment matches Phase_seg2 specified in the CAN standard.

Make sure to set also `BUS<m>:CAN:T1Segment` on page 1564 for correct definition of the sample point. Alternatively, you can use `BUS<m>:CAN:SAMPlepoint`.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 530

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<TimeSeg2>	Time quanta
	Range: 1 to 22
	Increment: 1
	*RST: 5

BUS<m>:CAN:JWIDth <JumpWidth>

Defines the maximum number of time quanta for phase correction. Time segment1 may be lengthened or Time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators.

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<JumpWidth>	Time quanta
	Range: 1 to 4, available maximum depends on the number of segments and the sample point
	Increment: 1
	*RST: 1

BUS<m>:CAN:FDATa:SAMPlepoint <FlexDatSmpPt>
BUS<m>:CAN:FDATa:T1Segment <FlexDatTimeSeg1>

BUS<m>:CAN:FDATa:T2Segment <FlexDatTimeSeg2>
BUS<m>:CAN:FDATa:JWIDth <FlexDatJumpWdt>

These commands define the synchronization of the data phase.

For a command description, see:

- `BUS<m>:CAN:T1Segment` on page 1564
- `BUS<m>:CAN:T2Segment` on page 1565
- `BUS<m>:CAN:SAMPlepoint` on page 1564
- `BUS<m>:CAN:JWIDth` on page 1565

Suffix:

<m>	1..4

Parameters:

<FlexDatJumpWdt>	Range:	1 to 4
	Increment:	1
	*RST:	1

Firmware/Software: FW 3.35

20.17.6.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CAN:TYPE <Type>

Selects the trigger type for CAN analysis.

See: "Trigger type" on page 532.

Parameters:

<Type>	STOF | FTYP | ID | IDDT | ERRC **STOF** STart Of Frame: triggers on the first edge of the dominant SOF bit (synchronization bit). **FTYP** Frame TYPe: triggers on a specified frame type (data, remote, error, or overload) and on the identifier format. To set the frame type, use `TRIGger<m>:CAN:FTYPe`. ´Set the identifier format with `TRIGger<m>:CAN:ITYPe` **ID** IDentifier: Sets the trigger to one specific identifier or an identifier range. To set the identifier, use `TRIGger<m>:CAN:ICONdition`, `TRIGger<m>:CAN:IMIN`, and `TRIGger<m>:CAN:IMAX`. **IDDT** IDentifier and DaTa: Combination of identifier and data conditions To set the identifier condition, use `TRIGger<m>:CAN:ICONdition`, `TRIGger<m>:CAN:IMIN`, and `TRIGger<m>:CAN:IMAX`. To set the data condition, use `TRIGger<m>:CAN:DCONdition`, `TRIGger<m>:CAN:DMIN`, and `TRIGger<m>:CAN:DMAX`. **ERRC** ERRor Condition: Define the error types with `TRIGger<m>:CAN:ACKerror`, `TRIGger<m>:CAN:BITSterror`, `TRIGger<m>:CAN:CRCerror`, `TRIGger<m>:CAN:FORMerror`, `TRIGger<m>:CAN:FDATa:SCERror` on page 1574. *RST: STOF

TRIGger<m>:CAN:FDATa:STANdard <StdSel>

Selects the CAN standard. Use `ANY` if the standard of the signal is unknown.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<StdSel>	ANY | CAN | CANFd *RST: CAN

TRIGger<m>:CAN:FTYPe <FrameType>

Selects the CAN frame type if `TRIGger<m>:CAN:TYPE` is set to FTYP (frame type) or ID (identifier).

For data and remote frames, the identifier format has to be set with `TRIGger<m>:CAN:ITYPe`.

See also: "Frame type" on page 533

Parameters:

<FrameType>	ANY | DATA | REMote | ERRor | OVERload Available values depend on the CAN standard and on the `TRIGger<m>:CAN:TYPE` setting: Remote frames are not available in the CAN FD protocol. If the trigger type is set to FTYP (frame type), you can set the values `DATA	REMote	ERRor	OVERload`. If the trigger type is set to ID (identifier), you can set the values `ANY	DATA	REMote`. *RST: ANY

TRIGger<m>:CAN:ITYPe <IdentifierType>

Selects the format of data and remote frames.

Remote frames are not available in the CAN FD protocol.

Parameters:

<IdentifierType>	ANY | B11 | B29 **B11** 11 bit identifier (standard format). The instrument triggers on the sample point of the IDE bit. **B29** 29 bit identifier (extended format). The instrument triggers on the sample point of the RTR bit. **ANY** The ID type and ID pattern are not relevant for the trigger condition. *RST: ANY

TRIGger<m>:CAN:ICONdition <IdtfOptor>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdtfOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `TRIGger<m>:CAN:IMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:IMIN` and `TRIGger<m>:CAN:IMAX` on page 1569. *RST: EQUal

---

TRIGger<m>:CAN:IMIN <IdtfPatt>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:CAN:IMAX <IdtfPattTo>

Sets the the end value of an identifier range if `TRIGger<m>:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:CAN:FDATa:FDF <FDFBit>

Specifies the CAN FD frame format. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format.

Parameters:

<FDFBit>	ONE | ZERO | DC ONE: CAN FD. ZERO: CAN. DC: don't care, the format is not relevant. *RST: DC

TRIGger<m>:CAN:FDATa:BRS <BRSBit>

Sets the bit rate switch bit.

Parameters:

<BRSBit>	ONE | ZERO | DC ONE: the bit rate switches from the bit rate of the arbitration phase to the faster data rate. *RST: ONE

TRIGger<m>:CAN:FDATa:ESI <ESIBit>

Sets the error state indicator bit.

Parameters:

<ESIBit>	ONE | ZERO | DC DC: don't care, bit is nor relevant *RST: DC

TRIGger<m>:CAN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:CAN:DMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:DMIN` and `TRIGger<m>:CAN:DMAX`. *RST: EQUal

---

TRIGger<m>:CAN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer. Only for CAN protocol.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:CAN:DLCCondition <DLCOperator>

Operator to set the data length code for triggering on CAN and CAN FD data.

For details, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 536.

The number of data bytes to be found is set with `TRIGger<m>:CAN:DLC`.

See also: `TRIGger<m>:CAN:BORDer`.

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

TRIGger<m>:CAN:DLC <WordCount>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `TRIGger<m>:CAN:DLCCondition` on page 1571.

Parameters:

<WordCount>	Range:	CAN: 1 to 8, CAN FD: 1 to 15 (64 bytes)
	Increment:	1
	*RST:	1

TRIGger<m>:CAN:NDBYtes?

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 536.

Return values:

<NDBytes>	Range:	1 to 64
	Increment:	1
	*RST:	1

Usage: Query only

TRIGger<m>:CAN:FDATa:DPOPerator <DatPosiOptor>

Sets the operator to define an exact position or a data range where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTO-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if `TRIGger<m>:CAN:DLC`≥9.

Parameters:

<DatPosiOptor> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the trigger condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:FDATa:DPOSition` and `TRIGger<m>:CAN:FDATa:DPTO`.

*RST: ANY

TRIGger<m>:CAN:FDATa:DPOSition <DataPosition>

Defines the number of the first data byte at which the data pattern may start.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<DataPosition>	Range:	1 to 57
	Increment:	1
	*RST:	1

TRIGger<m>:CAN:FDATa:DPTO <DataPositionTo>

Sets the number of the last byte at which the required data pattern may start.

Parameters:

<DataPositionTo>	Range:	8 to 64
	Increment:	1
	*RST:	8

TRIGger<m>:CAN:ACKerror <AckError>

Triggers when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<AckError>	ON | OFF	
	*RST:	ON

TRIGger<m>:CAN:BITSterror <BtStfErr>

Triggers if astuff error occurs - when the 6th consecutive equal bit level in the mentioned fields is detected.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<BtStfErr>	ON | OFF	
	*RST:	ON

TRIGger<m>:CAN:CRCerror <ChecksumError>

Triggers on CRC errors. A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<ChecksumError>	ON | OFF	
	*RST:	ON

TRIGger<m>:CAN:FORMerror <FormError>

Triggers when a fixed-form bit field contains one or more illegal bits.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<FormError>	ON | OFF	
	*RST:	ON

TRIGger<m>:CAN:FDATa:SCERror <StuffCountError>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

The trigger type `TRIGger<m>:CAN:TYPE` must be set to `ERRC`.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError>	ON | OFF	
	*RST:	ON

20.17.6.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:CAN:FCOunt?

Returns the number of decoded frames of the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames. Range: 0 to 100000 Increment: 1 *RST: 0
Usage:	Query only

BUS<m>:CAN:FDATa:FRAMe<n>:STANdard?

Returns the CAN standard.

The setting is available in CAN FD option R&S RTO-K9.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* The frame suffix is irrelevant.

Return values:

<Standard>	CAN | CANFd *RST: CAN
Usage:	Query only

BUS<m>:CAN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE OK: the frame is valid. FORM: Fixed-bit form error BTST: Bit stuffing error occured. CRC: Cyclic redundancy check failed. CRCD: Wrong CRC delimiter occured. NOACK: Acknowlegde is missing. ACKD: Wrong ACK delimiter occured. EOFD: Wrong end of frame. CAERror: CRC error followed by an acknowledgement error (missing acknowledge) FCERor: CRC error followed by a form error (wrong CRC delimiter or wrong ACK delimiter) INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. SERRror: Stuff count error (CAN-FD ISO only) SFER: Stuff count error and FORM error (CAN-FD ISO only) SCER: Stuff count error and CRC error (CAN-FD ISO only) SAER: Stuff count error and ACK error (CAN-FD ISO only) SCAE: Stuff count error and CRC error and ACK error (CAN-FD ISO only) SCFE: Stuff count error and CRC error and FORM error (CAN-FD ISO only) *RST: OK
Usage:	Query only

BUS<m>:CAN:FRAMe<n>:NDBYtes?

REturns the number of data bytes.

Suffix:

<m>	1..4
<n>	*

Return values:

<NDBytes>	Range: 1 to 64 Increment: 1 *RST: 1
Usage:	Query only
Firmware/Software:	FW 3.35

BUS<m>:CAN:FRAMe<n>:STARt?
BUS<m>:CAN:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart> <FrameStop>	Time Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:CAN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic label of the identifier

Example: `BUS:CAN:FRAMe:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:CAN:FRAMe<n>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>	DATA | REMote | ERR | OVLD Data, remote, error or overload frame. *RST: DATA

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Data>	Comma-separated list of integer values. The first value is the number of bytes, followed by the values of the data bytes.

Example:

```
BUS1:CAN:FRAMe2:DATA?
--> 3,208,231,32
```

Returns the data of the second frame: the number of bytes is 3 data (first value).

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKState?
BUS<m>:CAN:FRAMe<n>:CSSTate?
BUS<m>:CAN:FRAMe<n>:DLCState?
BUS<m>:CAN:FRAMe<n>:IDSTate?

Return the states of following parts of a message

- ACKState: state of acknowledgement field
- CSSTate: state of checksum field (CRC)
- DLCState: state of data length code
- IDSTate: identifier state

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierState>	OK | ERRor | UNDF UNDF: Undefined *RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKValue?

Returns the value of the acknowledge slot for the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AckValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 1

*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ChecksumValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 2097151

*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DLCValue?

Returns the data length code of the selected frame - the number of data bytes in the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DataLengthCode> Number of data bytes in decimal values.

Range: 0 to 15

*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDTYpe?

Returns the identifier type of the selected frame, the identifier format of data and remote frames.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierType> ANY | B11 | B29

B11: standard format, 11 bit
B29: extended format, 29 bit

*RST: B11

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 536870911
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BSEPosition?

Returns the location of a bit stuffing error.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<BtStuffErrPos>	Time when the error occured Range: 0 to 5000 *RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:FERCause?

Returns information on a form error, if the frame status query returned a FORM error.

See also: `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1575

Suffix:

<m>	1..4
<n>	*

Return values:

<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror

CRCD = CRC delimiter error
ACKD = ACK delimiter error
FSBE = Fixed stuff bit error (CAN-FD ISO only)
RESE = Reserved bit error

*RST: NONE

Usage: Query only

BUS<m>:CAN:FDATa:FRAMe<n>:SCValue?

Returns the stuff bit count modulo 8 value.

Suffix:

<m>	1..4
<n>	*

Return values:

<StuffCount>	Range: 0 to 7 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

<o>	* Selects the byte number.

Return values:

<State>	OK | ERRor | UNDF UNDF: Undefined *RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<Value>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 255 *RST: 0

Usage: Query only

20.17.6.4 Search Settings

SEARch:TRIGger:CAN[:STATe] <SearchName>,<State>
SEARch:TRIGger:CAN[:STATe]? <SearchName>

Includes the search conditions for the CAN trigger event type in the next search.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN[:SSOFrame] <SearchName>,<ChkStrtFrm>
SEARch:TRIGger:CAN[:SSOFrame]? <SearchName>

Enables the search for a start of frame.

Parameters:

<ChkStrtFrm>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFTYpe <SearchName>,<CheckFrameType>
SEARch:TRIGger:CAN:SFTYpe? <SearchName>

Enables the search for a specified frame type.

Parameters:

<CheckFrameType>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFIDentifier <SearchName>,<CheckIdentifier>
SEARch:TRIGger:CAN:SFIDentifier? <SearchName>

Enables the search for frame indentifier.

Parameters:

<CheckIdentifier>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SIDData <SearchName>,<ChkIdtfDat>
SEARch:TRIGger:CAN:SIDData? <SearchName>

Enables the search for identifier and data.

Parameters:

<ChkIdtfDat>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SERRor <SearchName>,<ChkErrCond>
SEARch:TRIGger:CAN:SERRor? <SearchName>

Enables the search for a specified error.

Parameters:

<ChkErrCond>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:FDATa:STANdard <SearchName>,<StdSel>
SEARch:TRIGger:CAN:FDATa:STANdard? <SearchName>

Selects the CAN standard: CAN, CAN FD, or Any.

Use "Any" to search on either CAN or CAN-FD frame. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<StdSel>	ANY | CAN | CANFd *RST: CAN

Parameters for setting and query:

<SearchName>	String with the search name

SEARch:TRIGger:CAN:FTYPe <SearchName>,<RemoteFrameType>
SEARch:TRIGger:CAN:FTYPe? <SearchName>

Selects the CAN frame type to be searched for.

For data and remote frames, the identifier format has to be set with `SEARch:TRIGger:CAN:ITYPe` on page 1585.

Parameters:

<RemoteFrameType>	ANY | DATA | REMote | ERRor | OVERload *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:ITYPe <SearchName>,<IdentifierType>
SEARch:TRIGger:CAN:ITYPe? <SearchName>

Selects the format of data and remote frames: 11 bit for CAN base frames, or 29 bits for CAN extended frames.

Parameters:

<IdentifierType>	ANY | B11 | B29 *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:ICONdition <SearchName>,<IdtfOptor>
SEARch:TRIGger:CAN:ICONdition? <SearchName>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdtfOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `SEARch:TRIGger:CAN:IMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:IMIN` and `SEARch:TRIGger:CAN:IMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:IMAX <SearchName>,<IdtfPattTo>
SEARch:TRIGger:CAN:IMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:IMIN <SearchName>,<IdtfPatt>
SEARch:TRIGger:CAN:IMIN? <SearchName>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:CAN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:CAN:DMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:DMIN` and `SEARch:TRIGger:CAN:DMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:CAN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:CAN:DMAX? <SearchName>

Sets the the end value of an data range if `SEARch:TRIGger:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:DLCCondition <SearchName>,<DLCOperator>
SEARch:TRIGger:CAN:DLCCondition? <SearchName>

Operator to set the data length code for search.

Parameters:

<DLCOperator>	EQUal | GETHan	
	*RST:	GETHan

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:DLC <SearchName>,<WordCount>
SEARch:TRIGger:CAN:DLC? <SearchName>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `SEARch:TRIGger:CAN:DLCCondition`.

Parameters:

<WordCount>	Range:	1 to 8
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:RESult:CAN:FRAMe<m>:NDBYtes? <SearchName>

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 536.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<NDBytes>	Range:	1 to 64
	Increment:	1
	*RST:	1

Usage: Query only

SEARch:TRIGger:CAN:FDATa:DPOPerator <SearchName>,<DatPosiOptor>
SEARch:TRIGger:CAN:FDATa:DPOPerator? <SearchName>

Sets the operator for the data position if DLC ≥ 9. You can define an exact position, or a position range.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<DatPosiOptor> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the search.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:FDATa:DPOSition` and `SEARch:TRIGger:CAN:FDATa:DPTO`.

*RST: ANY

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:CAN:FDATa:DPOSition? <SearchName>

Defines the first possible start position of the data pattern.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<DataPosition>	Range:	1 to 57
	Increment:	1
	*RST:	1

Parameters for setting and query:

<SearchName>	String with the search name

SEARch:TRIGger:CAN:FDATa:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:CAN:FDATa:DPTO? <SearchName>

Defines the last possible start position of the data pattern if the position operator `SEARch:TRIGger:CAN:FDATa:DPOPerator` defines a range.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<DataPositionTo>	Range:	8 to 64
	Increment:	1
	*RST:	8

Parameters for setting and query:

<SearchName>	String with the search name

SEARch:TRIGger:CAN:ACKerror <SearchName>,<AckError>
SEARch:TRIGger:CAN:ACKerror? <SearchName>

Searches for acknowledgement errors. An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

Parameters:

<AckError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:BITSterror <SearchName>,<BtStfErr>
SEARch:TRIGger:CAN:BITSterror? <SearchName>

Searches for bit stuffing errors.

Parameters:

<BtStfErr>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:CRCerror <SearchName>,<ChecksumError>
SEARch:TRIGger:CAN:CRCerror? <SearchName>

Searches for errors in the Cyclic Redundancy Check.

Parameters:

<ChecksumError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:FORMerror <SearchName>,<FormError>
SEARch:TRIGger:CAN:FORMerror? <SearchName>

Searches for form errors. A form error occurs when a fixed-form bit field contains one or more illegal bits.

Parameters:

<FormError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:FDATa:SCERror <SearchName>,<StuffCountError>
SEARch:TRIGger:CAN:FDATa:SCERror? <SearchName>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:FDATa[:FDF] <SearchName>,<FDFBit>
SEARch:TRIGger:CAN:FDATa[:FDF]? <SearchName>

Sets the EDL bit (extended data length), which determines whether a frame is CAN or CAN-FD.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<FDFBit>	ONE | ZERO | DC ONE: CAN FD. ZERO: CAN. DC: don't care, the format is not relevant. *RST: DC

Parameters for setting and query:

<SearchName>	String with the search name

SEARch:TRIGger:CAN:FDATa:BRS <SearchName>,<BRSBit>
SEARch:TRIGger:CAN:FDATa:BRS? <SearchName>

Sets the bit rate switching bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<BRSBit>	ONE | ZERO | DC DC: Don't care *RST: ONE

Parameters for setting and query:

<SearchName>	String with the search name

SEARch:TRIGger:CAN:FDATa:ESI <SearchName>,<ESIBit>
SEARch:TRIGger:CAN:FDATa:ESI? <SearchName>

Sets the error state indicator bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTO-K9.

Parameters:

<ESIBit>	ONE | ZERO | DC *RST: DC

Parameters for setting and query:

<SearchName>	String with the search name

20.17.6.5 Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.6.3, "Decode Results", on page 1574.

SEARch:RESult:CAN:FCOunt? <SearchName>

Query parameters:

<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKState? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameAckState>	OK | ERRor | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKValue? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameAckValue>	Range:	0 to 1
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BSEPosition? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmBtStfErrPosi>	Range:	0 to 5000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<State> OK | ERRor | UNDF

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<Value>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:CSSTate? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<FrmCksumSt> OK | ERRor | UNDF

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:CSValue? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmCksumVal>	Range:	0 to 2097151
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DLCState? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameDLCState>	OK | ERRor | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DLCValue? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameDLCValue>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:FERCause? <SearchName>

Returns information on a form error, if the frame status query returned a FORM error.

See also: `SEARch:RESult:CAN:FRAMe<m>:STATus?` on page 1597.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FormErrorCause>	NONE | CRCDerror | ACKDerror | FSBE | RESerror See `BUS<m>:CAN:FRAMe<n>:FERCause?` on page 1581.	
	*RST:	NONE

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDSTate? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmIdtfSt>	OK | ERRor | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDTYpe? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrmIdtfTyp>	ANY | B11 | B29	
	*RST:	B11

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDValue? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrmIdtfVal>	Range:	0 to 536870911
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:SCValue? <SearchName>

Returns the stuff bit count modulo 8.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<StuffCount>	Range:	0 to 7
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard? <SearchName>

Returns the CAN protocol standard: CAN or CAN FD.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Standard>	CAN | CANFd *RST: CAN

Usage:	Query only

SEARch:RESult:CAN:FRAMe<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage:	Query only

SEARch:RESult:CAN:FRAMe<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameState>	OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE See `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1575. *RST: OK

Usage:	Query only

SEARch:RESult:CAN:FRAMe<m>:STOP? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:SYMBol? <SearchName>

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	* Selects the number of the frame in the current acquisition, 1...n.

Query parameters:

<SearchName>	String parameter that contains the search definition name

Return values:

<Label>	Symbolic label (string)

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameType>	DATA | REMote | ERR | OVLD	
	*RST:	DATA

Usage: Query only

20.17.6.6 Symbolic Trigger, Decode and Search

Symbolic Trigger

TRIGger<m>:CAN:SYMBolic:MSGValue <MessageName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1601

Parameters:

<MessageName>	String with the symbolic message name

TRIGger<m>:CAN:SYMBolic:TSIGnals <SymbTrigOnSign>

Enables the trigger on a specific signal value that is part of the selected message.

Parameters:

<SymbTrigOnSign>	ON | OFF	
	*RST:	OFF

TRIGger<m>:CAN:SYMBolic:SIGValue <SignalName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1602

Parameters:

<SignalName>	String with the signal name as defined in the DBC file.

TRIGger<m>:CAN:SYMBolic:DMAX <SymbMaxSignVal>

Defines the maximum data value of the signal.

This value is required to specify a range if condition `INRange | OORange` is set with `TRIGger<m>:CAN:DCONdition`.

Parameters:

<SymbMaxSignVal>	Decimal representation of the data pattern	
	Range:	-100E+24 to 100E+24
	Increment:	0.5
	*RST:	1

TRIGger<m>:CAN:SYMBolic:DMIN <SymbMinSignVal>

Defines the minimum data value of the signal.

To set the condition, use `TRIGger<m>:CAN:DCONdition`.

Parameters:

<SymbMinSignVal> Decimal representation of the data pattern

Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 0

TRIGger<m>:CAN:SYMBolic:SGEValue <SignalEnumValue>

Sets a symbolic data value for signals with enumerated values.

Parameters:

<SignalEnumValue> Numeric value according to the value definition in the DBC file

Example: Definition line in DBC file:

```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```

Search for "Gear_4"

```
TRIGger:CAN:SYMBolic:SGEValue "Search1",4
```

Symbolic Decode Results

BUS<m>:CAN:FRAMe<n>:SDATa?

Returns the complete symbolic data of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<SymbolicData> String with comma-separated list of symbolic data

Example:

```
BUS:CAN:FRAMe9:SDATa?
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```

Returns the symbolic results of the 9th frame.

Usage: Query only

Symbolic Search

SEARch:RESult:CAN:FRAMe<m>:SDATa? <SearchName>

Returns the symbolic data of the selected result frame.

Suffix:

<m>	* Sets the index of the search result frame.

Query parameters:

<SearchName>	String that contains the search definition name

Return values:

<SymbolicData>	String with comma-separated list of symbolic data

Example:

```
SEARch:RESult:CAN:FRAMe:SDATa? 'Search1'
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```

Returns the symbolic results of the first search result.

Usage: Query only

SEARch:TRIGger:CAN:SSYMbolic <SearchName>,<CheckSymbolic>
SEARch:TRIGger:CAN:SSYMbolic? <SearchName>

Enables the symbolic search and disables all other search criteria.

Parameters:

<CheckSymbolic>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:MSGValue <SearchName>, <MessageName>
SEARch:TRIGger:CAN:SYMBolic:MSGValue? <SearchName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: `TRIGger<m>:CAN:SYMBolic:MSGValue` on page 1599

Parameters:

<MessageName>	String that contains the symbolic message name

Parameters for setting and query:

<SearchName>	String that contains the search definition name

Example:	`SEARch:TRIGger:CAN:SYMBolic:MSGValue "Search1", "EngineData"`

SEARch:TRIGger:CAN:SYMBolic:SSIGnals <SearchName>,<SymbTrigOnSign>
SEARch:TRIGger:CAN:SYMBolic:SSIGnals? <SearchName>

Enables the search for a specific signal value that is part of the selected message.

Parameters:

<SymbTrigOnSign>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SIGValue <SearchName>, <SignalName>
SEARch:TRIGger:CAN:SYMBolic:SIGValue? <SearchName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1599

Parameters:

<SignalName>	String that contains the symbolic signal name

Parameters for setting and query:

<SearchName>	String that contains the search definition name
Example:	`SEARch:TRIGger:CAN:SYMBolic:SIGValue "Search1", "EngForce"`

SEARch:TRIGger:CAN:SYMBolic:DMIN <SearchName>,<SymbMinSignVal>
SEARch:TRIGger:CAN:SYMBolic:DMIN? <SearchName>

Defines the minimum data value of the signal.

To set the condition, use `SEARch:TRIGger:CAN:DCONdition`.

Parameters:

<SymbMinSignVal>	Range: -100E+24 to 100E+24 Increment: 0.5 *RST: 0

Parameters for setting and query:

<SearchName>	String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:DMAX <SearchName>,<SymbMaxSignVal>
SEARch:TRIGger:CAN:SYMBolic:DMAX? <SearchName>

Defines the maximum data value of the signal.

This value is required to specify a range if condition `INRange | OORange` is set with `SEARch:TRIGger:CAN:DCONdition` on page 1586.

Parameters:

<SymbMaxSignVal>	Range:	-100E+24 to 100E+24
	Increment:	0.5
	*RST:	1

Parameters for setting and query:

<SearchName>	String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SGEValue <SearchName>, <SignalEnumValue>
SEARch:TRIGger:CAN:SYMBolic:SGEValue? <SearchName>

Sets a symbolic data value for signals with enumerated values.

Parameters:

<SignalEnumValue>	Numeric value according to the value definition in the DBC file

Parameters for setting and query:

<SearchName>	String that contains the search definition name

Example: Definition line in DBC file:

```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```

Search for "Gear_3"

```
SEARch:TRIGger:CAN:SYMBolic:SGEValue "Search1",3
```

20.17.7 LIN (Option R&S RTO-K3)

20.17.7.1 Configuration

BUS<m>:LIN:DATA:SOURce <DataSource>

Sets the waveform of the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 See Chapter 20.4.2, "Waveform Parameter", on page 1173 *RST: C1W1
Usage:	Asynchronous command

BUS<m>:LIN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:LIN:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Threshold>	Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:LIN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology>	V15 | V25 | V35 | V6 | V9 | MAN **V15** 1.5 Volt (TTL) **V25** 2.5 Volt (CMOS 5.0 V) **V35 | V6 | V9** 3.5 V (7 V supply), 6.0 V (12 V supply), 9.0 V (18 V supply) respectively **MAN** Manual setting of user-defined values with `BUS<m>:LIN:DATA:THReshold`. *RST: V35

BUS<m>:LIN:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Bitrate>	Range: 1000 to 20000 Increment: 1 *RST: 9600 Default unit: bps

---

BUS<m>:LIN:POLarity <Polarity>

Defines the idle state of the bus. The idle state is the rezessive state and corresponds to a logic 1.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Polarity>	IDLLow | IDLHigh *RST: IDLHigh

BUS<m>:LIN:STANdard <Standard>

Selects the version of the LIN standard.

See also: "LIN standard" on page 567

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Standard>	V1X | V2X | J2602 | AUTO
	*RST: AUTO

20.17.7.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:LIN:TYPE <Type>

Selects the trigger type for LIN analysis.

See: "Trigger type" on page 568.

Parameters:

<Type>	SYNC | ID | IDOR | IDDT | WKFR | ERRC **SYNC** Start of the frame, triggers on the stop bit of the sync field. **ID** Sets the trigger to one specific identifier or an identifier range. To set the identifier, use `TRIGger<m>:LIN:ICONdition`, `TRIGger<m>:LIN:IMIN` on page 1608, and `TRIGger<m>:LIN:IMAX` on page 1608. **IDOR** Triggers on an OR combination with up to four four identifier conditions. For each identifier condition, enable it with `TRIGger<m>:LIN:IDOR<n>:ENABle` and set the value with `TRIGger<m>:LIN:IDOR<n>[:VALue]` **IDDT** Combination of identifier and data conditions To set the identifier condition, use `TRIGger<m>:LIN:ICONdition`, `TRIGger<m>:LIN:IMIN`, and `TRIGger<m>:LIN:IMAX`. To set the data condition, use `TRIGger<m>:LIN:DCONdition`, `TRIGger<m>:LIN:DMIN`, and `TRIGger<m>:LIN:DMAX`. **WKFR** Wakeup frame **ERRC** Error condition. Define the error types with `TRIGger<m>:LIN:CHKSerror` on page 1611, `TRIGger<m>:LIN:IPERror`, and `TRIGger<m>:LIN:SYERror` *RST: SYNC

TRIGger<m>:LIN:ICONdition <IdtfOptor>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdtfOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `TRIGger<m>:LIN:IMIN` **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:LIN:IMIN` and `TRIGger<m>:LIN:IMAX` *RST: EQUal

---

TRIGger<m>:LIN:IMIN <IdtfPatt>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:LIN:IMAX <IdtfPattTo>

Sets the the end value of an identifier range if `TRIGger<m>:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:LIN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:LIN:DMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:LIN:DMIN` and `TRIGger<m>:LIN:DMAX` *RST: EQUal

---

TRIGger<m>:LIN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer.

According to the standard, LIN data is transmitted in little endian transfer order.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:LIN:DLECondition <DLCOperator>

Operator to set the data length for triggering on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `TRIGger<m>:LIN:DLENgth` on page 1609.

See also:`TRIGger<m>:LIN:BORDer` on page 1609 .

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

TRIGger<m>:LIN:DLENgth <WordCount>

Sets the length of the bit pattern to be found, in bytes. For "Big Endian" transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the beginning of the data pattern. For "Little Endian" transfer direction, the exact number of data bytes in the frame must be set.

For complete definition, set also the operator with `TRIGger<m>:LIN:DLECondition` on page 1609.

Parameters:

<WordCount>	Range: 1 to 8 Increment: 1 *RST: 1

TRIGger<m>:LIN:IDOR<n>:ENABle <UseIdentifier>

Includes the indicated IDOR address in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<UseIdentifier>	ON | OFF *RST: OFF

Firmware/Software: V 1.25

TRIGger<m>:LIN:IDOR<n>[:VALue] <IdtfPatt>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The parameter accepts the bit value X (don't care).

Firmware/Software: V 1.25

TRIGger<m>:LIN:SYERror <SyncError>

Triggers if a synchronization error occurs.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

Parameters:

<SyncError>	ON | OFF *RST: ON

TRIGger<m>:LIN:IPERror <IdtfParErr>

Triggers if an error occurs in the identifier parity bits. These are the bits 6 and 7 of the identifier.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

Parameters:

<IdtfParErr>	ON | OFF *RST: ON

TRIGger<m>:LIN:CHKSerror <ChecksumError>

Triggers on checksum errors according to the LIN standard set with `BUS<m>:LIN:STANdard`.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

The frame identifier must be set with `TRIGger<m>:LIN:ERRPattern` on page 1611 and the data length with `TRIGger<m>:LIN:CRCDatalen` on page 1612.

Parameters:

<ChecksumError>	ON | OFF *RST: ON

TRIGger<m>:LIN:ERRPattern <ErrorPattern>

Sets the frame identifier to trigger on a checksum error with `TRIGger<m>:LIN:CHKSerror` on page 1611.

Parameters:

<ErrorPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.
Possible values depend on `TRIGger<m>:LIN:CRCDatalen`.
Defining don't care bits 'X' in the ERRP bit string resets CRCDatalen to 0. When CRCDatalen is different than 0, then all the bits in ERRP must be 1 or 0, and X bits are set to 0.

Example:

```
FORM:BPAT STRG
TRIG1:LIN:ERRP '1X0'
TRIG1:LIN:ERRP?
<-- 1X0XXX
TRIGger:LIN:CRCDatalen?
<-- 0
TRIGger:LIN:CRCDatalen 4
TRIG1:LIN:ERRP?
<-- 100000
TRIG1:LIN:ERRP '00x11'
TRIG1:LIN:ERRP?
<-- 00X11X
TRIGger:LIN:CRCDatalen?
<-- 0
```

Firmware/Software: V 1.25

TRIGger<m>:LIN:CRCDatalen <CRCDataLength>

Sets the number of data bytes to trigger on CRC errors (`TRIGger<m>:LIN:TYPE` is set to ERRC and `TRIGger<m>:LIN:CHKSerror` is set ON.)

Parameters:

<CRCDataLength>	Values ≠0 restrict allowed bit values in `TRIGger<m>:LIN:ERRPattern` to 0 and 1. Range: 0 to 8 Increment: 1 *RST: 0

TRIGger<m>:LIN:STANdard <CksumStd>

Sets the LIN standard to trigger on CRC errors (`TRIGger<m>:LIN:TYPE` is set to ERRC and `TRIGger<m>:LIN:CHKSerror` is set ON.)

See also: "LIN standard" on page 567.

Parameters:

<CksumStd>	V1X | V2X | J2602 | AUTO *RST: AUTO

20.17.7.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:LIN:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames.

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient UART: at least one UART error occured. LIN uses UART words without parity bit. CHCKsum: checksum error VERS: the version of the LIN standard is not valid LENer: unexpected length SPERror: stop error PRERror: parity error in identifier SYERror: synchronization error WAKeup: the frame is a wakeup frame CPERror: parity error and checksum error INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STARt?
BUS<m>:LIN:FRAMe<n>:STOP?

Returns the start time and stop time of the selected frame, respectively.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart> <FrameStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic name of the identifier

Example: `BUS:LIN:FRAMe2:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:LIN:FRAMe<n>:VERSion?

Returns the version of the LIN standard for the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameVersion>	V1X | V2X | UNK UNK: Unknown *RST: UNK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:DATA?

Returns the data bytes of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.

<n>	* Selects the frame.

Return values:

<Data>	Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example:
```
BUS:LIN:FRAMe4:DATA?
<-- 4,118,39,71,123
```

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDSTate?

Returns the identifier state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierState>	OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient STERror: start error SPERror: stop error PRERror: parity error UVAL: unexpected value NOEXists: byte does not exist INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 63 *RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDPValue?

Returns the value of the identifier parity bits of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdtfParityValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 3 *RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYSTate?

Returns the state of the sync field for the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<SyncState>	OK | STERror | SPERror | UVAL | NOEXists | INSufficient STERror: start error SPERror: stop error UVAL: unexpected value NOEXists: byte does not exist INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSSTate?

Returns the checksum state of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ChecksumState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSValue?

Returns the checksum value of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ChecksumValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

<o>	* Selects the byte number.

Return values:

<ByteState>	OK | STERror | SPERror | UVAL | NOEXists | INSufficient STERror: start error SPERror: stop error UVAL: unexpected value NOEXists: byte does not exist INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte.

Return values:

<ByteValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 255 *RST: 0

Usage: Query only

20.17.7.4 LIN Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to LIN trigger commands.

SEARch:TRIGger:LIN:SSOFrame <SearchName>,<SearchStrtFrm>
SEARch:TRIGger:LIN:SSOFrame? <SearchName>

Enables the search for the stop bit of the sync field, which marks the frame start.

Parameters:

<SearchStrtFrm>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SFIDentifier <SearchName>,<SearchSymbol>
SEARch:TRIGger:LIN:SFIDentifier? <SearchName>

Enables the search for one specific identifier or an identifier range.

Parameters:

<SearchSymbol>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDENtifieror <SearchName>,<SearchSymbol>
SEARch:TRIGger:LIN:IDENtifieror? <SearchName>

Enables the search for one to four address conditions.

Parameters:

<SearchSymbol>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SIDData <SearchName>,<SearchIdtfDat>
SEARch:TRIGger:LIN:SIDData? <SearchName>

Enables the search for a combination of identifier and data conditions.

Parameters:

<SearchIdtfDat>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SERRor <SearchName>,<SearchErrCond>
SEARch:TRIGger:LIN:SERRor? <SearchName>

Enables the search for various errors in the frame.

Parameters:

<SearchErrCond>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:WUFRame <SearchName>,<WakeUpFrame>
SEARch:TRIGger:LIN:WUFRame? <SearchName>

Enables the search for wakeup frames.

Parameters:

<WakeUpFrame>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:ICONdition <SearchName>,<IdtfOptor>
SEARch:TRIGger:LIN:ICONdition? <SearchName>

Sets the operator to define a specific identifier or an identifier range.

Parameters:

<IdtfOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These operators require one identifier pattern to be set with `SEARch:TRIGger:LIN:IMIN` **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:IMIN` and `SEARch:TRIGger:LIN:IMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IMIN <SearchName>,<IdtfPatt>
SEARch:TRIGger:LIN:IMIN? <SearchName>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IMAX <SearchName>,<IdtfPattTo>
SEARch:TRIGger:LIN:IMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDOR<m>:ENABle <SearchName>,<UseIdentifier>
SEARch:TRIGger:LIN:IDOR<m>:ENABle? <SearchName>

Includes the indicated IDOR address in the "identifier OR" search.

Suffix:

<m>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<UseIdentifier>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDOR<m>[:VALue] <SearchName>,<IdtfPatt>
SEARch:TRIGger:LIN:IDOR<m>[:VALue]? <SearchName>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:

<m>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:LIN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:LIN:DMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:DMIN` and `SEARch:TRIGger:LIN:DMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:LIN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:LIN:DMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:BORDer <SearchName>,<Endianness>
SEARch:TRIGger:LIN:BORDer? <SearchName>

Sets the byte order (endianness) of the data transfer.

Parameters:

<Endianness>	BENDian | LENDian **BENDian** Big endian, data is analyzed and evaluated in the order of reception. **LENDian** Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word. *RST: BENDian

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DLECondition <SearchName>,<DLCOperator>
SEARch:TRIGger:LIN:DLECondition? <SearchName>

Operator to set the data length for search on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `SEARch:TRIGger:LIN:DLENgth`.

See also: `SEARch:TRIGger:LIN:BORDer` on page 1623.

Parameters:

<DLCOperator>	EQUal | GETHan For little endian transfer direction, EQUal must be set. *RST: GETHan

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:DLENgth <SearchName>,<WordCount>
SEARch:TRIGger:LIN:DLENgth? <SearchName>

Sets the length of the bit pattern to be found, in bytes.

For complete definition, set the operator using `SEARch:TRIGger:LIN:DLECondition`, and the transfer direction with `SEARch:TRIGger:LIN:BORDer`.

Parameters:

<WordCount>	Range:	1 to 8
	Increment:	1
	*RST:	1

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IPERror <SearchName>,<IdtfParErr>
SEARch:TRIGger:LIN:IPERror? <SearchName>

Searches for errors in the identifier parity bits. These are the bits 6 and 7 of the identifier.

Parameters:

<IdtfParErr>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:SYERror <SearchName>,<SyncError>
SEARch:TRIGger:LIN:SYERror? <SearchName>

Searches for synchronization errors.

Parameters:

<SyncError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:CHKSerror <SearchName>,<ChecksumError>
SEARch:TRIGger:LIN:CHKSerror? <SearchName>

Searches for checksum errors according to the LIN standard.

Use the following commands to configure the checksum error search:

- `SEARch:TRIGger:LIN:ERRPattern` on page 1625
- `SEARch:TRIGger:LIN:CRCDatalen` on page 1625
- `SEARch:TRIGger:LIN:STANdard` on page 1626

Parameters:

<ChecksumError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:ERRPattern <SearchName>,<ErrorPattern>
SEARch:TRIGger:LIN:ERRPattern? <SearchName>

Sets the frame identifier to search for a checksum error.

Parameters:

<ErrorPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:CRCDatalen <SearchName>,<CRCDataLength>
SEARch:TRIGger:LIN:CRCDatalen? <SearchName>

Sets the number of data bytes search for CRC errors.

Parameters:

<CRCDataLength>	Range: 0 to 8 Increment: 1 *RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:STANdard <SearchName>,<CksumStd>
SEARch:TRIGger:LIN:STANdard? <SearchName>

Sets the LIN standard to search for CRC errors.

Parameters:

<CksumStd>	V1X | V2X | J2602 | AUTO	
	*RST:	AUTO

Parameters for setting and query:
<SearchName>

20.17.7.5 LIN Search Results

The search on decoded LIN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.7.3, "Decode Results", on page 1612.

SEARch:RESult:LIN:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameState>	OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient *RST: OK
Usage:	Query only

SEARch:RESult:LIN:FRAMe<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s
Usage:	Query only	

SEARch:RESult:LIN:FRAMe<m>:STOP? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s
Usage:	Query only	

SEARch:RESult:LIN:FRAMe<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSSTate? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmCksumSt>	OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient *RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSValue? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmCksumVal>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDSTate? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrmIdtfSt>	OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient *RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDValue? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrmIdtfVal>	Range:	0 to 63
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDPValue? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrmIdtfParVal>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYMBol? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<SearchName>

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYSTate? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameSyncState>	OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient *RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:VERSion? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameVersion>	V1X | V2X | UNK *RST: UNK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteState>	OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient *RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteValue>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

20.17.8 FlexRay (Option R&S RTO-K4)

20.17.8.1 Configuration

BUS<m>:FLXRay:SRCType <SourceType>

Sets the type of measurement.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SourceType> SINGle | DIFFerential | LOGic

SINGle
Used for measurements with single-ended probes or single-ended voltage measurements with differential probes on the FlexRay bus. Two thresholds have to be defined as absolute voltage levels, see `BUS<m>:FLXRay:THReshold<n>` on page 1632.

DIFFerential
Used for differential measurements on the FlexRay bus. This is the most common measurement. Two thresholds have to be defined as differential voltages.

LOGic
Used for measurements of the logic signal inside the FlexRay node, between the communication controller and the bus driver. It is possible to measure simultaneously on a data line and on the "enable" line. Each line requires its own threshold.

*RST: SINGle

BUS<m>:FLXRay:SOURce<n> <Sources>

Sets the input channel of the bus signal, or of the data and enable lines in case of a LOGic source type.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	1 | 2 Selects the source: 1 = bus signal or data line, 2 = enable line

Parameters:

<Sources>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 **C1W1 | C2W1 | C3W1 | C4W1** Always available **NONE** Only available for SOURce2 (enable line) **M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4** Only available if the trigger source is one of the input channels but not the serial bus. **D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15** Only available if `BUS<m>:FLXRay:SOURce<n>` is set to `LOGic`.

BUS<m>:FLXRay:THReshold<n> <THResholds>

Sets the thresholds for the bus signal if the source type is SINGle or DIFFerential.

For LOGic source type, use `BUS<m>:FLXRay:THData` on page 1633 and `BUS<m>:FLXRay:THENable` on page 1632.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	1 | 2 1 = threshold high, 2 = threshold low

Parameters:

<THResholds>	Differential or absolute voltage level, depending on the source type. See `BUS<m>:FLXRay:SRCType` on page 1631.

BUS<m>:FLXRay:THENable <ThresholdEnable>

Sets the threshold for the enable line if the source type is LOGic.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdEnable>	Range: -12 to 12 Increment: 0.1 *RST: 2.65 Default unit: V

BUS<m>:FLXRay:THData <ThresholdData>

Sets the threshold for the data line if the source type is LOGic.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdData>	Range: -12 to 12 Increment: 0.1 *RST: 2.35 Default unit: V

BUS<m>:FLXRay:PRSingle <PresetSgEnd>

Selects a default threshold voltage if `BUS<m>:FLXRay:SRCType` is set to `SINGle`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<PresetSgEnd>	MV150 | MV200 | MV250 | MV300 | MAN **MV150 | MV200 | MV250 | MV300** 2.5 ± 0.15 V; 2.5 ± 0.2 V; 2.5 ± 0.25 V; 2.5 ± 0.3 V, respectively **MAN** Manual setting of user-defined values with `BUS<m>:FLXRay:THReshold<n>` on page 1632. *RST: MV150

BUS<m>:FLXRay:PRDiff <PresetDiff>

Selects a default threshold voltage if `BUS<m>:FLXRay:SRCType` is set to `DIFFerential`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<PresetDiff>	MV150 | MV200 | MV250 | MV300 | MAN **MV150 | MV200 | MV250 | MV300** ±150 mV, ±200 mV, ±250 mV, ±300 mV respectively **MAN** Manual setting of user-defined values with `BUS<m>:FLXRay:THReshold<n>` on page 1632. *RST: MV150

BUS<m>:FLXRay:PRLogic <PresetLogic>

Selects a default threshold voltage if `BUS<m>:FLXRay:SRCType` is set to `LOGic`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<PresetLogic>	V25 | V165 | V125 | V09 | V0 | MAN **V25 | V165 | V125 | V09 | V0** 2.5 V (CMOS 5.0 V); 1.65 V (CMOS 3.5V), 1.25 V (CMOS 2.5V), 0.9 V (CMOS 1.8V), 0 V (ground) **MAN** Manual setting of user-defined values with `BUS<m>:FLXRay:THReshold<n>` on page 1632. *RST: V25

BUS<m>:FLXRay:POLarity <Polarity>

Selects the wire on which the bus signal is measured in case of SINGle source type. The setting affects the digitization of the signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Polarity>	BPLus | BMINus *RST: BPLus

BUS<m>:FLXRay:BITRate <Bitrate>

Selects the number of transmitted bits per second.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Bitrate>	M10 | M5 | M2_5 10, 5, or 2.5 Mbit/s. The return value of 2.5 Mbit/s is M25. *RST: M10

Example:

```
BUS:FLXRay:BITRate M2_5
BUS:FLXRay:BITRate?
M25
```

BUS<m>:FLXRay:CHTYpe <Channel>

Selects the channel on which the signal is measured. The setting is considered in the calculation of the frame CRC.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Channel>	CHA | CHB Channel A or channel B *RST: CHA

BUS<m>:FLXRay:SEHB <SeparateHdrBts>

The command affects the decoding and its display. If ON, the leading five indicator bits of the header are decoded as five single bits. Otherwise, the indicator bits are shown as one word with word length five bit.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SeparateHdrBts>	ON | OFF *RST: OFF

20.17.8.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:FLXRay:TYPE <Type>

Selects the trigger type for FlexRay analysis.

Parameters:

<Type>	STOF | IDDT | SYMBol | ERRC **STOF** STart Of Frame: triggers on the first rising edge after the transmission start sequence (TSS). **IDDT** IDentifier and DaTa: triggers on the decoded frame content, on header and payload data. For all settings that are not needed for the trigger condition, make sure to set its condition to `OFF`. *Indicator bits*: see `TRIGger<m>:FLXRay:NUFRame` **Frame identifier**: sets the trigger to one specific frame ID or an identifier range. To set the identifier, use `TRIGger<m>:FLXRay:FCONdition`, `TRIGger<m>:FLXRay:FMIN`, and `TRIGger<m>:FLXRay:FMAX`. *Payload length*: trigger on the number of words in the payload segment. To set the payload length, use `TRIGger<m>:FLXRay:PCONdition`, `TRIGger<m>:FLXRay:PMIN`, and `TRIGger<m>:FLXRay:PMAX`. *Cycle count*: trigger on the number of the current FlexRay cycle. To set the cycle count, use `TRIGger<m>:FLXRay:CENable`, `TRIGger<m>:FLXRay:CMIN`, `TRIGger<m>:FLXRay:CMAX`, and `TRIGger<m>:FLXRay:CSTep`. *Data position*: sets the position of the data bit pattern within the payload segment. To set the data position, use `TRIGger<m>:FLXRay:DPOPerator`, `TRIGger<m>:FLXRay:DPOSition`, and `TRIGger<m>:FLXRay:DPTO`. *Data bit pattern*: sets the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by the data position. To set the bit pattern, use `TRIGger<m>:FLXRay:DCONdition`, `TRIGger<m>:FLXRay:DMIN`, and `TRIGger<m>:FLXRay:DMAX`. **SYMBol** Triggers on a symbol or wakeup pattern. Set the required symbol with `TRIGger<m>:FLXRay:SYMBol` **ERRC** ERRor Condition: triggers on one or more errors that are detected in the decoded data. Use `TRIGger<m>:FLXRay:BSSerror`, `TRIGger<m>:FLXRay:FESerror`, `TRIGger<m>:FLXRay:FSSerror`, and `TRIGger<m>:FLXRay:PCRCerror`. *RST: STOF

TRIGger<m>:FLXRay:PLPReamble <PayloadPreamble>

Triggers on the payload preamble indicator bit that indicates a Network Management Vector in the payload segment.

Parameters:

<PayloadPreamble>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

TRIGger<m>:FLXRay:NUFRame <NullFrame>

Triggers on the null frame indicator bit, a frame without usable data.

Parameters:

<NullFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

TRIGger<m>:FLXRay:SYFRame <SyncFrame>

Triggers on the sync frame used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

Parameters:

<SyncFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

TRIGger<m>:FLXRay:STFRame <StartupFrame>

Triggers on startup frames used for startup of the network. Only specific start nodes can send this frame type.

Parameters:

<StartupFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

TRIGger<m>:FLXRay:FCONdition <IdtfOptor>

Sets the operator to set a frame ID or a frame ID range.

Parameters:

<IdtfOptor>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The frame ID is not relevant for the trigger condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one frame ID to be set with `TRIGger<m>:FLXRay:FMIN`. **INRange | OORange** In range, Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:FMIN` and `TRIGger<m>:FLXRay:FMAX`. *RST: EQUal

---

TRIGger<m>:FLXRay:FMIN <IdtfPatt>

Specifies a frame identifier pattern - the number of the slot - or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

TRIGger<m>:FLXRay:FMAX <IdtfPattTo>

Sets the the end value of an identifier range if the condition `TRIGger<m>:FLXRay:FCONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. FMAX must be greater or equal than FMIN, and the position of the X bits are common to FMIN and FMAX.

TRIGger<m>:FLXRay:PCONdition <PloadlgthOptor>

Sets the operator for the payload length trigger setting. You can defined an exact value, or a range.

Parameters:

<PloadlgthOptor>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The payload length is not relevant for the trigger condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one payload length to be set with `TRIGger<m>:FLXRay:PMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:PMIN` and `TRIGger<m>:FLXRay:PMAX`. *RST: OFF

TRIGger<m>:FLXRay:PMIN <PloadlgthMin>

Specifies a payload length - the number of words in the payload segment - or sets the the start value of an payload length range. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Parameters:

<PloadlgthMin>	Range:	0 to 127
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:PMAX <PloadlgthMax>

Sets the the end value of a payload length range if the condition `TRIGger<m>:FLXRay:PCONdition` is set to `INRange` or `OORange`.

Parameters:

<PloadlgthMax>	Range:	0 to 127
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:CENable <CycleCount>

Sets the operator to define a cycle count or a cycle count range.

Parameters:

<CycleCount>	OFF | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF** The cycle count is not relevant for the trigger condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one cycle count number to be set with `TRIGger<m>:FLXRay:CMIN`. **INRange | OORange** In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:CMIN` and `TRIGger<m>:FLXRay:CMAX`. *RST: OFF

TRIGger<m>:FLXRay:CMIN <CycleCount>

Specifies a cycle count - the number of the current FlexRay cycle - or sets the the start value of an cycle count range.

Parameters:

<CycleCount>	Range:	0 to 63
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:CMAX <CycleCountTo>

Sets the the end value of a cycle count range if the condition `TRIGger<m>:FLXRay:CENable` on page 1640 is set to `INRange` or `OORange`.

Parameters:

<CycleCountTo>	Range:	0 to 63
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:CSTep <CycleCountStep>

Specifies a step to trigger on each n-th cycle inside the given range. This allows for specific triggering if slot multiplexing is used.

The condition `TRIGger<m>:FLXRay:CENable` on page 1640 must be set to `INRange` or `OORange`.

Parameters:

<CycleCountStep>	Range:	1 to 63
	Increment:	1
	*RST:	1

TRIGger<m>:FLXRay:DPOPerator <DatPosiOptor>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DatPosiOptor> ANY | OFF | EQUal | GETHan | INRange | RANGe

OFF = ANY
The data position is not relevant for the trigger condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:FLXRay:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:DPOSition` and `TRIGger<m>:FLXRay:DPTO`.

*RST: EQUal

TRIGger<m>:FLXRay:DPOSition <DataPosition>

Sets the number of data bytes to be skipped after start of the payload segment

Parameters:

<DataPosition>	Range:	0 to 255
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:DPTO <DataPositionTo>

Defines the last byte of interest, if the position operator `TRIGger<m>:FLXRay:DPOPerator` defines a range.

Parameters:

<DataPositionTo>	Range:	0 to 255
	Increment:	1
	*RST:	0

TRIGger<m>:FLXRay:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The data position is not relevant for the trigger condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:FLXRay:DMIN`. **INRange | OORange** In range, Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:DMIN` and `TRIGger<m>:FLXRay:DMAX`. *RST: EQUal

---

TRIGger<m>:FLXRay:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:FLXRay:DMAX <DataPatternTo>

Sets the the end value of an data range if the operator `TRIGger<m>:FLXRay:DCONdition` is set to INRange or OORange.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:FLXRay:SYMBol <Symbol>

Triggers on a symbol or on a wakeup pattern.

Parameters:

<Symbol>	CASMts | WAKeup **CASMts** Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start. **WAKeup** The wakeup pattern is sent to activate the nodes of the system. *RST: CASMts

---

TRIGger<m>:FLXRay:BSSerror <BSSError>

Triggers on error in SyteStart Sequence. The BSS is transmitted before each byte.

Parameters:

<BSSError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:FESerror <FESError>

Triggers on error in Frame End Sequence. FES indicates the end of each frame.

Parameters:

<FESError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:FSSerror <FSSError>

Triggers on Error in a Frame Start Sequence. FSS follows the Transmission Start Sequence TSS at the beginning of each frame.

Parameters:

<FSSError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:HCRCerror <CRCHeaderError>

Triggers on error in the Cyclic Redundancy Check of the header data (mainly frame ID and payload length).

Parameters:

<CRCHeaderError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:PCRCerror <CRCPayloadError>

Triggers on error in the Cyclic Redundancy Check of the payload data.

Parameters:

<CRCPayloadError>	ON | OFF	
	*RST:	ON

20.17.8.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496
- `BUS<m>:RESDetail` on page 1496

BUS<m>:FLXRay:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Returns the number of decoded frames. Range: 0 to 100000 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | FSS | BSS | FES | INDicator | HCRCerror | CRCerr | LENER | LENer | HCFCerror | INSufficient OK: the frame is valid. FSS: Frame Start Sequence after TSS is missing. BSS: Byte Start Sequence is missing. FES: error in the Frame End Sequence. INDicator: Error in indicator bits. HCRCerror: Header CRC is not valid. CRCerr: Payload CRC is not valid. LENER = LENer: Unexpected length of the frame. HCFCerror: Header CRC error and frame CRC error INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:STARt?
BUS<m>:FLXRay:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStop>	Time Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic name of the identifier

Example: `BUS:FLXRay:FRAMe2:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:FLXRay:FRAMe<n>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>

UNKNown | STATic | DYNamic | WAKE | SYMBol

STATic: frame of the static segment
DYNamic: frame of the dynamic segment
WAKE: frame contains wakeup pattern
SYMBol: frame contains a MTS or CAS symbol

*RST: STATic

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Data>

Comma-separated list of integer values (N, D1, D2,..., DN). N is the number of bytes in the frame, and D1...DN are the values of the bytes.

Example:

```
BUS:FLXRay:FRAMe4:DATA?
<-- 4,17,85,170,85
```

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FLAGs?

Returns the value of the indicator bits at the beginning of the header segment. The five bits are read as one word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IndicatorBits>	Range:	0 to 31
	*RST:	0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:ADID?

Returns the frame identifier, the number of the slot in which the frame is transmitted.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameIDvalue> To set the value format, use `FORMat:BPATtern` on page 1183. The values below – range, increment and default – are decimal values.

Range:	0 to 2047
*RST:	0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:PAYLength?

Returns the payload length, the number of data words in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Value>	Range:	0 to 127
	*RST:	0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CYCount?

Returns the number of the current FlexRay cycle.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<CycleCount>	Range:	0 to 63
	*RST:	0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CSSTate?

Returns the state of the cyclic redundancy check code of the header data.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<HdrCksumSt>

OK | UVAL | INSufficient

OK: the CRC is valid.
UVAL: unexpected value
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CSValue?

Returns the checksum value of the header CRC.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<HdrCksumVal>	To set the value format, use FORMat:BPATtern on page 1183. The values below – range, increment and default – are decimal values. Range: 0 to 2047 *RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FCSTate?

Returns the state of the cyclic redundancy check code of the frame data.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrmCksumSt>	OK | UVAL | INSufficient OK: the CRC is valid. UVAL: unexpected value INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FCValue?

Returns the cyclic redundancy check code of the frame CRC.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrmCksumVal>	To set the value format, use FORMat:BPATtern on page 1183. The values below – range, increment and default – are decimal values. Range: 0 to 16777215 *RST: 0

Usage: Query only

20.17.8.4 Search Settings

SEARch:TRIGger:FLXRay[:STATe] <SearchName>,<State>
SEARch:TRIGger:FLXRay[:STATe]? <SearchName>

Includes the search conditions for the FlexRay trigger event type in the next search.

Parameters:

<State>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:ACOPy <SearchName>

Copies the trigger event configuration from Trigger A for the selcted FlexRay bus to the search condition settings.

Setting parameters:
<SearchName>

Usage:	Setting only

SEARch:TRIGger:FLXRay:SERRor <SearchName>,<ChkErrCond>
SEARch:TRIGger:FLXRay:SERRor? <SearchName>

Enables the search for specified error or error combination.

Parameters:

<ChkErrCond>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SIDData <SearchName>,<ChkIdtfDat>
SEARch:TRIGger:FLXRay:SIDData? <SearchName>

Enables the search for indentifier and data.

Parameters:

<ChkIdtfDat>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay[:SSOFrame] <SearchName>,<ChkStrtFrm>
SEARch:TRIGger:FLXRay[:SSOFrame]? <SearchName>

Enables the search for a start of frame.

Parameters:

<ChkStrtFrm>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SSYMbol <SearchName>,<CheckSymbol>
SEARch:TRIGger:FLXRay:SSYMbol? <SearchName>

Enables the search for specified symbol.

Parameters:

<CheckSymbol>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:CENable <SearchName>,<CycleCount>
SEARch:TRIGger:FLXRay:CENable? <SearchName>

Sets the operator to define a cycle count or a cycle count range.

Parameters:

<CycleCount>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The cycle count is not relevant for the search condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one cycle count number to be set with `SEARch:TRIGger:FLXRay:CMIN`. **INRange | OORange** In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:CMIN` and `SEARch:TRIGger:FLXRay:CMAX`. *RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:CMAX <SearchName>,<CycleCountMax>
SEARch:TRIGger:FLXRay:CMAX? <SearchName>

Sets the the end value of a cycle count range if the condition `SEARch:TRIGger:FLXRay:CENable` is set to `INRange` or `OORange`.

Parameters:

<CycleCountMax>	Range: 0 to 63 Increment: 1 *RST: 0

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:CMIN <SearchName>,<CycleCountMin>
SEARch:TRIGger:FLXRay:CMIN? <SearchName>

Specifies a cycle count - the number of the current FlexRay cycle - or sets the the start value of an cycle count range.

Parameters:

<CycleCountMin>	Range:	0 to 63
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:CSTep <SearchName>,<CycleCountStep>
SEARch:TRIGger:FLXRay:CSTep? <SearchName>

Specifies a step to search for each n-th cycle inside the given range. This allows for a specific search if slot multiplexing is used.

The condition `SEARch:TRIGger:FLXRay:CENable` must be set to `INRange` or `OORange`.

Parameters:

<CycleCountStep>	Range:	1 to 63
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:FLXRay:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:
<DataOperator>

OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The data pattern is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:FLXRay:DMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:DMIN` and `SEARch:TRIGger:FLXRay:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:FLXRay:DMAX? <SearchName>

Sets the the end value of an data range if `SEARch:TRIGger:FLXRay:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:FLXRay:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DPOPerator <SearchName>,<DatPosiOptor>
SEARch:TRIGger:FLXRay:DPOPerator? <SearchName>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DatPosiOptor>
ANY | OFF | EQUal | GETHan | INRange | RANGe

OFF = ANY
The data position is not relevant for the search condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:FLXRay:DPOSition`

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:DPOSition` and `SEARch:TRIGger:FLXRay:DPTO`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:FLXRay:DPOSition? <SearchName>

Sets the number of data bytes to be skipped after start of the payload segment.

Parameters:

<DataPosition>	Range:	0 to 255
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:FLXRay:DPTO? <SearchName>

Defines the last byte of interest, if the position operator `SEARch:TRIGger:FLXRay:DPOPerator` defines a range.

Parameters:

<DataPositionTo>	Range:	0 to 255
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FCONdition <SearchName>,<IdtfOptor>
SEARch:TRIGger:FLXRay:FCONdition? <SearchName>

Sets the operator to set a frame ID or a frame ID range.

Parameters:

<IdtfOptor>

OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The frame ID is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one frame ID to be set with `SEARch:TRIGger:FLXRay:FMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:FMIN` and `SEARch:TRIGger:FLXRay:FMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FMAX <SearchName>,<IdtfPattTo>
SEARch:TRIGger:FLXRay:FMAX? <SearchName>

Sets the the end value of an identifier range if the condition `SEARch:TRIGger:FLXRay:FCONdition` is set to `INRange` or `OORange`.

Parameters:

<IdtfPattTo>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FMIN <SearchName>,<IdtfPatt>
SEARch:TRIGger:FLXRay:FMIN? <SearchName>

Specifies a frame identifier pattern - the number of the slot - or sets the the start value of an identifier range.

Parameters:

<IdtfPatt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:NUFRame <SearchName>,<NullFrame>
SEARch:TRIGger:FLXRay:NUFRame? <SearchName>

Searches for the null frame indicator bit, a frame without usable data.

Parameters:

<NullFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PLPReamble <SearchName>,<PayloadPreamble>
SEARch:TRIGger:FLXRay:PLPReamble? <SearchName>

Searches for the payload preamble indicator bit that indicates a Network Management Vector in the payload segment.

Parameters:

<PayloadPreamble>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PCONdition <SearchName>,<PloadlgthOptor>
SEARch:TRIGger:FLXRay:PCONdition? <SearchName>

Sets the operator for the payload length search setting. You can defined an exact value, or a range.

Parameters:

<PloadlgthOptor>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The payload length is not relevant for the search condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one payload length to be set with `SEARch:TRIGger:FLXRay:PMIN`. **INRange | OORange** In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:PMIN` and `SEARch:TRIGger:FLXRay:PMAX`. *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PMAX <SearchName>,<PloadlgthMax>
SEARch:TRIGger:FLXRay:PMAX? <SearchName>

Sets the the end value of a payload length range if the condition `SEARch:TRIGger:FLXRay:PCONdition` is set to `INRange` or `OORange`.

Parameters:

<PloadlgthMax>	Range:	0 to 127
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PMIN <SearchName>,<PloadlgthMin>
SEARch:TRIGger:FLXRay:PMIN? <SearchName>

Specifies a payload length - the number of words in the payload segment - or sets the the start value of an payload length range. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Parameters:

<PloadlgthMin>	Range:	0 to 127
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:STFRame <SearchName>,<StartupFrame>
SEARch:TRIGger:FLXRay:STFRame? <SearchName>

Searches for startup frames used for startup of the network. Only specific start nodes can send this frame type.

Parameters:

<StartupFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SYFRame <SearchName>,<SyncFrame>
SEARch:TRIGger:FLXRay:SYFRame? <SearchName>

Searches for the sync frame used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

Parameters:

<SyncFrame>	ONE | ZERO | DC Bit value: 1, 0, or X (don't care) *RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SYMBol <SearchName>,<Symbol>
SEARch:TRIGger:FLXRay:SYMBol? <SearchName>

Searches for a symbol or for a wakeup pattern.

Parameters:

<Symbol>	CASMts | WAKeup **CASMts** Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start. **WAKeup** The wakeup pattern is sent to activate the nodes of the system. *RST: CASMts

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:BSSerror <SearchName>,<BSSError>
SEARch:TRIGger:FLXRay:BSSerror? <SearchName>

Searches for error in SyteStart Sequence. The BSS is transmitted before each byte.

Parameters:

<BSSError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FESerror <SearchName>,<FESError>
SEARch:TRIGger:FLXRay:FESerror? <SearchName>

Searches for error in Frame End Sequence. FES indicates the end of each frame.

Parameters:

<FESError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FSSerror <SearchName>,<FSSError>
SEARch:TRIGger:FLXRay:FSSerror? <SearchName>

Searches for an error in a Frame Start Sequence(FSS). FSS follows the Transmission Start Sequence (TSS) at the beginning of each frame.

Parameters:

<FSSError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:HCRCerror <SearchName>,<CRCHeaderError>
SEARch:TRIGger:FLXRay:HCRCerror? <SearchName>

Searches for an error in the Cyclic Redundancy Check of the header data (mainly frame ID and payload length).

Parameters:

<CRCHeaderError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:PCRCerror <SearchName>,<CRCPayloadError>
SEARch:TRIGger:FLXRay:PCRCerror? <SearchName>

Searches for error in the Cyclic Redundancy Check of the payload data.

Parameters:

<CRCPayloadError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

20.17.8.5 Search Results

The search on decoded FlexRay data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.8.3, "Decode Results", on page 1644.

SEARch:RESult:FLXRay:FCOunt? <SearchName>

Query parameters:

<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:ADID? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderFlags>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CSSTate? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HdrCksumSt> OK | STERror | SPERror | PRERror | UVAL | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CSValue? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HdrCksumVal>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CYCount? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<CycleCount>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:DATA? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FCSTate? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrmCksumSt> OK | STERror | SPERror | PRERror | UVAL | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FCValue? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrmCksumVal>	Range:	0 to 16777215
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FLAGs? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderFlags>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:PAYLength? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderFlags>	Range:	0 to 127
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STATus? <SearchName>

Returns the overall state of the selected frame.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameState>	OK | FSS | BSS | FES | INDicator | HCRCerror | CRCerr | LENER | LENer | HCFCerror | INSufficient OK: the frame is valid. FSS: Frame Start Sequence after TSS is missing. BSS: Byte Start Sequence is missing. FES: error in the Frame End Sequence. INDicator: Error in indicator bits. HCRCerror: Header CRC is not valid. CRCerr: Payload CRC is not valid. LENER = LENer: Unexpected length of the frame. HCFCerror: Header CRC error and frame CRC error INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. *RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameType>	UNKNown | STATic | DYNamic | WAKE | SYMBol *RST: STATic
Usage:	Query only

SEARch:RESult:FLXRay:FRAMe<m>:SYMBol? <SearchName>

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	* Selects the number of the frame in the current acquisition, 1...n.

Query parameters:

<SearchName>	String parameter that contains the search definition name

Return values:

<Translation>	Symbolic label (string)
Usage:	Query only

20.17.9 Audio Signals (Option R&S RTO-K5)

20.17.9.1 Configuration

BUS<m>:I2S:AVARiant <AudioVariant>

Selects the audio signal type.

For details, see "Audio Variant" on page 600.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<AudioVariant>	I2S | LJ | RJ | TDM I2S: Inter-IC Sound standard audio format. LJ: left-justified data format RJ: right-justified data format TDM: Time Division Multiplexed audio format *RST: I2S

BUS<m>:I2S:CLOCk:SOURce <ClockSource>

Selects the source of the clock line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ClockSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital channels require installation of R&S RTO-B1. Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required. *RST: C1W1

BUS<m>:I2S:CLOCk:POLarity <BitClockEdge>

Sets the polarity of the clock signal, that is the edge at which the instrument samples the data on the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<BitClockEdge>	FALLing | RISing *RST: RISing

BUS<m>:I2S:WSELect:SOURce <WSsource>

Selects the source of the word select line for I²S standard, left- und right-justified data formats, or the source of the frame synchronization pulse for TDM audio signals.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WSsource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital channels require installation of R&S RTO-B1. Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required. *RST: C1W1

BUS<m>:I2S:WSELect:POLarity <WSPolarity>

For a word select line, the polarity defines the signal values assigned to the left and right channels.

For an FSYNC line (TDM), the polarity defines the edge of the FSYNC pulse that identifies the beginning of a frame.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WSPolarity>	NORMal | INVert NORMal: 0 = left, 1 = right channel; or rising edge for TDM INVert: 1= left, 0 = right channel; or falling edge for TDM *RST: NORMal

---

BUS<m>:I2S:DATA:SOURce <DataSource>

Selects the source of the audio data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital channels require installation of R&S RTO-B1.Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required. *RST: C1W1

BUS<m>:I2S:DATA:POLarity <SDataPolarity>

Defines the interpretation of high and low signal states on the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SDataPolarity>	ACTLow | ACTHigh ACTHigh: HIGH = 1 and LOW = 0 ACTLow: HIGH = 0 and LOW = 1 *RST: ACTHigh

---

BUS<m>:I2S:TCOupling <Coupling>

Sets all thresholds to the value of the clock threshold `BUS<m>:I2S:CLOCk:THReshold`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Coupling>	ON | OFF *RST: ON

BUS<m>:I2S:CLOCk:THReshold <SCLKThreshold>

Sets the threshold value for the clock line SCLK.

If `BUS<m>:I2S:TCOupling` is `ON`, the command sets the threshold for all lines.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SCLKThreshold>	Range: -10 to 10 Increment: 1E-3 *RST: 1.6 Default unit: V

BUS<m>:I2S:WSELect:THReshold <WSThreshold>

Sets the threshold value for the word select and FSYNC lines.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WSThreshold>	Range: -10 to 10 Increment: 1E-3 *RST: 1.6 Default unit: V

BUS<m>:I2S:DATA:THReshold <SDATAThreshold>

Sets the threshold value for the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SDATAThreshold>	Range: -10 to 10 Increment: 1E-3 *RST: 1.6 Default unit: V

BUS<m>:I2S:CHANnel:ORDer <ChannelOrder>

Defines if the left or the right channel is the first channel in the frame.

The setting is not available for TDM audio signals.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ChannelOrder>	LFIRst | RFIRst Left channel first or right first *RST: LFIRst

---

BUS<m>:I2S:WLENgth <WordLength>

Defines the number of bits in an audio data word.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WordLength>	Range: 4 to 32 Increment: 4 *RST: 8 Default unit: bit

---

BUS<m>:I2S:BORDer <BitOrder>

Sets the bit order of the audio data words.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<BitOrder>	LSBF | MSBF LSB first or MSB first *RST: MSBF

BUS<m>:I2S:CHANnel:OFFSet <ChannelOffset>

Sets the number of bits between the channel start and the start of the audio word.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ChannelOffset>	Range: 0 to 32 (left-justified). TDM: maximum delay is Channel length - Word length Increment: 1 *RST: 0 Default unit: bit

---

BUS<m>:I2S:CHANnel:TDMCount <ChannelsTDM>

Sets the number of channels transmitted on the TDM audio line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ChannelsTDM>	Range: 1 to 8 Increment: 1 *RST: 1

BUS<m>:I2S:FOFFset <FrameOffsetTDM>

Sets the number of bits between the frame start and the start of the first channel of a TDM audio line. Each FSYNC edge restarts the offset count.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<FrameOffsetTDM>	Range: 0 to 256 Increment: 1 *RST: 0 Default unit: bit

---

BUS<m>:I2S:CHANnel:LENGth <ChlgthTDM>

Sets the number of bits in a TDM channel block.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ChlgthTDM>	Range: 4 to 32 Increment: 4 *RST: 8 Default unit: bit

20.17.9.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:I2S:TYPE <Type>

Selects the trigger type for audio signal analysis.

Parameters:

<Type> DATA | WINDow | CONDition | WSELect | ECONdition

DATA
Triggers on a data word or data range on a specified channel or on any channel.
To set the channel, use `TRIGger<m>:I2S:TCONdition<n>:CHANnel`.
To set the data condition, use:
`TRIGger<m>:I2S:TCONdition<n>:CONDtion`,
`TRIGger<m>:I2S:TCONdition<n>:DMIN` and `TRIGger<m>:I2S:TCONdition<n>:DMAX`.

WINDow
Triggers if the decoded data values stay inside a "window" that is formed by a data range and a time specified by a number of subsequent words. It considers a selected channel or all channels.
To set up a window trigger, you define the channel and data condition in the same way as for DATA trigger type. Additionally, you set the time limit with `TRIGger<m>:I2S:SOWords`.

CONDition
The frame condition trigger sets the trigger on an AND combination of data conditions on different channels. The instrument triggers if all conditions are met inside one frame.
To set up a CONDition trigger, you define up to four channel and data conditions in the same way as for DATA trigger type.

WSELect
WordSELect: Triggers on the selected edge of the WS line (I²S standard, left- and right-justified). For TDM signals, it triggers on the selected edge of the FSYNC line. Set the edge with `TRIGger<m>:I2S:WSSLope`.

ECONdition
ErrorCONdition: Triggers on irregularities between the WS or FSYNC edges.

*RST: DATA

Usage: Asynchronous command

TRIGger<m>:I2S:TCONdition<n>:CHANnel <Channel>

Selects the audio channel on which the instrument looks for the specified data condition.

Suffix:

<n> 1..4
1 if trigger type is DATA or WINDow
Specifies the condition number if trigger type is CONDition:
– 1 | 2 for I²S standard, left- und right-justified data formats
– 1 | 2 | 3 | 4 for TDM signals

Parameters:

<Channel>	ANY | TDMC1 | TDMCh1 | TDMC2 | TDMCh2 | TDMC3 | TDMCh3 | TDMC4 | TDMCh4 | TDMC5 | TDMCh5 | TDMC6 | TDMCh6 | TDMC7 | TDMCh7 | TDMC8 | TDMCh8 | LEFT | RIGHT | RIGHt **ANY** The instrument triggers on any channel on which the specified data is found. **LEFT | RIGHT = RIGHt** Available for I²S Standard, left- und right-justified data formats. **TDMCh1 | TDMCh2 | TDMCh3 | TDMCh4 | TDMCh5 | TDMCh6 | TDMCh7 | TDMCh8** Available for TDM audio signals TDMC1 = TDMCh1, TDMC2 = TDMCh2, TDMC3 = TDMCh3, TDMC4 = TDMCh4, TDMC5 = TDMCh5, TDMC6 = TDMCh6, TDMC7 = TDMCh7, TDMC8 = TDMCh8. Query returns short form. **Note**: Available audio channels depend on the configuration of the audio bus. The command `BUS<m>:I2S:CHANnel:TDMCount` specifies the number of channels in a TDM frame. *RST: ANY

TRIGger<m>:I2S:TCONdition<n>:CONDtion <DataCondition>

Sets the operator to set a specific data pattern or a data pattern range.

Suffix:

<n>	1..4 1 if trigger type is DATA or WINDow Specifies the condition number if trigger type is CONDition: – 1 | 2 for I²S standard, left- und right-justified data formats – 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataCondition>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** No range is defined. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:I2S:TCONdition<n>:DMIN`. **INRange | OORange** In range, Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:I2S:TCONdition<n>:DMIN` and `TRIGger<m>:I2S:TCONdition<n>:DMAX`. *RST: OFF

TRIGger<m>:I2S:TCONdition<n>:DMIN <DataMinPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Suffix:

<n>	1..4 1 if trigger type is DATA or WINDow Specifies the condition number if trigger type is CONDition: – 1 | 2 for I²S standard, left- und right-justified data formats – 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataMinPattern>	Numeric pattern in 2's complement format. See also: Chapter 20.4.6, "Bit Pattern Parameter", on page 1175 X bits are not allowed. If the bit string is shorter than the word length, the rightmost bit of the input bit string is aligned to the rightmost (LSB) bit of the word.

TRIGger<m>:I2S:TCONdition<n>:DMAX <DataMaxPattern>

Sets the the end value of an data range if the operator `TRIGger<m>:I2S:TCONdition<n>:CONDtion` is set to `INRange` or `OORange`.

Suffix:

<n>	1..4 1 if trigger type is DATA or WINDow Specifies the condition number if trigger type is CONDition: – 1 | 2 for I²S standard, left- und right-justified data formats – 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataMaxPattern>	Numeric pattern in 2's complement format. See also: Chapter 20.4.6, "Bit Pattern Parameter", on page 1175 DMAX must be greater or equal than DMIN. X bits are not allowed. If the bit string is shorter than the word length, the rightmost bit of the input bit string is aligned to the rightmost (LSB) bit of the word.

TRIGger<m>:I2S:SOWords <SequenceOfWords>

Sets the number of words that is used as time limit for the "Window" trigger type. The instrument triggers if the data condition is fulfilled on the same channel for the given number of subsequent frames.

Parameters:

<SequenceOfWords>	Range:	1 to 1000000
	Increment:	1
	*RST:	1
	Default unit:	word

Usage: Asynchronous command

TRIGger<m>:I2S:WSSLope <WSSlope>

Sets the edge of the WS or FSYNC signal as trigger condition. The instrument triggers on the first clock edge after the specified edge.

Parameters:

<WSSlope>	POSitive | NEGative *RST: POSitive
Usage:	Asynchronous command

20.17.9.3 Decode Results

BUS<m>:I2S:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Number of decoded audio frames
Usage:	Query only

BUS<m>:I2S:FRAMe<n>:STATe?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	ERRor | OK | INSufficient OK: the frame is valid. ERRor: an error occured in the frame. INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

Usage: Query only

BUS<m>:I2S:FRAMe<n>:STARt?
BUS<m>:I2S:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>, <Stop>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

BUS<m>:I2S:FRAMe<n>:LEFT:VALue?
BUS<m>:I2S:FRAMe<n>:RIGHt:VALue?

Return the data values of the left and right channel, respectively.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Value>	Comma-separated list of values. To set the value format, use `FORMat:BPATtern`.	
	Range:	0 to 4294967295
	*RST:	0

Usage: Query only

BUS<m>:I2S:FRAMe<n>:LEFT:STATe?
BUS<m>:I2S:FRAMe<n>:RIGHt:STATe?

Return the status of the left and right channel of the selected frame.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
Return values:	
<WordState>	ERRor | OK | INSufficient OK: the channel data is valid. ERRor: an error occured in the channel. INSufficient: the channel is not completely contained in the acquisition.
Usage:	Query only

BUS<m>:I2S:FRAMe<n>:TDM<o>:STATe?

Returns the state of the indicated channel of the selected frame.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	1..8 Selects the TDM channel.
Return values:	
<State>	ERRor | OK | INSufficient OK: the channel data is valid. ERRor: an error occured in the channel. INSufficient: the channel is not completely contained in the acquisition. *RST: UNDefined
Usage:	Query only

BUS<m>:I2S:FRAMe<n>:TDM<o>:VALue?

Return the data value of the indicated TDM channel.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	1..8 Selects the TDM channel.

Return values:

<Value>	To set the value format, use `FORMat:BPATtern` on page 1183. The values below – range, increment and default – are decimal values. Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only

20.17.9.4 Track and Trend

BUS<m>:I2S:TRACk:LEFT <Channel>
BUS<m>:I2S:TRACk:RIGHt <Channel>

Enables or disables the track of the indicated channel. The commands are relevant for I²S standard, left-justified and right-justified audio data formats.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Channel>	ON | OFF *RST: OFF

BUS<m>:I2S:TRACk:TD1Ch <TDMCh1>
BUS<m>:I2S:TRACk:TD2Ch <TDMCh2>
BUS<m>:I2S:TRACk:TD3Ch <TDMCh3>
BUS<m>:I2S:TRACk:TD4Ch <TDMCh4>
BUS<m>:I2S:TRACk:TD5Ch <TDMCh5>
BUS<m>:I2S:TRACk:TD6Ch <TDMCh6>

BUS<m>:I2S:TRACk:TD7Ch <TDMCh7>
BUS<m>:I2S:TRACk:TD8Ch <TDMCh8>

Enables or disables the track of the indicated channel. The commands are relevant for TDM audio data.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<TDMChX>	ON | OFF *RST: OFF

MEASurement<m>:TRACk[:STATe] <State>

Enables the track functionality and displays the track.

The track functionality requires at least one option, see "Enable (Track)" on page 359.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<State>	ON | OFF *RST: OFF

MEASurement<m>:TRACk:DATA:HEADer?

Returns the header of the track.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Query only

MEASurement<m>:TRACk:DATA:STYPe?

Returns the data type: TRK (track).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage: Query only

MEASurement<m>:TRACk:DATA[:VALues]?

Returns the data of track points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Usage:	Query only

20.17.10 MIL-1553 (Option R&S RTO-K6)

20.17.10.1 Configuration

BUS<m>:MILStd:SOURce <SourceData>

Sets the channel for the signal source.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:MILStd:MAXResponse:BITS <MaxResponseTime>

Sets the value for the maximum response time.

See also: `BUS<m>:MILStd:MAXResponse:SELect`.

Suffix:

<m>	1..4

Parameters:

<MaxResponseTime>	Range:	2E-6 to 262E-6
	Increment:	100E-9
	*RST:	14E-6
	Default unit:	s

BUS<m>:MILStd:MAXResponse:SELect <MaxRespSelect>

Enables the detection of the maximum response time between the last bit of a word and the following status word sync during decoding.

To specify the maximum response time, use `BUS<m>:MILStd:MAXResponse:BITS` on page 1681.

Suffix:

<m>	1..4

Parameters:

<MaxRespSelect>	ON | OFF	
	*RST:	ON

BUS<m>:MILStd:MINGap:SELect <MinGapSelect>

Enables the detection of the minimum idle time between the last bit of a message and the following command word sync during decoding.

To specify the minimum gap, use `BUS<m>:MILStd:MINGap:BITS`.

Suffix:

<m>	1..4

Parameters:

<MinGapSelect>	ON | OFF	
	*RST:	ON

BUS<m>:MILStd:MINGap:BITS <MinGapTime>

Sets a value for the minimum gap.

See also: `BUS<m>:MILStd:MINGap:SELect`.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range: 2E-6 to 262E-6 Increment: 100E-9 *RST: 4E-6 Default unit: s

---

BUS<m>:MILStd:POLarity <Polarity>

Selects the wire on which the bus signal is measured.

Suffix:

<m>	1..4

Parameters:

<Polarity>	NORMal | INVerted *RST: NORMal

BUS<m>:MILStd:PRESet <Preset>

Sets the default threshold voltage.

Suffix:

<m>	1..4

Parameters:

<Preset>	V05 | V2 | V5 | V7 | MAN *RST: V5

BUS<m>:MILStd:THReshold:HIGH <ThresholdHigh>

Sets the lower threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdHigh>	Range: 0 to 14 Increment: 0.1 *RST: 5 Default unit: V

BUS<m>:MILStd:THReshold:LOW <ThresholdLow>

Sets the lower threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdLow>	Range: -14 to 0 Increment: 0.1 *RST: -5 Default unit: V

20.17.10.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MILStd:TYPE <Type>

Sets the trigger type for MIL-1553 analysis.

Parameters:

<Type>	STYPe | WTYPe | DATA | CDST | CMD | STATword | ERR **STYPe** SyncTYPe: triggers on a sync impulse. **WTYPe** WordTYPe: triggers on the selected word type. **DATA** Triggers on a data word that can be specified. **CDST** CommanDSTatus word: triggers on a command word or on a status word that can be specified. **CMD** CoMmanD word: triggers on a command word or on a status word that can be specified. **STATword** STATus word: triggers on a status word that can be specified. **ERR** ERRor: triggers on any combination of protocol errors. *RST: STYPe

---

TRIGger<m>:MILStd:DATA:RCONdition <RTAOperator>
TRIGger<m>:MILStd:CMD:RCONdition <RTAOperator>
TRIGger<m>:MILStd:CDST:RCONdition <RTAOperator>

Sets the operator to define a remote terminal address:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CDST:RMIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CDST:RMIN` and `TRIGger<m>:MILStd:CDST:RMAX`. *RST: EQUal

---

TRIGger<m>:MILStd:DATA:RMIN <RTAPatternMin>
TRIGger<m>:MILStd:CMD:RMIN <RTAPatternMin>
TRIGger<m>:MILStd:CDST:RMIN <RTAPatternMin>

Specify a remote terminal address or set the the start value of a remote terminal address range:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:RMAX <RTAPatternMax>
TRIGger<m>:MILStd:CMD:RMAX <RTAPatternMax>
TRIGger<m>:MILStd:CDST:RMAX <RTAPatternMax>

Set the end value of a data range if `TRIGger<m>:MILStd:CDST:RCONdition` is set to `INRange` or `OORange`:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:CCONdition <WordCntOptor>

Sets the operator to set a specific data word count or mode code pattern.

Parameters:

<WordCntOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CMD:CMIN`. **INRange | OORange** In range/Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CMD:CMIN` and `TRIGger<m>:MILStd:CMD:CMAX`. *RST: EQUal

---

TRIGger<m>:MILStd:CMD:CMAX <WordCntPattMax>

Sets the end value of a data word count/mode code pattern if `TRIGger<m>:MILStd:CMD:CCONdition` is set to `INRange` or `OORange`.

Parameters:

<WordCntPattMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:CMIN <WordCntPattMin>

Specifies a data word count/mode code pattern or sets the the start value of a pattern range.

Parameters:

<WordCntPattMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:SCONdition <SubaddrOptor>

Sets the operator to set a specific subaddress/mode pattern.

Parameters:

<SubaddrOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with`TRIGger<m>:MILStd:CMD:SMIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CMD:SMIN` and `TRIGger<m>:MILStd:CMD:SMAX`. *RST: EQUal

---

TRIGger<m>:MILStd:CMD:SMAX <SubaddrPattMax>

Sets the end value of the subaddress range if `TRIGger<m>:MILStd:CMD:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<SubaddrPattMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:SMIN <SubaddrPattMin>

Specifies a subaddress or sets the the start value of a subaddress range.

Parameters:

<SubaddrPattMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:TR <TRFlag>

Triggers on a transmission mode.

Parameters:

<TRFlag>	ONE | ZERO | DC **ONE** Transmit direction. **ZERO** Receive direction. **DC** Either directions. *RST: DC

TRIGger<m>:MILStd:CDST:ICONdition <InfoOperator>

Sets the operator to set a specific info for the 9th to 19th bit of a command or status word.

Parameters:

<InfoOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CDST:IMIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CDST:IMIN` and `TRIGger<m>:MILStd:CDST:IMAX`. *RST: EQUal

---

TRIGger<m>:MILStd:CDST:IMAX <InfoPatternMax>

Sets the end value of the info range if `TRIGger<m>:MILStd:CDST:ICONdition` is set to `INRange`.

Parameters:

<InfoPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CDST:IMIN <InfoPatternMin>

Specifies an info or sets the the start value of an info range.

Parameters:

<InfoPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:DCONdition <DataOperator>

Sets the operator to set a specific data pattern.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:DATA:DMIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:DATA:DMIN` and `TRIGger<m>:MILStd:DATA:DMAX`. *RST: EQUal

---

TRIGger<m>:MILStd:DATA:DMAX <DataPatternMax>

Sets the end value of a data pattern range if `TRIGger<m>:MILStd:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:DMIN <DataPatternMin>

Specifies a data pattern or sets the the start value of a data pattern range.

Parameters:

<DataPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:ICONdition <DatIdxOptor>

Sets the operator to set a specific range within this series of the data words that is considered for the analysis.

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal| LTHan | LETHan | GTHan | GETHan** Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:DATA:IMIN`. **INRange = RANGe** In range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:DATA:IMIN` and `TRIGger<m>:MILStd:DATA:IMAX`. *RST: INRange

---

TRIGger<m>:MILStd:DATA:IMAX <DataIndexMax>

Sets the end value of a data word series index range if `TRIGger<m>:MILStd:DATA:ICONdition` is set to `INRange`.

Parameters:

<DataIndexMax>	Range:	1 to 32
	Increment:	1
	*RST:	32

TRIGger<m>:MILStd:DATA:IMIN <DataIndexMin>

Specifies an index or sets the the start value of a data word series index range.

Parameters:

<DataIndexMin>	Range:	1 to 32
	Increment:	1
	*RST:	1

TRIGger<m>:MILStd:ERRor:MANChester <ManCodingError>

Triggers on an error of the manchester coding if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`.

Parameters:

<ManCodingError>	ON | OFF *RST: ON

TRIGger<m>:MILStd:ERRor:PARity <ParityError>

Triggers on even parity if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`.

Parameters:

<ParityError>	ON | OFF *RST: ON

TRIGger<m>:MILStd:ERRor:SYNC <SyncError>

Triggers on an error of the synchronization if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`.

Parameters:

<SyncError>	ON | OFF	
	*RST:	ON

TRIGger<m>:MILStd:MAXResponse:BITS <MaxResponseTime>

Sets the value for the maximum response time to be triggered on if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`

Enable the error trigger on maximum response time with `TRIGger<m>:MILStd:MAXResponse:SELect`.

Parameters:

<MaxResponseTime>	Range:	2E-6 to 262E-6
	Increment:	100E-9
	*RST:	14E-6
	Default unit:	s

TRIGger<m>:MILStd:MAXResponse:SELect <MaxRespSel>

Enables the trigger on exceeding the maximum response time if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`. You can set the maximum time with: `TRIGger<m>:MILStd:MAXResponse:BITS`.

Parameters:

<MaxRespSel>	ON | OFF	
	*RST:	ON

TRIGger<m>:MILStd:MINGap:BITS <MinGapTime>

Sets the value for the minimum gap to be triggered on if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`.

Parameters:

<MinGapTime>	Range:	2E-6 to 262E-6
	Increment:	100E-9
	*RST:	4E-6
	Default unit:	s

TRIGger<m>:MILStd:MINGap:SELect <MinGapSelect>

Enables triggering when the minimum gap is out of range if `TRIGger<m>:MILStd:TYPE` is set to `ERRor`. You can set the minimum gap with: `TRIGger<m>:MILStd:MINGap:BITS`.

Parameters:

<MinGapSelect>	ON | OFF *RST: ON

TRIGger<m>:MILStd:STATus:BCReceived <BcstCmdFlag>

Triggers on the state of the broadcast command received bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<BcstCmdFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:BUSY <BusyFlag>

Triggers on the state of the busy bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<BusyFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:DBCaccept <DynBCFlag>

Triggers on the state of the dynamic bus control accept bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<DynBCFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:INSTrument <InstFlag>

Triggers on the state of the instrumentation bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<InstFlag>	ONE | ZERO | DC *RST: ZERO

TRIGger<m>:MILStd:STATus:MERRor <MsgErrorFlag>

Triggers on the state of the message error bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<MsgErrorFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:SREQuest <SvcRequestFlag>

Triggers on the state of the the service request bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<SvcRequestFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:SUBSystem <SubsystemFlag>

Triggers on the state of the subsystem flag bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<SubsystemFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:STATus:TERMinal <TerminalFlag>

Triggers on the state of theterminal flag bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<TerminalFlag>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MILStd:TPSPecifier <TypeSpecifier>

Sets the sync impulse/ word type to be triggered on.

Parameters:

<TypeSpecifier>	CStatus | DATA | ALL CStatus: command/status word *RST: ALL

20.17.10.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:MILStd:WCOunt?

Returns the number of decoded words.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MILStd:WORD<n>:DATA?

Return the data bytes of the specified word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameData>	16-bit data of the specified word as a 2-byte bit pattern (B1, B2). The first byte B1 is the most significant byte.

Example:

```
BUS:MILStd:WORD4:DATA?
<-- #H08,#H49
```

Usage: Query only

BUS<m>:MILStd:WORD<n>:INFO?

Returns the info value for the specified word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameInfo>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MILStd:WORD<n>:RTADdress?

Returns the RT address for the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameRta>	Range:	0 to 31
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MILStd:WORD<n>:STARt?

Return the start time of the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:MILStd:WORD<n>:STATus?

Returns the overall state of the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameState>	OK | SYNC | MANC | PAR | GAP | RT OK: the word is valid. SYNC: synchronization error occured. MANC: manchester coding error occured. PAR: parity error occured. GAP: timing gap error occured. RT: remote terminal error occured. *RST: OK

Usage: Query only

BUS<m>:MILStd:WORD<n>:STOP?

Return the stop time of the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:MILStd:WORD<n>:SYMBol?

Returns the label name of the word ID.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<Translation>

Usage: Query only

BUS<m>:MILStd:WORD<n>:TYPE?

Returns the type of the specified word.

Suffix:	
<m>	1..4 Selects the serial bus.
<n>	* Selects the word.
Return values:	
<FrameType>	UNKNown | DATA | CMD | STAT | CMST | IM CMD: command word CMST: command/status word IM: inter message. Shows if there are gap errors or response timeout. *RST: DATA
Usage:	Query only

20.17.10.4 Search Settings

The search remote commands are very similar to the trigger commands. Therefore, search coommands are described in short, for more details, see the corresponding trigger command in Chapter 20.17.10.2, "Trigger", on page 1684.

SEARch:TRIGger:MILStd:TYPE <SearchName>,<Type>
SEARch:TRIGger:MILStd:TYPE? <SearchName>

Sets the event to be searched for.

Parameters:

<Type>	STYPe | WTYPe | DATA | CDST | CMD | STATword | ERR See `TRIGger<m>:MILStd:TYPE` on page 1685 *RST: STYPe

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:RCONdition <SearchName>,<RTAOperator>
SEARch:TRIGger:MILStd:DATA:RCONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:RCONdition <SearchName>,<RTAOperator>
SEARch:TRIGger:MILStd:CMD:RCONdition? <SearchName>
SEARch:TRIGger:MILStd:CDST:RCONdition <SearchName>,<RTAOperator>
SEARch:TRIGger:MILStd:CDST:RCONdition? <SearchName>

Set the operator to define a remote terminal address:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `SEARch:TRIGger:MILStd:CDST:RMIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MILStd:CDST:RMIN` and `SEARch:TRIGger:MILStd:CDST:RMAX` on page 1700. *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:MILStd:DATA:RMIN <SearchName>,<RTAPatternMin>
SEARch:TRIGger:MILStd:DATA:RMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:RMIN <SearchName>,<RTAPatternMin>
SEARch:TRIGger:MILStd:CMD:RMIN? <SearchName>
SEARch:TRIGger:MILStd:CDST:RMIN <SearchName>,<RTAPatternMin>
SEARch:TRIGger:MILStd:CDST:RMIN? <SearchName>

Specify a remote terminal address or set the the start value of a remote terminal address range:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:RMAX <SearchName>,<RTAPatternMax>
SEARch:TRIGger:MILStd:DATA:RMAX? <SearchName>
SEARch:TRIGger:MILStd:CMD:RMAX <SearchName>,<RTAPatternMax>
SEARch:TRIGger:MILStd:CMD:RMAX? <SearchName>
SEARch:TRIGger:MILStd:CDST:RMAX <SearchName>,<RTAPatternMax>
SEARch:TRIGger:MILStd:CDST:RMAX? <SearchName>

Set the end value of a data range if `SEARch:TRIGger:MILStd:CDST:RCONdition` is set to `INRange` or `OORange`:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<RTAPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:CDST:ICONdition <SearchName>,<InfoOperator>
SEARch:TRIGger:MILStd:CDST:ICONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:CCONdition <SearchName>,<WordCntOptor>
SEARch:TRIGger:MILStd:CMD:CCONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:SCONdition <SearchName>,<SubaddrOptor>
SEARch:TRIGger:MILStd:CMD:SCONdition? <SearchName>
SEARch:TRIGger:MILStd:DATA:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:MILStd:DATA:DCONdition? <SearchName>

Sets the operator for the corresponding search:

- CDST:ICON - specific info for the 9th to 19th bit of a command or status word.
- CMD:CCON - specific data word count or mode code pattern in a command word
- CMD:SCON - specific subaddress/mode pattern in a command word
- DATA:DCON - data pattern in a data word

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:CDST:IMIN <SearchName>,<InfoPatternMin>
SEARch:TRIGger:MILStd:CDST:IMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:CMIN <SearchName>,<WordCntPattMin>
SEARch:TRIGger:MILStd:CMD:CMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:SMIN <SearchName>,<SubaddrPattMin>
SEARch:TRIGger:MILStd:CMD:SMIN? <SearchName>
SEARch:TRIGger:MILStd:DATA:DMIN <SearchName>,<DataPatternMin>
SEARch:TRIGger:MILStd:DATA:DMIN? <SearchName>

Sets the pattern or the start value of a pattern range for the corresponding search:

- CDST:IMIN - specific info for the 9th to 19th bit of a command or status word.
- CMD:CMIN - specific data word count or mode code pattern in a command word
- CMD:SMIN - specific subaddress/mode pattern in a command word
- DATA:DMIN - data pattern in a data word

Parameters:
<DataPatternMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:CDST:IMAX <SearchName>,<InfoPatternMax>
SEARch:TRIGger:MILStd:CDST:IMAX? <SearchName>
SEARch:TRIGger:MILStd:CMD:CMAX <SearchName>,<WordCntPattMax>
SEARch:TRIGger:MILStd:CMD:CMAX? <SearchName>

SEARch:TRIGger:MILStd:CMD:SMAX <SearchName>,<SubaddrPattMax>
SEARch:TRIGger:MILStd:CMD:SMAX? <SearchName>
SEARch:TRIGger:MILStd:DATA:DMAX <SearchName>,<DataPatternMax>
SEARch:TRIGger:MILStd:DATA:DMAX? <SearchName>

Sets the end value of a pattern range for the corresponding search:

- CDST:IMAX - specific info for the 9th to 19th bit of a command or status word.
- CMD:CMAX - specific data word count or mode code pattern in a command word
- CMD:SMAX - specific subaddress/mode pattern in a command word
- DATA:DMAX - data pattern in a data word

Parameters:
<DataPatternMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:ICONdition <SearchName>,<DatIdxOptor>
SEARch:TRIGger:MILStd:DATA:ICONdition? <SearchName>

Sets the operator to set a range within a series of the data words that is considered for the search.

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe INRange = RANGe *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:MILStd:DATA:IMIN? <SearchName>

Specifies an index or sets the the start value of a data word series index range.

Parameters:

<DataIndexMin>	Range:	1 to 32
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:MILStd:DATA:IMAX? <SearchName>

Sets the end value of a data word series index range if the operator is set to `INRange`.

Parameters:

<DataIndexMax>	Range:	1 to 32
	Increment:	1
	*RST:	32

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:CMD:TR <SearchName>,<TRFlag>
SEARch:TRIGger:MILStd:CMD:TR? <SearchName>

Searches for a transmission mode.

Parameters:

<TRFlag>	ONE | ZERO | DC	
	*RST:	DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:ERRor:MANChester <SearchName>,<ManCodingError>
SEARch:TRIGger:MILStd:ERRor:MANChester? <SearchName>
SEARch:TRIGger:MILStd:ERRor:PARity <SearchName>,<ParityError>
SEARch:TRIGger:MILStd:ERRor:PARity? <SearchName>
SEARch:TRIGger:MILStd:ERRor:SYNC <SearchName>,<SyncError>
SEARch:TRIGger:MILStd:ERRor:SYNC? <SearchName>
SEARch:TRIGger:MILStd:ERRor:TIMing <SearchName>,<MinGapSelect>
SEARch:TRIGger:MILStd:ERRor:TIMing? <SearchName>

Enables search for errors if `SEARch:TRIGger:MILStd:TYPE` is set to `ERRor`.

- MANChester: error of the manchester coding
- PARity: even parity (parity error)
- SYNC: error of the synchronization
- TIMing: Minimum gap is out of range

Parameters:

<SyncError>, <ParityError>, <ManCodingError>, <MinGapSelect>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:STATus:BCReceived <SearchName>,<BcstCmdFlag>
SEARch:TRIGger:MILStd:STATus:BCReceived? <SearchName>
SEARch:TRIGger:MILStd:STATus:BUSY <SearchName>,<BusyFlag>
SEARch:TRIGger:MILStd:STATus:BUSY? <SearchName>

SEARch:TRIGger:MILStd:STATus:DBCaccept <SearchName>,<DynBCFlag>
SEARch:TRIGger:MILStd:STATus:DBCaccept? <SearchName>
SEARch:TRIGger:MILStd:STATus:INSTrument <SearchName>,<InstFlag>
SEARch:TRIGger:MILStd:STATus:INSTrument? <SearchName>
SEARch:TRIGger:MILStd:STATus:MERRor <SearchName>,<MsgErrorFlag>
SEARch:TRIGger:MILStd:STATus:MERRor? <SearchName>
SEARch:TRIGger:MILStd:STATus:SREQuest <SearchName>,<SvcRequestFlag>
SEARch:TRIGger:MILStd:STATus:SREQuest? <SearchName>
SEARch:TRIGger:MILStd:STATus:SUBSystem <SearchName>,<SubsystemFlag>
SEARch:TRIGger:MILStd:STATus:SUBSystem? <SearchName>
SEARch:TRIGger:MILStd:STATus:TERMinal <SearchName>,<TerminalFlag>
SEARch:TRIGger:MILStd:STATus:TERMinal? <SearchName>

Specifies the values (0, 1, X) of the status flags if `SEARch:TRIGger:MILStd:TYPE` is set to `STATword`.

Parameters:

<TerminalFlag> ONE | ZERO | DC
*RST: DC

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:TPSPecifier <SearchName>,<TypeSpecifier>
SEARch:TRIGger:MILStd:TPSPecifier? <SearchName>

Sets the sync impulse/ word type to be searched for.

Parameters:

<TypeSpecifier> CSTatus | DATA | ALL
CSTatus: command/status word
*RST: ALL

Parameters for setting and query:

<SearchName>

20.17.10.5 Search Results

The search on decoded MIL-1553 data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.10.3, "Decode Results", on page 1694.

SEARch:RESult:MILStd:WCOunt <SearchName>

Setting parameters:
<SearchName>

Return values:
<Count>

SEARch:RESult:MILStd:WORD<m>:TYPE? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameType>	UNKNown | DATA | CMD | STAT | CMST | IM *RST: DATA
Usage:	Query only

SEARch:RESult:MILStd:WORD<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameState>	OK | SYNC | MANC | PAR | GAP | RT *RST: OK
Usage:	Query only

SEARch:RESult:MILStd:WORD<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:SYMBol? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:RTADdress? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameRta>	Range: 0 to 31 Increment: 1 *RST: 0

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrmDatPatt>

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:INFO? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameInfo>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

20.17.11 ARINC 429 (Option R&S RTO-K7)

20.17.11.1 Configuration

BUS<m>:ARINc:SOURce <SourceData>

Sets the channel for the signal source.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:ARINc:BRValue <BitRateValue>

Sets the number of transmitted bits per second.

Suffix:

<m>	1..4

Parameters:

<BitRateValue>	Range:	10000 to 110000
	Increment:	100
	*RST:	100000
	Default unit:	bps

BUS<m>:ARINc:BRMode <BitRateMode>

Sets the bit rate mode to high or low speed.

Suffix:

<m>	1..4

Parameters:

<BitRateMode>	HIGH | LOW *RST: HIGH

BUS<m>:ARINc:MAXGap:SELect <MaxGapSelect>

Enables the detection of the maximum gap time during decoding.

To specify the minimum gap time `BUS<m>:ARINc:MINGap:BITS`.

Suffix:

<m>	1..4

Parameters:

<MaxGapSelect>	ON | OFF *RST: OFF

BUS<m>:ARINc:MAXGap:BITS <MaxGapBits>

Sets the value for the maximum gap between two words.

See also: `BUS<m>:ARINc:MAXGap:SELect`

Suffix:

<m>	1..4

Parameters:

<MaxGapBits>	Range: 0 to 1000 Increment: 1 *RST: 100 Default unit: bit

---

BUS<m>:ARINc:MINGap:SELect <MinGapSelect>

Enables the detection of the minimum idle time between two words during decoding.

To specify the minimum gap, use`BUS<m>:ARINc:MINGap:BITS`.

Suffix:

<m>	1..4

Parameters:

<MinGapSelect>	ON | OFF *RST: ON

BUS<m>:ARINc:MINGap:BITS <MinGapBits>

Sets a value for the minimum timing gap between two words.

See also: `BUS<m>:ARINc:MINGap:SELect` on page 1709.

Suffix:

<m>	1..4

Parameters:

<MinGapBits>	Range: 0 to 100 Increment: 1 *RST: 4 Default unit: bit

---

BUS<m>:ARINc:POLarity <Polarity>

Sets the wire on which the bus signal is measured.

Suffix:

<m>	1..4

Parameters:

<Polarity>	ALEG | BLEG *RST: ALEG

BUS<m>:ARINc:PRESet <Preset>

Sets the default threshold voltage.

Suffix:

<m>	1..4

Parameters:

<Preset>	V25 | V5 | MAN	
	*RST:	V5

BUS<m>:ARINc:THReshold:HIGH <ThresholdHigh>

Sets the high threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdHigh>	Range:	0 to 12
	Increment:	0.1
	*RST:	5
	Default unit:	V

BUS<m>:ARINc:THReshold:LOW <ThresholdLow>

Sets the low threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdLow>	Range:	-12 to 0
	Increment:	0.1
	*RST:	-5
	Default unit:	V

20.17.11.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:ARINc:TYPE <Type>

Sets the trigger type for ARINC 429 analysis.

Parameters:

<Type>	STARt | STOP | LABel | ERRor *RST: STARt

TRIGger<m>:ARINc:DATA:CONDition <DataOperator>

Sets the condition for the data. You can define an exact data patterm or a data range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:ARINc:DATA:MIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:ARINc:DATA:MIN` and `TRIGger<m>:ARINc:DATA:MAX`. *RST: EQUal

---

TRIGger<m>:ARINc:DATA:MIN <DataMin>

Defines the minimum bit pattern for the data.

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:ARINc:DATA:MAX <DataMax>

Sets the end value of a data pattern if `TRIGger<m>:ARINc:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DataMax>

TRIGger<m>:ARINc:ERRor:CODing <CodingError>

Enables triggering when a coding error occurs.

Parameters:

<CodingError>	ON | OFF *RST: ON

TRIGger<m>:ARINc:ERRor:PARity <ParityError>

Enables triggering when a parity error occurs.

Parameters:

<ParityError>	ON | OFF *RST: ON

TRIGger<m>:ARINc:LABel:CONDition <LabelOperator>

Sets the condition for the label. You can define an exact label or a label range.

Parameters:

<LabelOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with`TRIGger<m>:ARINc:LABel:MIN`. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with`TRIGger<m>:ARINc:LABel:MIN` and `TRIGger<m>:ARINc:LABel:MAX`. *RST: EQUal

---

TRIGger<m>:ARINc:LABel:MIN <LabelMin>

Defines the minimum bit pattern for the label.

Parameters:

<LabelMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:ARINc:LABel:MAX <LabelMax>

Sets the end value of a label pattern if `TRIGger<m>:ARINc:LABel:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LabelMax>	Numeric or string pattern, see `TRIGger<m>:ARINc:LABel:MIN`

TRIGger<m>:ARINc:MINGap:SELect <MinGapSelect>

Enables triggering when the minimum gap is out of range. You can set the minimum gap with: `TRIGger<m>:ARINc:MINGap:BITS`.

Parameters:

<MinGapSelect>	ON | OFF *RST: ON

TRIGger<m>:ARINc:MINGap:BITS <MinGapBits>

Sets the value for the minimum gap to be triggered on.

Parameters:

<MinGapBits>	Range: 0 to 100 Increment: 1 *RST: 4 Default unit: bit

---

TRIGger<m>:ARINc:MAXGap:SELect <MaxGapSelect>

Enables triggering when the maximum gap is out of range. You can set the maximum gap with: `TRIGger<m>:ARINc:MAXGap:BITS`.

Parameters:

<MaxGapSelect>	ON | OFF *RST: OFF

TRIGger<m>:ARINc:MAXGap:BITS <MaxGapBits>

Sets the value for the maximum gap to be triggered on.

Parameters:

<MaxGapBits>	Range: 0 to 1000 Increment: 1 *RST: 100 Default unit: bit

---

TRIGger<m>:ARINc:SDI <SDI>

Sets the source/destination identifier (SDI) bits.

Parameters:
<SDI>

TRIGger<m>:ARINc:SSM <SSM>

Sets the sign/status matrix (SSM) bits.

Parameters:
<SSM>

20.17.11.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:ARINc:WCOunt?

Returns the number of decoded words.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:ARINc:WORD<n>:DATA?

Returns the data of the specified word.

Suffix:

<m>	1..4

<n>	*

Return values:

<FrameData>	19-bit data field of the word as an integer Range: 0 to 0 Increment: 1 *RST: 0

Example:

```
BUS:ARINc:WORD3:DATA?
<-- 148035
```

Usage: Query only

BUS<m>:ARINc:WORD<n>:LABel?

Returns the label of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameLabel>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:ARINc:WORD<n>:PATTern?

Returns all 32 bits of the specified word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	*

Return values:

<FrmDatPatt>	Comma-separated list of 4 bytes in big endian order. The format of each byte is defined by `FORMat:BPATtern`.

Example:

```
BUS2:ARINc:WORD3:PATTern?
--> #H75,#H11,#H55,#H82
FORMat:BPATtern DEC
BUS2:ARINc:WORD3:PATTern?
--> 117,17,85,130
```

Usage: Query only

BUS<m>:ARINc:WORD<n>:SDI?

Returns the source/destination identifier (SDI) bits of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:ARINc:WORD<n>:SSM?

Returns the sign/status matrix(SSM) bits of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameInfo>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:ARINc:WORD<n>:STARt?

Returns the start time of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:ARINc:WORD<n>:STATe?

Returns the overall state of the specified word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameState>	OK | CODE | GAP | PAR CODE: coding error occured. GAP: timing gap error occured. PAR: parity error occured. *RST: OK
Usage:	Query only

BUS<m>:ARINc:WORD<n>:STOP?

Returns the end time of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:ARINc:WORD<n>:SYMBol?

Returns the label name of the word ID.

Suffix:

<m>	1..4
<n>	*

Return values:

<Translation>

Usage: Query only

20.17.11.4 Search Settings

SEARch:TRIGger:ARINc:TYPE <SearchName>,<Type>
SEARch:TRIGger:ARINc:TYPE? <SearchName>

Sets the search type.

Parameters:

<Type>	STARt | STOP | LABel | ERRor *RST: STARt

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:LABel:CONDition <SearchName>,<LabelOperator>
SEARch:TRIGger:ARINc:LABel:CONDition? <SearchName>
SEARch:TRIGger:ARINc:DATA:CONDition <SearchName>,<DataOperator>
SEARch:TRIGger:ARINc:DATA:CONDition? <SearchName>

Set the condition for the label or data, respectively. You can define an exact value or a value range

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding SEARch:TRIGger:ARINc:...:MIN command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range. with`TRIGger<m>:ARINc:LABel:MIN` and `TRIGger<m>:ARINc:LABel:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:LABel:MIN <SearchName>,<LabelMin>
SEARch:TRIGger:ARINc:LABel:MIN? <SearchName>
SEARch:TRIGger:ARINc:DATA:MIN <SearchName>,<DataMin>
SEARch:TRIGger:ARINc:DATA:MIN? <SearchName>

Specifies a label or data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ARINc:LABel:MAX <SearchName>,<LabelMax>
SEARch:TRIGger:ARINc:LABel:MAX? <SearchName>
SEARch:TRIGger:ARINc:DATA:MAX <SearchName>,<DataMax>
SEARch:TRIGger:ARINc:DATA:MAX? <SearchName>

Set the end value of a label or data pattern if the condition is set to `INRange` or `OORange`.

Parameters:

<DataMax>	Numeric or string pattern, see `SEARch:TRIGger:ARINc:LABel:MIN`

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:SDI <SearchName>,<SDI>
SEARch:TRIGger:ARINc:SDI? <SearchName>

Sets the source/destination identifier (SDI) bits.

Parameters:

<SDI>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:SSM <SearchName>,<SSM>
SEARch:TRIGger:ARINc:SSM? <SearchName>

Sets the sign/status matrix (SSM) bits.

Parameters:

<SSM>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:ERRor:CODing <SearchName>,<CodingError>
SEARch:TRIGger:ARINc:ERRor:CODing? <SearchName>

Enables the search for coding errors.

Parameters:

<CodingError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:ERRor:PARity <SearchName>,<ParityError>
SEARch:TRIGger:ARINc:ERRor:PARity? <SearchName>

Enables the search for parity errors.

Parameters:

<ParityError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:ERRor:TIMing <SearchName>,<MinGapSelect>
SEARch:TRIGger:ARINc:ERRor:TIMing? <SearchName>

Enables the search for timing errors, when the minimum gap is out of range.

Parameters:

<MinGapSelect>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

20.17.11.5 Search Results

The search on decoded ARINC 429 data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.11.3, "Decode Results", on page 1714.

SEARch:RESult:ARINc:WORD<m>:LABel? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameRta>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:PATTern? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<FrmDatPatt>

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameData>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SSM? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameInfo>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SYMBol? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:ARINc:WCOunt <Key>

Setting parameters:

<Key>

Return values:

<Count>

SEARch:RESult:ARINc:WORD<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SDI? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameType> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:STATe? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameState> OK | CODE | GAP | PAR
*RST: OK

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

20.17.12 Ethernet (Option R&S RTO-K8)

20.17.12.1 Configuration

In all `BUS<m>:ETHernet` commands, the suffix <m> selects the serial bus.

BUS<m>:ETHernet:VARiant <Variant>

Selects the Ethernet protocol variant and transmission speed.

Suffix:

<m>	1..4

Parameters:

<Variant>	B10T | B100TX | B100tx
	B10T Ethernet protocol variant 10BASE-T (10 Mbit/s)
	B100TX = B100tx Ethernet protocol variant 100BASE-TX (100 Mbit/s)
	*RST: B10T

BUS<m>:ETHernet:SOURce <SourceData>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
	See Chapter 20.4.2, "Waveform Parameter", on page 1173

BUS<m>:ETHernet:POLarity <Polarity>

Defines the polarity of the data signal. This setting is only available in 10BASE-T.

Suffix:

<m>	1..4

Parameters:

<Polarity>	NORMal | INVert
	NORMal Normal (non-inverted) data signal polarity
	INVert Inverted data signal polarity
	*RST: NORMal

BUS<m>:ETHernet:THReshold:HIGH <ThresholdUpper>

Sets the upper threshold value for the signal digitization. If the signal value is higher than the this threshold, the signal state is considered high.

Suffix:

<m>	1..4

Parameters:

<ThresholdUpper>	Range:	0 to 10
	Increment:	0.1
	*RST:	1.25
	Default unit:	V

BUS<m>:ETHernet:THReshold:LOW <ThresholdLower>

Sets the lower threshold value for the signal digitization. If the signal value is below this threshold, the signal state is considered low.

Suffix:

<m>	1..4

Parameters:

<ThresholdLower>	Range:	-10 to 0
	Increment:	0.1
	*RST:	-1.25
	Default unit:	V

BUS<m>:ETHernet:PRESet <ThresholdPreset>

Sets the thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset>	T0 | T100 | TX0 | TX100 | MAN **T0** Sets the thresholds to the default values for 10BASE-T (0 meters): upper threshold to 1.25 V, lower threshold to -1.25 V **T100** Sets the thresholds to the default values for 10BASE-T (100 meters): upper threshold to 0.75 V, lower threshold to -0.75 V **TX0** Sets the thresholds to the default values for 100BASE-TX (0 meters): upper threshold to 0.5 V, lower threshold to -0.5 V **TX100** Sets the thresholds to the default values for 100BASE-TX (100 meters): upper threshold to 0.35 V, lower threshold to -0.35 V **MAN** Allows to set individual threshold voltage levels *RST: T0

BUS<m>:ETHernet:BITRate <BitRateValue>

Sets the bit rate value that defines the transmission speed in bits per second.

Suffix:

<m>	1..4

Parameters:

<BitRateValue>	Range: 10000 to 150000000 Increment: 1000 *RST: 10000000 Default unit: bps

20.17.12.2 Decode Results

In all `BUS<m>:ETHernet:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

As an example, with reference to Table 12-13, a set of query commands for bus #1 and word #1 is shown in the following, together with examples for results of these queries:

- `BUS1:ETH:WCOunt?` !2
- `BUS1:ETH:WORD1:STATe?` !OK
- `BUS1:ETH:WORD1:STARt?` !-0.000135
- `BUS1:ETH:WORD1:STOP?` !-6.62e-5
- `BUS1:ETH:WORD1:DEST?` !FF:FF:FF:FF:FF:FF
- `BUS1:ETH:WORD1:SRC?` !0F:0E:0D:0C:0B:0A

- `BUS1:ETH:WORD1:DATA?` ![60]45003c3e6210...
- `BUS1:ETH:WORD1:TYPE?` !2048
- `BUS1:ETH:WORD1:CRC?` !-1821935433
- `BUS1:ETH:WORD1:SSYM?` !
- `BUS1:ETH:WORD1:DSYM?` !BroadCast
- `BUS1:ETH:WORD1:BYTE1:VAL?` !69
- `BUS1:ETH:WORD1:BYTE2:VAL?` !0

BUS<m>:ETHernet:WCOunt?

Returns the frame count for the selected serial bus, i.e. the number of frames in the current acquisition. The result corresponds to the number of rows in the result table.

Suffix:

<m>	1..4

Return values:

<Count>

Usage:	Query only

BUS<m>:ETHernet:WORD<n>:FTYPe?

Returns the frame type of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType>	MAC | IDLE | SLEep | EOS | UNKNown *RST: MAC

Usage:	Query only

BUS<m>:ETHernet:WORD<n>:STATe?

Returns the frame state of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<State> OK | ERR_PREAMBLE | ERR_LENGTH

OK
No error detected

ERR_PREAMBLE
Error in the preamble of the selected word

ERR_SFD
Error in the start frame delimiter (SFD). The value of a correct SFD byte is 171. The SFD is transmitted LSB first.

ERR_LENGTH
Error in the number of bits in the selected word

*RST: OK

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STARt?

Returns the frame start time of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STOP?

Returns the frame stop time of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage:	Query only

BUS<m>:ETHernet:WORD<n>:DESTaddress?

Returns the destination address of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<DestAddress>	String parameter
Usage:	Query only

BUS<m>:ETHernet:WORD<n>:SRCaddress?

Returns the source address of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<SrcAddress>	String parameter
Usage:	Query only

BUS<m>:ETHernet:WORD<n>:TYPE?

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent. The query either returns the word type (specific for the sub-protocol), or the length of the selected word.

Suffix:

<m>	1..4
<n>	*

Return values:

<Type>	
Usage:	Query only

BUS<m>:ETHernet:WORD<n>:DATA?

Returns the number of word bytes in brackets [.] followed by the first six word bytes of data in hexadecimal format.

Use `BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?` to access the word bytes.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>	String parameter

Example:
```
BUS:ETHernet:WORD3:DATA?
<-- '[60]FF00FFFF1234'
```

Usage: Query only

BUS<m>:ETHernet:WORD<n>:CRC?

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word.

Suffix:

<m>	1..4
<n>	*

Return values:

<CRC>

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DSYMbol?

Returns the symbolic label (or translation) of the destination address of the specified word, if the label list is enabled.

Suffix:

<m>	1..4
<n>	*

Return values:

<DestTranslation>	String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:SSYMbol?

Returns the symbolic label (or translation) of the source address of the specified word, if the label list is enabled.

Suffix:

<m>	1..4
<n>	*

Return values:

<SrcTranslation>	String parameter

Usage:	Query only

BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details". The format of the byte value is hexadecimal.

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the byte number.

Return values:

<FrameByteValue>

Usage:	Query only

BUS<m>:ETHernet:WORD<n>:NUMWords?

Returns the number of words in the selected frame. The result corresponds to the "Number of Words" column in the results table.

Suffix:

<m>	1..4
<n>	* Frame index

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage:	Query only

20.17.12.3 Search Settings

SEARch:TRIGger:ETHernet:FRAMe:SELect <SearchName>,<CheckFrame>
SEARch:TRIGger:ETHernet:FRAMe:SELect? <SearchName>

Defines, whether a search within a frame shall be activated or not.

Parameters:

<CheckFrame>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:DCONdition <SearchName>,<DestAddrOptor>
SEARch:TRIGger:ETHernet:FRAMe:DCONdition? <SearchName>

Defines the operator to search a specific destination address within a frame.

Parameters:

<DestAddrOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with `SEARch:TRIGger:ETHernet:FRAMe:DMIN`. **INRange | OORange** In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:DMIN` and `SEARch:TRIGger:ETHernet:FRAMe:DMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMIN <SearchName>,<DestAddrPattMin>
SEARch:TRIGger:ETHernet:FRAMe:DMIN? <SearchName>

Defines a destination address, or sets the start value of a destination address range.

Parameters:

<DestAddrPattMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMAX <SearchName>,<DestAddrPattMax>
SEARch:TRIGger:ETHernet:FRAMe:DMAX? <SearchName>

Sets the end value of a destination address range, if `SEARch:TRIGger:ETHernet:FRAMe:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DestAddrPattMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:SCONdition <SearchName>,<SrcAddrOperator>
SEARch:TRIGger:ETHernet:FRAMe:SCONdition? <SearchName>

Defines the operator to search a specific source address within a frame.

Parameters:

<SrcAddrOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with `SEARch:TRIGger:ETHernet:FRAMe:SMIN`. **INRange | OORange** In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:SMIN` and `SEARch:TRIGger:ETHernet:FRAMe:SMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMIN <SearchName>,<SrcAddrPattMin>
SEARch:TRIGger:ETHernet:FRAMe:SMIN? <SearchName>

Defines a source address, or sets the start value of a source address range.

Parameters:

<SrcAddrPattMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMAX <SearchName>,<SrcAddrPattMax>
SEARch:TRIGger:ETHernet:FRAMe:SMAX? <SearchName>

Sets the end value of a source address range, if `SEARch:TRIGger:ETHernet:FRAMe:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<SrcAddrPattMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:TCONdition <SearchName>,<TypeOperator>
SEARch:TRIGger:ETHernet:FRAMe:TCONdition? <SearchName>

Defines the operator to search for a specific frame length or type.

Parameters:

<TypeOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a pattern to be set with `SEARch:TRIGger:ETHernet:FRAMe:TMIN`. **INRange | OORange** In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:TMIN` and `SEARch:TRIGger:ETHernet:FRAMe:TMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMIN <SearchName>,<TypePatternMin>
SEARch:TRIGger:ETHernet:FRAMe:TMIN? <SearchName>

Defines a frame length/type, or sets the start value for a range of frame lengths/types.

Parameters:

<TypePatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMAX <SearchName>,<TypePatternMax>
SEARch:TRIGger:ETHernet:FRAMe:TMAX? <SearchName>

Sets the end value of a range of frame lengths/types, if `SEARch:TRIGger:ETHernet:FRAMe:TCONdition` is set to `INRange` or `OORange`.

Parameters:

<TypePatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:CCONdition <SearchName>,<CRCOperator>
SEARch:TRIGger:ETHernet:FRAMe:CCONdition? <SearchName>

Defines the operator to search for a Cyclic Redundancy Code (CRC, or frame check) error condition within a frame.

Parameters:

<CRCOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a CRC pattern to be set with `SEARch:TRIGger:ETHernet:FRAMe:CMIN`. **INRange | OORange** In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:CMIN` and `SEARch:TRIGger:ETHernet:FRAMe:CMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMIN <SearchName>,<CRCPatternMin>
SEARch:TRIGger:ETHernet:FRAMe:CMIN? <SearchName>

Defines a CRC error condition pattern, or sets the start value of such a pattern.

Parameters:

<CRCPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMAX <SearchName>,<CRCPatternMax>
SEARch:TRIGger:ETHernet:FRAMe:CMAX? <SearchName>

Sets the end value of a CRC error condition pattern, if `SEARch:TRIGger:ETHernet:FRAMe:CCONdition` is set to `INRange` or `OORange`.

Parameters:

<CRCPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:ERRor:SELect <SearchName>,<ChkErrCond>
SEARch:TRIGger:ETHernet:ERRor:SELect? <SearchName>

Defines, whether a search for an error condition shall be activated or not.

Parameters:

<ChkErrCond>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:ERRor:PREamble <SearchName>,<ErrorPreamble>
SEARch:TRIGger:ETHernet:ERRor:PREamble? <SearchName>

Defines, whether a search for any preamble error shall be activated or not.

Parameters:

<ErrorPreamble>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:ETHernet:ERRor:LENGth <SearchName>,<ErrorLength>
SEARch:TRIGger:ETHernet:ERRor:LENGth? <SearchName>

Defines, whether a search for any word length error (too few or too many bits per word) shall be activated or not.

Parameters:

<ErrorLength>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String parameter

20.17.12.4 Search Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496
- `BUS<m>:RESDetail` on page 1496

In all `SEARch:RESult:ETHernet:WORD<m>` commands, the suffix <m> selects the word number in the list of search results.

SEARch:RESult:ETHernet:WCOunt <Key>

Returns the number of decoded words within the search result.

Setting parameters:

<Key>	String parameter

Return values:
<Count>

SEARch:RESult:ETHernet:WORD<m>:STATe? <SearchName>

Returns the frame state of the selected word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<State>	OK | ERR_PREAMBLE | ERR_LENGTH **OK** No error detected **ERR_PREAMBLE** Error in the preamble of the selected word **ERR_SFD** Error in the start frame delimiter (SFD). The value of a correct SFD byte is 171. The SFD is transmitted LSB first. **ERR_LENGTH** Error in the number of bits in the selected word *RST: OK

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STARt? <SearchName>

Returns the frame start time of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STOP? <SearchName>

Returns the frame stop time of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DESTaddress? <SearchName>

Returns the destination address of the specified word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<DestAddrstr>	String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:SRCaddress? <SearchName>

Returns the source address of the specified word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<SrcAddrstr>	String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:TYPE? <SearchName>

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent. The query either returns the word type (specific for the sub-protocol), or the length of the selected word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<Type>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:FTYPe? <SearchName>

Returns the frame type of the specified frame.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameType>	MAC | IDLE | SLEep | EOS | UNKNown *RST: MAC

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DATA? <SearchName>

Returns the data bytes of the specified word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<Data>	String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:CRC? <SearchName>

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<CRC>	Range: 0 to 0 Increment: 1 *RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DSYMbol? <SearchName>

Returns the symbolic label (or translation) of the destination address of the specified word within the search result, if the label list is enabled.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<DestTranslation>	String parameter

Usage:	Query only

SEARch:RESult:ETHernet:WORD<m>:SSYMbol? <SearchName>

Returns the symbolic label (or translation) of the source address of the specified word within the search result, if the label list is enabled.

Suffix:

<m>	*

Query parameters:

<SearchName>	String parameter

Return values:

<SrcTranslation>	String parameter

Usage:	Query only

SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue? <SearchName>

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details". The format of the byte value is hexadecimal.

Suffix:

<m>	*
<n>	* Selects the byte number.

Query parameters:

<SearchName>	String parameter

Return values:

<FrameByteValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

20.17.13 SENT (Option R&S RTO-K10)

20.17.13.1 Configuration

BUS<m>:SENT:DATA:SOURce <DataSource>

Selects the source of the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

Usage: Asynchronous command

BUS<m>:SENT:DATA:THReshold <Threshold>

Sets a user-defined threshold value. Alternatively, you can set the threshold according to the signal technology `BUS<m>:SENT:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Threshold>	Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:SENT:TECHnology <Technology>

Selects the threshold voltage.

Suffix:

<m>	1..4 Selects the serial data bus.

Parameters:

<Technology>	V25 | MAN **V25** The threshold value is 2.5 V, according to CMOS technology. **MAN** Sets the threshold to the value set with `BUS<m>:SENT:DATA:THReshold`. *RST: V25

BUS<m>:SENT:CLKPeriod <ClockPeriod>

Sets the nominal clock period (clock tick).

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ClockPeriod>	Range:	1E-6 to 100E-6
	Increment:	1E-6
	*RST:	3E-6
	Default unit:	s

BUS<m>:SENT:CLKTolerance <ClockTolerance>

Sets a tolerated deviation of the clock signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ClockTolerance>	Range:	0 to 25
	Increment:	1
	*RST:	20
	Default unit:	%

BUS<m>:SENT:DNIBbles <DataNibbles>

Sets the number of data nibbles for a transmission sequence.

Suffix:

<m>	1..4 Selects the serial data bus.

Parameters:

<DataNibbles>	Range:	1 to 6
	Increment:	1
	*RST:	3

BUS<m>:SENT:SFORmat <Format>

Selects the serial message format.

Suffix:

<m>	1..4

Parameters:

<Format>	SHORt | ENHanced | NONE Short serial message, Enhanced serial message, none = single transmission sequence. *RST: NONE

BUS<m>:SENT:CRCVersion <CRCVersion>

Selects the calculaction method for the cyclic redundancy check (CRC).

Suffix:

<m>	1..4 Selects the serial data bus.

Parameters:

<CRCVersion>	LEGA | V2010 **Legacy**: method used up to 2010 **V2010**: current method *RST: V2010

BUS<m>:SENT:CRCMethod <CRCCalculation>

Selects the calculation method for the CRC checksum.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<CRCCalculation>	SAEJ | TLE **SAEJ**: according to the standard **TLE**: according to the computing method for TLE_4998X sensors. *RST: SAEJ

BUS<m>:SENT:PPULse <PausePulse>

Determines if a pause pulse is part of the SENT transmission sequence.

Suffix:

<m>	1..4 Selects the serial data bus.

Parameters:

<PausePulse>	NPP | PP | PPFL **NPP** Transmits the SENT message without pause pulse. **PP** Transmits the message with a fixed pulse length, automatically calculated. **PPFL** Transmits the pause pulse with a user-defined frame length to obtain a transmission sequence with constant length. *RST: NPP

BUS<m>:SENT:PPFLength <FrameLength>

Defines a constant transmission sequence length. To select the fixed sequence length, set BUS:SENT:PPUL PPFL.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<FrameLength>	Range:	104 to 922
	Increment:	1
	*RST:	128

20.17.13.2 Trigger

Event in a trigger sequence: 1 = A-event only

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:SENT:TYPE <Type>

Selects the trigger event for the SENT transmission type.

Parameters:

<Type>	CALI | TSEQ | SMSG | ERRC **CALI** CALIbration: triggers on the falling edge of the calibration/ synchronization pulse. **TSEQ** Transmission SEQuence: triggers either on the falling edge of the status nibble, or on the last data nibble. To set the transmission sequence conditions, use `TRIGger<m>:SENT:TTYPe` and `TRIGger<m>:SENT:STATus`. To set the data condition, use `TRIGger<m>:SENT:TDCN`, `BUS<m>:SENT:DNIBbles`, `TRIGger<m>:SENT:TDMN` and `TRIGger<m>:SENT:TDMX`. **SMSG** Serial Message: combination of identifier and data conditions. To select the sequence condition, use `TRIGger<m>:SENT:STYPe`. To select the message ID format for an enhanced serial message, use `TRIGger<m>:SENT:SIDType`. To set the identifier condition, use `TRIGger<m>:SENT:SICN`, `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`. To set the data condition, use `TRIGger<m>:SENT:SCONdition`, `TRIGger<m>:SENT:SDMN` and `TRIGger<m>:SENT:SDMX`. **ERRC** ERRor Condition: triggers on an error event. Define the error types with `TRIGger<m>:SENT:PULSeerror`, `TRIGger<m>:SENT:PPERioderror` or `TRIGger<m>:SENT:CRCerror`. *RST: CALI

TRIGger<m>:SENT:TTYPe <TSFieldType>

Selects the trigger sequence type for TRIGger<m>:SENT:TYPE TSEQ (transmission sequence).

Parameters:

<TSFieldType>

STAT | STDA

STAT
Triggers on the status nibble.

STDA
Triggers at the end of the combination of status and data nibble(s).
Define the data conditions with `TRIGger<m>:SENT:STATus`, `TRIGger<m>:SENT:TDCN`, `BUS<m>:SENT:DNIBbles`, `TRIGger<m>:SENT:TDMN` and `TRIGger<m>:SENT:TDMX`

*RST: STAT

TRIGger<m>:SENT:STATus <StatusBits>

Sets the status nibble data.

Parameters:

<StatusBits>

Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:TDCN <TSDataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<TSDataOperator>

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:SENT:TDMN`.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with `TRIGger<m>:SENT:TDMN` and `TRIGger<m>:SENT:TDMX`.

*RST: EQUal

TRIGger<m>:SENT:TDMN <TSDataPattern>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<TSDataPattern>

Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:TDMX <TSDataPatternTo>

Sets the end value of an identifier range for TRIGger:SENT:TDCN INRange or OORange.

Parameters:

<TSDataPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:STYPe <SMFieldType>

Selects the trigger sequence type for TRIGger:SENT:TYPE SSMSg or ESMSg (serial message).

Parameters:

<SMFieldType> ID | IDDT

ID
Triggers on the identifier.
To set the identifier condition for a serial message, use `TRIGger<m>:SENT:SICN`, `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`.

IDDT
Triggers at the end of the combination of identifier and data.
To set the identifier condition, use the commands shown above.
To set the data condition, use `TRIGger<m>:SENT:SCONdition`, `TRIGger<m>:SENT:SDMN` and `TRIGger<m>:SENT:SDMX`.

*RST: ID

TRIGger<m>:SENT:SIDType <SMIDType>

Sets the message ID format (4 bit or 8 bit) of the enhanced serial message.

Parameters:

<SMIDType> B4 | B8

*RST: B4

TRIGger<m>:SENT:SICN <SMIDOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMIDOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:SENT:SIMN`. **INRange | OORange** In range / Out of range. To define the range set the minimum and maximum values with `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`. *RST: EQUal

---

TRIGger<m>:SENT:SIMN <SMIDPattern>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:

<SMIDPattern>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SIMX <SMIDPatternTo>

Sets the end value of an identifier range for TRIGger<m>:SENT:SICN INRange or OORange.

Parameters:

<SMIDPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SCONdition <SSMDataOperator>

Sets the operator to define a specific data pattern or a data pattern range.

Parameters:

<SSMDataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:SENT:SIMN`. **INRange | OORange** In range / Out of range. To define the range set the minimum and maximum values with `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`. *RST: EQUal

TRIGger<m>:SENT:SDMN <SMDataPattern>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<SMDataPattern>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SDMX <SMDataPatternTo>

Sets the end value of an identifier range for TRIGger<m>:SENT:SCONdition INRange or OORange.

Parameters:

<SMDataPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:FORMerror <FormError>

Triggers on format errors in serial messages.

A form error occurs when at least one of the transmission sequences that form a serial message has an error.

To trigger on an error event, select the corresponding trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<FormError>	ON | OFF *RST: OFF

TRIGger<m>:SENT:PULSeerror <CalibPulseError>

Trigger son calibration pulse erors in transmission sequences.

An error occurs when

- the duration of the "Calibration/Sync" pulse (in ticks) is less than 56*(1-clock tolerance) or more than 56*(1+clock tolerance)
- the "Calibration/Sync" pulse duration of frame (n-1) varies by more than 1.5625% from the "Calibration/Sync" pulse duration of frame (n)

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<CalibPulseError>	ON | OFF *RST: OFF

TRIGger<m>:SENT:PPERioderror <PlsPeriodErr>

Triggers on pulse period errors.

An error occurs when a nibble has any of the following:

- number of ticks at low is less than 4 ticks.
- nibble value < 0 (less than 12 ticks) or > 15 (more than 27 ticks).

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<PlsPeriodErr>	ON | OFF	
	*RST:	OFF

TRIGger<m>:SENT:CRCerror <CRCError>

Triggers on CRC errors in both, the transmission sequences and serial messages.

A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence. The CRC length is 4 bits for transmission sequences and short serial messages, and 6 bit of enhanced serial messages.

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<CRCError>	ON | OFF	
	*RST:	ON

TRIGger<m>:SENT:IRFLength <IrregularFrmLen>

Triggers on frame length errors in transmission sequences when pause pulse for constant frame length is set, see BUS<m>:SENT:PPULse PPFL.

An error occurs when the total length of the transmission sequence (including pause pulse) does not match the frame length setting, see `BUS<m>:SENT:PPFLength` on page 1745.

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<IrregularFrmLen>	ON | OFF	
	*RST:	OFF

20.17.13.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:SENT:FCOunt?

Returns the number of decoded frames of the acquisition.

Suffix:

<m>	1..4 Selects the serial data bus.

Return values:

<Count> Total number of decoded frames.

Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial data bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | SYNC | PULSe | CRC | IRFL | FORM | INSufficient OK: the frame is valid. SYNC: Synchronization error occurred. PULse: Pulse error occurred. CRC: Cyclic redundancy check failed. IRFL: Irregular frame length error occurred. FORM: Format error occurred. INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid. *RST: OK
Usage:	Query only

BUS<m>:SENT:FRAMe<n>:STARt?
BUS<m>:SENT:FRAMe<n>:STOP?

Returns the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart> <FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:SENT:FRAMe<n>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ChecksumValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 63 Increment: 1 *RST: 0

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Parameters:

<Data>	Comma-separated sequence of integer values (N, D1, D2,…, DN). N is the number of nibbles in the frame, and D1…DN are the values of the nibbles.

Example:

```
BUS:SENT:FRAMe4:DATA?
<-- 4,3,15,11,9
```

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:IDTYpe?

Returns the identifier type of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierType>	B4 | B8 B4: standard format, 4 bit B8: extended format, 8 bit *RST: B4

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierValue>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:NIBBle<o>:STATe?

Returns the state of the specified nibble.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the nibble number.

Return values:

<State>	OK | UNDF UNDF: Undefined *RST: OK

Usage: Query only

BUS<m>:SENT:FRAMe<n>:NIBBle<o>:VALue?

Returns the value of the specified nibble.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the nibble number.

Return values:

<Value>	To set the value format, use `FORMat:BPATtern`. The values below – range, increment and reset – are decimal values. Range: 0 to 15 Increment: 1 *RST: 0

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:PAPTicks?

Returns the number of the pulse pause clock ticks.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<PausePulseTicks>	Range:	12 to 768
	Increment:	1
	*RST:	12

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:SCOM?

Returns the value of the status/communication pulse.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<StatusComm>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:SDATa?

Returns the symbolic data of the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<SymbolicData>	Comma-separated list of values. The first value is the number of bytes, followed by the decoded data bytes. To set the value format, use `FORMat:BPATtern`.

Usage:	Query only

BUS<m>:SENT:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Translation>	String with symbolic label of the identifier.
Example:	`BUS:SENT:FRAMe:SYMBol?` Response: `Air Temperature`
Usage:	Query only

BUS<m>:SENT:FRAMe<n>:SYNCduration?

Returns the time of the synchronization pulse.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<SyncDuration>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:SENT:FRAMe<n>:TYPE?

Returns the type of SENT message.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>	TRSQ | SMSG | EMSG Transmission sequence, short serial message or enhanced serial message. *RST: TRSQ

Usage:	Query only

BUS<m>:SENT:RDSL <RessDispSel>

Selects the results to be displayed.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<RessDispSel>	TRSQ | SMSG | ALL Transmission sequence, serial messages or all. *RST: ALL

20.17.13.4 SENT Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to SENT trigger commands.

SEARch:TRIGger:SENT:TYPE <SearchName>,<Type>
SEARch:TRIGger:SENT:TYPE? <SearchName>

Selects the SENT transmission type to be searched for.

Parameters:

<Type>	CALI | TSEQ | SMSG | ERRC **CALI** CALIbration: searches for the calibration/synchronization pulse. **TSEQ** Transmission sequence: combination of status and data conditions. To set the transmission sequence conditions, use `SEARch:TRIGger:SENT:TTYPe` and `SEARch:TRIGger:SENT:STATus` . To set the data condition, use `SEARch:TRIGger:SENT:TDCN`, `TRIGger<m>:SENT:TDCN`, `SEARch:TRIGger:SENT:TDMN` and `SEARch:TRIGger:SENT:TDMX`. **SMSG** Short serial message: combination of identifier and data conditions. To select the sequence condition, use `SEARch:TRIGger:SENT:STYPe`. To set the identifier condition for the serial message, use `SEARch:TRIGger:SENT:SICN`, `SEARch:TRIGger:SENT:SIMN` and `SEARch:TRIGger:SENT:SIMX`. To set the data condition, use `SEARch:TRIGger:SENT:SDCN`, `SEARch:TRIGger:SENT:SDMN` and `SEARch:TRIGger:SENT:SDMX`. **ERRC** Error condition: searches for error events. Define the error types with `SEARch:TRIGger:SENT:PULSeerror`, `SEARch:TRIGger:SENT:PPERioderror`, `SEARch:TRIGger:SENT:FORMerror` on page 1766 and `SEARch:TRIGger:SENT:CRCerror`. *RST: CALI

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:CALibration <SearchName>,<CheckCalibSync>
SEARch:TRIGger:SENT:CALibration? <SearchName>

Enables the search for the Calibration/Synchronization pulse.

Parameters:

<CheckCalibSync>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TRANsmission <SearchName>,<CheckTransSeq>
SEARch:TRIGger:SENT:TRANsmission? <SearchName>

Enables the search for a transmission sequence.

Parameters:

<CheckTransSeq>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SMSG <SearchName>,<CheckSerialMsg>
SEARch:TRIGger:SENT:SMSG? <SearchName>

Enables the search in a serial message.

Parameters:

<CheckSerialMsg>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:ERRor <SearchName>,<ChkErrCond>
SEARch:TRIGger:SENT:ERRor? <SearchName>

Enables the search for a specified error.

Parameters:

<ChkErrCond>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TTYPe <SearchName>,<TSFieldType>
SEARch:TRIGger:SENT:TTYPe? <SearchName>

Selects the SENT transmission sequence to be searched for.

To enable the search for the transmission sequence, use `SEARch:TRIGger:SENT:TRANsmission`.

Parameters:

<TSFieldType>	STAT | STDA **STAT** Searches on the status nibble. **STDA** Searches for the end of the combination of status and data nibble(s). Define the data conditions with `SEARch:TRIGger:SENT:STATus`, `SEARch:TRIGger:SENT:TDCN`, `BUS<m>:SENT:DNIBbles`, `SEARch:TRIGger:SENT:TDMN` and `SEARch:TRIGger:SENT:TDMX`. *RST: STAT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:STATus <SearchName>,<StatusBits>
SEARch:TRIGger:SENT:STATus? <SearchName>

Sets the status nibble data.

Parameters:

<StatusBits>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TDCN <SearchName>,<TSDataOperator>
SEARch:TRIGger:SENT:TDCN? <SearchName>

Sets the operator for a specific data pattern or a data pattern range.

Parameters:

<TSDataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:SENT:TDMN`. **INRange | OORange** In range / Out of range. To define the range set the minimum and maximum values with `SEARch:TRIGger:SENT:TDMN` and `SEARch:TRIGger:SENT:TDMX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TDMN <SearchName>,<TSDataPattern>
SEARch:TRIGger:SENT:TDMN? <SearchName>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<TSDataPattern>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TDMX <SearchName>,<TSDataPatternTo>
SEARch:TRIGger:SENT:TDMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:DCONdition INRange or OORange.

Parameters:

<TSDataPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:STYPe <SearchName>,<SMFieldType>
SEARch:TRIGger:SENT:STYPe? <SearchName>

Selects the serial message sequence to be searched for.

To enable the search for one of the serial message types, use `BUS<m>:SENT:SFORmat` and enable with `SEARch:TRIGger:SENT:SMSG`.

Parameters:

<SMFieldType> ID | IDDT

ID
Searches for the identifier.
To set the identifier condition for the serial message, use `SEARch:TRIGger:SENT:SICN`, `SEARch:TRIGger:SENT:SIMN` and `SEARch:TRIGger:SENT:SIMX`.

IDDT
Searches for the combination of identifier and data.
To set the identifier condition, use the commands shown above.
To set the data condition, use `SEARch:TRIGger:SENT:SDCN`, `SEARch:TRIGger:SENT:SDMN` and `SEARch:TRIGger:SENT:SDMX`.

*RST: ID

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIDType <SearchName>,<SMIDType>
SEARch:TRIGger:SENT:SIDType? <SearchName>

Sets the message ID format (4 bit or 8 bit) of the enhanced serial message.

Parameters:

<SMIDType>	B4 | B8 *RST: B4

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SICN <SearchName>,<SMIDOperator>
SEARch:TRIGger:SENT:SICN? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMIDOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:SENT:SIMN`. **INRange | OORange** In range / Out of range. To define the range set the minimum and maximum values with `SEARch:TRIGger:SENT:SIMN` and `SEARch:TRIGger:SENT:SIMX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIMN <SearchName>,<SMIDPattern>
SEARch:TRIGger:SENT:SIMN? <SearchName>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:

<SMIDPattern>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIMX <SearchName>,<SMIDPatternTo>
SEARch:TRIGger:SENT:SIMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:SICN INRange or OORange.

Parameters:

<SMIDPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SDCN <SearchName>,<SMDataOperator>
SEARch:TRIGger:SENT:SDCN? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMDataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:SENT:SDMN`. **INRange | OORange** In range / Out of range. To define the range set the minimum and maximum values with `SEARch:TRIGger:SENT:SDMN` and `SEARch:TRIGger:SENT:SDMX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SDMN <SearchName>,<SMDataPattern>
SEARch:TRIGger:SENT:SDMN? <SearchName>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<SMDataPattern>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SDMX <SearchName>,<SMDataPatternTo>
SEARch:TRIGger:SENT:SDMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:SDCN INRange or OORange.

Parameters:

<SMDataPatternTo>	Numeric or string pattern, Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:PULSeerror <SearchName>,<CalibPulseError>
SEARch:TRIGger:SENT:PULSeerror? <SearchName>

Enables the search for pulse errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<CalibPulseError>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:PPERioderror <SearchName>,<PlsPeriodErr>
SEARch:TRIGger:SENT:PPERioderror? <SearchName>

Enables the search for pulse period errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<PlsPeriodErr>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:IRFLength <SearchName>,<IrregularFrmLen>
SEARch:TRIGger:SENT:IRFLength? <SearchName>

Enables the search for irregular frame length errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<IrregularFrmLen>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:FORMerror <SearchName>,<FormError>
SEARch:TRIGger:SENT:FORMerror? <SearchName>

Enables the search for format errors in serial messages.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC.

Parameters:

<FormError>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:CRCerror <SearchName>,<CRCError>
SEARch:TRIGger:SENT:CRCerror? <SearchName>

Enables the search for errors in the Cyclic Redundancy Check.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<CRCError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

20.17.13.5 SENT Search Results

The search on decoded SENT data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.13.3, "Decode Results", on page 1751.

SEARch:RESult:SENT:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:CSValue? <SearchName>

Returns the checksum value.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrmCksumVal>	Range:	0 to 63
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:DATA? <SearchName>

Returns the data of the specified frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:IDTYpe? <SearchName>

Returns the identifier type of the selected frame.

Suffix:

<m>	* Selects the frame.

Query parameters:

<SearchName>

Return values:

<FrameIdType>	B4 | B8	
	B4: standard format, 4 bit B8: extended format, 8 bit	
	*RST:	B4

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:IDValue? <SearchName>

Returns the identifier value of the selected frame.

Suffix:

<m>	* Selects the serial bus.

Query parameters:

<SearchName>

Return values:

<FrameIdValue>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:STATe? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrmNibbleSt>	OK | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<FrmNibbleVal>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:PAPTicks? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<PausePulseTicks>	Range:	12 to 768
	Increment:	1
	*RST:	12

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SCOM? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<StatusComm>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SDATa? <SearchName>

Returns the symbolic data of the specified frame.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<SymbolicData>	String that contain the symbolic data.

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STATus? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameState>	OK | SYNC | PULSe | CRC | IRFL | FORM | INSufficient *RST: OK

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STOP? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SYMBol? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SYNCduration? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<SyncDuration>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameType>	TRSQ | SMSG | EMSG *RST: TRSQ

Usage: Query only

20.17.14 RFFE (Option R&S RTO-K40)

For programming examples, see Chapter 20.3.6.1, "RFFE (Option R&S RTO-K40)", on page 1166.

20.17.14.1 Configuration

In all BUS<m>:RFFE commands, the suffix <m> selects the serial bus.

For programming examples, see "Configuring RFFE Bus" on page 1166.

BUS<m>:RFFE:CLOCk:SOURce <SourceClock>

Sets the source of the RFFE clock line.

For triggering on a serial bus, analog or digital input channels are required.

Suffix:

<m>	1..4

Parameters:

<SourceClock>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:RFFE:DATA:SOURce <SourceData>

Sets the source of the RFFE data line. For triggering on a serial bus, analog or digital input channels are required.

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:RFFE:PRESet <ThresholdPreset>

Sets default threshold voltages for 1.2 V or 1.8 V bus. Set the value to MAN if you want to define individual thresholds.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset> V12 | V18 | MAN

*RST: V12

BUS<m>:RFFE:COUPling <ThresCpl>

If enabled, the SDATA thresholds are set to the SCLK threshold values.

Suffix:

<m>	1..4

Parameters:

<ThresCpl> ON | OFF

*RST: ON

BUS<m>:RFFE:DATA:THReshold:HIGH <ThresDatPos>

Set the positive going threshold (V_{TP}) for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresDatPos>

Range: 0 to 2.5
Increment: 0.1
*RST: 0.72
Default unit: V

BUS<m>:RFFE:DATA:THReshold:LOW <ThresDatNeg>

Set the negative going threshold (V_{TN}) for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresDatNeg>

Range: 0 to 2.5
Increment: 0.1
*RST: 0.48
Default unit: V

BUS<m>:RFFE:DATA:THReshold:HYSTeresis <ThresDatHyst>

Set the hysteresises between V_{TP} and V_{TN} for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresDatHyst>	Range:	0 to 1
	Increment:	0.1
	*RST:	0.2
	Default unit:	V

BUS<m>:RFFE:CLOCk:THReshold:HIGH <ThresClkPos>

Set the positive going threshold (V_{TP}) for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresClkPos>	Range:	0 to 2.5
	Increment:	0.1
	*RST:	0.72
	Default unit:	V

BUS<m>:RFFE:CLOCk:THReshold:LOW <ThresClkNeg>

Set the negative going threshold (V_{TN}) for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresClkNeg>	Range:	0 to 2.5
	Increment:	0.1
	*RST:	0.48
	Default unit:	V

BUS<m>:RFFE:CLOCk:THReshold:HYSTeresis <ThresClkHyst>

Set the hysteresis between V_{TP} and V_{TN} for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresClkHyst>	Range: 0 to 1 Increment: 0.1 *RST: 0.2 Default unit: V

BUS<m>:RFFE:GFILter <GlitchFilter>

Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<GlitchFilter>	ON | OFF *RST: OFF

BUS<m>:RFFE:GFWidth <GlitchFilterWdt>

Sets the maximum glitch width to be ignored.

Suffix:

<m>	1..4

Parameters:

<GlitchFilterWdt>	Range: 10E-12 to 10E-9 Increment: 10E-12 *RST: 1E-9 Default unit: s

---

BUS<m>:RFFE:MINGap:SELect <MinGapSelect>

If the minimum gap is enabled, the instrument detects the specified gap.

Set the minimum gap time using `BUS<m>:RFFE:MINGap:TIME`.

Suffix:

<m>	1..4

Parameters:

<MinGapSelect>	ON | OFF *RST: OFF

BUS<m>:RFFE:MINGap:TIME <MinGapTime>

Sets the minimum idle time between the Bus Park Cycle (BP) and Sequence Start Condition (SSC).

The setting is only relevant if `BUS<m>:RFFE:MINGap:SELect` is enabled.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range: 10E-9 to 10E-6 Increment: 10E-9 *RST: 1E-6 Default unit: s

20.17.14.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

For programming examples, see "Triggering on RFFE Bus" on page 1166.

TRIGger<m>:RFFE:TYPE <Type>

Selects the trigger type for RFFE analysis.

Parameters:

<Type> STARt | STOP | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | ERRor

STARt
Triggers on the beginning of a command sequence, exactly after the slave address. Optionally, you can specify a slave address condition.

STOP
Triggers on the end of a command sequence, exactly at the start of the bus park cycle. Optionally, you can specify a slave address condition.

RZWR
Triggers on "Register 0 Write" command sequences. Optionally, you can specify a slave address condition and a data pattern condition.

RWR
Triggers on "Register Write" command sequences. Optionally, you can specify a slave address condition, a register address condition, and a data pattern condition.

RRD
Triggers on "Register Read" command sequences. Optionally, you can specify a slave address condition, a register address condition, and a data pattern condition.

ERWR
Triggers on "Extended Register Write" command sequences. Optionally, you can specify a slave address condition, a register address condition, a byte count condition, a data index condition, and a data pattern condition.

ERRD
Triggers on "Extended Register Read" command sequences. Optional trigger conditions are the same as for ERWR.

ERWL
Triggers on "Extended Register Write Long" command sequences. Optional trigger conditions are the same as for ERWR.

ERRL
Triggers on "Extended Register Read Long" command sequences. Optional trigger conditions are the same as for ERWR.

ERRor
Triggers if one of the enabled errors occurs in a frame.
To enable the error types, use `TRIGger<m>:RFFE:ERRor:BP`, `TRIGger<m>:RFFE:ERRor:LENGth`, `TRIGger<m>:RFFE:ERRor:NOResponse`, `TRIGger<m>:RFFE:ERRor:PARity`, `TRIGger<m>:RFFE:ERRor:SSC`, and `TRIGger<m>:RFFE:ERRor:USEQuence`.

*RST: STARt

To specify additional trigger conditions for command sequences, use the following commands:

Slave address	`TRIGger<m>:RFFE:SADD:CONDition`
	`TRIGger<m>:RFFE:SADD:MIN`
	`TRIGger<m>:RFFE:SADD:MAX`

Register address	`TRIGger<m>:RFFE:ADDRess:CONDition`
	`TRIGger<m>:RFFE:ADDRess:MIN`
	`TRIGger<m>:RFFE:ADDRess:MAX`

Data pattern	`TRIGger<m>:RFFE:DATA:DCON`
	`TRIGger<m>:RFFE:DATA:DMIN`
	`TRIGger<m>:RFFE:DATA:DMAX`

Byte count	`TRIGger<m>:RFFE:BCOunt:CONDition`
	`TRIGger<m>:RFFE:BCOunt:MIN`
	`TRIGger<m>:RFFE:BCOunt:MAX`

Data index	`TRIGger<m>:RFFE:DATA:ICON`
	`TRIGger<m>:RFFE:DATA:IMIN`
	`TRIGger<m>:RFFE:DATA:IMAX`

TRIGger<m>:RFFE:SADD:CONDition <SIDOperator>
TRIGger<m>:RFFE:ADDRess:CONDition <AddressOperator>
TRIGger<m>:RFFE:BCOunt:CONDition <BteCntOptor>
TRIGger<m>:RFFE:DATA:DCON <DatPattOptor>

Sets the operator to trigger on a specific pattern or a range.

Parameters:

<DatPattOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using the corresponding TRIGger<m>:RFFE:...:MIN command.

INRange | OORange
In range / Out of range: Set the minimum and maximum value using the corresponding TRIGger<m>:RFFE:...:MIN and TRIGger<m>:RFFE:...:MAX

*RST: EQUal

Example: See "Triggering on RFFE Bus" on page 1166.

TRIGger<m>:RFFE:DATA:ICON <DatIdxOptor>

Sets the operator to define the data frames in which the data pattern is expected.

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | LTHan | LETHan | GTHan | GETHan** Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using `TRIGger<m>:RFFE:DATA:IMIN`. **INRange = RANGe** In range: Set the minimum and maximum value using `TRIGger<m>:RFFE:DATA:IMIN` and `TRIGger<m>:RFFE:DATA:IMAX`. *RST: INRange

---

TRIGger<m>:RFFE:SADD:MIN <SIDMin>
TRIGger<m>:RFFE:ADDRess:MIN <AddressMin>
TRIGger<m>:RFFE:BCOunt:MIN <ByteCountMin>
TRIGger<m>:RFFE:DATA:IMIN <DataIndexMin>
TRIGger<m>:RFFE:DATA:DMIN <DataPatternMin>

Specifies a pattern, or sets the the start value of a pattern range.

Parameters:

<DataPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Example:	See "Triggering on RFFE Bus" on page 1166.

TRIGger<m>:RFFE:SADD:MAX <SIDMax>
TRIGger<m>:RFFE:ADDRess:MAX <AddressMax>
TRIGger<m>:RFFE:BCOunt:MAX <ByteCountMax>
TRIGger<m>:RFFE:DATA:IMAX <DataIndexMax>
TRIGger<m>:RFFE:DATA:DMAX <DataPatternMax>

Sets the the end value of an range if the corresponding condition is set to `INRange` or `OORange`. See TRIGger<m>:RFFE:...:CON

Parameters:

<DataPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).
Example:	See "Triggering on RFFE Bus" on page 1166.

TRIGger<m>:RFFE:ERRor:BP <BusParkError>

Enables the trigger on a bus park error - when an incorrect bus parlk cycle has been found.

Parameters:

<BusParkError>	ON | OFF	
	*RST:	ON

TRIGger<m>:RFFE:ERRor:LENGth <LengthError>

Enables the trigger on a length error - when an incorrect length of the command sequence has been found.

Parameters:

<LengthError>	ON | OFF	
	*RST:	ON

TRIGger<m>:RFFE:ERRor:NOResponse <NoResponse>

Enables the trigger on any No Response Frame.

Parameters:

<NoResponse>	ON | OFF	
	*RST:	ON

TRIGger<m>:RFFE:ERRor:PARity <ParityError>

Enables the trigger on incorrect parity bits.

Parameters:

<ParityError>	ON | OFF	
	*RST:	ON

TRIGger<m>:RFFE:ERRor:SSC <SSCError>

Enables the trigger on an SSC error - when no valid SSC sequence has been found after the idle time.

Parameters:

<SSCError>	ON | OFF	
	*RST:	ON

TRIGger<m>:RFFE:ERRor:USEQuence <UnkSeqErr>

Enables the trigger on an unknown sequence - when the instrument cannot detect any supported command sequence.

Parameters:

<UnkSeqErr>	ON | OFF	
	*RST:	ON

20.17.14.3 Decode Results

In all BUS<m>:RFFE commands, the suffix <m> selects the serial bus. Suffix <n> selects index of the command sequence.

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1497
- `BUS<m>:SYMBols` on page 1498

BUS<m>:RFFE:FCOunt?

Returns the number of command sequences in the current acquisition.

Suffix:

<m>	1..4

Return values:

<Count>

Usage:	Query only

BUS<m>:RFFE:SEQuence<n>:STATe?

Returns the overall state of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameState>	OK | SSC | GAP | PARity | LENGth | BP | USEQuence | INComplete OK: the sequence is valid. SSC: SSC error GAP: Timing error PARity: parity error LENGth: length error BP: bus park error USEQuence: Unknown sequence INComplete: The sequence is not completely contained in the acquisition. The acquired part of the sequence is valid. *RST: OK
Usage:	Query only

BUS<m>:RFFE:SEQuence<n>:STARt?
BUS<m>:RFFE:SEQuence<n>:STOP?

Return the start time (SSC) and stop time (BP) of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameStart> <FrameStop>	Time Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:RFFE:SEQuence<n>:TYPE?

Returns the type of the selected command sequence.

Return values:

<FrameType>	UNDESC | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | UNDEF | ERRor RZWR: Register 0 Write RWR: Register Write RRD: Register Read ERWR: Extended Register Write ERRD: Extended Register Read ERWL: Extended Register Write Long ERRL: Extended Register Read Long MASR: Master Read MASW: Master Write MASOHO: Master Ownership Handover IRSUM: Interrupt Summary and Notification ERRor: the bits defining the command sequence are not valid, no supported command sequence *RST: RZWR

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:SADD?

Returns the slave address of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameSID>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:ADDRess?

Returns the register address of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameAddress>	Range:	Depends on the sequence type, address can have 0, 5, 8, or 16 bits
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BCOunt?

Returns the byte count of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<ByteCount>	Decimal value Range: 15 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:DATA?

Returns the data bytes of the specified command sequence.

Use `BUS<m>:RFFE:SEQuence<n>:BYTE<o>:VALue?` to access the sequence bytes.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>	Bit pattern (B1, B2, B3, B4…) in variable length up to eight bytes.

Example:

```
BUS:RFFE:SEQuence3:DATA?
<-- #H08,#H49,#H54,#H33,#HFF
```

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:SYMBol?

Returns the symbolic label that belongs to the address of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<Translation>	String containing the label name

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BYTE<o>:STATe?

Returns the state of the specified data byte.

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the number of the data byte (1...n).

Return values:

<FrameByteState> OK | PARity

OK: the byte is valid.
PARity: parity error

*RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BYTE<o>:VALue?

Returns the value of the specified byte in the specified command sequence.

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the number of the data byte (1...n).

Return values:

<FrameByteValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

20.17.14.4 Search Settings

For programming example, see "Searching RFFE Data " on page 1167.

SEARch:TRIGger:RFFE:TYPE <SearchName>,<SearchType>
SEARch:TRIGger:RFFE:TYPE? <SearchName>

Sets the event to be searched for.

See also: "Type" on page 720

Parameters:

<SearchType>

STARt | STOP | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | ERRor

STARt
Start of a command sequence (SSC). Optional: slave address.

STOP
End of a command sequence (start of the bus park cycle). Optional: slave address condition.

RZWR
"Register 0 Write" command sequence. Optional: slave address condition and data pattern condition.

RWR
"Register Write" command sequence. Optional: slave address condition, register address condition, and data pattern condition.

RRD
"Register Read" command sequence. Optional: slave address condition, register address condition, and data pattern condition.

ERWR
"Extended Register Write" command sequences. Optional: slave address condition, register address condition, byte count condition, data index condition, and data pattern condition.

ERRD
"Extended Register Read" command sequence. Optional search conditions are the same as for ERWR.

ERWL
"Extended Register Write Long" command sequence. Optional search conditions are the same as for ERWR.

ERRL
"Extended Register Read Long" command sequence. Optional search conditions are the same as for ERWR.

MASR
Master Read. Optional: slave address condition, register address condition, and data pattern condition.

MASW
Master Write. Optional: slave address condition, register address condition, and data pattern condition.

MASOHO
Master Ownership Handover. Optional: slave address condition, and data pattern condition.

IRSUM
Interrupt Summary and Notification. Optional: slave address condition, byte count condition, and data pattern condition.

ERRor
Searches for enabled errors. To enable the error types, use:
`SEARch:TRIGger:RFFE:ERRor:BP`
`SEARch:TRIGger:RFFE:ERRor:LENGth`

SEARch:TRIGger:RFFE:ERRor:NOResponse
SEARch:TRIGger:RFFE:ERRor:PARity
SEARch:TRIGger:RFFE:ERRor:SSC
SEARch:TRIGger:RFFE:ERRor:USEQuence.

*RST: STARt

Parameters for setting and query:

<SearchName> String parameter

Example: See "Searching RFFE Data " on page 1167

To specify additional search conditions for command sequences, use the following commands:

Slave address	SEARch:TRIGger:RFFE:SADD:CONDition SEARch:TRIGger:RFFE:SADD:MIN SEARch:TRIGger:RFFE:SADD:MAX
Register address	SEARch:TRIGger:RFFE:ADDRess:CONDition SEARch:TRIGger:RFFE:ADDRess:MIN SEARch:TRIGger:RFFE:ADDRess:MAX
Data pattern	SEARch:TRIGger:RFFE:DATA:DCON SEARch:TRIGger:RFFE:DATA:DMIN SEARch:TRIGger:RFFE:DATA:DMAX
Byte count	SEARch:TRIGger:RFFE:BCOunt:CONDition SEARch:TRIGger:RFFE:BCOunt:MIN SEARch:TRIGger:RFFE:BCOunt:MAX
Data index	SEARch:TRIGger:RFFE:DATA:ICON SEARch:TRIGger:RFFE:DATA:IMIN SEARch:TRIGger:RFFE:DATA:IMAX

SEARch:TRIGger:RFFE:SADD:CONDition <SearchName>,<SIDOperator>
SEARch:TRIGger:RFFE:SADD:CONDition? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:CONDition <SearchName>,<AddressOperator>
SEARch:TRIGger:RFFE:ADDRess:CONDition? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:CONDition <SearchName>,<BteCntOptor>
SEARch:TRIGger:RFFE:BCOunt:CONDition? <SearchName>
SEARch:TRIGger:RFFE:DATA:DCON <SearchName>,<DatPattOptor>
SEARch:TRIGger:RFFE:DATA:DCON? <SearchName>

Sets the operator to search for a specific pattern or a range

Parameters:

<DatPattOptor>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using the corresponding SEARch:TRIGger:RFFE:...:MIN command. **INRange | OORange** In range / Out of range: Set the minimum and maximum value using the corresponding SEARch:TRIGger:RFFE:...:MIN and SEARch:TRIGger:RFFE:...:MAX *RST: EQUal

Parameters for setting and query:

<SearchName>	String parameter

Example: See "Searching RFFE Data " on page 1167

SEARch:TRIGger:RFFE:DATA:ICON <SearchName>,<DatIdxOptor>
SEARch:TRIGger:RFFE:DATA:ICON? <SearchName>

Sets the operator to define the data frames in which the data pattern is searched

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | LTHan | LETHan | GTHan | GETHan** Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using `SEARch:TRIGger:RFFE:DATA:IMIN`. **INRange = RANGe** In range: Set the minimum and maximum value using `SEARch:TRIGger:RFFE:DATA:IMIN` and `SEARch:TRIGger:RFFE:DATA:IMAX`. *RST: INRange

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:SADD:MIN <SearchName>,<SIDMin>
SEARch:TRIGger:RFFE:SADD:MIN? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:MIN <SearchName>,<AddressMin>
SEARch:TRIGger:RFFE:ADDRess:MIN? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:MIN <SearchName>,<ByteCountMin>
SEARch:TRIGger:RFFE:BCOunt:MIN? <SearchName>

SEARch:TRIGger:RFFE:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:RFFE:DATA:IMIN? <SearchName>
SEARch:TRIGger:RFFE:DATA:DMIN <SearchName>,<DataPatternMin>
SEARch:TRIGger:RFFE:DATA:DMIN? <SearchName>

Specifies a pattern, or sets the the start value of a pattern range.

Parameters:

<DataPatternMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter
Example:	See "Searching RFFE Data " on page 1167

SEARch:TRIGger:RFFE:SADD:MAX <SearchName>,<SIDMax>
SEARch:TRIGger:RFFE:SADD:MAX? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:MAX <SearchName>,<AddressMax>
SEARch:TRIGger:RFFE:ADDRess:MAX? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:MAX <SearchName>,<ByteCountMax>
SEARch:TRIGger:RFFE:BCOunt:MAX? <SearchName>
SEARch:TRIGger:RFFE:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:RFFE:DATA:IMAX? <SearchName>
SEARch:TRIGger:RFFE:DATA:DMAX <SearchName>,<DataPatternMax>
SEARch:TRIGger:RFFE:DATA:DMAX? <SearchName>

Sets the the end value of an range if the corresponding condition is set to `INRange` or `OORange`. See SEARch:TRIGger:RFFE:...:CON

Parameters:

<DataPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:INTerrupt <SearchName>,<Interrupt>
SEARch:TRIGger:RFFE:INTerrupt? <SearchName>

Defines the pattern of the interrrupt identification sequence, which consists of interrupt slots 15 to 0.

Parameters:

<Interrupt>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>	String parameter
Firmware/Software:	FW 3.30

SEARch:TRIGger:RFFE:ERRor:BP <SearchName>,<BusParkError>
SEARch:TRIGger:RFFE:ERRor:BP? <SearchName>

Enables the search for bus park errors - when an incorrect bus parlk cycle has been found.

Parameters:

<BusParkError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:ERRor:LENGth <SearchName>,<LengthError>
SEARch:TRIGger:RFFE:ERRor:LENGth? <SearchName>

Enables the search for length errors - when an incorrect length of the command sequence has been found.

Parameters:

<LengthError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:ERRor:NOResponse <SearchName>,<NoResponse>
SEARch:TRIGger:RFFE:ERRor:NOResponse? <SearchName>

Enables the search for No Response Frames.

Parameters:

<NoResponse>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:ERRor:PARity <SearchName>,<ParityError>
SEARch:TRIGger:RFFE:ERRor:PARity? <SearchName>

Enables the search for incorrect parity bits.

Parameters:

<ParityError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:ERRor:SSC <SearchName>,<SSCError>
SEARch:TRIGger:RFFE:ERRor:SSC? <SearchName>

Enables the search for SSC errors - when no valid SSC sequence has been found after the idle time.

Parameters:

<SSCError>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String parameter

SEARch:TRIGger:RFFE:ERRor:USEQuence <SearchName>,<UnkSeqErr>
SEARch:TRIGger:RFFE:ERRor:USEQuence? <SearchName>

Enables the search for unknown sequences - when the instrument cannot detect any supported command sequence.

Parameters:

<UnkSeqErr>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String parameter

20.17.14.5 Search Results

The search on decoded RFFE data returns the same results as the queries for decode results.

In all SEARch:RESult:RFFE commands, the suffix <m> selects the command sequence. Suffix <n> selects index of byte inside a command sequence.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.14.3, "Decode Results", on page 1782.

For programming example, see "Searching RFFE Data " on page 1167.

SEARch:RESult:RFFE:FCOunt <Key>

Setting parameters:
<Key>

Return values:
<Count>

SEARch:RESult:RFFE:SEQuence<m>:TYPE? <SearchName>

Returns the type of the specified command sequence.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameType>	UNDESC | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | UNDEF | ERRor See `SEARch:TRIGger:RFFE:TYPE`. *RST: RZWR

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STATe? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameState>	OK | SSC | GAP | PARity | LENGth | BP | USEQuence | INComplete *RST: OK

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:SADD? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameSID>	Range:	0 to 15
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:ADDRess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameAddress>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:BCOunt? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<ByteCount>	Range:	0 to 16
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Data>

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:SYMBol? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:STATe? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteState>	OK | SSC | GAP | PARity | LENGth | BP | USEQuence | INComplete *RST: OK
Usage:	Query only

SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<FrameByteValue>	Range: 0 to 255 Increment: 1 *RST: 0
Usage:	Query only

20.17.15 D-PHY (Option R&S RTO-K42)

20.17.15.1 D-PHY Configuration

BUS<m>:DPHY:CP:PROBe <ProbeCP>

Selects the type of probe used for the clock lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ProbeCP>	DIFFerential | SINGle *RST: SINGle

BUS<m>:DPHY:CP:SOURce <ClockSource>

Selects the source of the clock lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ClockSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

BUS<m>:DPHY:DLANes <DataLaneCount>

Sets the number of data lanes. You can select up to four lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataLaneCount>	Range: 1 to 4 Increment: 1 *RST: 4

BUS<m>:DPHY:DRATe <DataRate>

Sets a data rate.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataRate>	Range: 1000000 to 2500000000 Increment: 1000000 *RST: 800000000 Default unit: bps

---

BUS<m>:DPHY:DSPData <DispDatVect>

Enables the display of the data vector, which means that the whole frame will be decoded.

When the display vector is disabled only the packet header will be decoded and not the actual data payload of the frame. This will speed up the decoding.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DispDatVect>	ON | OFF *RST: OFF

BUS<m>:DPHY:THCoupling <ThresCpl>

Enables coupling, i.e. the same threshold and hysteresis value is used for all lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresCpl>	ON | OFF *RST: ON

BUS<m>:DPHY:THPReset <ThresholdPreset>

Prests the threshold and hysteresis values of the high speed data lanes. A preset sets the low power threshold to 1.20V and high speed threshold to 200 mV.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdPreset>	LPHS | MANual	
	*RST:	LPHS

BUS<m>:DPHY:VARiant <ProtSel>

Selects the protocol running on the interface.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ProtSel>	DSI | CSI2	
	*RST:	CSI2

BUS<m>:DPHY:DNZero:LPOWer:THUPper <ThresLPDN0High>
BUS<m>:DPHY:DPZero:LPOWer:THUPper <ThresLPDP0High>

Sets the upper threshold value for the respective lane used for the low power mode.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresLPDP0High>	Range:	-1.5 to 1.5
	Increment:	0.01
	*RST:	0.88
	Default unit:	V

BUS<m>:DPHY:DNZero:LPOWer:THLower <ThresLPDN0Low>
BUS<m>:DPHY:DPZero:LPOWer:THLower <ThresLPDP0Low>

Sets the lower threshold value for the respective lane used for the low power mode.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresLPDP0Low>	Range:	-1.5 to 1.5
	Increment:	0.01
	*RST:	0.55
	Default unit:	V

BUS<m>:DPHY:DPZero:SOURce <DataSource>

Selects the source of the DP0 data line.

Suffix:

<m>	1..4

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:DPHY:DNZero:SOURce <DataSource>
BUS<m>:DPHY:DPONe:SOURce <DataSource>
BUS<m>:DPHY:DPTWo:SOURce <DataSource>
BUS<m>:DPHY:DPTHree:SOURce <DataSource>

Selects the source of the corresponding data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

BUS<m>:DPHY:DNZero:PROBe <ProbeDN0>
BUS<m>:DPHY:DPZero:PROBe <ProbeDP0>
BUS<m>:DPHY:DPONe:PROBe <ProbeDP1>
BUS<m>:DPHY:DPTWo:PROBe <ProbeDP2>
BUS<m>:DPHY:DPTHree:PROBe <ProbeDP3>

Selects the type of probe used for the corresponding data lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ProbeDP3>	DIFFerential | SINGle *RST: SINGle

BUS<m>:DPHY:CP:HSPeed:HYSTeresis <HysteresisHSCP>
BUS<m>:DPHY:DPZero:HSPeed:HYSTeresis <HysteresisHSDP0>
BUS<m>:DPHY:DPONe:HSPeed:HYSTeresis <HysteresisHSDP1>
BUS<m>:DPHY:DPTWo:HSPeed:HYSTeresis <HysteresisHSDP2>
BUS<m>:DPHY:DPTHree:HSPeed:HYSTeresis <HysteresisHSDP3>

Sets a value for the hysteresis of the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<HysteresisHSDP3>	Range: 0 to 0.5 Increment: 0.01 *RST: 0.2 Default unit: V

BUS<m>:DPHY:CP:HSPeed:THReshold <ThresholdHSCP>
BUS<m>:DPHY:DPZero:HSPeed:THReshold <ThresholdHSDP0>
BUS<m>:DPHY:DPONe:HSPeed:THReshold <ThresholdHSDP1>
BUS<m>:DPHY:DPTWo:HSPeed:THReshold <ThresholdHSDP2>
BUS<m>:DPHY:DPTHree:HSPeed:THReshold <ThresholdHSDP3>

Sets the threshold value for the digitization of the respective high speed data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdHSDP3>	Range: -1 to 1 Increment: 0.01 *RST: 0.2 Default unit: V

20.17.15.2 D-PHY Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:DPHY:TYPE <Type>

Sets the type of frame to be triggered on.

Parameters:

<Type>	HS_SOP | HS_EOP | HS_PH | HS_DATA | LP_ESC | LP_TURN | LP_HSRQ **HS_SOP** High speed start of packet **HS_EOP** High speed end of packet **HS_PH** High speed packet header **HS_DATA** High speed data **LP_ESC** Low power escape mode frame **LP_TURN** Low power lane turnaround **LP_HSRQ** Low power high speed request *RST: HS_SOP

TRIGger<m>:DPHY:DATA:CONDition <Format>

Set the condition for the data value. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:DPHY:DATA:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:DATA:MIN` and `TRIGger<m>:DPHY:DATA:MAX`. *RST: EQUal

---

TRIGger<m>:DPHY:DATA:MAX <DataMax>

Sets the the end value of a data type range if `TRIGger<m>:DPHY:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DataMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DATA:MIN <DataMin>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DIDX:CONDition <Format>

Sets the condition for the data index. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:DIDX:MIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `TRIGger<m>:DPHY:DIDX:MIN` and `TRIGger<m>:DPHY:DIDX:MAX`. *RST: INRange

---

TRIGger<m>:DPHY:DIDX:MAX <DXSymbol>

Sets the the end value of a data index range if `TRIGger<m>:DPHY:DIDX:CONDition` is set to `INRange` or `RANGe`.

Parameters:

<DXSymbol>	Range:	0 to 0
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:DIDX:MIN <SymbolType>

Specifies a data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType>	Range:	0 to 0
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:DTYPe:CONDition <Format>

Set the condition for the data type. You can define an exact value or a value range

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:DTYPe:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:DTYPe:MIN` and `TRIGger<m>:DPHY:DTYPe:MAX`. *RST: EQUal

TRIGger<m>:DPHY:DTYPe:MAX <HSDataTypeMax>

Sets the the end value of a data type range if `TRIGger<m>:DPHY:DTYPe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSDataTypeMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DTYPe:MIN <HSDataTypeMin>

Specifies a data type pattern, or sets the the start value of a pattern range.

Parameters:

<HSDataTypeMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESCMode:CONDition <Format>

Set the condition for the escape mode. You can define an exact value or a value range

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:ESCMode:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:ESCMode:MIN` and `TRIGger<m>:DPHY:ESCMode:MAX`. *RST: EQUal

---

TRIGger<m>:DPHY:ESCMode:MAX <LPEscapeModeMax>

Sets the the end value of an escape mode range if `TRIGger<m>:DPHY:ESCMode:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LPEscapeModeMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESCMode:MIN <LPEscapeModeMin>

Specifies a escape mode bit pattern, or sets the the start value of a pattern range.

Parameters:

<LPEscapeModeMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESDTa:CONDition <Format>

Set the condition for the escape mode data value. You can define an exact value or a value range.

Parameters:

<Format>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:DPHY:ESDTa:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:ESDTa:MIN` and `TRIGger<m>:DPHY:ESDTa:MAX`. **OFF | ANY** Any pattern is detected. *RST: EQUal

---

TRIGger<m>:DPHY:ESDTa:MAX <LPEscpMdDatMax>

Sets the the end value of a escape mode data type range if `TRIGger<m>:DPHY:ESDTa:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LPEscpMdDatMax>

TRIGger<m>:DPHY:ESDTa:MIN <LPEscpMdDatMin>

Specifies an escape mode data bit pattern, or sets the the start value of a pattern range.

Parameters:

<LPEscpMdDatMin>

TRIGger<m>:DPHY:ESINdex:CONDition <Format>

Sets the condition for the escape mode data index. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:ESINdex:MIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `TRIGger<m>:DPHY:ESINdex:MIN` and `TRIGger<m>:DPHY:ESINdex:MAX`. *RST: INRange

---

TRIGger<m>:DPHY:ESINdex:MAX <DXSymbol>

Sets the the end value of a data index range if `TRIGger<m>:DPHY:ESINdex:CONDition` is set to `INRange` or `RANGe`.

Parameters:

<DXSymbol>	Range:	0 to 0
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:ESINdex:MIN <SymbolType>

Specifies an escape mode data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType>	Range:	0 to 0
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:HSVC <HSVC>

Sets the virtual channel to be triggered on.

Parameters:

<HSVC>

TRIGger<m>:DPHY:WCOunt:CONDition <Format>

Set the condition for the word count. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:WCOunt:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:WCOunt:MIN` and `TRIGger<m>:DPHY:WCOunt:MAX`. *RST: EQUal

---

TRIGger<m>:DPHY:WCOunt:MAX <HSWordCountMax>

Sets the the end value of a data type range if `TRIGger<m>:DPHY:WCOunt:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSWordCountMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:WCOunt:MIN <HSWordCountMin>

Specifies a word bit pattern, or sets the the start value of a pattern range.

Parameters:

<HSWordCountMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

20.17.15.3 D-PHY Decode Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496
- `BUS<m>:RESDetail` on page 1496

BUS<m>:DPHY:RESult:FCOunt?

Returns the number of decoded frames for the selected serial bus.

Suffix:

<m>	1..4

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:CS?

Returns the checksum of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<CS>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DATA?

Returns the data or word count value.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<WordCountOrData>	16 bit integer value	
	Range:	0 to 0
	Increment:	1
	*RST:	0

Example:	`BUS:DPHY:RESult:FRAMe2:DATA?` `<-- 13245`
Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DTName?

Returns the data type name for the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DataTypeName>

Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DTYPe?

Returns the data type for the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DataType>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:ECC?

Returns the error correction code (ECC) of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ECC>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:PACKet<o>:IDX?

Returns the index of the data payload.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the packet number.

Return values:

<PacketIndex>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:PACKet<o>:VALue?

Returns the byte value of the data payload.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the packet number.

Return values:

<PacketValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STATe?

Returns the overall state of the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<State> OK | SYNC | GAP | PARity | LENGth | UNKNOWN_FRAME | INComplete

OK
The frame is valid.

SYNC
Synchronisation error

GAP
Timing error

PARity
Parity error

LENGth
Length error.

UNKNOWN_FRAME
Unknown frame type

INComplete
The sequence is not completely contained in the acquisition

*RST: OK

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:TYPE?

Returns the type of frame.

Suffix:

<m>
1..4
Selects the serial bus.

<n>
*
Selects the frame.

Return values:

<FrameType>
HS_SP | HS_LP | HS_INCOMPLETE | LP_HSREQ | LP_TA | LP_ESC

HS_SP
High speed short packet frame

HS_LP
High speed long packet frame

HS_INCOMPLETE
Incomplete high speed frame

LP_HSREQ
High speed request frame

LP_TA
Low power lane turnaround frame

LP_ESC
Low power escape mode frame

*RST: HS_SP

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:NUMPackets?

Returns the number of packets in the indicated frame.

Suffix:

<m>
1..4
Selects the serial bus.

<n>
*
Selects the frame.

Return values:

<NumPackets>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:VCHannel?

Returns the number of virtual channels.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<VirtualChannel>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

20.17.15.4 D-PHY Search Settings

SEARch:TRIGger:DPHY:TYPE <SearchName>,<Type>
SEARch:TRIGger:DPHY:TYPE? <SearchName>

Sets the type of frame to be searched for.

Parameters:

<Type> HS_SOP | HS_EOP | HS_PH | HS_DATA | LP_ESC | LP_TURN | LP_HSRQ

HS_SOP
High speed start of packet

HS_EOP
High speed end of packet

HS_PH
High speed packet header

HS_DATA
High speed data

LP_ESC
Low power escape mode frame

LP_TURN
Low power lane turnaround

LP_HSRQ
Low power high speed request

*RST: HS_SOP

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DATA:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DATA:CONDition? <SearchName>

Set the condition for the data value. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DATA:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:DATA:MIN` and `SEARch:TRIGger:DPHY:DATA:MAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:DATA:MAX <SearchName>,<DataMax>
SEARch:TRIGger:DPHY:DATA:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DataMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:DATA:MIN <SearchName>,<DataMin>
SEARch:TRIGger:DPHY:DATA:MIN? <SearchName>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:DIDX:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DIDX:CONDition? <SearchName>

Sets the condition for the data index. You can define an exact value or a value range.

Parameters:	
<Format>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DIDX:MIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `SEARch:TRIGger:DPHY:DIDX:MIN` and `SEARch:TRIGger:DPHY:DIDX:MAX`. *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DIDX:MAX <SearchName>,<DXSymbol>
SEARch:TRIGger:DPHY:DIDX:MAX? <SearchName>

Sets the the end value of a data index range if `SEARch:TRIGger:DPHY:DIDX:CONDition` is set to `INRange` or `RANGe`.

Parameters:		
<DXSymbol>	Range:	0 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DIDX:MIN <SearchName>,<SymbolType>
SEARch:TRIGger:DPHY:DIDX:MIN? <SearchName>

Specifies a data index minimum, or sets the the start value of a range.

Parameters:		
<SymbolType>	Range:	0 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DTYPe:CONDition? <SearchName>

Set the condition for the data type. You can define an exact value or a value range

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DTYPe:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:DATA:MIN` and `SEARch:TRIGger:DPHY:DATA:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:MAX <SearchName>,<HSDataTypeMax>
SEARch:TRIGger:DPHY:DTYPe:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:DTYPe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSDataTypeMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:MIN <SearchName>,<HSDataTypeMin>
SEARch:TRIGger:DPHY:DTYPe:MIN? <SearchName>

Specifies a data type pattern, or sets the the start value of a pattern range.

Parameters:

<HSDataTypeMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ERRor:CHKSum <SearchName>,<SymbolType>
SEARch:TRIGger:DPHY:ERRor:CHKSum? <SearchName>

Enables/disables the search for an error in the checksum.

Parameters:

<SymbolType>	ON | OFF
	*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ERRor:ECC <SearchName>,<Format>
SEARch:TRIGger:DPHY:ERRor:ECC? <SearchName>

Enables/disables the search for an error correction code (ECC).

Parameters:

<Format>	ON | OFF
	*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ESCMode:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESCMode:CONDition? <SearchName>

Set the condition for the escape mode. You can define an exact value or a value range

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESCMode:MIN` command.
	INRange | OORange In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:ESCMode:MIN` and `SEARch:TRIGger:DPHY:ESCMode:MAX`.
	*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ESCMode:MAX <SearchName>,<LPEscapeModeMax>
SEARch:TRIGger:DPHY:ESCMode:MAX? <SearchName>

Sets the the end value of an escape mode range if `SEARch:TRIGger:DPHY:ESCMode:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LPEscapeModeMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ESCMode:MIN <SearchName>,<LPEscapeModeMin>
SEARch:TRIGger:DPHY:ESCMode:MIN? <SearchName>

Specifies a escape mode bit pattern, or sets the the start value of a pattern range.

Parameters:

<LPEscapeModeMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ESDTa:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESDTa:CONDition? <SearchName>

Set the condition for the escape mode data value. You can define an exact value or a value range.

Parameters:

<Format> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESDTa:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:ESDTa:MIN` and `SEARch:TRIGger:DPHY:ESDTa:MAX`.

OFF | ANY
Any pattern is detected.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:DPHY:ESDTa:MAX <SearchName>,<LPEscpMdDatMax>
SEARch:TRIGger:DPHY:ESDTa:MAX? <SearchName>

Sets the the end value of a escape mode data type range if `SEARch:TRIGger:DPHY:ESDTa:CONDition` is set to `INRange` or `OORange`.

Parameters:
<LPEscpMdDatMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESDTa:MIN <SearchName>,<LPEscpMdDatMin>
SEARch:TRIGger:DPHY:ESDTa:MIN? <SearchName>

Specifies an escape mode data bit pattern, or sets the the start value of a pattern range.

Parameters:
<LPEscpMdDatMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESINdex:CONDition? <SearchName>

Sets the condition for the escape mode data index. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESINdex:MIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `SEARch:TRIGger:DPHY:ESINdex:MIN` and `SEARch:TRIGger:DPHY:ESINdex:MAX`. *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:MAX <SearchName>,<DXSymbol>
SEARch:TRIGger:DPHY:ESINdex:MAX? <SearchName>

Sets the the end value of a data index range if `SEARch:TRIGger:DPHY:ESINdex:CONDition` is set to `INRange` or `RANge`.

Parameters:

<DXSymbol>	Range:	0 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:MIN <SearchName>,<SymbolType>
SEARch:TRIGger:DPHY:ESINdex:MIN? <SearchName>

Specifies an escape mode data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType>	Range:	0 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:HSVC <SearchName>,<HSVC>
SEARch:TRIGger:DPHY:HSVC? <SearchName>

Sets the virtual channel to be searched for.

Parameters:
<HSVC>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:WCOunt:CONDition? <SearchName>

Set the condition for the word count. You can define an exact value or a value range.

Parameters:

<Format>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:WCOunt:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:WCOunt:MIN` and `SEARch:TRIGger:DPHY:WCOunt:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:MAX <SearchName>,<HSWordCountMax>
SEARch:TRIGger:DPHY:WCOunt:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:WCOunt:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSWordCountMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:MIN <SearchName>,<HSWordCountMin>
SEARch:TRIGger:DPHY:WCOunt:MIN? <SearchName>

Specifies a word bit pattern, or sets the the start value of a pattern range.

Parameters:

<HSWordCountMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

20.17.15.5 D-PHY Search Results

In all `SEARch:RESult:DPHY:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:DPHY:FCOunt? <SearchName>

Returns the number of frames within the search result for the selected serial bus.

Query parameters:
<SearchName>

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:CS? <SearchName>

Returns the checksum for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<CS>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DATA? <SearchName>

Returns the data or word count value for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<WordCountOrData>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DTName? <SearchName>

Returns the data type name for the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<DataTypeName>

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DTYPe? <SearchName>

Returns the data type for the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<DataType>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:ECC? <SearchName>

Returns the error correction code (ECC) of the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<ECC>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:IDX? <SearchName>

Returns the index of the data payload for the selected frame within the search result.

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<PacketIndex>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:VALue? <SearchName>

Returns the byte value of the data payload for the selected frame within the search result.

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<PacketValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STARt? <SearchName>

Returns the start time of the specified frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STATe? <SearchName>

Returns the overall state of the selected frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<State> OK | SYNC | GAP | PARity | LENGth | UNKNOWN_FRAME | INComplete

OK
The frame is valid.

SYNC
Synchronisation error

GAP
Timing error

PARity
Parity error

LENGth
Length error.

UNKNOWN_FRAME
Unknown frame type

*RST: OK

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:TYPE? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameType> HS_SP | HS_LP | HS_INCOMPLETE | LP_HSREQ | LP_TA | LP_ESC

HS_SP
High speed short packet frame

HS_LP
High speed long packet frame

HS_INCOMPLETE
Incomplete high speed frame

LP_HSREQ
High speed request frame

LP_TA
Low power lane turnaround frame

LP_ESC
Low power escape mode frame

*RST: HS_SP

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:VCHannel? <SearchName>

Returns the number of virtual channels for the selected frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<VirtualChannel>	Range: 0 to 3 Increment: 1 *RST: 0

Usage:	Query only

20.17.16 M-PHY (Option R&S RTO-K44)

20.17.16.1 Configuration

BUS<m>:MPHY:VARiant <Protocol>

Selects the protocol running on the interface.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Protocol>	MPHY | UNIPRO	
	*RST:	MPHY

BUS<m>:MPHY:DLANes <DataLaneCount>

Sets the number of data lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataLaneCount>	Range:	1 to 4
	Increment:	1
	*RST:	4

BUS<m>:MPHY:DZERo:SOURce <DataSource>

Sets the source for Lane 0.

Suffix:

<m>	1..4

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:MPHY:DONE:SOURce <DataSource>
BUS<m>:MPHY:DTWO:SOURce <DataSource>
BUS<m>:MPHY:DTHRee:SOURce <DataSource>

Selects the source of the corresponding data lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | NONE

BUS<m>:MPHY:DZERo:THReshold <ThresholdD0>
BUS<m>:MPHY:DONE:THReshold <ThresholdD1>
BUS<m>:MPHY:DTWO:THReshold <ThresholdD2>
BUS<m>:MPHY:DTHRee:THReshold <ThresholdD3>

Sets the threshold value for the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdD1> <ThresholdD2> <ThresholdD3>	Range: 0 to 1 Increment: 0.01 *RST: 0.1 Default unit: V

BUS<m>:MPHY:THCoupling <Coupling>

Enables the same threshold value to be used for all lanes.

When the threshold coupling is disabled, changes to the threshold value only affect the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Coupling>	ON | OFF *RST: ON

BUS<m>:MPHY:THPReset <ThresholdPreset>

Selects the predefined value to preset the threshold value of the data lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdPreset>	THRES_60MV | THRES_120MV | THRES_240MV | MANual **THRES_60MV | THRES_120MV | THRES_240MV** Sets the threshold value of the data lane to the selected predefined value. **MANual** Automatically switches to this option if you edit the threshold text box manually. *RST: MANual

20.17.16.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MPHY:TYPE <Type>

Selects the type of frame to be triggered on.

Suffix:

<m>	1..3

Parameters:

<Type>	START | BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | ERRor **START** M-PHY or UniPro start of frame. **BURST** M-PHY burst frame. **ADAPT** M-PHY Adapt frame. This control frame is used for clock/bit synchronization. **LCC** M-PHY LCC frame. This control frame is used for line configuration depending on the LCC Type. **DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC** UniPro DL PDU frame. **PACP** UniPro PACP frame. This control frame is used mainly for power mode change and L1.5 link management. **TRIGUPR0 | TRIGUPR1 | TRIGUPR2** UniPro Trigger Upper frame. This control frame is used for link startup sequence. **ERRor** M-PHY or UniPro error frame. *RST: START

TRIGger<m>:MPHY:LCCType <LCCType>

Selects the type of LCC frame to be triggered on.

Suffix:

<m>	1..3

Parameters:

<LCCType>	ANY | SLEEP | STALL | READCAP | READMFG | READVEND | WRITEATTR | PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7 | HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B | RESERVED **ANY** All the available LCC commands. **SLEEP** Switches the power-saving state to ultra-low power. In this state, up to 90% power saving is achieved. **STALL** Switches the power-saving state to ultra-low power. In this state, up to 75% power saving is achieved. **READCAP** Recovers data about the OMC's capabilities. **READMFG** Retrieves manufacturing ID and vendor-specific information. **READVEND** Retrieves the additional four delimited bytes containing vendor-specific information. **WRITEATTR** Sets the configuration parameters required for lane operation. **PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7** Switches the transmission mode to the selected low-power gear. **HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B** Switches the transmission mode to the selected high-speed gear. **RESERVED** Reserved bit command. These bits are reserved for future use. *RST: ANY

TRIGger<m>:MPHY:LWONe:CONDition <CondOperator>

Sets the condition for WORD 1. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWONe:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWONe:MIN` and `TRIGger<m>:MPHY:LWONe:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:LWONe:MIN <LCCWORD1Min>

Specifies the WORD 1 pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<LCCWORD1Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWONe:MAX <LCCWORD1Max>

Sets the end value of the WORD 1 range if `TRIGger<m>:MPHY:LWONe:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<LCCWORD1Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTWo:CONDition <CondOperator>

Sets the condition for WORD 2. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWTWo:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWTWo:MIN` and `TRIGger<m>:MPHY:LWTWo:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:LWTWo:MIN <LCCWORD2Min>

Specifies the WORD 2 pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<LCCWORD2Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTWo:MAX <LCCWORD2Max>

Sets the end value of the WORD 2 range if `TRIGger<m>:MPHY:LWTWo:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<LCCWORD2Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTHree:CONDition <CondOperator>

Sets the condition for WORD 3. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWTHree:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWTHree:MIN` and `TRIGger<m>:MPHY:LWTHree:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:LWTHree:MIN <LCCWORD3Min>

Specifies the WORD 3 pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<LCCWORD3Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTHree:MAX <LCCWORD3Max>

Sets the end value of the WORD 3 range if `TRIGger<m>:MPHY:LWTHree:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<LCCWORD3Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWFour:CONDition <CondOperator>

Sets the condition for WORD 4. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWFour:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWFour:MIN` and `TRIGger<m>:MPHY:LWFour:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:LWFour:MIN <LCCWORD4Min>

Specifies the WORD 4 pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<LCCWORD4Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWFour:MAX <LCCWORD4Max>

Sets the end value of the WORD 4 range if `TRIGger<m>:MPHY:LWFour:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<LCCWORD4Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:TC <TC>

Specifies the TC bit pattern.

Suffix:

<m>	1..3

Parameters:

<TC>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:DCON <DataOperator>

Sets the condition for the data. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:DATA:DMIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:DATA:DMIN` and `TRIGger<m>:MPHY:DATA:DMAX`. *RST: EQUal

---

TRIGger<m>:MPHY:DATA:DMIN <DataMin>

Specifies the data bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:DMAX <DataMax>

Sets the end value of the data range if `TRIGger<m>:MPHY:DATA:DCON` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<DataMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:ICON <DatIdxOptor>

Sets the condition for the index. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DatIdxOptor> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:DATA:IMIN` command.

INRange = RANGe
In range: Set the minimum and maximum value using `TRIGger<m>:MPHY:DATA:IMIN` and `TRIGger<m>:MPHY:DATA:IMAX`.

*RST: INRange

TRIGger<m>:MPHY:DATA:IMIN <DataIndexMin>

Specifies the index minimum, or sets the start value of a range.

Suffix:

<m>	1..3

Parameters:

<DataIndexMin>

Range:	1 to 0
Increment:	1
*RST:	1

TRIGger<m>:MPHY:DATA:IMAX <DataIndexMax>

Sets the end value of the index range if `TRIGger<m>:MPHY:DATA:ICON` is set to `INRange` or `RANGe`.

Suffix:

<m>	1..3

Parameters:

<DataIndexMax>

Range:	1 to 0
Increment:	1
*RST:	0

TRIGger<m>:MPHY:FSNumber:CONDition <FSNOperator>

Sets the condition for FSN. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<FSNOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:FSNumber:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:FSNumber:MIN` and `TRIGger<m>:MPHY:FSNumber:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:FSNumber:MIN <FSNMin>

Specifies the FSN bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<FSNMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:FSNumber:MAX <FSNMax>

Sets the end value of the FSN range if `TRIGger<m>:MPHY:FSNumber:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<FSNMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CRC:CONDition <CRCOperator>

Sets the condition for CRC. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CRCOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:CRC:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:CRC:MIN` and `TRIGger<m>:MPHY:CRC:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:CRC:MIN <CRCMin>

Specifies the CRC bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<CRCMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CRC:MAX <CRCMax>

Sets the end value of the CRC range if `TRIGger<m>:MPHY:CRC:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<CRCMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CREQ <REQ>

Specifies the CREQ bit pattern.

Suffix:

<m>	1..3

Parameters:

<REQ>	ONE | ZERO | DC **ONE** Sets the trigger condition to binary 1. **ZERO** Sets the trigger condition to binary 0. **DC** Sets the trigger condition to any CREQ value (don't care). *RST: DC

TRIGger<m>:MPHY:RREQ <REQ>

Specifies the RREQ bit pattern.

Suffix:

<m>	1..3

Parameters:

<REQ>	ONE | ZERO | DC **ONE** Sets the trigger condition to binary 1. **ZERO** Sets the trigger condition to binary 0. **DC** Sets the trigger condition to any RREQ value (don't care). *RST: DC

TRIGger<m>:MPHY:CREDit:CONDition <CreditOperator>

Sets the condition for Credit. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CreditOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:CREDit:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:CREDit:MIN` and `TRIGger<m>:MPHY:CREDit:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:CREDit:MIN <CreditMin>

Specifies the Credit bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<CreditMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CREDit:MAX <CreditMax>

Sets the end value of the Credit range if `TRIGger<m>:MPHY:CREDit:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<CreditMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PBEGin:CONDition <CondPACPBegin>

Sets the condition for PACP Begin. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CondPACPBegin>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:PBEGin:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:PBEGin:MIN` and `TRIGger<m>:MPHY:PBEGin:MAX`. *RST: EQUal

---

TRIGger<m>:MPHY:PBEGin:MIN <PACPBEGINMin>

Specifies the PACP Begin bit pattern, or sets the start value of a pattern range.

Suffix:	
<m>	1..3
Parameters:	
<PACPBEGINMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PBEGin:MAX <PACPBEGINMax>

Sets the end value of the PACP Begin range if `TRIGger<m>:MPHY:PBEGin:CONDition` is set to `INRange` or `OORange`.

Suffix:	
<m>	1..3
Parameters:	
<PACPBEGINMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PFID:CONDition <CondPACPFunc>

Sets the condition for PACP Function ID. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CondPACPFunc> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:PFID:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:PFID:MIN` and `TRIGger<m>:MPHY:PFID:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:PFID:MIN <PACPFunIDMin>

Specifies the PACP Function ID bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:

<PACPFunIDMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PFID:MAX <PACPFunIDMax>

Sets the end value of the PACP Function ID range if `TRIGger<m>:MPHY:PFID:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<PACPFunIDMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PRPLength <Width>

Sets the width for the width trigger based upon the data rate.

Suffix:

<m>	1..3

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:MPHY:ERRor:LCMD <LCCError>

Enables/disables trigger on LCC error.

Suffix:

<m>	1..3

Parameters:

<LCCError>	ON | OFF *RST: ON

TRIGger<m>:MPHY:ERRor:LENGth <ErrorLength>

Enables/disables trigger on length error.

Suffix:

<m>	1..3

Parameters:

<ErrorLength>	ON | OFF *RST: ON

TRIGger<m>:MPHY:ERRor:REServed <ErrorReserved>

Enables/disables trigger on reserved bit error.

Suffix:

<m>	1..3

Parameters:

<ErrorReserved>	ON | OFF *RST: ON

TRIGger<m>:MPHY:ERRor:SYMBol <ErrorSymbol>

Enables/disables trigger on 8b10b symbol error.

Suffix:

<m>	1..3

Parameters:

<ErrorSymbol>	ON | OFF *RST: ON

TRIGger<m>:MPHY:ERRor:UNKNown <ErrorUnknown>

Enables/disables trigger on unidentified UniPro frame error.

Suffix:

<m>	1..3

Parameters:

<ErrorUnknown>	ON | OFF *RST: ON

20.17.16.3 Decode Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496
- `BUS<m>:RESDetail` on page 1496

BUS<m>:MPHY:RESult:FRAMe<n>:FTYPe?

Returns the type of frame for the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType> BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | SKIP | FILLER | SPACER | UNKNOWN

BURST
M-PHY burst frame.

ADAPT
M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC
M-PHY LCC frame. This control frame is used for line configuration depending on the LCC Type.

DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC
UniPro DL PDU frame.

PACP
UniPro frame. This control frame is used mainly for power mode change and L1.5 link management.

TRIGUPR0 | TRIGUPR1 | TRIGUPR2
UniPro frame. This control frame is used for link startup sequence.

SKIP
UniPro frame with Skip symbols for reducing protocol payload bandwidth.

FILLER
M-PHY or UniPro frame with filler words to maintain transmission activity.

SPACER
Scrambled UniPro frame with filler words.

UNKNOWN
No meaningful frame can be determined.

*RST: UNKNOWN

Usage:	Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STATe?

Returns the state of the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<State>

OK | RSVDERROR | CMDERROR | LENGTHERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE

OK
Valid frame.

RSVDERROR
Erroneous frame due to reserved bit error.

CMDERROR
Erroneous frame due to LCC error.

LENGTHERROR
Erroneous frame due to length error.

SYMBOLERROR
Erroneous frame due to 8b10b symbol error.

UNKNOWNERROR
Erroneous frame due to unidentified UniPro frame error.

INVALID
Invalid frame.

INCOMPLETE
The frame is not complete.

*RST: OK

Usage:	Query only

BUS<m>:MPHY:RESult:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CCOunt?

Returns the number of decoded cells for the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:DATA?

Returns the data value for the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the cell.

Return values:

<WordValue>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:TYPE?

Returns the data type for the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the cell.

Return values:
<WordType>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:DATA?

Returns the data for the selected frame, corresponds to the Data column in the decode results table.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:
<Data>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:INFO?

Returns the selected frame label. This label is on top of the frame as seen in the honeycomb display, also corresponds to the Info column in the decode results table.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:
<Info>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STARt?

Returns the start time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STOP?

Returns the end time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

20.17.16.4 Search Settings

SEARch:TRIGger:MPHY:TYPE <SearchName>,<Type>
SEARch:TRIGger:MPHY:TYPE? <SearchName>

Selects the type of frame to be searched for.

Parameters:

<Type>	START | BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | ERRor **START** M-PHY or UniPro start of frame. **BURST** M-PHY burst frame. **ADAPT** M-PHY Adapt frame. This control frame is used for clock/bit synchronization. **LCC** M-PHY LCC frame. This control frame is used for line configuration depending on the LCC Type. **DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC** UniPro DL PDU frame. **PACP** UniPro PACP frame. This control frame is used mainly for power mode change and L1.5 link management. **TRIGUPR0 | TRIGUPR1 | TRIGUPR2** UniPro Trigger Upper frame. This control frame is used for link startup sequence. **ERRor** M-PHY or UniPro error frame. *RST: START

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LCCType <SearchName>,<LCCType>
SEARch:TRIGger:MPHY:LCCType? <SearchName>

Selects the type of LCC frame to be searched for.

Parameters:

<LCCType>	ANY | SLEEP | STALL | READCAP | READMFG | READVEND | WRITEATTR | PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7 | HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B | RESERVED **ANY** All the available LCC commands. **SLEEP** Switches the power-saving state to ultra-low power. In this state, up to 90% power saving is achieved. **STALL** Switches the power-saving state to ultra-low power. In this state, up to 75% power saving is achieved. **READCAP** Recovers data about the OMC's capabilities. **READMFG** Retrieves manufacturing ID and vendor-specific information. **READVEND** Retrieves the additional four delimited bytes containing vendor-specific information. **WRITEATTR** Sets the configuration parameters required for lane operation. **PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7** Switches the transmission mode to the selected low-power gear. **HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B** Switches the transmission mode to the selected high-speed gear. **RESERVED** Reserved bit command. These bits are reserved for future use. *RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWONe:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWONe:CONDition? <SearchName>

Sets the condition for WORD 1. You can define an exact value or a value range.

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWONe:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWONe:MIN` and `SEARch:TRIGger:MPHY:LWONe:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWONe:MIN <SearchName>,<LCCWORD1Min>
SEARch:TRIGger:MPHY:LWONe:MIN? <SearchName>

Specifies the WORD 1 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD1Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWONe:MAX <SearchName>,<LCCWORD1Max>
SEARch:TRIGger:MPHY:LWONe:MAX? <SearchName>

Sets the end value of the WORD 1 range if `SEARch:TRIGger:MPHY:LWONe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD1Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWTWo:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWTWo:CONDition? <SearchName>

Sets the condition for WORD 2. You can define an exact value or a value range.

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWTWo:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWTWo:MIN` and `SEARch:TRIGger:MPHY:LWTWo:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWTWo:MIN <SearchName>,<LCCWORD2Min>
SEARch:TRIGger:MPHY:LWTWo:MIN? <SearchName>

Specifies the WORD 2 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD2Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWTWo:MAX <SearchName>,<LCCWORD2Max>
SEARch:TRIGger:MPHY:LWTWo:MAX? <SearchName>

Sets the end value of the WORD 2 range if `SEARch:TRIGger:MPHY:LWTWo:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD2Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWTHree:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWTHree:CONDition? <SearchName>

Sets the condition for WORD 3. You can define an exact value or a value range.

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWTHree:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWTHree:MIN` and `SEARch:TRIGger:MPHY:LWTHree:MAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTHree:MIN <SearchName>,<LCCWORD3Min>
SEARch:TRIGger:MPHY:LWTHree:MIN? <SearchName>

Specifies the WORD 3 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD3Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTHree:MAX <SearchName>,<LCCWORD3Max>
SEARch:TRIGger:MPHY:LWTHree:MAX? <SearchName>

Sets the end value of the WORD 3 range if `SEARch:TRIGger:MPHY:LWTHree:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD3Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWFour:CONDition? <SearchName>

Sets the condition for WORD 4. You can define an exact value or a value range.

Parameters:

<CondOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWFour:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWFour:MIN` and `SEARch:TRIGger:MPHY:LWFour:MAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:MIN <SearchName>,<LCCWORD4Min>
SEARch:TRIGger:MPHY:LWFour:MIN? <SearchName>

Specifies the WORD 4 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD4Min>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:MAX <SearchName>,<LCCWORD4Max>
SEARch:TRIGger:MPHY:LWFour:MAX? <SearchName>

Sets the end value of the WORD 4 range if `SEARch:TRIGger:MPHY:LWFour:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD4Max>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:TC <SearchName>,<TC>
SEARch:TRIGger:MPHY:TC? <SearchName>

Specifies the TC bit pattern.

Parameters:

<TC>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:MPHY:DATA:DCONdition? <SearchName>

Sets the condition for the data. You can define an exact value or a value range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:DATA:DMIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:DATA:DMIN` and `SEARch:TRIGger:MPHY:DATA:DMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:MPHY:DATA:DMIN? <SearchName>

Specifies the data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:MPHY:DATA:DMAX? <SearchName>

Sets the end value of the data range if `SEARch:TRIGger:MPHY:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:ICONdition <SearchName>,<DatIdxOptor>
SEARch:TRIGger:MPHY:DATA:ICONdition? <SearchName>

Sets the condition for the index. You can define an exact value or a value range.

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | LTHan | LETHan | GTHan | GETHan** Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:DATA:IMIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `SEARch:TRIGger:MPHY:DATA:IMIN` and `SEARch:TRIGger:MPHY:DATA:IMAX`. *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:MPHY:DATA:IMIN? <SearchName>

Specifies the index minimum, or sets the start value of a range.

Parameters:

<DataIndexMin>	Range:	1 to 0
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:MPHY:DATA:IMAX? <SearchName>

Sets the end value of the index range if `SEARch:TRIGger:MPHY:DATA:ICONdition` is set to `INRange` or `RANge`.

Parameters:

<DataIndexMax>	Range: 1 to 0 Increment: 1 *RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:FSNumber:CONDition <SearchName>,<FSNOperator>
SEARch:TRIGger:MPHY:FSNumber:CONDition? <SearchName>

Sets the condition for FSN. You can define an exact value or a value range.

Parameters:

<FSNOperator>

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:FSNumber:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:FSNumber:MIN` and `SEARch:TRIGger:MPHY:FSNumber:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:FSNumber:MIN <SearchName>,<FSNMin>
SEARch:TRIGger:MPHY:FSNumber:MIN? <SearchName>

Specifies the FSN bit pattern, or sets the start value of a pattern range.

Parameters:

<FSNMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:FSNumber:MAX <SearchName>,<FSNMax>
SEARch:TRIGger:MPHY:FSNumber:MAX? <SearchName>

Sets the end value of the FSN range if `SEARch:TRIGger:MPHY:FSNumber:CONDition` is set to `INRange` or `OORange`.

Parameters:

<FSNMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CRC:CONDition <SearchName>,<CRCOperator>
SEARch:TRIGger:MPHY:CRC:CONDition? <SearchName>

Sets the condition for CRC. You can define an exact value or a value range.

Parameters:

<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:CRC:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:CRC:MIN` and `SEARch:TRIGger:MPHY:CRC:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CRC:MIN <SearchName>,<CRCMin>
SEARch:TRIGger:MPHY:CRC:MIN? <SearchName>

Specifies the CRC bit pattern, or sets the start value of a pattern range.

Parameters:

<CRCMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CRC:MAX <SearchName>,<CRCMax>
SEARch:TRIGger:MPHY:CRC:MAX? <SearchName>

Sets the end value of the CRC range if `SEARch:TRIGger:MPHY:CRC:CONDition` is set to `INRange` or `OORange`.

Parameters:

<CRCMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CREQ <SearchName>,<REQ>
SEARch:TRIGger:MPHY:CREQ? <SearchName>

Specifies the CREQ bit pattern.

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any CREQ value (don't care).

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:RREQ <SearchName>,<REQ>
SEARch:TRIGger:MPHY:RREQ? <SearchName>

Specifies the RREQ bit pattern.

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any RREQ value (don't care).

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CREDit:CONDition <SearchName>,<CreditOperator>
SEARch:TRIGger:MPHY:CREDit:CONDition? <SearchName>

Sets the condition for Credit. You can define an exact value or a value range.

Parameters:

<CreditOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:CREDit:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:CREDit:MIN` and `SEARch:TRIGger:MPHY:CREDit:MAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CREDit:MIN <SearchName>,<CreditMin>
SEARch:TRIGger:MPHY:CREDit:MIN? <SearchName>

Specifies the Credit bit pattern, or sets the start value of a pattern range.

Parameters:

<CreditMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CREDit:MAX <SearchName>,<CreditMax>
SEARch:TRIGger:MPHY:CREDit:MAX? <SearchName>

Sets the end value of the Credit range if `SEARch:TRIGger:MPHY:CREDit:CONDition` is set to `INRange` or `OORange`.

Parameters:

<CreditMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:PBEGin:CONDition <SearchName>,<CondPACPBegin>
SEARch:TRIGger:MPHY:PBEGin:CONDition? <SearchName>

Sets the condition for PACP Begin. You can define an exact value or a value range.

Parameters:

<CondPACPBegin>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:PBEGin:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:PBEGin:MIN` and `SEARch:TRIGger:MPHY:PBEGin:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PBEGin:MIN <SearchName>,<PACPBEGINMin>
SEARch:TRIGger:MPHY:PBEGin:MIN? <SearchName>

Specifies the PACP Begin bit pattern, or sets the start value of a pattern range.

Parameters:

<PACPBEGINMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PBEGin:MAX <SearchName>,<PACPBEGINMax>
SEARch:TRIGger:MPHY:PBEGin:MAX? <SearchName>

Sets the end value of the PACP Begin range if `SEARch:TRIGger:MPHY:PBEGin:CONDition` is set to `INRange` or `OORange`.

Parameters:

<PACPBEGINMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:CONDition <SearchName>,<CondPACPFunc>
SEARch:TRIGger:MPHY:PFID:CONDition? <SearchName>

Sets the condition for PACP Function ID. You can define an exact value or a value range.

Parameters:

<CondPACPFunc>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:PFID:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:PFID:MIN` and `SEARch:TRIGger:MPHY:PFID:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:MIN <SearchName>,<PACPFunIDMin>
SEARch:TRIGger:MPHY:PFID:MIN? <SearchName>

Specifies the PACP Function ID bit pattern, or sets the start value of a pattern range.

Parameters:

<PACPFunIDMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:MAX <SearchName>,<PACPFunIDMax>
SEARch:TRIGger:MPHY:PFID:MAX? <SearchName>

Sets the end value of the PACP Function ID range if `SEARch:TRIGger:MPHY:PFID:CONDition` is set to `INRange` or `OORange`.

Parameters:

<PACPFunIDMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:REServed <SearchName>,<ErrorReserved>
SEARch:TRIGger:MPHY:ERRor:REServed? <SearchName>

Enables/disables search for reserved bit error.

Parameters:

<ErrorReserved>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:LCMD <SearchName>,<LCCError>
SEARch:TRIGger:MPHY:ERRor:LCMD? <SearchName>

Enables/disables search for LCC error.

Parameters:

<LCCError>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:SYMBol <SearchName>,<ErrorSymbol>
SEARch:TRIGger:MPHY:ERRor:SYMBol? <SearchName>

Enables/disables search for 8b10b symbol error.

Parameters:

<ErrorSymbol>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:UNKNown <SearchName>,<ErrorUnknown>
SEARch:TRIGger:MPHY:ERRor:UNKNown? <SearchName>

Enables/disables search for unidentified UniPro frame error.

Parameters:

<ErrorUnknown>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:LENGth <SearchName>,<ErrorLength>
SEARch:TRIGger:MPHY:ERRor:LENGth? <SearchName>

Enables/disables search for length error.

Parameters:

<ErrorLength>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

20.17.16.5 Search Results

In all `SEARch:RESult:MPHY:FRAMe<m>` commands, the suffix <m> selects the frame number and suffix <n> selects the cell number in the list of search results.

SEARch:RESult:MPHY:FCOunt? <SearchName>

Returns the number of frames within the search result.

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CCOunt? <SearchName>

Returns the number of cells within the search result for the selected frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:DATA? <SearchName>

Returns the data value within the search result for the selected cell.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<WordValue>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:TYPE? <SearchName>

Returns the data type within the search result for the selected cell.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<WordType>

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:DATA? <SearchName>

Returns the data for the selected frame within the search result, corresponds to the Data column in the search results table.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Data>

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:FTYPe? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameType>	BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | SKIP | FILLER | SPACER | UNKNOWN **BURST** M-PHY burst frame. **ADAPT** M-PHY Adapt frame. This control frame is used for clock/bit synchronization. **LCC** M-PHY LCC frame. This control frame is used for line configuration depending on the LCC Type. **DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC** UniPro DL PDU frame. **PACP** UniPro frame. This control frame is used mainly for power mode change and L1.5 link management. **TRIGUPR0 | TRIGUPR1 | TRIGUPR2** UniPro frame. This control frame is used for link startup sequence. **SKIP** UniPro frame with Skip symbols for reducing protocol payload bandwidth. **FILLER** M-PHY or UniPro frame with filler words to maintain transmission activity. **SPACER** Scrambled UniPro frame with filler words. **UNKNOWN** No meaningful frame can be determined. *RST: UNKNOWN
Usage:	Query only

SEARch:RESult:MPHY:FRAMe<m>:STATe? <SearchName>

Returns the state of the selected frame within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<State>	OK | RSVDERROR | CMDERROR | LENGTHERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE **OK** Valid frame. **RSVDERROR** Erroneous frame due to reserved bit error. **CMDERROR** Erroneous frame due to LCC error. **LENGTHERROR** Erroneous frame due to length error. **SYMBOLERROR** Erroneous frame due to 8b10b symbol error. **UNKNOWNERROR** Erroneous frame due to unidentified UniPro frame error. **INVALID** Invalid frame. **INCOMPLETE** The frame is not complete. *RST: OK

Usage:	Query only

SEARch:RESult:MPHY:FRAMe<m>:STARt? <SearchName>

Returns the start time of the selected frame within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage:	Query only

SEARch:RESult:MPHY:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

20.17.17 Custom: Manchester / NRZ (Option R&S RTO-K50)

20.17.17.1 Configuration

In all `BUS<m>:CMSB` commands, the suffix <m> selects the serial bus.

In all `BUS<m>:CMSB:FRAMe<n>` commands, the suffix <n> selects a frame number, and the suffix <o> selects a cell number.

BUS<m>:CMSB:CODing <CodingStandard>

Selects the custom serial bus coding standard.

Suffix:

<m>	1..4

Parameters:

<CodingStandard> MANC | MANT | NRZ | NRZU

MANC
Manchester (normal polarity)

MANT
Manchester II (inverted polarity).
Note that some additional subtle differences between MANC and MANT require separate protocols.

NRZ
NRZ (non-return-to-zero), clocked

NRZU
NRZ (non-return-to-zero), unclocked

*RST: MANC

BUS<m>:CMSB:MANChester:DATA <SourceMANData>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m>	1..4

Parameters:

<SourceMANData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: C1W1

BUS<m>:CMSB:MANChester:POLarity <MANPolarityData>

Selects the polarity of the custom serial bus data signal in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<MANPolarityData>	NORMal | INVert **NORMal** Manchester or Manchester II polarity remains unchanged **INVert** Manchester polarity is inverted and becomes Manchester II polarity, Manchester II polarity is inverted and becomes Manchester polarity *RST: NORMal

---

BUS<m>:CMSB:MANChester:THReshold:HIGH <MANThresUpp>

Sets the upper threshold for data signal digitization in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<MANThresUpp>	Range:	-25 to 25
	Increment:	0.1
	*RST:	5
	Default unit:	V

BUS<m>:CMSB:MANChester:THReshold:LOW <MANThresLow>

Sets the lower threshold for data signal digitization in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<MANThresLow>	Range:	-25 to 25
	Increment:	0.1
	*RST:	-5
	Default unit:	V

BUS<m>:CMSB:MANChester:THReshold:PRESet <MANThresPreset>

Sets the Manchester thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<MANThresPreset>	V05 | V2 | V5 | V7 | MAN **V05** Sets the upper threshold to +0.5 V and the lower threshold to -0.5 V **V2** Sets the upper threshold to +2.0 V and the lower threshold to -2.0 V **V5** Sets the upper threshold to +5.0 V and the lower threshold to -5.0 V **V7** Sets the upper threshold to +7.0 V and the lower threshold to -7.0 V **MAN** Allows to set individual threshold voltage levels *RST: V5

BUS<m>:CMSB:MANChester:THReshold:COUPling <MANThresCpl>

Couples the upper and lower threshold values for the Manchester and Manchester II coding standards. The values are coupled to voltages with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.

Suffix:

<m>	1..4

Parameters:

<MANThresCpl>	ON | OFF **ON** Activates coupling of the upper and lower threshold values. **OFF** Disables coupling of the upper and lower threshold values. *RST: ON

BUS<m>:CMSB:MANChester:CPHase <MANClkPhaseMd>

Selects the phase of the custom serial bus clock signal for the "Manchester" coding standards. For details, see "Clock Phase (Manchester)" on page 785.

Suffix:

<m>	1..4

Parameters:

<MANClkPhaseMd>	FEDGe | SEDGe | AUTO **FEDGe** Sets the sampling edge to be on the first edge. **SEDGe** Sets the sampling edge to be on the second edge. **AUTO** Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the sampling edge. *RST: AUTO

BUS<m>:CMSB:NRZ:CLCK <SourceNRZClock>

Selects the source channel for the clock signal in the NRZ Clocked coding standard.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m>	1..4

Parameters:

<SourceNRZClock>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C2W1

BUS<m>:CMSB:NRZ:DATA <SourceNRZData>

Selects the source channel for the data signal in NRZ coding standards.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

For triggering on the serial bus when the NRZ unclocked coding standard is selected, analog channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m>	1..4

Parameters:

<SourceNRZData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:CMSB:NRZ:IDLPolarity <NRZPolarityIdle>

Selects the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked").

Suffix:

<m>	1..4

Parameters:

<NRZPolarityIdle>	IDLLow | IDLHigh **IDLLow** Sets the base value of the data bus to be "0". After an idle period, the data signal starts with a low-to-high transition **IDLHigh** Sets the base value of the data bus to be "1". After an idle period, the data signal starts with a high-to-low transition *RST: IDLLow

---

BUS<m>:CMSB:NRZ:CPOLarity <CPOLMode>

Selects the custom serial bus clock signal polarity for the coding standard NRZ Clocked.

Suffix:

<m>	1..4

Parameters:

<CPOLMode>	IDLLow | IDLHigh **IDLLow** Sets the base value of the clock to be "0", the clock signal starts with a low-to-high transition **IDLHigh** Sets the base value of the clock to be "1", the clock signal starts with a high-to-low transition. *RST: IDLLow

---

BUS<m>:CMSB:NRZ:CPHase <CPHAMode>

Selects the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on `BUS<m>:CMSB:NRZ:IDLPolarity` on page 1880.

Suffix:

<m>	1..4

Parameters:	
<CPHAMode>	FEDGe | SEDGe **FEDGe** Sets the clocking transaction to be on the first edge: If Clock Polarity = "IDLLow", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge If Clock Polarity = "IDLHigh", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge **SEDGe** Sets the clocking transaction to be on the second edge: If Clock Polarity = "IDLLow", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge If Clock Polarity = "IDLHigh", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge *RST: FEDGe

---

BUS<m>:CMSB:NRZ:ENBLe <SourceNRZEnable>

Selects the input source for the custom serial bus enable signal.

If an input is chosen, signals will be only decoded while this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m> 1..4

Parameters:

<SourceNRZEnable> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

BUS<m>:CMSB:NRZ:ENAPolarity <NRZPolaEnab>

Sets whether the transmitted enable signal is active when the voltage is below the threshold (`ENALow`) or higher than it (`ENAHIgh`).

Suffix:

<m> 1..4

Parameters:

<NRZPolaEnab> ENALow | ENAHigh

*RST: ENAHigh

BUS<m>:CMSB:NRZ:POLarity <NRZPolarityData>

Selects the polarity of the custom serial bus data signal in NRZ coding standards.

Suffix:

<m>	1..4

Parameters:

<NRZPolarityData>	ACTLow | ACTHigh **ACTLow** Active low: the value "1" is represented by a voltage below the threshold **ACTHigh** Active high: the value "1" is represented by a voltage above the threshold *RST: ACTHigh

---

BUS<m>:CMSB:NRZ:THReshold:CLCK <NRZThresClk>

Sets the threshold for the clock signal digitization in the NRZ Clocked coding standard.

Suffix:

<m>	1..4

Parameters:

<NRZThresClk>	Range:	-25 to 25
	Increment:	0.1
	*RST:	2
	Default unit:	V

BUS<m>:CMSB:NRZ:THReshold:DATA <NRZThresDat>

Sets the threshold for the data signal digitization in NRZ coding standards.

Suffix:

<m>	1..4

Parameters:

<NRZThresDat>	Range:	-25 to 25
	Increment:	0.1
	*RST:	2
	Default unit:	V

BUS<m>:CMSB:NRZ:THReshold:ENBLe <NRZThresEnab>

Sets the threshold for the enable signal digitization in NRZ coding standards.

Suffix:

<m>	1..4

Parameters:

<NRZThresEnab>	Range:	-25 to 25
	Increment:	0.1
	*RST:	2
	Default unit:	V

BUS<m>:CMSB:NRZ:THReshold:PRESet <NRZThresPreset>

Sets the NRZ thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<NRZThresPreset> V05 | V2 | V5 | V7 | MAN

V05
Sets the clock and data threshold to +0.5 V (in case of NRZ Unclocked: data threshold, only)

V2
Sets the clock and data threshold to +2.0 V (in case of NRZ Unclocked: data threshold, only)

V5
Sets the clock and data threshold to +5.0 V (in case of NRZ Unclocked: data threshold, only)

V7
Sets the clock and data threshold to +7.0 V (in case of NRZ Unclocked: data threshold, only)

MAN
Allows to set individual threshold voltage levels

*RST: V5

BUS<m>:CMSB:NRZ:THReshold:COUPling <NRZThresCpl>

Couples the clock and data threshold values for the NRZ Clocked coding standard. The values are coupled to the same number.

Suffix:

<m>	1..4

Parameters:

<NRZThresCpl> ON | OFF

ON
Activates coupling of the NRZ clock and data threshold values.

OFF
Disables coupling of the NRZ clock and data threshold values.

*RST: ON

BUS<m>:CMSB:BITRate:ENABle <BitrateEnable>

Enables the bit rate settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m>	1..4

Parameters:

<BitrateEnable> ON | OFF

ON
Bit rate settings enabled

OFF
Bit rate settings disabled

*RST: OFF

BUS<m>:CMSB:BITRate:VALue <Bitrate>

Sets the transmission speed setting for the custom serial bus data signal.

Suffix:

<m>	1..4

Parameters:

<Bitrate>

Range: 300 to 100000000
Increment: 100000
*RST: 10000000
Default unit: bps

BUS<m>:CMSB:GAPTime:ENABle <GapTimeEnable>

Enables the gap time settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m>	1..4

Parameters:

<GapTimeEnable> ON | OFF

ON
Gap time settings enabled

OFF
Gap time settings disabled

*RST: OFF

BUS<m>:CMSB:GAPTime:VALue <MinGapTime>

Sets a minimum gap time for synchronization.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range: 1E-9 to 1 Increment: 1E-9 *RST: 10E-6 Default unit: s

---

BUS<m>:CMSB:ADDFrame

Creates an empty frame format description and adds it to the end of the frame description list.

Suffix:

<m>	1..4
Usage:	Event

BUS<m>:CMSB:FCOunt?

Returns the number of frames.

Suffix:

<m>	1..4

Return values:

<Count>

Usage:	Query only

BUS<m>:CMSB:CLR

Erases all cells and frames that have been created for a specific custom protocol.

Suffix:

<m>	1..4
Usage:	Event

BUS<m>:CMSB:FRAMe<n>:TYPE <FrameType>

Enables the user to set a string to describe the frame type, typically according to the applicable protocol standard specifications. (For example, MDIO (Option R&S RTO-K55) defines the frames READ, WRITE, ADDRESS, etc.)

Suffix:

<m>	1..4
<n>	*

Parameters:

<FrameType>

BUS<m>:CMSB:FRAMe<n>:APPend

Creates an empty cell description and adds it to the end of the active frame description.

Suffix:

<m>	1..4
<n>	*

Usage:	Event

BUS<m>:CMSB:FRAMe<n>:CCOunt?

Returns the number of cells in the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:
<Count>

Usage:	Query only

BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME <CellName>

Enables the user to set a cell name within a frame. Names do not have to be unique, they are just for user support.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:
<CellName>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount <BitCount>

Sets the bit count of a cell, hence its length. Based upon the lengths of the previous cells, this also defines the position of the cell start and end within a frame.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitCount>	Range: 1 to 65535 Increment: 1 *RST: 1

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition <Condition>

Sets various operators for a cell, to identify, e.g., mandatory values such as a CRC checksum or an ID, that help to identify a frame.

The implemented conditions and functionalities are the "equal" and "array" operators. For details, see "Condition" on page 793.

The numeric format of the condition needs to be set according to `BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat` on page 1887.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<Condition>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat <CellFormat>

Selects the numeric data format for the command `BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1887, as well as for the result and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<CellFormat> DEC | HEX | OCT | BIN

DEC
Decimal

HEX
Hexadecimal

OCT
Octal

BIN
Binary

*RST: BIN

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder <BitOrder>

Selects in which order the bits of a cell are evaluated, as well as presented in the results table and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first, evaluation starts at the LSB

MSBF
Most significant bit first, evaluation starts at the MSB

*RST: MSBF

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB <Color>

Selects a cell's color representation in the honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<Color> ARGB value of the color to be used for the table entry.
ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 0

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN <Column>

Selects which cell shall be displayed in which result column of the decode table.

The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, different result columns can be defined to display unrelated information.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<Column>	NONE | COL1 | COL2 | COL3 **NONE** The result is not displayed in the decode table. **COL1** The result is displayed in column 1 of the decode table. **COL2** The result is displayed in column 2 of the decode table. **COL3** The result is displayed in column 3 of the decode table. *RST: NONE

BUS<m>:CMSB:LOAD <FileName>

Opens an existing frame description file in xml format. The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:

<m>	1..4

Setting parameters:
<FileName>

Usage: Setting only

BUS<m>:CMSB:SAVE <FileName>

Saves a created frame description into an xml file ("Save As..."). The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:

<m>	1..4

Setting parameters:
<FileName>

Usage: Setting only

20.17.17.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CMSB:TYPE <Type>

Selects the trigger type for custom serial bus analysis.

Parameters:

<Type>	STARt | PATTern **STARt** Triggers on the frame start, which is the end of the gap time as specified in `BUS<m>:CMSB:GAPTime:VALue` on page 1884 **PATTern** Triggers on a data pattern to be specified in `TRIGger<m>:CMSB:PATTern` on page 1890 *RST: STARt

---

TRIGger<m>:CMSB:PATTern <DataPattern>

Sets the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time (`BUS<m>:CMSB:GAPTime:VALue` on page 1884), and after the detected start of the data frame.

Parameters:

<DataPattern>

TRIGger<m>:CMSB:ICONdition <DatIdxOptor>

Sets the operator to set a specific bit index (data position).

Suffix:

<m>	1..3

Parameters:

<DatIdxOptor>	EQUal | GETHan | INRange **EQUal** Equal **GETHan** Greater than or equal **INRange** In range *RST: INRange

---

TRIGger<m>:CMSB:IMIN <DataPosition>

Sets the bit index (data position). If `TRIGger<m>:CMSB:ICONdition` on page 1890 is set to "INRange", "IMIN" sets the start value of the bit index range.

Parameters:

<DataPosition>	Range:	0 to 65535
	Increment:	1
	*RST:	0

TRIGger<m>:CMSB:IMAX <DataPositionTo>

Sets the end value of the bit index range (data position range), if `TRIGger<m>:CMSB:ICONdition` on page 1890 is set to "INRange".

Parameters:

<DataPositionTo>	Range:	0 to 65535
	Increment:	1
	*RST:	65535

TRIGger<m>:CMSB:NRZ:WRDLength <NRZWordLength>

Sets the number of bits in an NRZ Unclocked word.

Suffix:

<m>	1..3

Parameters:

<NRZWordLength>	Range:	0 to 31
	Increment:	1
	*RST:	8

20.17.17.3 Decode Results

In all `BUS<m>:CSMB:RESult<n>` commands, the suffix <m> selects the serial bus, the suffix <n> selects the result number in the decode table, and the suffix <o> selects the cell number.

As an example, with reference to Figure 12-97, Table 12-19 and Table 12-20, a set of query commands for bus #1 and result #1 is shown in the following, together with examples for outcomes of these queries:

- `:BUS1:CMSB:RCOunt?` !5

- `:BUS1:CMSB:RESult1:STATe?` !OK
- `:BUS1:CMSB:RESult1:STARt?` ! -0.0024964177
- `:BUS1:CMSB:RESult1:STOP?` ! -0.0024030384
- `:BUS1:CMSB:RESult1:TYPE?` !ff
- `:BUS1:CMSB:RESult1:CONE?` !0b11111111
- `:BUS1:CMSB:RESult1:CTWO?` !0xAA

- `:BUS1:CMSB:RESult1:CTHR?` !0xF590

- `:BUS1:CMSB:RESult1:CCOunt?` !5

- `:BUS1:CMSB:RESult1:CELL1:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL1:NAME?` !Start Delim
- `:BUS1:CMSB:RESult1:CELL1:VALue?` !101010101HL10HL0

- `:BUS1:CMSB:RESult1:CELL2:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL2:NAME?` !OP-FF
- `:BUS1:CMSB:RESult1:CELL2:VALue?` !0b11111111

- `:BUS1:CMSB:RESult1:CELL3:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL3:NAME?` !data
- `:BUS1:CMSB:RESult1:CELL3:VALue?` !0xAA

- `:BUS1:CMSB:RESult1:CELL4:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL4:NAME?` !CRC
- `:BUS1:CMSB:RESult1:CELL4:VALue?` !0xF590

- `:BUS1:CMSB:RESult1:CELL5:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL5:NAME?` !End Delim
- `:BUS1:CMSB:RESult1:CELL5:VALue?` !1HLHL101

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496
- `BUS<m>:RESDetail` on page 1496

BUS<m>:CMSB:RCOunt?

Returns the count number of decoded result frames in a custom serial bus waveform. Basically, this is the maximum result index <n> when querying results by using `BUS<m>:CMSB:RESult<n>:XXX`.

Suffix:

<m>	1..4

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:RESult<n>:STATe?

Returns the overall state of the frame: either OK or the relevant error condition. R&S RTO-K50 marks each frame with a status that indicates whether the decode succeeded or not.

Suffix:

<m>	1..4
<n>	*

Return values:
<State> OK | PARity | LENGth | UNKNown | INComplete | CRC

OK
The frame was decoded normally and conforms to the frame description.

LENGth
The length error indicates that the frame ended prematurely, or an array in the frame had too few elements. The amount of bits that the software expected (based upon the user's frame description) was not found before the frame was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The frame ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

PARity
Parity bit error, indicating a transmission error (only available if a parity is configured)

*RST: OK

Usage: Query only

BUS<m>:CMSB:RESult<n>:STARt?

Returns the start time of the frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:STOP?

Returns the stop time of the frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:TYPE?

Returns the name of the selected frame (n) from the user defined frame format description, labeled according to `BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1885.

Suffix:

<m>	1..4
<n>	*

Return values:

<Type>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CONE?

Returns the 1st cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m>	1..4
<n>	*

Return values:

<Custom1>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTWO?

Returns the 2nd cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m>	1..4
<n>	*

Return values:

<Custom2>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTHRee?

Returns the 3rd cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m>	1..4
<n>	*

Return values:

<Custom3>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CCOunt?

Returns the number of decoded cells in the specified result frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Count>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:NAME?

Returns the name of the specified cell. Cell names are not necessarily unique.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<Name>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:STATe?

Returns the state of the cell.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<State> OK | PARity | LENGth | UNKNown | INComplete | CRC

OK
No error detected

LENGth
The length error indicates that the cell ended prematurely. The amount of bits that the software expected (based upon the user's frame description) was not found before the cell was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The cell ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

PARity
Parity bit error, indicating a transmission error (only available if a parity is configured)

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:VALue?

Data content of the specified cell.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<Value>

Usage:	Query only

20.17.18 8B/10B (Option R&S RTO-K52)

20.17.18.1 Configuration

In all `BUS<m>:EBTB` commands, the suffix <m> selects the serial bus.

BUS<m>:EBTB:ACTestimate <Estimation>

Enables the automatic software bitrate determination.

Suffix:

<m>	1..4

Parameters:

<Estimation>	ON | OFF *RST: OFF

BUS<m>:EBTB:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m>	1..4

Parameters:

<Bitrate>	Range: 100 to 12.5E+9 Increment: 10 *RST: 1.25E+9 Default unit: bps

---

BUS<m>:EBTB:DIFFerential:SOURce <SourceDifferential>

Selects the source of the provided differential signal, if `BUS<m>:EBTB:TYPE DIFFerential` is set.

Suffix:

<m>	1..4

Parameters:

<SourceDifferential>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

Usage: Asynchronous command

BUS<m>:EBTB:DIFFerential:THRHigh <ThresholdHigh>

Sets the high threshold of the signal, if `BUS<m>:EBTB:TYPE DIFFerential`.

Suffix:

<m>	1..4

Parameters:

<ThresholdHigh>	Range: -10 to 10 Increment: 1E-3 *RST: 0.15 Default unit: V

BUS<m>:EBTB:DIFFerential:THRLow <ThresholdLow>

Sets the low threshold of the signal, if `BUS<m>:EBTB:TYPE DIFFerential`.

Suffix:

<m>	1..4

Parameters:

<ThresholdLow>	Range: -10 to 10 Increment: 1E-3 *RST: -0.15 Default unit: V

BUS<m>:EBTB:DISF <DisplayFormat>

Selects the display format for the results in the decode table and for the results of `BUS<m>:EBTB:SYMBol<n>:DATA?`.

Suffix:

<m>	1..4

Parameters:

<DisplayFormat>	KD | EB | TB
	KD: K/D codes EB: 8-bit pattern TB: 10-bit pattern
	*RST: KD

BUS<m>:EBTB:DMINus:SOURce <SourceDminus>

Selects the D- source of the provided single ended signal, if `BUS<m>:EBTB:TYPE SINGle` is set.

Suffix:

<m>	1..4

Parameters:

<SourceDminus>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
Usage:	Asynchronous command

BUS<m>:EBTB:DMINus:THReshold <ThresholdDminus>

Sets the low threshold (D-) of the signal, if `BUS<m>:EBTB:TYPE SINGle`.

Suffix:

<m>	1..4

Parameters:

<ThresholdDminus>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

BUS<m>:EBTB:DPLus:SOURce <SourceDplus>

Selects the D+ source of the provided single-ended signal, if `BUS<m>:EBTB:TYPE SINGle` is set.

Suffix:

<m>	1..4

Parameters:

<SourceDplus>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Usage: Asynchronous command

BUS<m>:EBTB:DPLus:THReshold <ThresholdDplus>

Sets the high threshold (D +) of the signal, if `BUS<m>:EBTB:TYPE SINGle`.

Suffix:

<m>	1..4

Parameters:

<ThresholdDplus>	Range:	-10 to 10
	Increment:	1E-3
	*RST:	0
	Default unit:	V

BUS<m>:EBTB:FCSY <CustSync>

Sets a pattern value, if `BUS<m>:EBTB:SYNC CUS`.

Suffix:

<m>	1..4

Parameters:

<CustSync>

BUS<m>:EBTB:SCOunt?

Returns the symbol count for the selected serial bus, i.e. the number of symbols in the present acquisition.

Suffix:

<m>	1..4

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:EBTB:SCSY <CustSync2>

Sets the value for the second pattern, if `BUS<m>:EBTB:SYNC CUS` and `BUS<m>:EBTB:USCS ON`.

Suffix:

<m>	1..4

Parameters:
<CustSync2>

BUS<m>:EBTB:SYNC <CommaSymbol>

Sets the sync symbol, a control symbol used for low level control functions.

Suffix:

<m>	1..4

Parameters:

<CommaSymbol>	K285 | K281 | K287 | CUS	
	*RST:	K285

BUS<m>:EBTB:TYPE <SignalType>

Selects the signal type that is used for the decoding. You can choose between a differential and single-ended signal.

Suffix:

<m>	1..4

Parameters:

<SignalType>	DIFFerential | SINGle	
	*RST:	DIFFerential

BUS<m>:EBTB:USCS <IsSecondSync>

Selects whether the second pattern is enabled, if `BUS<m>:EBTB:SYNC CUS`.

Suffix:

<m>	1..4

Parameters:

<IsSecondSync>	ON | OFF	
	*RST:	OFF

BUS<m>:EBTBBITDetermi

Starts a software algorithm for the automatic determination of the bitrate.

Suffix:

<m>	1..4
Usage:	Event Asynchronous command

BUS<m>:EBTBFAUToscale

Starts software algorithms for determining the signal threshold levels and bitrate.

Suffix:

<m>	1..4

Usage: Event
Asynchronous command

20.17.18.2 Trigger Settings

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:EBTB:DISParityerr <DispError>

Defines, if a trigger on a disparity error is activated or not.

Parameters:

<DispError>	ON | OFF
	*RST: OFF

TRIGger<m>:EBTB:DX <DXSymbol>

Sets thex value of the data character Dx.y to be triggered on, if `TRIGger<m>:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DXSymbol>	Range:	0 to 31
	Increment:	1
	*RST:	0

TRIGger<m>:EBTB:DY <DYSymbol>

Sets the y value of the data character Dx.y to be triggered on, if `TRIGger<m>:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DYSymbol>	Range:	0 to 7
	Increment:	1
	*RST:	0

TRIGger<m>:EBTB:EBPA <EBPattern>

Sets the 8-bit pattern to be triggered on, if `TRIGger<m>:EBTB:SYMFormat` is set to `EB`.

Parameters:
<EBPattern>

TRIGger<m>:EBTB:GLITcherror <GlitchError>

Defines, if a trigger on a glitch error is activated or not.

Parameters:

<GlitchError>	ON | OFF	
	*RST:	OFF

TRIGger<m>:EBTB:SSTYpe <SymbolType>

Selects the symbol type to be triggered on. You can select a single symbol or an expression (defined series of symbols).

Parameters:

<SymbolType>	SYMBol | EXPRession	
	*RST:	SYMBol

TRIGger<m>:EBTB:SYME <Expression>

Selects the format of the symbol to be triggered on, if `TRIGger<m>:EBTB:SSTYpe` is set to `EXPRession`.

Parameters:
<Expression>

TRIGger<m>:EBTB:SYMFormat <Format>

Selects the format of the symbol to be triggerd on, if `TRIGger<m>:EBTB:SSTYpe` is set to `SYMBol`.

Parameters:

<Format>	KD | EB | TB *RST: KD

TRIGger<m>:EBTB:SYMType <SymbolType>

Selects the data character (Dx.y) or control character to bea triggered on. You can specify he value of the data character to be triggered on with `TRIGger<m>:EBTB:DX` and `TRIGger<m>:EBTB:DY`.

Parameters:

<SymbolType>	DXY | K280 | K281 | K282 | K283 | K284 | K285 | K286 | K287 | K237 | K277 | K297 | K307 *RST: K285

TRIGger<m>:EBTB:TBPA <TBPattern>

Sets the 10-bit pattern to be triggered on, if `TRIGger<m>:EBTB:SYMFormat` is set to `TB`.

Parameters:

<TBPattern>

TRIGger<m>:EBTB:TYPE <Type>

Selects the type of condition to be triggered on. You can trigger on a certain symbol or enable a specific error condition.

Parameters:

<Type>	SYMBol | ERRor *RST: SYMBol

TRIGger<m>:EBTB:UNK <UnkError>

Defines, if a trigger on a unknown symbol error is activated or not.

Parameters:

<UnkError>	ON | OFF *RST: OFF

20.17.18.3 Decode Results

In all `BUS<m>:EBTB:SYMBol<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the symbol in the decode table.

BUS<m>:EBTB:SYMBol<n>:DATA?

Returns the data of the specified symbol.

The format is determined by the remote command `BUS<m>:EBTB:DISF`.

Suffix:

<m>	1..4
<n>	*

Return values:
<Data>

Example:
```
BUS<m>:EBTB:DISF EB
BUS:EBTB:SYMBol5:DATA?
<-- BC+
```

Example:
```
BUS<m>:EBTB:DISF KD
BUS:EBTB:SYMBol5:DATA?
<-- K28.5+
```

Example:
```
BUS<m>:EBTB:DISF TB
BUS:EBTB:SYMBol5:DATA?
<-- 305
```

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:STARt?

Returns the start time of the specified symbol.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:STATus?

Returns the status of the specified symbol. It can show what kind of error was detected or no error.

Suffix:

<m>	1..4
<n>	*

Return values:

<State>	OK | UNK | DISPARITY | DISParity | GLITCH | GLITch **OK** There are no errors in the state of the specified symbol. **UNK** An unknown error was detected for the specified symbol. **DISPARITY = DISParity** A disparity error was detected for the specified symbol. **GLITCH = GLITch** A glitch error was detected for the specified symbol. *RST: OK
Usage:	Query only

BUS<m>:EBTB:SYMBol<n>:STOP?

Returns the stop time of the specified symbol.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

20.17.18.4 Search Settings

SEARch:TRIGger:EBTB:DISParityerr <SearchName>,<DispError>
SEARch:TRIGger:EBTB:DISParityerr? <SearchName>

Defines, if a search for any disparity error is activated or not.

Parameters:

<DispError>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:DX <SearchName>,<DXSymbol>
SEARch:TRIGger:EBTB:DX? <SearchName>

Sets the x value of the data character Dx.y to be searched for, if `SEARch:TRIGger:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DXSymbol>	Range:	0 to 31
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:DY <SearchName>,<DYSymbol>
SEARch:TRIGger:EBTB:DY? <SearchName>

Sets the y value of the data character Dx.y to be searched for, if `SEARch:TRIGger:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DYSymbol>	Range:	0 to 7
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:EBPA <SearchName>,<EBPattern>
SEARch:TRIGger:EBTB:EBPA? <SearchName>

Sets the 8-bit pattern to be searched for, if `SEARch:TRIGger:EBTB:SYMFormat` is set to `EB`.

Parameters:
<EBPattern>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:GLITcherror <SearchName>,<GlitchError>
SEARch:TRIGger:EBTB:GLITcherror? <SearchName>

Defines, if a search for any glitch error is activated or not.

Parameters:

<GlitchError>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SSTYpe <SearchName>,<SymbolType>

SEARch:TRIGger:EBTB:SSTYpe? <SearchName>

Selects the symbol type to be searched for. You can select a single symbol or an expression (defined series of symbols).

Parameters:

<SymbolType>	SYMBol | EXPRession *RST: SYMBol

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SYME <SearchName>,<Expression>

SEARch:TRIGger:EBTB:SYME? <SearchName>

Selects the format of the symbol to be searched for, if `SEARch:TRIGger:EBTB:SSTYpe` is set to `EXPRession`.

Parameters:

<Expression>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SYMFormat <SearchName>,<Format>

SEARch:TRIGger:EBTB:SYMFormat? <SearchName>

Selects the format of the symbol to be searched for, if `SEARch:TRIGger:EBTB:SSTYpe` is set to `SYMBol`.

Parameters:

<Format>	KD | EB | TB KD: K/D codes EB: 8-bit pattern TB: 10-bit pattern *RST: KD

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SYMType <SearchName>,<SymbolType>
SEARch:TRIGger:EBTB:SYMType? <SearchName>

Selects the data character (Dx.y) or control character to bea searched for. You can specify he value of the data character to be searched for with `SEARch:TRIGger:EBTB:DX` and `SEARch:TRIGger:EBTB:DY`.

Parameters:

<SymbolType>	DXY | K280 | K281 | K282 | K283 | K284 | K285 | K286 | K287 | K237 | K277 | K297 | K307 *RST: K285

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:TBPA <SearchName>,<TBPattern>
SEARch:TRIGger:EBTB:TBPA? <SearchName>

Sets the 10-bit pattern to be searched for, if `SEARch:TRIGger:EBTB:SYMFormat` is set to `TB`.

Parameters:
<TBPattern>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:TYPE <SearchName>,<Type>
SEARch:TRIGger:EBTB:TYPE? <SearchName>

Selects the type of condition to be searched for. You can search for a certain symbol or enable a specific error condition.

Parameters:

<Type>	SYMBol | ERRor *RST: SYMBol

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:UNK <SearchName>,<UnkError>
SEARch:TRIGger:EBTB:UNK? <SearchName>

Defines, if a search for any unknown symbol error is activated or not.

Parameters:

<UnkError>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

20.17.18.5 Search Results

In all `SEARch:RESult:EBTB:SYMBol<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:EBTB:SCOunt<*>? <SearchName>

Returns the search result's symbol count, i.e. the number of symbols found in the search result.

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:DATA? <SearchName>

Returns the data of the specified symbol.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:STARt? <SearchName>

Returns the start time of the specified symbolwithin the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

SEARch:RESult:EBTB:SYMBol<m>:STATus? <SearchName>

Returns the status of the specified symbol within the search result. It can show what kind of error was detected or no error.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<State> OK | UNK | DISPARITY | DISParity | GLITCH | GLITch

OK
There are no errors in the state of the specified symbol.

UNK
An unknown error was detected for the specified symbol.

DISPARITY = DISParity
A disparity error was detected for the specified symbol.

GLITCH = GLITch
A glitch error was detected for the specified symbol.

*RST: OK

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:STOP? <SearchName>

Returns the stop time of the specified symbol within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

20.17.19 MDIO (Option R&S RTO-K55)

20.17.19.1 Configuration

In all `BUS<m>:MDIO` commands, the suffix <m> selects the serial bus.

BUS<m>:MDIO:CLOCk:SOURce <SourceClock>

Selects the source for the clock line (management data clock, MDC). Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15".

Suffix:

<m>	1..4

Parameters:

<SourceClock>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required. See Chapter 20.4.2, "Waveform Parameter", on page 1173

BUS<m>:MDIO:DATA:SOURce <SourceData>

Selects the source for the data signal. Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15", but not the same as for "Clock".

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required. See Chapter 20.4.2, "Waveform Parameter", on page 1173

BUS<m>:MDIO:MAXGap <MaxGapTime>

Sets the maximum idle time between two frames.

Suffix:

<m>	1..4

Parameters:

<MaxGapTime>	Range: 100E-9 to 100E-6 Increment: 500E-9 *RST: 1E-6 Default unit: s

---

BUS<m>:MDIO:CLOCk:THReshold:HIGH <ThresClkHigh>

Defines the upper threshold level for the clock signal.

Suffix:

<m>	1..4

Parameters:

<ThresClkHigh>	Range: -5 to 5 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:MDIO:CLOCk:THReshold:LOW <ThresClkLow>

Defines the lower threshold level for the clock signal.

Suffix:

<m>	1..4

Parameters:

<ThresClkLow>	Range: -5 to 5 Increment: 0.1 *RST: 0.8 Default unit: V

BUS<m>:MDIO:DATA:THReshold:HIGH <ThresDatHigh>

Defines the upper threshold level for the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresDatHigh>	Range: -5 to 5 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:MDIO:DATA:THReshold:LOW <ThresDatLow>

Defines the lower threshold level for the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresDatLow>	Range: -5 to 5 Increment: 0.1 *RST: 0.8 Default unit: V

BUS<m>:MDIO:PRESet <Preset>

Selects the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.

Suffix:

<m>	1..4

Parameters:

<Preset>	DEFault | MANual *RST: DEFault

BUS<m>:MDIO:COUPling <ThresCpl>

Overwrites the data thresholds with the clock thresholds.

Suffix:

<m>	1..4

Parameters:

<ThresCpl>	ON | OFF *RST: ON

20.17.19.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MDIO:TYPE <Type>

Selects the trigger type for MDIO analysis.

Parameters:

<Type> STARt | STOP | DATA

STARt
Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble. Trigger pattern: preamble (32 bits "1")

STOP
Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit. Trigger pattern: preamble (32 bits "1") + 32 bits "X"

DATA
Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI. Trigger pattern: preamble (32 bits "1") + 2 bits "ST" (Start of Frame Code) + 2 bits "OP" (Frame Type Code, or "OpCode") + 5 bits "PHYAD/PRTAD" (Physical Layer Entity Address / Port Address) + 5 bits "REGAD/DEVAD" (Register Address / Device Address) + 2 bits "TA" (turnaround time, X bits) + 16 bits "DATA/ADDRESS"

*RST: STARt

TRIGger<m>:MDIO:ST <StartCode>

Selects the start of frame code of the frame pattern; available only in trigger type "Data".

Note that Clause 22 is coded by "01", while Clause 45 is coded by "00", thus the lower Clause number is represented by the higher parameter value.

Parameters:

<StartCode>	ST00 | ST01 | ST0X **ST00** Clause 45 **ST01** Clause 22 **ST0X** Any permissible start pattern *RST: ST0X

TRIGger<m>:MDIO:FRAMetype <FrameType>

Selects the Type of Frame code (or OP code, OpCode, operation code); available only in trigger type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:

<FrameType>	OP00 | OP01 | OP10 | OP11 | OPXX **OP00** Address frame (in Clause 45, only) **OP01** Write frame (in Clause 22 or Clause 45) **OP10** Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45) **OP11** Read frame (in Clause 45) **OPXX** Any frame type *RST: OPXX Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation.

TRIGger<m>:MDIO:PHYS <PhyAddr>

Sets the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:

<PhyAddr>

TRIGger<m>:MDIO:REGI <RegAddr>

Sets the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:
<RegAddr>

TRIGger<m>:MDIO:DATA <Data>

Defines the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to trigger for; available only in trigger type "Data".

Parameters:
<Data>

20.17.19.3 Decode Results

In all `BUS<m>:MDIO:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

BUS<m>:MDIO:WCOunt?

Returns the word count for the selected serial bus, i.e. the number of words in the present acquisition.

Suffix:

<m>	1..4

Return values:
<Count>

Usage: Query only

BUS<m>:MDIO:WORD<n>:DATA?

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) in the present acquisition of the selected word and the selected serial bus. The most significant bit (MSB) is transmitted first.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>

Usage:	Query only

BUS<m>:MDIO:WORD<n>:PHYS?

Returns the 5-bit address field content (PHYAD/PRTAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<PhyAd>	Range:	0 to 32
	Increment:	1

Usage:	Query only

BUS<m>:MDIO:WORD<n>:REGI?

Returns the 5-bit register or device address field content (REGAD/DEVAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<RegAd>	Range:	0 to 32
	Increment:	1

Usage:	Query only

BUS<m>:MDIO:WORD<n>:ST?

Returns the Start Code (= start of frame code) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<StartCode>	Range: [bin]00 to [bin]11 Increment: 1 The parameter value "[bin]00" represents Clause 45, while "[bin]01" stands for Clause 22. Note that the values "[bin]10" and "[bin]11" do not correspond with any legal parameters according to the standard, but they can still be searched for.

Usage:	Query only

BUS<m>:MDIO:WORD<n>:STARt?

Returns the start time of the frame in the selected word of the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage:	Query only

BUS<m>:MDIO:WORD<n>:STATe?

Returns the state of the frame in the present acquisition of the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:	
<State>	OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt **OK** No error detected **UNSYN = UNSYncronized** UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded. **OPCO** OPcode Error **TA_ERROR** Tirnaround time error **INComplete** Incomplete Frame **SHORT = SHORt** Length Error *RST: OK
Usage:	Query only

BUS<m>:MDIO:WORD<n>:STOP?

Returns the stop time of the frame from the selected word within the search result.

Suffix:	
<m>	1..4
<n>	*
Return values:	
<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:MDIO:WORD<n>:SYMBol?

Returns a textual translation (called Register Name) of the PHY or port address label in the present acquisition of the selected word and the selected serial bus.

The translation is defined in the label list.

Suffix:	
<m>	1..4
<n>	*

Return values:
<Translation>

Usage:	Query only

BUS<m>:MDIO:WORD<n>:TYPE?

Returns the OpCode (= operation code or frame type) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType>	Range:	[bin]00 to [bin]11
	Increment:	1

Usage:	Query only

20.17.19.4 Search Settings

SEARch:TRIGger:MDIO:DATA <SearchName>,<Data>
SEARch:TRIGger:MDIO:DATA? <SearchName>

Allows to define the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to search for; available only in search criteria type "Data".

Parameters:
<Data>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:FRAMetype <SearchName>,<FrameType>
SEARch:TRIGger:MDIO:FRAMetype? <SearchName>

Allows to select the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:

<FrameType>	OP00 | OP01 | OP10 | OP11 | OPXX **OP00** Address frame (in Clause 45, only) **OP01** Write frame (in Clause 22 or Clause 45) **OP10** Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45) **OP11** Read frame (in Clause 45) **OPXX** Any frame type *RST: OPXX Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation. Also, note that OPXX will never be a result of decoding, but it is still an option for triggering.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:PHYS <SearchName>,<PhyAddr>
SEARch:TRIGger:MDIO:PHYS? <SearchName>

Allows to set the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<PhyAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:REGI <SearchName>,<RegAddr>
SEARch:TRIGger:MDIO:REGI? <SearchName>

Allows to set the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<RegAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:ST <SearchName>,<StartCode>
SEARch:TRIGger:MDIO:ST? <SearchName>

Allows to select the start of frame code of the frame pattern; available only in search criteria type "Data".

Parameters:

<StartCode> ST00 | ST01 | ST0X

ST00
Clause 45

ST01
Clause 22

ST0X
Any permissible start pattern

*RST: ST0X

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:TYPE <SearchName>,<Type>
SEARch:TRIGger:MDIO:TYPE? <SearchName>

Selects the event type to search for.

Parameters:

<Type> STARt | STOP | DATA

STARt
Searches for the start of frame (SOF).

STARt
Searches for the end of frame (EOF).

DATA
Allows to specify a payload data pattern (both in Clause 22 or Clause 45) or an address pattern (in Clause 45, only) to search for.

*RST: STARt

Parameters for setting and query:
<SearchName>

20.17.19.5 Search Results

In all `SEARch:RESult:MDIO:WORD<m>` commands, the suffix <m> selects the packet number in the list of search results.

SEARch:RESult:MDIO:WORD<m>:DATA? <SearchName>

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) from the selected word within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:PHYS? <SearchName>

Returns the 5-bit address field content (PHYAD/PRTAD) from the selected word within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<PhyAd>	Range:	0 to 32
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:REGI? <SearchName>

Returns the 5-bit register or device address field content (REGAD/DEVAD) from the selected word within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<RegAd>	Range:	0 to 32
	Increment:	1
	*RST:	0
Usage:	Query only	

SEARch:RESult:MDIO:WORD<m>:ST? <SearchName>

Returns the start of frame code from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<StartCode>	Range:	0 to 3
	Increment:	1
	*RST:	0
Usage:	Query only	

SEARch:RESult:MDIO:WORD<m>:STARt? <SearchName>

Returns the start time of the frame from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s
Usage:	Query only	

SEARch:RESult:MDIO:WORD<m>:STATe? <SearchName>

Returns the state of the frame from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<State>	OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt **OK** No error detected **UNSYN = UNSYncronized** UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded. **OPCO** OPcode error **TA_ERROR** turnaround time error **INComplete** Incomplete Frame **SHORT = SHORt** Length Error *RST: OK
Usage:	Query only

SEARch:RESult:MDIO:WORD<m>:STOP? <SearchName>

Returns the stop time of the frame from the selected word within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

SEARch:RESult:MDIO:WORD<m>:SYMBol? <SearchName>

Returns a textual translation (called Register Name) of the PHY or port address label from the selected word within the search result.

This translation can be user-configured through the translation table. For details on how the configuration is done, see Chapter 12.1.3, "Label Lists", on page 484.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:TYPE? <SearchName>

Returns the frame type (= operation code or OpCode) for the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> Range: 0 to 3
Increment: 1
*RST: 0
Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45: "0" (= [bin]00) represents Address, "1" (= [bin]01" represents Write, "2" (= [bin]10) represents Post Read, "3" (= [bin]11) represents Read. Clause 22 is not represented by this interpretation.

Usage: Query only

SEARch:RESult:MDIO:WCOunt <SearchName>

Returns the word count within the search result.

Setting parameters:
<SearchName>

Return values:
<Count>

20.17.20 USB (Option R&S RTO-K60)

20.17.20.1 Configuration

In all `BUS<m>:USB` commands, the suffix <m> selects the serial bus.

BUS<m>:USB:TECHnology <ProtocolType>

Defines the USB protocol technology and transmission speed.

Suffix:

<m>	1..4

Parameters:

<ProtocolType>	LOW | FULL | HIGH | HSIC **LOW** USB low speed protocol (1.5 Mbit/s) **FULL** USB full speed protocol (12 Mbit/s) **HIGH** USB high speed protocol (480 Mbit/s) **HSIC** USB high speed inter-chip (HSIC) protocol (480 Mbit/s) *RST: LOW

BUS<m>:USB:DPLus:SOURce <SourceDplus>

Selects the source for the D+ data signal (in USB low speed and USB full speed protocol, only).

Suffix:

<m>	1..4

Parameters:

<SourceDplus>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1
Usage:	Asynchronous command

BUS<m>:USB:DMINus:SOURce <SourceDminus>

Selects the source for the D- data signal (in USB low speed and USB full speed protocol, only).

Suffix:

<m>	1..4

Parameters:

<SourceDminus>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C2W1

Usage: Asynchronous command

BUS<m>:USB:DIFFerential:SOURce <SrcDiff>

Selects the source for the differential signal in the USB high speed protocol.

Suffix:

<m>	1..4

Parameters:

<SrcDiff>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

Usage: Asynchronous command

BUS<m>:USB:DATA:SOURce <SourceData>

Selects the source for the data signal in the USB HSIC protocol.

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Usage: Asynchronous command

BUS<m>:USB:STRobe:SOURce <SourceStrobe>

Selects the source for the strobe signal in the USB HSIC protocol.

Suffix:

<m>	1..4

Parameters:

<SourceStrobe>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C2W1

Usage:	Asynchronous command

BUS<m>:USB:DPLus:THReshold <ThresholdDplus>

Defines the threshold level for the D+ data signal (in USB low speed and USB full speed protocol, only).

Suffix:

<m>	1..4

Parameters:

<ThresholdDplus>	Range: -5 to 5 Increment: 0.01 *RST: 1.55 Default unit: V

BUS<m>:USB:DMINus:THReshold <ThresholdDminus>

Defines the threshold level for the D- data signal (in USB low speed and USB full speed protocol, only).

Suffix:

<m>	1..4

Parameters:

<ThresholdDminus>	Range: -5 to 5 Increment: 0.01 *RST: 1.55 Default unit: V

BUS<m>:USB:DIFFerential:THReshold <ThresDiff>

Defines the threshold level for the differential signal in the USB high speed protocol.

Suffix:

<m>	1..4

Parameters:

<ThresDiff>	Range: -2 to 2 Increment: 0.01 *RST: 0 Default unit: V

BUS<m>:USB:DATA:THReshold <ThresholdData>

Defines the threshold level for the data signal in the USB HSIC protocol.

Suffix:

<m>	1..4

Parameters:

<ThresholdData>	Range: -2 to 2 Increment: 0.01 *RST: 0.65 Default unit: V

BUS<m>:USB:STRobe:THReshold <ThresholdStrobe>

Defines the threshold level for the strobe signal in the USB HSIC protocol.

Suffix:

<m>	1..4

Parameters:

<ThresholdStrobe>	Range: -2 to 2 Increment: 0.01 *RST: 0.65 Default unit: V

20.17.20.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:USB:TYPE <Type>

Selects the trigger type for USB analysis. The available trigger types depend on the activated USB protocol type.

Parameters:

<Type>

SOP | EOP | RST | SUSPend | RESume | TOKen | DATA | HANDshake | SPECial | ERRCond

SOP
Sets the trigger to the SOP (start of packet) field. The start of packet condition is the end of the SYNC field. The trigger instant is the end of the SOP field.

EOP
Sets the trigger to the EOP (end of packet) field. Not available for USB High Speed and USB HSIC protocol types. The trigger instant is the beginning of the EOP field.

RST
Sets the trigger to the Reset field. Not available for USB High Speed and USB HSIC protocol types. For more information on the reset condition, see the USB standard. The trigger instant is the end of the 10 ms period after the SE0 field.

SUSPend
Sets the trigger to the Suspend field. Not available for USB High Speed and USB HSIC protocol types. For more information on the suspend condition, see the USB standard. The trigger instant will be declared after the defined 3 ms timeout.

RESume
Sets the trigger to the Resume field. Not available for USB High Speed and USB HSIC protocol types. For more information on the resume condition, see the USB standard. The trigger instant will be declared after the defined 20 ms timeout.

TOKen
Sets the trigger to one out of four different token trigger types: OUT, IN, SOF, or SETUP.

DATA
Sets the trigger to one out of four different data trigger types: DATA0, DATA1, DATA2, or MDATA.

HANDshake
Sets the trigger to one out of four different handshake trigger types: ACK, NAK, STALL, or NYET.

SPECial
Sets the trigger to one out of four different Special PID trigger types: PREamble, ERR, SPLIT, or PING.

ERRCond
Sets the trigger to one out of seven different error condition trigger types: PID error, CRC5 error, CRC16 error, Bitstuffing error, Unexpected PID error, SE1 error, or Glitching error.

*RST: SOP

TRIGger<m>:USB:ACONdition <OperatorAddress>

Sets the operator to set a specific address or an address range. The address values are set with `TRIGger<m>:USB:AMIN` and `TRIGger<m>:USB:AMAX`.

Parameters:

<OperatorAddress> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one address value to be set using `TRIGger<m>:USB:AMIN`.

INRange | OORange
In range, out of range. These conditions require an address range to be set using `TRIGger<m>:USB:AMIN` and `TRIGger<m>:USB:AMAX`.

*RST: EQUal

TRIGger<m>:USB:AMIN <Address>

Specifies the address, or sets the the start value of an address range. The string parameter does not accept the bit value X (don't care).

Parameters:

<Address>

TRIGger<m>:USB:AMAX <AddressTo>

Sets the the end value of an address range if `TRIGger<m>:USB:ACONdition` is set to `INRange` or `OORange`. The string parameter does not accept the bit value X (don't care).

Parameters:

<AddressTo>

TRIGger<m>:USB:DATA <USBDataType>

Sets the trigger to one out of four different payload data types: DATA0, DATA1, DATA2, or MDATA.

Parameters:

<USBDataType>	D0 | D1 | D2 | MD **D0** Sets the trigger to the DATA0 field (even PID). **D1** Sets the trigger to the DATA1 field (odd PID). **D2** Sets the trigger to the DATA2 field (data packet PID for high-speed, high bandwidth isochronous transaction in a microframe). **MD** Sets the trigger to the MDATA field (high-speed data packet PID for split and high bandwidth isochronous transactions). *RST: D0

TRIGger<m>:USB:DCONdition <OperatorData>

Sets the operator (equal or unequal) to set a specific payload data pattern.

Parameters:

<OperatorData>	EQUal | NEQual *RST: EQUal

TRIGger<m>:USB:DPOPerator <OptorPosi>

Sets the operator (any or equal) for the payload data index position.

Parameters:

<OptorPosi>	ANY | OFF | EQUal **ANY = OFF** The position of the bit pattern within the payload data is not relevant. **EQUal** Sets the operator for specifying a special start position for the bit pattern within the payload data. *RST: ANY

TRIGger<m>:USB:DPOSition <DataPosition>

Specifies the position within a payload data packet, in which a special data pattern is to be searched.

Parameters:

<DataPosition>	Range: 0 to 1024 Increment: 1 *RST: 0

TRIGger<m>:USB:ECONdition <OptorEndpoint>

Sets the operator to set a specific endpoint or an endpoint range. The endpoint values are set with `TRIGger<m>:USB:EMIN` and `TRIGger<m>:USB:EMAX`.

Parameters:

<OptorEndpoint>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:USB:EMIN`. **INRange | OORange** In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:USB:EMIN` and `TRIGger<m>:USB:EMAX`. *RST: EQUal

---

TRIGger<m>:USB:EMIN <Endp>

Specifies the endpoint, or sets the the start value of an endpoint range.

Parameters:
<Endp>

TRIGger<m>:USB:EMAX <EndpTo>

Sets the the end value of an endpoint range if `TRIGger<m>:USB:ECONdition` is set to `INRange` or `OORange`.

Parameters:
<EndpTo>

TRIGger<m>:USB:ERRC <ErrCondTyp>

Sets the trigger to one of the following eight error condition types: PID error, CRC5 error, CRC16 error, Bitstuffing error, unexpected PID error, SE1 error, or Glitching error, as well as Any of these errors.

Parameters:

<ErrCondTyp>	ANY | PIDerror | CRC5error | CRC16error | BTST | UNEXpid | SE1error | GLITcherr **ANY** Triggers on any of the errors listed below. **PIDerror** Triggers on any packet identifier error. **CRC5error** Triggers on any CRC5 error event. **CRC16error** Triggers on any CRC16 error event. **BTST** Triggers on any Bitstuffing error event (erroneous or missing bit stuffing sequence, see USB standard). **UNEXpid** Triggers on any unexpected PID error (illegal PID, that is not allowed in USB low speed and USB full speed protocols, especially PID's announcing packets such as SPLIT, DATA2, MDATA, or other noncompliant packets). **SE1error** Triggers on the illegal bus state Single Ended 1 (SE1 = both lines high). **GLITcherr** Triggers on any Glitching error (illegal bit period, see USB standard for the definition of glitching). *RST: ANY

TRIGger<m>:USB:FCONdition <OptorFrmNo>

Sets the operator to set a specific frame number or a frame number range. The frame number values are set with `TRIGger<m>:USB:FMIN` and `TRIGger<m>:USB:FMAX`.

Parameters:

<OptorFrmNo>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one frame number value to be set using `TRIGger<m>:USB:FMIN`. **INRange | OORange** In range, out of range. These conditions require a range of frame number values to be set using `TRIGger<m>:USB:FMIN` and `TRIGger<m>:USB:FMAX`. *RST: EQUal

---

TRIGger<m>:USB:FMIN <FrameNumber>

Specifies the frame number, or sets the the start value of a frame number range.

Parameters:
<FrameNumber>

TRIGger<m>:USB:FMAX <FrameNumberTo>

Sets the the end value of a frame number range if `TRIGger<m>:USB:FCONdition` is set to `INRange` or `OORange`.

Parameters:
<FrameNumberTo>

TRIGger<m>:USB:HAND <HandshakeType>

Sets the trigger to one out of four different handshake types: ACK, NAK, STALl, or NYET.

Parameters:

<HandshakeType>	ACK | NAK | STALl | NYET **ACK** Sets the trigger to the ACK field (acknowledgment of error-free data packet). **NAK** Sets the trigger to the NAK field (non-acknowledgment, no successful data transmission). **STALl** Sets the trigger to the STALL field (endpoint is halted or a control pipe request is not supported). **NYET** Sets the trigger to the NYET field (no response yet from receiver). *RST: ACK

TRIGger<m>:USB:PATT <PayloadMuster>

Specifies the payload data pattern that is to be searched.

Parameters:
<PayloadMuster>

TRIGger<m>:USB:PCONdition <OperatorPort>

Sets the operator to set a specific port number or a port number range. The port number values are set with `TRIGger<m>:USB:PMIN` and `TRIGger<m>:USB:PMAX`.

Parameters:

<OperatorPort>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one port number to be set using `TRIGger<m>:USB:PMIN`. **INRange | OORange** In range, out of range. These conditions require a port number range to be set using `TRIGger<m>:USB:PMIN` and `TRIGger<m>:USB:PMAX`. *RST: EQUal

---

TRIGger<m>:USB:PMIN <Port>

Specifies the port number, or sets the the start value of a port number range.

Parameters:

<Port>

TRIGger<m>:USB:PMAX <PortTo>

Sets the the end value of a port number range if `TRIGger<m>:USB:PCONdition` is set to `INRange` or `OORange`.

Parameters:

<PortTo>

TRIGger<m>:USB:SCONdition <OperatorSEU>

Sets the operator to set a specific SEU or an SEU range. The SEU values are set with `TRIGger<m>:USB:SMIN` and `TRIGger<m>:USB:SMAX`.

For SEU, see "SEU check" on page 855.

Parameters:

<OperatorSEU>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The position of the SEU is not relevant. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one SEU value to be set using `TRIGger<m>:USB:SMIN`. **INRange | OORange** In range, out of range. These conditions require a range of SEU values to be set using `TRIGger<m>:USB:SMIN` and `TRIGger<m>:USB:SMAX`. *RST: EQUal

---

TRIGger<m>:USB:SMIN <SEU>

Specifies the SEU, or sets the the start value of an SEU range.

Parameters:

<SEU>

TRIGger<m>:USB:SMAX <SEUTo>

Sets the the end value of an SEU range if `TRIGger<m>:USB:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<SEUTo>

TRIGger<m>:USB:SPEC <USBSpecialType>

Sets the trigger to one out of four different Special PID types: PREamble, ERR, SPLit, or PING.

Parameters:

<USBSpecialType>	PREamble | ERR | SPLit | PING **PREamble** Sets the trigger to the PREamble PID **ERR** Sets the trigger to the ERRor PID **SPLit** Sets the trigger to the SPLIT PID (in USB high speed transactions) **PING** Sets the trigger to the PING PID (in USB high speed transactions, flow control probe for a bulk/control endpoint) *RST: PREamble

---

TRIGger<m>:USB:STCO <SC>

Sets the trigger to a specific start-split or complete-split transaction endpoint.

Parameters:

<SC>	ONE | ZERO | DC **ONE** SC = 1 represents a complete-split (CSPLIT) transaction. **ZERO** SC = 0 represents a start-split (SSPLIT) transaction. **DC** SC = X represents "don't care" (DC) *RST: DC

TRIGger<m>:USB:TCONdition <OperatorET>

Sets the operator to set a specific endpoint type (ET) or an ET range. The ET values are set with `TRIGger<m>:USB:TMIN` and `TRIGger<m>:USB:TMAX`.

Parameters:

<OperatorET>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The position of the endpoint type is not relevant. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one ET value to be set using `TRIGger<m>:USB:TMIN`. **INRange | OORange** In range, out of range. These conditions require a range of ET values to be set using `TRIGger<m>:USB:SMIN` and `TRIGger<m>:USB:SMAX`. *RST: EQUal

---

TRIGger<m>:USB:TMIN <ET>

Specifies the endpoint type, or sets the the start value of an endpoint type range.

Parameters:

<ET>

TRIGger<m>:USB:TMAX <ETTo>

Sets the the end value of an endpoint type range if `TRIGger<m>:USB:TCONdition` is set to `INRange` or `OORange`.

Parameters:

<ETTo>

TRIGger<m>:USB:TOKen <USBTokenType>

Sets the trigger to one out of four different token types: OUT, IN, SOF, or SETup.

Parameters:

<USBTokenType>	OUT | IN | SOF | SETup **OUT** Sets the trigger to the OUT token (OUT packet from host to device). **IN** Sets the trigger to the IN token (IN packet from device to host). **SOF** Sets the trigger to the SOF token (start of frame marker and frame number). **SETup** Sets the trigger to the SETUP token (address and endpoint number in OUT transaction for setup to a control pipe). *RST: OUT

TRIGger<m>:USB:WADD <WthAddrChk>

Defines, whether the address check shall be activated or not.

Parameters:

<WthAddrChk>	ON | OFF *RST: OFF

TRIGger<m>:USB:WEND <WithEndpCheck>

Defines, whether the endpoint check shall be activated or not.

Parameters:

<WithEndpCheck>	ON | OFF *RST: OFF

TRIGger<m>:USB:WETCheck <WithETCheck>

Defines, whether the Endpoint Type (ET) check shall be activated or not.

Parameters:

<WithETCheck>	ON | OFF *RST: OFF

TRIGger<m>:USB:WFRN <WithFrameNoChk>

Defines, whether the frame number check shall be activated or not.

Parameters:

<WithFrameNoChk>	ON | OFF *RST: OFF

TRIGger<m>:USB:WPAY <WthPloadChk>

Defines, whether the payload data check shall be activated or not.

Parameters:

<WthPloadChk>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WPID <WithPIDCheck>

Defines, whether the packet ID error check shall be activated or not.

Parameters:

<WithPIDCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WPOR <WithPortCheck>

Defines, whether the port check shall be activated or not.

Parameters:

<WithPortCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WSEU <WithSEUCheck>

Defines, whether the SEU check shall be activated or not.

For SEU, see "SEU check" on page 855.

Parameters:

<WithSEUCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WSTC <WithSCCheck>

Defines, whether the Start / Complete (SC) check shall be activated or not.

Parameters:

<WithSCCheck>	ON | OFF	
	*RST:	OFF

20.17.20.3 Decode Results

In all `BUS<m>:USB:PACKet<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the packet number in the decode table.

As an example, with reference to Figure 12-116 (packet #19) in Chapter 12.19.4, "USB Decode Results", on page 856, the status of the Token IN packet can be queried in the following way:

- `BUS:USB:PACKet19:STAT?`

  The result of this remote command query should be "OK".

BUS<m>:USB:PACKet<n>:PID?

Returns the packet PID for the selected serial bus and packet number.

Suffix:

<m>	1..4
<n>	*

Return values:

<PID>

RES | OUT | ACK | DATA0 | DATa0 | PING | SOF | NYET | DATA2 | DATa2 | SPLIT | SPLit | IN | NAK | DATA1 | DATa1 | PRE | SETUP | SETup | STALL | STALl | MDATA | MDATa | UNK

RES
RES = Reserved

OUT
OUT Token PID

IN
IN Token PID

SOF
Start Of Frame PID

SETUP = SETup
SETUP PID

DATA0 = DATa0
DATA0 PID, even PID

DATA1 = DATa1
DATA1 PID, odd PID

DATA2 = DATa2
DATA2 PID (only valid in USB high speed and USB HSIC protocols)

MDATA = MDATa
MDATA PID (only valid in USB high speed and USB HSIC protocols)

ACK
ACKnowledgment PID

NAK
Non-AcKnowledgment PID

STALL = STALl
STALL PID

NYET
Not ready YET (only valid in USB high speed and USB HSIC protocols)

PRE
PREamble PID (only valid in USB high speed and USB HSIC protocols)

SPLIT = SPLit
SPLIT PID (only valid in USB high speed and USB HSIC protocols)

PING
PING PID (only valid in USB high speed and USB HSIC protocols)

UNK

UNK = Unknown PID

*RST: RES

Usage: Query only

BUS<m>:USB:PACKet<n>:ADDRess?

Returns the packet address for the selected serial bus and packet number.

Suffix:

<m>	1..4
<n>	*

Usage: Query only

BUS<m>:USB:PACKet<n>:CRC?

Returns the packet CRC (Cyclic Redundancy Code) for the selected serial bus and packet number.

Suffix:

<m>	1..4
<n>	*

Usage: Query only

BUS<m>:USB:PACKet<n>:DATA?

Returns the payload data from the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Parameters:

<Data> Comma-separated sequence of integer values (N, D1, D2,…, DN). N is the number of bytes in the packet. and D1…DN are the values of the bytes.

Example:

```
BUS:USB:PACKet4:DATA?
<-- 6,18,52,86,120,154,188
```

Usage: Query only

BUS<m>:USB:PACKet<n>:ENDPoint?

Returns the endpoint for the selected serial bus and packet number.

Suffix:

<m>	1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:ET?

Returns the endpoint type (ET) for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:FRAMe?

Returns the frame number for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:PORT?

Returns the port number for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:SC?

Returns the Start- / Complete-split transaction (SSPLIT / CSPLIT) flag bits for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:SEU?

Returns the SEU values for the selected serial bus and packet number.

For SEU, see "SEU check" on page 855.

Suffix:

<m>	1..4
<n>	*

Usage:	Query only

BUS<m>:USB:PACKet<n>:STARt?

Returns the start position of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Usage:	Query only

BUS<m>:USB:PACKet<n>:STATus?

Returns the status of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<State>	OK | PID | CRC | BTST | GLITCH | GLITch | BYTE *RST: OK

Usage:	Query only

BUS<m>:USB:PACKet<n>:STOP?

Returns the stop time of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s

Usage:	Query only

BUS<m>:USB:PCOunt?

Returns the packet count for the selected serial bus, i.e. the number of packets in the present acquisition.

Suffix:

<m>	1..4

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage:	Query only

20.17.20.4 Search Settings

SEARch:TRIGger:USB:ACONdition <SearchName>,<OperatorAddress>
SEARch:TRIGger:USB:ACONdition? <SearchName>

Sets the operator to set a specific address or an address range.

Parameters:

<OperatorAddress> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one address value to be set using `SEARch:TRIGger:USB:AMIN`.

INRange | OORange
In range, out of range. These conditions require an address range to be set using `SEARch:TRIGger:USB:AMIN` and `SEARch:TRIGger:USB:AMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:AMIN <SearchName>,<Address>
SEARch:TRIGger:USB:AMIN? <SearchName>

Specifies an address, or sets the start value of an address range. The string parameter does not accept the bit value X (don't care).

Parameters:
<Address>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:AMAX <SearchName>,<AddressTo>
SEARch:TRIGger:USB:AMAX? <SearchName>

Sets the the end value of an address range if `TRIGger<m>:USB:ACONdition` is set to `INRange` or `OORange`. The string parameter does not accept the bit value X (don't care).

Parameters:
<AddressTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:BITSterror <SearchName>,<SearchBstffErr>
SEARch:TRIGger:USB:BITSterror? <SearchName>

Defines, whether a search for any bitstuffing error shall be activated or not.

Parameters:

<SearchBstffErr>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:CRC16error <SearchName>,<SearchCRC16Err>
SEARch:TRIGger:USB:CRC16error? <SearchName>

Defines, whether a search for any CRC16 error shall be activated or not.

Parameters:

<SearchCRC16Err>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:CRC5error <SearchName>,<SearchCRC5Error>
SEARch:TRIGger:USB:CRC5error? <SearchName>

Defines, whether a search for any CRC5 error shall be activated or not.

Parameters:

<SearchCRC5Error>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DATA <SearchName>,<USBDataType>
SEARch:TRIGger:USB:DATA? <SearchName>

Defines, which data packet type is searched for: "DATA0", "DATA1", "DATA2", or "MDATA", as well as "Any" data packet.

Parameters:

<USBDataType> ANY | D0 | D1 | D2 | MD

ANY
Searches for any of the data packet types listed below

D0
Searches for a DATA0 packet (even PID)

D1
Searches for a DATA1 packet (odd PID)

D2
Searches for a DATA2 packet (high-speed data packet for high bandwidth isochronous transaction in a microframe)

MD
Searches for an MDATA packet (high-speed data packet for split and high bandwidth isochronous transactions)

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DCONdition <SearchName>,<OperatorData>
SEARch:TRIGger:USB:DCONdition? <SearchName>

Sets the operator (equal or unequal) to set a specific payload data pattern.

Parameters:

<OperatorData> EQUal | NEQual

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DPOPerator <SearchName>,<OptorPosi>
SEARch:TRIGger:USB:DPOPerator? <SearchName>

Sets the operator (any or equal) for the payload data index position.

Parameters:

<OptorPosi> ANY | OFF | EQUal

ANY = OFF
The position of payload data is not relevant for the search condition.

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:USB:DPOSition? <SearchName>

Specifies the position within a payload data packet, in which a special data pattern is to be searched.

Parameters:

<DataPosition>	Range:	0 to 1024
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:ECONdition <SearchName>,<OptorEndpoint>
SEARch:TRIGger:USB:ECONdition? <SearchName>

Sets the operator to set a specific endpoint or an endpoint range. The endpoint values are set with `SEARch:TRIGger:USB:EMIN` and `SEARch:TRIGger:USB:EMAX`.

Parameters:

<OptorEndpoint>

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:USB:EMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:USB:EMIN` and `SEARch:TRIGger:USB:EMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:EMIN <SearchName>,<Endp>
SEARch:TRIGger:USB:EMIN? <SearchName>

Specifies an endpoint, or sets the start value of an endpoint range.

Parameters:
<Endp>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:EMAX <SearchName>,<EndpTo>
SEARch:TRIGger:USB:EMAX? <SearchName>

Sets the the end value of an endpoint range if `TRIGger<m>:USB:ECONdition` is set to `INRange` or `OORange`.

Parameters:
<EndpTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FCONdition <SearchName>,<OptorFrmNo>
SEARch:TRIGger:USB:FCONdition? <SearchName>

Sets the operator to set a specific frame number or a frame number range. The frame number values are set with `SEARch:TRIGger:USB:FMIN` and `SEARch:TRIGger:USB:FMAX`.

Parameters:

<OptorFrmNo>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one frame number value to be set using `SEARch:TRIGger:USB:FMIN`. **INRange | OORange** In range, out of range. These conditions require a range of frame number values to be set using `SEARch:TRIGger:USB:FMIN` and `SEARch:TRIGger:USB:FMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FMIN <SearchName>,<FrameNumber>
SEARch:TRIGger:USB:FMIN? <SearchName>

Specifies a frame number, or sets the start value of a frame number range.

Parameters:
<FrameNumber>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FMAX <SearchName>,<FrameNumberTo>
SEARch:TRIGger:USB:FMAX? <SearchName>

Sets the the end value of a frame number range if `TRIGger<m>:USB:FCONdition` is set to `INRange` or `OORange`.

Parameters:
<FrameNumberTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:GLITcherror <SearchName>,<SearchGlitchErr>
SEARch:TRIGger:USB:GLITcherror? <SearchName>

Defines, whether a search for any glitch error shall be activated or not.

Parameters:

<SearchGlitchErr>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:HAND <SearchName>,<HandshakeType>
SEARch:TRIGger:USB:HAND? <SearchName>

Defines, which handshake type is searched for.

Parameters:

<HandshakeType>	ANY | ACK | NAK | STALI | NYET *RST: ACK

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PATT <SearchName>,<PayloadMuster>
SEARch:TRIGger:USB:PATT? <SearchName>

Defines the payload data pattern to search for.

Parameters:
<PayloadMuster>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PCONdition <SearchName>,<OperatorPort>
SEARch:TRIGger:USB:PCONdition? <SearchName>

Sets the operator to set a specific port number or a port number range. The port number values are set with `SEARch:TRIGger:USB:PMIN` and `SEARch:TRIGger:USB:PMAX`.

Parameters:

<OperatorPort>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one port number to be set using `SEARch:TRIGger:USB:PMIN`. **INRange | OORange** In range, out of range. These conditions require a port number range to be set using `SEARch:TRIGger:USB:PMIN` and `SEARch:TRIGger:USB:PMAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PMIN <SearchName>,<Port>
SEARch:TRIGger:USB:PMIN? <SearchName>

Specifies a port number, or sets the start value of a port number range.

Parameters:
<Port>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PMAX <SearchName>,<PortTo>
SEARch:TRIGger:USB:PMAX? <SearchName>

Sets the the end value of a port number range if `TRIGger<m>:USB:PCONdition` is set to `INRange` or `OORange`.

Parameters:
<PortTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PIDerror <SearchName>,<SearchPIDError>
SEARch:TRIGger:USB:PIDerror? <SearchName>

Defines, whether a search for any PID error shall be activated or not.

Parameters:

<SearchPIDError>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SCONdition <SearchName>,<OperatorSEU>
SEARch:TRIGger:USB:SCONdition? <SearchName>

Sets the operator to set a specific SEU or an SEU range. The SEU values are set with `SEARch:TRIGger:USB:SMIN` and `SEARch:TRIGger:USB:SMAX`.

For SEU, see "SEU check" on page 855.

Parameters:

<OperatorSEU> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The SEU is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one SEU value to be set using `SEARch:TRIGger:USB:SMIN`.

INRange | OORange
In range, out of range. These conditions require a range of SEU values to be set using `SEARch:TRIGger:USB:SMIN` and `SEARch:TRIGger:USB:SMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SMIN <SearchName>,<SEU>
SEARch:TRIGger:USB:SMIN? <SearchName>

Specifies an SEU, or sets the start value of an SEU range.

Parameters:
<SEU>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SMAX <SearchName>,<SEUTo>
SEARch:TRIGger:USB:SMAX? <SearchName>

Sets the the end value of an SEU range if `TRIGger<m>:USB:SCONdition` is set to `INRange` or `OORange`.

Parameters:
<SEUTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SDATa <SearchName>,<SearchDatPkt>
SEARch:TRIGger:USB:SDATa? <SearchName>

Defines, whether the search for any data packet shall be activated or not.

Parameters:

<SearchDatPkt>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SERRor <SearchName>,<SearchErrCond>
SEARch:TRIGger:USB:SERRor? <SearchName>

Defines, whether the search for any error condition shall be activated or not.

Parameters:

<SearchErrCond>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SHANdshake <SearchName>,<SearchHdshkPkt>
SEARch:TRIGger:USB:SHANdshake? <SearchName>

Defines, whether the search for any handshake packet shall be activated or not.

Parameters:

<SearchHdshkPkt>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SSOP <SearchName>,<SearchStrtPkt>
SEARch:TRIGger:USB:SSOP? <SearchName>

Defines, whether a start of packet (SOP) search shall be activated or not.

Parameters:

<SearchStrtPkt>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SSPE <SearchName>,<SearchSpclPkt>
SEARch:TRIGger:USB:SSPE? <SearchName>

Defines, whether the search for any special PID packet shall be activated or not.

Parameters:

<SearchSpclPkt>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SPEC <SearchName>,<USBSpecialType>
SEARch:TRIGger:USB:SPEC? <SearchName>

Defines, which special PID packet type is searched for: "PREamble", "ERR", "SPLit", "PING", or "Any" special PID packet.

Parameters:

<USBSpecialType>	ANY | PREamble | ERR | SPLit | PING **ANY** Searches for any of the special PID packet types listed below **PREamble** Searches for any host-issued preamble token (enables downstream bus traffic to low speed USB devices) **ERR** Searches for any SPLIT transaction error handshake token (reuses PRE value) **SPLit** Searches for any high speed SPLIT transaction token **PING** Searches for any high speed flow control probe for a bulk/control endpoint *RST: PREamble

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:STCO <SearchName>,<SC>
SEARch:TRIGger:USB:STCO? <SearchName>

Defines, which Start- / Complete- (SC) split transaction type is searched for: SSPLIT or CSPLIT.

Parameters:

<SC>	ONE | ZERO | DC **ONE** SC = 1 represents a complete-split (CSPLIT) transaction **ZERO** SC = 0 represents a start-split (SSPLIT) transaction **DC** SC = X represents "don't care" (DC) *RST: DC

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:USB:STOKen <SearchName>,<SearchTokenPkt>
SEARch:TRIGger:USB:STOKen? <SearchName>

Defines, whether a search for any token packet shall be activated or not.

Parameters:

<SearchTokenPkt>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:USB:TCONdition <SearchName>,<OperatorET>
SEARch:TRIGger:USB:TCONdition? <SearchName>

Sets the operator to set a specific endpoint type (ET) or an ET range. The ET values are set with `SEARch:TRIGger:USB:TMIN` and `SEARch:TRIGger:USB:TMAX`.

Parameters:

<OperatorET>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** The endpoint type is not relevant for the search condition. **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one ET value to be set using `SEARch:TRIGger:USB:TMIN`. **INRange | OORange** In range, out of range. These conditions require a range of ET values to be set using `SEARch:TRIGger:USB:TMIN` and `SEARch:TRIGger:USB:TMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:USB:TMIN <SearchName>,<ET>
SEARch:TRIGger:USB:TMIN? <SearchName>

Specifies an endpoint type (ET), or sets the start value of an ET range.

Parameters:
<ET>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TMAX <SearchName>,<ETTo>
SEARch:TRIGger:USB:TMAX? <SearchName>

Sets the the end value of an endpoint type (ET) range if `TRIGger<m>:USB:TCONdition` is set to `INRange` or `OORange`.

Parameters:
<ETTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TOKen <SearchName>,<USBTokenType>
SEARch:TRIGger:USB:TOKen? <SearchName>

Defines, which token packet type is searched for: "OUT", "IN", "SOF", "SETUP", or "Any" token packet.

Parameters:

<USBTokenType>	ANY | OUT | IN | SOF | SETup **ANY** Searches for any of the token packet types listed below. **OUT** Searches for an OUT token. **IN** Searches for an IN token. **SOF** Searches for a start of frame (SOF) token. **SETup** Searches for a SETup token. *RST: OUT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WADD <SearchName>,<WthAddrChk>
SEARch:TRIGger:USB:WADD? <SearchName>

Defines, whether a search for any address field shall be activated or not.

Parameters:

<WthAddrChk>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WEND <SearchName>,<WithEndpCheck>
SEARch:TRIGger:USB:WEND? <SearchName>

Defines, whether a search for any endpoint shall be activated or not.

Parameters:

<WithEndpCheck>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WETCheck <SearchName>,<WithETCheck>
SEARch:TRIGger:USB:WETCheck? <SearchName>

Defines, whether a search for any Endpoint Type (ET) shall be activated or not.

Parameters:

<WithETCheck>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WFRN <SearchName>,<WithFrameNoChk>
SEARch:TRIGger:USB:WFRN? <SearchName>

Defines, whether a search for any frame number shall be activated or not.

Parameters:

<WithFrameNoChk>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPAY <SearchName>,<WthPloadChk>
SEARch:TRIGger:USB:WPAY? <SearchName>

Defines, whether a search for any payload data shall be activated or not.

Parameters:

<WthPloadChk>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPID <SearchName>,<WithPIDCheck>
SEARch:TRIGger:USB:WPID? <SearchName>

Defines, whether a search for any packet ID error shall be activated or not.

Parameters:

<WithPIDCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPOR <SearchName>,<WithPortCheck>
SEARch:TRIGger:USB:WPOR? <SearchName>

Defines, whether a search for any port shall be activated or not.

Parameters:

<WithPortCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WSEU <SearchName>,<WithSEUCheck>
SEARch:TRIGger:USB:WSEU? <SearchName>

Defines, whether a search for any SEU shall be activated or not.

For SEU, see "SEU check" on page 855.

Parameters:

<WithSEUCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WSTC <SearchName>,<WithSCCheck>
SEARch:TRIGger:USB:WSTC? <SearchName>

Defines, whether a search for any Start / Complete (SC) shall be activated or not.

Parameters:

<WithSCCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

20.17.20.5 Search Results

In all `SEARch:RESult:USB:PACKet<m>` commands, the suffix <m> selects the packet number in the list of search results.

SEARch:RESult:USB:PACKet<m>:ADDRess? <SearchName>

Returns the packet address for the selected packet number within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:CRC? <SearchName>

Returns the packet CRC (Cyclic Redundancy Code) for the selected packet number within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:DATA? <SearchName>

Returns the payload data from the packet with the selected packet number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:ENDPoint? <SearchName>

Returns the endpoint for the selected packet number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:ET? <SearchName>

Returns the endpoint type (ET) for the selected packet number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:FRAMe? <SearchName>

Returns the frame number for the selected packet number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:PID? <SearchName>

Returns the packet PID for the selected packet number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:	
<PID>	RES | OUT | ACK | DATA0 | DATa0 | PING | SOF | NYET | DATA2 | DATa2 | SPLIT | SPLit | IN | NAK | DATA1 | DATa1 | PRE | SETUP | SETup | STALL | STALl | MDATA | MDATa | UNK For a description of the return values, see `BUS<m>:USB:PACKet<n>:PID?` on page 1945. *RST: RES
Usage:	Query only

SEARch:RESult:USB:PACKet<m>:PORT? <SearchName>

Returns the port number for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:SC? <SearchName>

Returns the Start- / Complete-split transaction (SSPLIT / CSPLIT) flag bits for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:SEU? <SearchName>

Returns the SEU values for the selected packet number within the search result.

For SEU, see "SEU check" on page 855.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:STARt? <SearchName>

Returns the start time of the packet with the selected packet number within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s

Usage:	Query only

SEARch:RESult:USB:PACKet<m>:STATus? <SearchName>

Returns the status of the packet with the selected packet number within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<State>	OK | PID | CRC | BTST | GLITCH | GLITch | BYTE *RST: OK

Usage:	Query only

SEARch:RESult:USB:PACKet<m>:STOP? <SearchName>

Returns the stop time of the packet with the selected packet number within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s

Usage:	Query only

SEARch:RESult:USB:PCOunt? <SearchName>

Returns the search result's packet count, i.e. the number of packets found in the search result.

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

20.17.21 USB 3.1 (Option R&S RTO-K61)

20.17.21.1 Configuration

In all `BUS<m>:USBT` commands, the suffix <m> selects the serial bus.

BUS<m>:USBThree:SOURce <SourceData>

Selects the source for the data signal in the USB 3.1 protocol.

Suffix:
<m> 1..4

Parameters:
<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: C1W1

Usage: Asynchronous command

BUS<m>:USBThree:POLarity <Polarity>

Defines the polarity of the data signal for the active (U0) state of the port.

Suffix:

<m>	1..4

Parameters:

<Polarity> NORMal | INVert

NORMal
Normal (non-inverted) data signal polarity

INVert
Inverted data signal polarity

*RST: NORMal

BUS<m>:USBThree:THRHigh <ThresholdUpper>

Defines the upper threshold level for digitization of the data signal in the USB 3.1 protocol.

Suffix:

<m>	1..4

Parameters:

<ThresholdUpper>

Range: -2 to 2
Increment: 0.01
*RST: 0.05
Default unit: V

BUS<m>:USBThree:THRLow <ThresholdLower>

Defines the lower threshold level for digitization of the data signal in the USB 3.1 protocol.

Suffix:

<m>	1..4

Parameters:

<ThresholdLower>

Range: -2 to 2
Increment: 0.01
*RST: -0.05
Default unit: V

BUS<m>:USBThree:SCRMode <ScrambleMode>

Selects if the data pattern is scrambled or unscambled.

Suffix:

<m>	1..4

Parameters:

<ScrambleMode>	SCRM | NSCR **SCRM** Scrambling is enabled as specified in the standard, to minimize EMI emissions. **NSCR** No scrambling: To simplify testing and debugging, scrambling is disabled. *RST: SCRM

20.17.21.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:USBThree:TYPE <Type>

Selects the trigger type.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:	
<Type>	STARt | FRAMe | ERR **STARt** Frame (packet) start **FRAMe** Frame content. Define the frame and its content using the `TRIGger:USBThree:FRAMe:FIELd...` commands. **ERR** Errors. Define the error types with `TRIGger<m>:USBThree:ERRor:ENABle`. *RST: STARt

---

TRIGger<m>:USBThree:FRAMe:SELect <FrameName>

Selects the frame (packet) type.

For frames that contain fields, the packet selection can also be done implicit by a parameter in the `TRIGger:USBThree:FRAMe:FIELd...` command.

Suffix:	
<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
Setting parameters:	
<FrameName>	Specifies the name of the frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?`.
Usage:	Setting only

TRIGger<m>:USBThree:ERRor:ENABle <ErrorName>,<Enable>
TRIGger<m>:USBThree:ERRor:ENABle? <ErrorName>

Defines the error type to be triggered on. You can trigger on all error types in parallel.

Suffix:	
<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
Parameters:	
<Enable>	ON | OFF *RST: ON
Parameters for setting and query:	
<ErrorName>	The following error strings are available: "CRC Error", "Length Error", and "Value out of range"
Example:	Trigger on CRC and length errors:

```
TRIGger:USBThree:ERRor:ENABle "CRC Error",ON
TRIGger:USBThree:ERRor:ENABle "Length Error",ON
TRIGger:USBThree:ERRor:ENABle "Value out of
range",OFF
```

TRIGger<m>:USBThree:FRAMe:FIELd<n>:ENABle <FrameName>,<CondEnabler>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:ENABle? <FrameName>

Enables or disables the checking condition for a specific data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<CondEnabler>	ON | OFF **ON** Checking condition enabled **OFF** Checking condition disabled *RST: OFF

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:DOPerator
<FrameName>,<DataOperator>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:DOPerator? <FrameName>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMIN`. **INRange | OORange** In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMIN` and `TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMAX`. *RST: EQUal

Parameters for setting and query:

<FrameName>	Specifies the name of the frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMIN <FrameName>,<DataMin>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMIN? <FrameName>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<DataMin>	Specifies the data pattern or the start value of a data pattern range within the field.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMAX <FrameName>,<DataMax>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:DMAX? <FrameName>

Sets the end value of a data pattern range if `TRIGger<m>:USBThree:FRAMe:FIELd<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n>	* Specifies the field number within the frame.

Parameters:

<DataMax>	Specifies the end value of a data pattern range within the field.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:BIT <FrameName>,<BitState>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:BIT? <FrameName>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" (DC) = X

*RST: DC

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:IOPerator <FrameName>,<IndexOperator>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:IOPerator? <FrameName>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<IndexOperator>	EQUal | INRange | RANGe **EQUal** This condition requires one endpoint value to be set using `TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMIN`. **INRange | RANGe** This condition requires a range of endpoint values to be set using `TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMIN` and `TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMAX`. *RST: INRange

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMIN <FrameName>,<IndexMin>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMIN? <FrameName>

Specifies the index, or sets the start value of an index range.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<IndexMin>	Specifies the index value or index start value within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMAX <FrameName>,<IndexMax>
TRIGger<m>:USBThree:FRAMe:FIELd<n>:IMAX? <FrameName>

Sets the end value of an index range if `TRIGger<m>:USBThree:FRAMe:FIELd<n>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1978.

20.17.21.3 Decode Results

In all `BUS<m>:USBT:RESult:FRAMe<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:USBThree:RESult:FCOunt?

Returns the number of decoded frames in the selected serial bus.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range: 0 to 100000 Increment: 1

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:INFO?

Returns specific frame information details of the selected frame. This information is also shown in the "Info" column of the decode results table, see Figure 12-123.

Suffix:

<m>	1..4
<n>	* Specifies the frame number.

Return values:

<Info>

Usage:	Query only

BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?

Returns the frame type for the selected serial bus and frame number.

Suffix:

<m>	1..4
<n>	* Selects the frame number.

Return values:

<FrameType>	TSEQ | TS1T | TS2T | SLF | U2IT | VDT | PCAP | PCNF | PCNR | LDM | ACK | NRDY | ERDY | STATus | STALI | FWAKe | LTM | BIAM | HRR | SSPD | PING | PNGR | DPH | DPP | DPPA | ITP | LC | SKIP | BRST | BDAT | BERC | BCNT | IDLE | UHP | ULMP | UTP | UDVN | UDEF | ERRor For a description of the frame types, see "Frame types" on page 871.
Usage:	Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STATe?

Returns the status of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.

Return values:

<State>	OK | INComplete | UNCorrelated | UNKNown | CRC | LENGth | VOOR **VOOR** Value out of range
Usage:	Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STARt?

Returns the start time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STOP?

Returns the stop time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *
Selects the frame number.

Return values:

<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *
Selects the frame number.

<o> *
Selects the field number.

Return values:

<FieldType>

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STATus?

Returns the status of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *
Selects the frame number.

<o>	* Selects the field number.

Return values:

<FieldState>	OK | INComplete | UNCorrelated | UNKNown | CRC | LENGth | VOOR **VOOR** Value out of range

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FrameByteValue>

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FrameByteValue>

Usage: Query only

20.17.21.4 Search Settings

SEARch:TRIGger:USBThree:TYPE <SearchName>,<Type>
SEARch:TRIGger:USBThree:TYPE? <SearchName>

Selects the search type.

Parameters:

<Type>	STARt | FRAMe | ERR **STARt** Frame (packet) start **FRAMe** Frame content. Define the frame and its content using the `SEARch:TRIGger:USBThree:FRAMe:FIELd...` commands. **ERR** Errors. Define the error types with `SEARch:TRIGger:USBThree:ERRor:ENABle`. *RST: STARt

Parameters for setting and query:

<SearchName>	String with the name of the search.

SEARch:TRIGger:USBThree:FRAMe:SELect <SearchName>, <FrameName>

Selects the frame (packet) type.

For frames that contain fields, the packet selection can also be done implicit by a parameter in the `TRIGger:USBThree:FRAMe:FIELd...` command.

Setting parameters:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?`.

Usage: Setting only

SEARch:TRIGger:USBThree:ERRor:ENABle <SearchName>,
<ErrorName>,<Enable>
SEARch:TRIGger:USBThree:ERRor:ENABle? <SearchName>, <ErrorName>

Defines the error type to be searched for. You can search for all error types in parallel.

Parameters:

<Enable>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String with the name of the search.
<ErrorName>	The following error strings are available: "CRC Error", "Length Error", and "Value out of range"

Example: Search for CRC and length errors:

```
SEARch:TRIGger:USBThree:ERRor:ENABle "CRC
Error",ON
SEARch:TRIGger:USBThree:ERRor:ENABle "Length
Error",ON
SEARch:TRIGger:USBThree:ERRor:ENABle "Value out
of range",OFF
```

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:ENABle <SearchName>, <FrameName>,<CondEnabler>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:ENABle? <SearchName>, <FrameName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<CondEnabler>	ON | OFF **ON** Checking condition enabled **OFF** Checking condition disabled *RST: OFF

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DOPerator <SearchName>, <FrameName>,<DataOperator>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DOPerator? <SearchName>, <FrameName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN`. **INRange | OORange** In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN` and `SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMAX` on page 1986. *RST: EQUal

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMIN <SearchName>, <FrameName>,<DataMin>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMIN? <SearchName>, <FrameName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataMin>	Specifies the data pattern or the start value of a data pattern range within the field to be searched.

Parameters for setting and query:

<SearchName>	String with the name of the search.

<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMAX <SearchName>,
<FrameName>,<DataMax>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DMAX? <SearchName>,
<FrameName>

Sets the end value of a data pattern range if `SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataMax>	Specifies the end value of a data pattern range within the field to be searched.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:BIT <SearchName>,
<FrameName>,<BitState>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:BIT? <SearchName>,
<FrameName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<BitState>	ONE | ZERO | DC **ONE** 1 **ZERO** 0 **DC** "Don't care" (DC) = X *RST: DC

Parameters for setting and query:

<SearchName>	String with the name of the search.

<FrameName>	Specifies the name of the frame, see SEARch:RESult:USBThree:FRAMe<m>:TYPE?.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IOPerator <SearchName>,
<FrameName>,<IndexOperator>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IOPerator? <SearchName>,
<FrameName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN.

INRange | RANGe
This condition requires a range of endpoint values to be set using SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN and SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMAX.

*RST: INRange

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see SEARch:RESult:USBThree:FRAMe<m>:TYPE? on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN <SearchName>,
<FrameName>,<IndexMin>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMIN? <SearchName>,
<FrameName>

Specifies the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<IndexMin>	Specifies the index value or the start value of an index range within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMAX <SearchName>, <FrameName>,<IndexMax>
SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IMAX? <SearchName>, <FrameName>

Sets the end value of an index range if `SEARch:TRIGger:USBThree:FRAMe:FIELd<m>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1986.

20.17.21.5 Search Results

In all `SEARch:RESult:USBThree:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:USBThree:FRAMe<m>:TYPE? <SearchName>

Returns the frame type for the selected frame number within the search result.

Suffix:	
<m>	*
Query parameters:	
<SearchName>	
Return values:	
<FrameType>	TSEQ | TS1T | TS2T | SLF | U2IT | VDT | PCAP | PCNF | PCNR | LDM | ACK | NRDY | ERDY | STATus | STALI | FWAKe | LTM | BIAM | HRR | SSPD | PING | PNGR | DPH | DPP | DPPA | ITP | LC | SKIP | BRST | BDAT | BERC | BCNT | IDLE | UHP | ULMP | UTP | UDVN | UDEF | ERRor For a description of the frame types, see "Frame types" on page 871.
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:INFO? <SearchName>

Returns specific frame information details of the selected frame in the search result. This information is also shown in the "Info" column of the decode results table, see Figure 12-123.

Suffix:	
<m>	* Specifies the frame number.
Query parameters:	
<SearchName>	
Return values:	
<Info>	
Usage:	Query only

SEARch:RESult:USBThree:FCOunt? <SearchName>

Returns the number of decoded frames in the search result.

Query parameters:	
<SearchName>	
Return values:	
<FrameCount>	
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:STATe? <SearchName>

Returns the status of the frame with the selected frame number within the search result.

Suffix:	
<m>	*

Query parameters:
<SearchName>

Return values:

<State>	OK | INComplete | UNCorrelated | UNKNown | CRC | LENGth | VOOR **VOOR** Value out of range
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:STARt? <SearchName>

Returns the start time of the frame with the selected frame number within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:STOP? <SearchName>

Returns the stop time of the frame with the selected frame number within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:TYPE? <SearchName>

Returns the field name of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*

<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldType>

Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STATus? <SearchName>

Returns the field status of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:

<FieldState>	OK | INComplete | UNCorrelated | UNKNown | CRC | LENGth | VOOR **VOOR** Value out of range
Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:VAL? <SearchName>

Returns the value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<FrameByteValue>

Usage:	Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:FVAL? <SearchName>

Returns the formatted value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<FrameByteValue>

Usage: Query only

20.17.22 USBPD (Option R&S RTO-K63)

20.17.22.1 Configuration

In all `BUS<m>:USBPd` commands, the suffix <m> selects the serial bus.

BUS<m>:USBPd:DETail <Detail>

If enabled, the data words are broken down into subframes. If not enabled the data words are displayed as 32-bit data words.

Suffix:

<m>	1..4

Parameters:

<Detail>	ON | OFF *RST: OFF

BUS<m>:USBPd:HYSTeresis <Hysteresis>

Sets a value for the hysteresis of the data.

Suffix:

<m>	1..4

Parameters:

<Hysteresis>	Range: -10 to 10 Increment: 0.01 *RST: 0.05 Default unit: V

BUS<m>:USBPd:SOURce <SourceData>

Selects the source for the data signal in the USBPD protocol.

For triggering on a serial bus, analog or digital input channels are required.

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
Usage:	Asynchronous command

BUS<m>:USBPd:THReshold <Threshold>

Sets the threshold value of the data.

Suffix:

<m>	1..4

Parameters:

<Threshold>	Range: -10 to 10 Increment: 0.01 *RST: 0.6 Default unit: V

BUS<m>:USBPd:THRBottom <ThresholdBot>

Sets the bottom threshold (for the low current) for the current advertisment mode.

Suffix:

<m>	1..4

Parameters:

<ThresholdBot>	Range: -10 to 10 Increment: 0.01 *RST: 0.2 Default unit: V

BUS<m>:USBPd:THRMid <ThresholdMid>

Sets the middle threshold (at default USB Type-C currnet) for the current advertisment mode.

Suffix:

<m>	1..4

Parameters:

<ThresholdMid>	Range: -10 to 10 Increment: 0.01 *RST: 0.66 Default unit: V

BUS<m>:USBPd:THRTop <ThresholdTop>

Sets the top threshold (at USB Type-C currnet of 1.5 A) for the current advertisment mode.

Suffix:

<m>	1..4

Parameters:

<ThresholdTop>	Range: -10 to 10 Increment: 0.01 *RST: 1.23 Default unit: V

20.17.22.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:USBPd:TYPE <Type>

Sets the trigger type for the USBPD analysis.

Suffix:

<m>	1..3

Parameters:

<Type>	STARt | FRAMe | ERR *RST: STARt

TRIGger<m>:USBPd:ERRor:ENABle <ErrorName>,<Enable>
TRIGger<m>:USBPd:ERRor:ENABle? <ErrorName>

Enables or disables the checking condition for a specific error in the selected field of the selected frame.

Suffix:

<m>	1..3

Parameters:

<Enable>	ON | OFF *RST: ON

Parameters for setting and query:

<ErrorName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:SELect <FrameName>

Selects the frame to be triggered on, if the frame does not have any fields, e.g. a test frame.

Suffix:

<m>	1..3

Setting parameters:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

Usage: Setting only

TRIGger<m>:USBPd:FRAMe:FIELd<n>:BIT <FrameName>,<BitState>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:BIT? <FrameName>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<BitState>	ONE | ZERO | DC **ONE** 1 **ZERO** 0 **DC** "Don't care" (DC) = X *RST: DC

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMAX <FrameName>,<DataMax>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMAX? <FrameName>

Sets the end value of a data pattern range if `TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMAX` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<DataMax>	Specifies the end value of a data pattern range within the field.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMIN <FrameName>,<DataMin>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMIN? <FrameName>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<DataMin>	Specifies the data pattern or the start value of a data pattern range within the field.

Parameters for setting and query:

<FrameName>

TRIGger<m>:USBPd:FRAMe:FIELd<n>:DOPerator <FrameName>,<DataOperator>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:DOPerator? <FrameName>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMIN`. **INRange | OORange** In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMIN` and `TRIGger<m>:USBPd:FRAMe:FIELd<n>:DMAX`. *RST: EQUal

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:ENABle <FrameName>,<CondEnabler>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:ENABle? <FrameName>

Enables or disables the checking condition for a specific data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<CondEnabler>	ON | OFF **ON** Checking condition enabled **OFF** Checking condition disabled *RST: OFF

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMAX <FrameName>,<IndexMax>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMAX? <FrameName>

Sets the end value of an index range if `TRIGger<m>:USBPd:FRAMe:FIELd<n>:IOPerator` on page 1996 is set to `INRange` or `RANGe`.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMIN <FrameName>,<IndexMin>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMIN? <FrameName>

Specifies the index, or sets the start value of an index range.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.

Parameters:

<IndexMin>	Specifies the index value or index start value within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<FrameName>	Specifies the name of the generic trigger setting frame, see `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 2001.

TRIGger<m>:USBPd:FRAMe:FIELd<n>:IOPerator <FrameName>,<IndexOperator>
TRIGger<m>:USBPd:FRAMe:FIELd<n>:IOPerator? <FrameName>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m>	1..3

<n>	*

Parameters:

<IndexOperator>	EQUal | INRange | RANGe **EQUal** This condition requires one endpoint value to be set using `TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMIN`. **INRange | RANGe** This condition requires a range of endpoint values to be set using `TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMIN` and `TRIGger<m>:USBPd:FRAMe:FIELd<n>:IMAX`. *RST: INRange

Parameters for setting and query:

<FrameName>

20.17.22.3 Decode Results

In all `BUS<m>:USBPd:RESult:FRAMe<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:USBPd:RESult:FCOunt?

Returns the number of decoded frames in the selected serial bus.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range: 0 to 100000 Increment: 1

Usage:	Query only

BUS<m>:USBPd:RESult:FRAMe<n>:DATA?

Returns the data from the frame with the selected frame number (for the selected serial bus). This is the hex value of the first four bytes of data fields, prefixed by the total number of data fields (in square brackets), e.g. `[5]FF008041`.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FrameByteValue>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STATus?

Returns the status of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FieldState> OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP

Start of packet warning

CRC

Cyclic redundancy check error

FBFB

4b5b error

*RST: OK

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:
<FieldType>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:
<FrameByteValue>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:INFO?

Returns information on the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:
<Info>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STARt?

Returns the start time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STATe?

Returns the status of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<State> OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP
Start of packet warning

CRC
Cyclic redundancy check error

FBFB
4b5b error

*RST: OK

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STOP?

Returns the stop time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s
Usage:	Query only

BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?

Returns the frame type for the selected serial bus and frame number.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType>	STARt | RESet | CTRL | DATA | BIST | RQST | SINK | SRC | VEND | BATT | ALRT | XMSG | XSRC | XSTA | XGBC | XGBS | XBAC | XGMI | XMFI | XSRQ | XSRS | XFRQ | XFRS | TEST | LOWP | UNKNown For a description of the frame types, see "Frame packet types" on page 891. *RST: UNKNown
Usage:	Query only

20.17.22.4 Search Settings

SEARch:TRIGger:USBPd:TYPE <SearchName>,<Type>
SEARch:TRIGger:USBPd:TYPE? <SearchName>

Sets the search type for the USBPD analysis.

Parameters:

<Type>	STARt | FRAMe | ERR *RST: STARt

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USBPd:ERRor:ENABle <SearchName>, <ErrorName>,<Enable>
SEARch:TRIGger:USBPd:ERRor:ENABle? <SearchName>, <ErrorName>

Enables or disables the checking condition for searching a specific error in the selected field of the selected frame.

Parameters:

<Enable>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

<ErrorName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:SELect <SearchName>, <FrameName>

Sepcifies the frame to be searched for, if the frame does not have any fields, e.g. a test frame.

Setting parameters:
<SearchName>

<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.
Usage:	Setting only

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:BIT <SearchName>, <FrameName>,<BitState>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:BIT? <SearchName>, <FrameName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<BitState>	ONE | ZERO | DC **ONE** 1 **ZERO** 0 **DC** "Don't care" (DC) = X *RST: DC

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMAX <SearchName>,
<FrameName>,<DataMax>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMAX? <SearchName>,
<FrameName>

Sets the end value of a data pattern range if `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataMax>	Specifies the end value of a data pattern range within the field to be searched.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMIN <SearchName>,
<FrameName>,<DataMin>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMIN? <SearchName>,
<FrameName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataMin>	Specifies the data pattern or the start value of a data pattern range within the field to be searched.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DOPerator <SearchName>, <FrameName>,<DataOperator>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DOPerator? <SearchName>, <FrameName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMIN`. **INRange | OORange** In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMIN` and `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:DMAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:ENABle <SearchName>, <FrameName>,<CondEnabler>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:ENABle? <SearchName>, <FrameName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<CondEnabler>	ON | OFF **ON** Checking condition enabled **OFF** Checking condition disabled *RST: OFF

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMAX <SearchName>, <FrameName>,<IndexMax>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMAX? <SearchName>, <FrameName>

Sets the end value of an index range if `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMIN <SearchName>, <FrameName>,<IndexMin>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMIN? <SearchName>, <FrameName>

Specifies the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m>	* Specifies the field number within the frame.

Parameters:	
<IndexMin>	Specifies the index value or the start value of an index range within the field. The index range, increment and *RST values depend on the field type.
Parameters for setting and query:	
<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IOPerator <SearchName>, <FrameName>,<IndexOperator>
SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IOPerator? <SearchName>, <FrameName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:	
<m>	* Specifies the field number within the frame.
Parameters:	
<IndexOperator>	EQUal | INRange | RANGe **EQUal** This condition requires one endpoint value to be set using `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMIN`. **INRange | RANGe** This condition requires a range of endpoint values to be set using `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMIN` and `SEARch:TRIGger:USBPd:FRAMe:FIELd<m>:IMAX`. *RST: INRange
Parameters for setting and query:	
<SearchName>	String with the name of the search.
<FrameName>	Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 2010.

20.17.22.5 Search Results

In all `SEARch:RESult:USBPd:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:USBPd:FCOunt? <SearchName>

Returns the number of decoded frames in the search result.

Query parameters:
<SearchName>

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:DATA? <SearchName>

Searches for data from the frame with the selected frame number (for the selected serial bus). This is the hex value of the first four bytes of data fields, prefixed by the total number of data fields (in square brackets), e.g. `[5]FF008041`.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:FVAL? <SearchName>

Returns the formatted value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<FrameByteValue>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STATus? <SearchName>

Returns the field status of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:

<FieldState>	OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB **SOP** Start of packet warning **CRC** Cyclic redundancy check error **FBFB** 4b5b error *RST: OK

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:TYPE? <SearchName>

Returns the field name of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldType>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:VAL? <SearchName>

Returns the value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*

<n> *

Selects the field number.

Query parameters:

<SearchName>

Return values:

<FrameByteValue>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:INFO? <SearchName>

Returns specific frame information details of the selected frame in the search result. This information is also shown in the "Info" column of the decode results table.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Info>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:STARt? <SearchName>

Returns the start time of the frame with the selected frame number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:STATe? <SearchName>

Returns the status of the frame with the selected frame number within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<State>	OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB **SOP** Start of packet warning **CRC** Cyclic redundancy check error **FBFB** 4b5b error *RST: OK
Usage:	Query only

SEARch:RESult:USBPd:FRAMe<m>:STOP? <SearchName>

Returns the stop time of the frame with the selected frame number within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s
Usage:	Query only

SEARch:RESult:USBPd:FRAMe<m>:TYPE? <SearchName>

Returns the frame type for the selected frame number within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<FrameType>	STARt | RESet | CTRL | DATA | BIST | RQST | SINK | SRC | VEND | BATT | ALRT | XMSG | XSRC | XSTA | XGBC | XGBS | XBAC | XGMI | XMFI | XSRQ | XSRS | XFRQ | XFRS | TEST | LOWP | UNKNown For a description of the frame types, see "Frame packet types" on page 891. *RST: UNKNown
Usage:	Query only

20.17.23 Space Wire (Option R&S RTO-K65)

20.17.23.1 Configuration

BUS<m>:SWIRe:BPOSition <SyncBitPos>

Sets the bit position, the align position for the manual synchronisation mode. This can be useful when parity errors exist in the signal, and parity check is the main indicator for the decoder to do packet alignment.

Suffix:

<m>	1..4

Parameters:

<SyncBitPos>	Range:	0 to 10
	Increment:	1
	*RST:	0

BUS<m>:SWIRe:DATA:HYSTeresis <HysteresisData>

Sets a value for the hysteresis of the data signal.

Suffix:

<m>	1..4

Parameters:

<HysteresisData>	Range:	0 to 0.8
	Increment:	0.01
	*RST:	0.2
	Default unit:	V

BUS<m>:SWIRe:DATA:SOURce <SourceData>

Selects the source of the data signal.

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:SWIRe:DATA:THReshold <ThresholdData>

Sets the threshold value for the digitization of the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdData>	Range: -10 to 10 Increment: 0.1 *RST: 1.25 Default unit: V

BUS<m>:SWIRe:MGAP <MinGapTime>

Sets the minimum duration of a gap. Any inactivity greater than this time will be interpreted as a gap and lead to a resynchronization to the signal.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range: 1E-9 to 10E-6 Increment: 100E-9 *RST: 200E-9 Default unit: s

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:MINGap`.

BUS<m>:SWIRe:STRBe:HYSTeresis <HystStrobe>

Sets a value for the hysteresis of the strobe signal.

Suffix:

<m>	1..4

Parameters:

<HystStrobe>	Range: 0 to 0.8 Increment: 0.01 *RST: 0.2 Default unit: V

BUS<m>:SWIRe:STRBe:SOURce <SourceStrobe>

Selects the source of the strobe signal.

Suffix:

<m>	1..4

Parameters:

<SourceStrobe>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:SWIRe:STRBe:THReshold <ThresholdStrobe>

Sets the threshold value for the digitization of the strobe signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdStrobe>	Range: -10 to 10 Increment: 0.1 *RST: 1.25 Default unit: V

BUS<m>:SWIRe:SYSLect <SyncSelector>

Selects the mode for the synchronisation settings, i.e i.e. packet align.

Suffix:

<m>	1..4

Parameters:

<SyncSelector>	AUTO | MANual *RST: AUTO

BUS<m>:SWIRe:COUPling <ThresCpl>

Enables coupling, i.e. the same threshold and hysteresis value is used for the strob and the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresCpl>	ON | OFF *RST: ON

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:THRCoupling`.

BUS<m>:SWIRe:PRESet <ThresholdPreset>

Prests the threshold and hysteresis value of the strobe and data signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset>	V25 | V165 | V125 | V09 | V12 | V0 | MAN V25: 2.5 V (CMOS 5.0 V) V165: 1.65 V (CMOS 3.5 V) V125: 1.25 V (CMOS 1.5 V) V09: 2.5 V (CMOS 1.8V) V12: 1.2 V (LVDS single ended) V0: 0 V (LVDS differential) MAN: user-defined value *RST: V12

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:THRPreset`.

20.17.23.2 Trigger

TRIGger<m>:SWIRe:CTYPe <ControlType>

Triggers on a specific control type character.

Suffix:

<m>	1..3

Parameters:

<ControlType>	ANY | FCT | EOP | EEP **FCT** Flow Control Token **EOP** Normal End of Packet **EEP** Error End of Packet *RST: ANY

TRIGger<m>:SWIRe:DATA:CONDition <DataOperator>

Set the condition for the data value. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:SWIRe:DATA:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:SWIRe:DATA:MIN` and `TRIGger<m>:SWIRe:DATA:MAX`. *RST: EQUal

---

TRIGger<m>:SWIRe:DATA:MAX <DataPatternMax>

Sets the the end value of a data for the data pattern range if `TRIGger<m>:SWIRe:DATA:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<DataPatternMax>

TRIGger<m>:SWIRe:DATA:MIN <DataPatternMin>

Specifies a data for the data pattern, or sets the the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:
<DataPatternMin>

TRIGger<m>:SWIRe:ERRor:ESC <ErrorESC>

Enables searching for an escape error.

Suffix:

<m>	1..3

Parameters:

<ErrorESC>	ON | OFF *RST: ON

TRIGger<m>:SWIRe:ERRor:PARity <ErrorParity>

Enables triggering on a parity error (even parity).

Suffix:

<m>	1..3

Parameters:

<ErrorParity>	ON | OFF *RST: ON

TRIGger<m>:SWIRe:TIME:CONDition <TimeOperator>

Set the condition for the data value for the time code. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<TimeOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:SWIRe:TIME:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:SWIRe:TIME:MIN` and `TRIGger<m>:SWIRe:TIME:MAX`. *RST: EQUal

TRIGger<m>:SWIRe:TIME:MAX <TimePatternMax>

Sets the the end value of a data value for the time code range if `TRIGger<m>:SWIRe:TIME:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:
<TimePatternMax>

TRIGger<m>:SWIRe:TIME:MIN <TimePatternMin>

Specifies a pattern for the data value for the time code, or sets the the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:
<TimePatternMin>

TRIGger<m>:SWIRe:TYPE <Type>

Sets the trigger type for the SpaceWire analysis.

Suffix:

<m>	1..3

Parameters:

<Type>	CTRL | DATA | NULL | TIME | ERRor *RST: CTRL

20.17.23.3 Decode Results

BUS<m>:SWIRe:RESults:FCOunt <Key>

Returns the number of decoded frames for the selected serial bus.

Suffix:

<m>	1..4

Setting parameters:
<Key>

Return values:
<Count>

BUS<m>:SWIRe:RESults:FRAMe<n>:DATA?

Returns the data value.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Data>	8-bit data value

Example:

```
BUS:SWIRe:RESults:FRAMe2:DATA?
<-- #H12
```

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STATe?

Returns the overall state of the frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the serial bus.

Return values:

<State>	OK | PAR | ESC | AMB | INComplete **OK** The frame is valid. **PARity** Parity error **ESC** Escape error **AMB** Ambiguous **INComplete** The frame is incomplete *RST: OK

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:TYPE?

Returns the type of frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Type> DATA | FCT | EOP | EEP | ESC | NULL | TCOD

DATA
Data frame

FCT
Flow control token

EOP
End of packet

EEP
Error end of packet

ESC
Escape

NULL
Null symbol

TCOD
Time code

*RST: DATA

Usage: Query only

20.17.23.4 Search Settings

SEARch:TRIGger:SWIRe:CTYPe <SearchName>,<ControlType>
SEARch:TRIGger:SWIRe:CTYPe? <SearchName>

Searches for a specific control type character.

Parameters:

<ControlType> ANY | FCT | EOP | EEP

FCT
Flow Control Token

EOP
Normal End of Packet

EEP
Error End of Packet

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:CONDition <SearchName>,<DataOperator>
SEARch:TRIGger:SWIRe:DATA:CONDition? <SearchName>

Set the condition for the data pattern data value. You can define an exact value or a value range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:SWIRe:DATA:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:SWIRe:DATA:MIN` and `SEARch:TRIGger:SWIRe:DATA:MAX`. *RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:MAX <SearchName>,<DataPatternMax>
SEARch:TRIGger:SWIRe:DATA:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:SWIRe:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:MIN <SearchName>,<DataPatternMin>
SEARch:TRIGger:SWIRe:DATA:MIN? <SearchName>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:
<DataPatternMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:ERRor:ESC <SearchName>,<ErrorESC>
SEARch:TRIGger:SWIRe:ERRor:ESC? <SearchName>

Enables triggering on an escape error.

Parameters:

<ErrorESC>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:ERRor:PARity <SearchName>,<ErrorParity>
SEARch:TRIGger:SWIRe:ERRor:PARity? <SearchName>

Enables searching for a parity error (even parity).

Parameters:

<ErrorParity>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TIME:CONDition <SearchName>,<TimeOperator>
SEARch:TRIGger:SWIRe:TIME:CONDition? <SearchName>

Set the condition for the data value of the time code. You can define an exact value or a value range.

Parameters:

<TimeOperator>

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:SWIRe:TIME:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:SWIRe:TIME:MIN` and `SEARch:TRIGger:SWIRe:TIME:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TIME:MAX <SearchName>,<TimePatternMax>
SEARch:TRIGger:SWIRe:TIME:MAX? <SearchName>

Sets the the end value of a data type range for the time code if `SEARch:TRIGger:SWIRe:TIME:CONDition` is set to `INRange` or `OORange`.

Parameters:
<TimePatternMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TIME:MIN <SearchName>,<TimePatternMin>
SEARch:TRIGger:SWIRe:TIME:MIN? <SearchName>

Specifies a data bit pattern for the time code, or sets the the start value of a pattern range.

Parameters:
<TimePatternMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TYPE <SearchName>,<Type>
SEARch:TRIGger:SWIRe:TYPE? <SearchName>

Sets the search type for the SpaceWire analysis.

Parameters:

<Type>	CTRL | DATA | NULL | TIME | ERRor	
	*RST:	CTRL

Parameters for setting and query:
<SearchName>

20.17.23.5 Search Results

In all `SEARch:RESult:DPHY:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:SWIRe:FCOunt <Key>

Returns the number of frames within the search result for the selected serial bus.

Setting parameters:
<Key>

Return values:
<Count>

SEARch:RESult:SWIRe:FRAMe<m>:DATA? <SearchName>

Returns the data value for the selected frame within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<Data>

Usage:	Query only

SEARch:RESult:SWIRe:FRAMe<m>:STARt? <SearchName>

Returns the start time of the specified frame within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage:	Query only

SEARch:RESult:SWIRe:FRAMe<m>:STATe? <SearchName>

Returns the overall state of the selected frame within the search result.

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<State>	OK | PAR | ESC | AMB | INComplete **OK** The frame is valid **PARity** Parity error **ESC** Escape Error **AMB** Ambiguous **INComplete** The frame is incomplete *RST: OK

Usage:	Query only

SEARch:RESult:SWIRe:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage:	Query only

SEARch:RESult:SWIRe:FRAMe<m>:TYPE? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Type> DATA | FCT | EOP | EEP | ESC | NULL | TCOD

DATA
Data frame

FCT
Flow control token

EOP
End of packet

EEP
Error end of packet

ESC
Escape

NULL
Null symbol

TCOD
Time code

*RST: DATA

Usage: Query only

20.17.24 PCIe Gen 1/2 (Option R&S RTO-K72)

20.17.24.1 Configuration

In all `BUS<m>:PCIE` commands, the suffix <m> selects the serial bus.

BUS<m>:PCIE:DSCRambling <Active>

Enables descrambling of the data.

Suffix:

<m>	1..4

Parameters:

<Active>	ON | OFF *RST: ON

BUS<m>:PCIE:GEN <Generation>

Sets the generation of the PCIe technology.

Suffix:

<m>	1..4

Parameters:

<Generation>	V1 | V2 **V1** PCIe Gen1 (2.5 Gbit/s) **V2** PCIe Gen2 (5 Gbit/s) *RST: V1

BUS<m>:PCIE:LNKW <LinkWidth>

Sets the link width, the number of lanes that are used for the transmission of the data.

Suffix:

<m>	1..4

Parameters:

<LinkWidth>	X1 | X2 | X4 *RST: X1

BUS<m>:PCIE:LZER:SOURce <SourceL0>

Sets the signal sources for Lane 0.

Suffix:

<m>	1..4

Parameters:

<SourceL0>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:PCIE:LONE:SOURce <SourceL1>
BUS<m>:PCIE:LTWO:SOURce <SourceL2>
BUS<m>:PCIE:LTHRee:SOURce <SourceL3>

Sets the signal sources for the corresponding logical lane.

Suffix:

<m>	1..4

Parameters:

<SourceLx>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | NONE

BUS<m>:PCIE:LZER:THRHigh <ThresholdL0High>
BUS<m>:PCIE:LONE:THRHigh <ThresholdL1High>
BUS<m>:PCIE:LTWO:THRHigh <ThresholdL2High>
BUS<m>:PCIE:LTHRee:THRHigh <ThresholdL3High>

Sets the high threshold value for the respective lane.

Suffix:

<m>	1..4

Parameters:

<ThresholdL3High>	Range:	-5 to 5
	Increment:	1E-3
	*RST:	0.02
	Default unit:	V

BUS<m>:PCIE:LZER:THRLow <ThresholdL0Low>
BUS<m>:PCIE:LONE:THRLow <ThresholdL1Low>
BUS<m>:PCIE:LTWO:THRLow <ThresholdL2Low>
BUS<m>:PCIE:LTHRee:THRLow <ThresholdL3Low>

Sets the lower threshold value for the respective lane.

Suffix:

<m>	1..4

Parameters:

<ThresholdL3Low>	Range:	-5 to 5
	Increment:	1E-3
	*RST:	-0.02
	Default unit:	V

20.17.24.2 Clock Data Recovery

BUS<m>:CDR:BITRate <Bitrate>

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Suffix:

<m>	1..4

Parameters:

<Bitrate>	Range:	100 to 5E+9
	Increment:	10
	*RST:	1E+9
	Default unit:	bps

BUS<m>:CDR:PLL:BWIDth <PLLBandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Suffix:

<m>	1..4

Parameters:

<PLLBandwidth>	Range:	20E+3 to 10E+6
	Increment:	10
	*RST:	599.88E+3
	Default unit:	Hz

BUS<m>:CDR:PLL:DAMPing <DampingFactor>

Sets the damping factor, which is only relevant for second order PLL.

Suffix:

<m>	1..4

Parameters:

<DampingFactor>	Range:	0.5 to 1
	Increment:	0.01
	*RST:	0.7

BUS<m>:CDR:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Suffix:

<m>	1..4

Parameters:

<PLLOrder>	FIRSt | SECond	
	*RST:	FIRSt

BUS<m>:CDR:PLL:RELBwidth <PLLRelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Suffix:

<m>	1..4

Parameters:

<PLLRelBw>	Range:	10 to 5000
	Increment:	1
	*RST:	1667

BUS<m>:CDR:RESults <Results>

The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges.

Suffix:

<m>	1..4

Parameters:

<Results>	ALL | AISYnc	
	*RST:	AISYnc

BUS<m>:CDR:SYNC <InitialSync>

Defines the phase reference for the first clock edge.

Suffix:

<m>	1..4

Parameters:	
<InitialSync>	SAMPle | DATaedge **SAMPle** The first clock edge matches the first sample of the waveform at the left border of the display. **DATaedge** The first clock edge matches the first edge of the data signal. *RST: SAMPle

20.17.24.3 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:PCIE:DLLP:FCTL:CRET <CreditType>

Sets credit type value to be triggered on for the data link layer trigger.

Parameters:

<CreditType>	ANY | P | NP | CPL *RST: ANY

TRIGger<m>:PCIE:DLLP:FCTL:VCID <VirtualChnID>

Sets the virtual channel ID to be triggered on for the data link layer trigger.

Parameters:

<VirtualChnID>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:AUTH <Authorized>

Sets the authorized presence state to be triggered on for the data link layer trigger.

Parameters:

<Authorized>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:CRET <CreditType>

Sets the credit type to be triggered on for the multi-root data link layer trigger.

Parameters:

<CreditType>	ANY | DATA | HEADER *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:DVPT <DevicePortType>

Sets the device/port type to be triggered on for the data link layer trigger.

Parameters:

<DevicePortType>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:HABS <VHAbsent>

Sets the state of the absent virtual hieararchies (VH) to be triggered on for the data link layer trigger.

Parameters:

<VHAbsent>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:MIXT <MixedType>

Sets the mixed type presence state to be triggered on for the data link layer trigger.

Parameters:

<MixedType>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:PHAS <Phase>

Sets the phase state to be triggered on for the data link layer trigger.

Parameters:

<Phase>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:RESA <ResetA>

Sets the on the value of the A bit to be triggered on for the data link layer trigger.

Parameters:

<ResetA>	ANY | ACK | REQUEST *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:TLPT <TLPType>

Sets the multi-root type to be triggered on for the data link layer trigger.

Parameters:

<TLPType>	ANY | P | NP | CPL **P** Posted credit. **NP** Non posted credit. **CL** Completion credit. *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:TYPE <Type>

Sets the multi-root type for the data link layer to be triggered on.

Parameters:

<Type>	MRINIT | MRRESET | MRUPDATEFC | MRINITFC1 | MRINITFC2 *RST: MRINIT

TRIGger<m>:PCIE:DLLP:MULT:VHFC <InitVHFC>

Sets the virtual hierarchies flow control presence state to be triggered on for the data link layer trigger.

Parameters:

<InitVHFC>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:VHGR <ResetVHGroup>

Sets the virtual hierarchies group to be triggered on for the data link layer trigger.

Parameters:

<ResetVHGroup>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:VLNR <VirtualLink>

Sets the virtual link (VL) number to be triggered on for the data link layer trigger.

Parameters:

<VirtualLink>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

TRIGger<m>:PCIE:DLLP:POWM <PowerMngtType>

Sets the power management type to be triggered on for the data link layer trigger.

Parameters:

<PowerMngtType>	ANY | ENTERL1 | ENTERL23 | ACTREQL1 | REQUESTACK
	*RST: ANY

TRIGger<m>:PCIE:DLLP:SEQ <ACKNAKSequence>

Sets the sequence field, indicating what TLPs are affected by the ACK/NAK, to be triggered on for the data link layer trigger.

Parameters:

<ACKNAKSequence>

TRIGger<m>:PCIE:DLLP:TYPE <Type>

Sets the DLLP t type to be triggered on for the data link layer trigger.

Parameters:

<Type>	ANY | MRDLLP | ACK | NAK | INITFC1 | INITFC2 | UPDATEFC | PM | VENDOR
	*RST: ANY

TRIGger<m>:PCIE:DLLP:VPAT <VendorBtPatt>

Sets the vendor pattern to be triggered on for the data link layer trigger.

Parameters:

<VendorBtPatt>	24-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:ERRC:CRC <CRC16>

Enables triggering on 16-bit cyclic redundancy check (CRC) errors.

Parameters:

<CRC16>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:DISP <Display>

Enables triggering on disparity errors.

Parameters:

<Display>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:ECRC <ECRC>

Enables triggering on end-to-end cyclic redundancy checksum (ECRC) errors.

Parameters:

<ECRC>	ON | OFF *RST: OFF

TRIGger<m>:PCIE:ERRC:INVP <InvalidSymbol>

Enables triggering on invalid symbol errors.

Parameters:

<InvalidSymbol>	ON | OFF *RST: OFF

TRIGger<m>:PCIE:ERRC:LCRC <LCRC>

Enables triggering on link cyclic redundancy check (LCRC) errors.

Parameters:

<LCRC>	ON | OFF *RST: OFF

TRIGger<m>:PCIE:OSET:TYPE <Type>

Sets the ordered set to be triggered on.

Parameters:

<Type>	SKP | TS1 | TS2 | FTS | EIOS | EIEOS | COMP **SKP** SKP ordered sets **TS1** Training sequence 1 **TS2** Training sequence 2 **FTS** Fast training sequence **EIOS** Electrical idle ordered set **EIEOS** Electrical idle exit ordered set **COMP** Compliance pattern *RST: SKP

TRIGger<m>:PCIE:TLP:ADRT <AddressType>

Sets the address type to be triggered on for the transaction layer type trigger.

Parameters:

<AddressType>	ANY | X32 | X64 *RST: ANY

TRIGger<m>:PCIE:TLP:CFGT <ConfigType>

Sets the configuration type to be triggered on for the transaction layer type trigger.

Parameters:

<ConfigType>	ANY | TYPE0 | TYPE1 *RST: ANY

TRIGger<m>:PCIE:TLP:CPID <TLPCompleterID>

Sets the completer ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPCompleterID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:CPLS <CplStatus>

Sets the completion status to be triggered on for the transaction layer type trigger.

Parameters:

<CplStatus>	ANY | SUCCESS | UNSUPPORTED | RETRY | ABORT *RST: ANY

TRIGger<m>:PCIE:TLP:DEID <TLPDeviceID>

Sets the device ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPDeviceID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:MERW <MemRW>

Sets the read/ write type to be triggered on for the transaction layer type trigger.

Parameters:

<MemRW>	ANY | READ | WRITE *RST: ANY

TRIGger<m>:PCIE:TLP:MSGC <TLPMessageCode>

Sets the message code to be triggered on for the transaction layer type trigger.

Parameters:

<TLPMessageCode>	8-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:MSGR <MsgRouting>

Sets the message routing type to be triggered on for the transaction layer type trigger.

Parameters:

<MsgRouting>	ANY | ROOTCOMPLEX | ADDRESS | DEVICEID | BROADCAST | LOCAL | GATHERED *RST: ANY

TRIGger<m>:PCIE:TLP:ORDE <Ordering>

Sets the ordering type to be triggered on for the transaction layer type trigger.

Parameters:

<Ordering>	ANY | STRONG | RELAX *RST: ANY

TRIGger<m>:PCIE:TLP:REID <TLPRequesterID>

Sets the requester ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPRequesterID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:SNOO <Snoop>

Sets the snoop state to be triggered on for the transaction layer type trigger.

Parameters:

<Snoop>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:TLP:SNUM <TLPSeqNo>

Sets the sequence numbe to be triggered on for the transaction layer type trigger.

Parameters:

<TLPSeqNo>	12-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:TCHN <TrafficClass>

Sets the traffic class to be triggered on for the transaction layer type trigger.

Parameters:

<TrafficClass>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

TRIGger<m>:PCIE:TLP:TYPE <Type>

Sets the transaction type to be triggered on for the transaction layer type trigger.

Parameters:

<Type>	ANY | MEM | IO | CFG | MSG | CPL | FETCH | SWAP | CAS *RST: ANY

TRIGger<m>:PCIE:TYPE <Type>

Sets the trigger type for the PCI express analysis..

Parameters:

<Type>	TLP | DLLP | ORD | ERR *RST: TLP

20.17.24.4 Decode Results

In all `BUS<m>:PCIE:RESult:PACKet<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:PCIE:RESult:PACKet<n>:ADDR?

Returns the packet address for thespecified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Address>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:CPID?

Returns the completer ID of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<CompleterID>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:CPS?

Returns the completion status field value of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<CplStatus>	RESERVED | SC | UR | CRS | CA **RESERVED** Others **SC** Successful Completion **UR** Unsupported Request **CRS** Configuration Request Retry Status **CA** Completer Abort *RST: RESERVED

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:DATA?

Returns the data value of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:DFC?

Returns the credit value of the payload data of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<DataFC>	Range: 0 to 0 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FCOunt?

Returns the number of decoded fields in the selected packet.

Suffix:

<m>	1..4

<n>	*

Return values:

<FieldCount>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the field number.

Return values:

<FrameByteValue>

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:STATus?

Returns the status of the frame with the selected field number within the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the field number.

Return values:

<State>	OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated **MALF** Mal formated packet **CRC16** CRC16 error **ECRC** ECRC error **LCRC** LCRC error **LEN** Length error **POE** TLP prefix error **MEE** Max end-end TLP prefix error *RST: OK
Usage:	Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the field number.

Return values:

<Type>

Usage:	Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the field number.

Return values:

<FrameByteValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:HFC?

Returns the credit value of the header of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<HdrFC>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:LEN?

Returns the length of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Length>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:RQID?

Returns the requester ID of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<RequesterID>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:SEQN?

Returns the sequence number of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<SequenceNumber>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STARt?

Returns the start time of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STATe?

Returns the state of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<State>	OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated **MALF** Mal formated packet **CRC16** CRC16 error **ECRC** ECRC error **LCRC** LCRC error **LEN** Length error **POE** TLP prefix error **MEE** Max end-end TLP prefix error *RST: OK

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STOP?

Returns the stop time of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:TAG?

Returns the tag of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Tag>	Range: 0 to 0 Increment: 1 *RST: 0

Usage:	Query only

BUS<m>:PCIE:RESult:PACKet<n>:TYPE?

Returns the type of the specified packet. For a description of the packet types, see Chapter 12.23.1, "The PCIe Protocol", on page 920.

Suffix:

<m>	1..4
<n>	*

Return values:

<Type>	MRD32 | MRD64 | MRDLK32 | MRDLK64 | MWR32 | MWR64 | IORD | IOWR | CFGRD0 | CFGWR0 | CFGRD1 | CFGWR1 | MSG | MSGD | CPL | CPLD | CPLLK | CPLDLK | FA32 | FA64 | SWP32 | SWP64 | CAS32 | CAS64 | LPRFX | EPRFX | ACK | NAK | PMEL1 | PMEL23 | PMASRL1 | PMRA | VENDS | IFC1P | IFC1NP | IFC1CPL | IFC2P | IFC2NP | IFC2CPL | UPDFCP | UPDFCNP | UPDFCCPL | MRUPDFC | MRIFC1 | MRIFC2 | MRINIT | MRRESET | UNK | SKPOS | EIOS | FTSOS | TS1OS | TS2OS | EIEOS | COMPL | MCOMPL *RST: UNK
Usage:	Query only

BUS<m>:PCIE:RESult:PCOunt?

Returns the packet count for the selected serial bus, i.e. the number of packets in the present acquisition.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range: 0 to 100000 Increment: 1 *RST: 0
Usage:	Query only

20.17.24.5 Search Settings

SEARch:TRIGger:PCIE:DLLP:FCTL:CRET <SearchName>,<CreditType>
SEARch:TRIGger:PCIE:DLLP:FCTL:CRET? <SearchName>

Sets credit type value to be searched for, for the data link layer.

Parameters:

<CreditType>	ANY | P | NP | CPL
	*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:FCTL:VCID <SearchName>,<VirtualChnID>
SEARch:TRIGger:PCIE:DLLP:FCTL:VCID? <SearchName>

Sets the virtual channel ID to be searched for, for the data link layer.

Parameters:

<VirtualChnID>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN
	*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:AUTH <SearchName>,<Authorized>
SEARch:TRIGger:PCIE:DLLP:MULT:AUTH? <SearchName>

Sets the authorized presence state to be searched for, for the data link layer.

Parameters:

<Authorized>	ANY | YES | NO
	*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:CRET <SearchName>,<CreditType>
SEARch:TRIGger:PCIE:DLLP:MULT:CRET? <SearchName>

Sets the credit type to be searched for, for the data link layer.

Parameters:

<CreditType>	ANY | DATA | HEADER
	*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:DVPT <SearchName>,<DevicePortType>
SEARch:TRIGger:PCIE:DLLP:MULT:DVPT? <SearchName>

Sets the device/port type to be searched for, for the data link layer.

Parameters:

<DevicePortType>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN
	*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:HABS <SearchName>,<VHAbsent>
SEARch:TRIGger:PCIE:DLLP:MULT:HABS? <SearchName>

Sets the state of the absent virtual hieararchies (VH) to be searched for, for the data link layer.

Parameters:

<VHAbsent>	ANY | YES | NO	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:MIXT <SearchName>,<MixedType>
SEARch:TRIGger:PCIE:DLLP:MULT:MIXT? <SearchName>

Sets the mixed type presence state to be searched for, for the data link layer.

Parameters:

<MixedType>	ANY | YES | NO	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:PHAS <SearchName>,<Phase>
SEARch:TRIGger:PCIE:DLLP:MULT:PHAS? <SearchName>

Sets the phase state to be searched for, for the data link layer.

Parameters:

<Phase>	ANY | YES | NO	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:RESA <SearchName>,<ResetA>
SEARch:TRIGger:PCIE:DLLP:MULT:RESA? <SearchName>

Sets the on the value of the A bit to be searched for, for the data link layer.

Parameters:

<ResetA>	ANY | ACK | REQUEST	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:TLPT <SearchName>,<Type>
SEARch:TRIGger:PCIE:DLLP:MULT:TLPT? <SearchName>

Sets the multi-root type to be searched for, for the data link layer.

Parameters:

<Type>	ANY | P | NP | CPL **P** Posted credit. **NP** Non posted credit. **CL** Completion credit. *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:TYPE <SearchName>,<MRType>
SEARch:TRIGger:PCIE:DLLP:MULT:TYPE? <SearchName>

Sets the multi-root type to be searched for, for the data link layer.

Parameters:

<MRType>	MRINIT | MRRESET | MRUPDATEFC | MRINITFC1 | MRINITFC2 *RST: MRINIT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VHFC <SearchName>,<InitVHFC>
SEARch:TRIGger:PCIE:DLLP:MULT:VHFC? <SearchName>

Sets the virtual hierarchies flow control presence state to be searched for, for the data link layer.

Parameters:

<InitVHFC>	ANY | YES | NO *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VHGR <SearchName>,<ResetVHGroup>
SEARch:TRIGger:PCIE:DLLP:MULT:VHGR? <SearchName>

Sets the virtual hierarchies group to be searched for, for the data link layer.

Parameters:

<ResetVHGroup>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VLNR <SearchName>,<VirtualLink>
SEARch:TRIGger:PCIE:DLLP:MULT:VLNR? <SearchName>

Sets the virtual link (VL) number to be searched for, for the data link layer.

Parameters:

<VirtualLink>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:POWM <SearchName>,<PowerMngtType>
SEARch:TRIGger:PCIE:DLLP:POWM? <SearchName>

Sets the power management type to be searched for, for the data link layer.

Parameters:

<PowerMngtType>	ANY | ENTERL1 | ENTERL23 | ACTREQL1 | REQUESTACK *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:SEQ <SearchName>,<ACKNAKSequence>
SEARch:TRIGger:PCIE:DLLP:SEQ? <SearchName>

Sets the sequence field, indicating what TLPs are affected by the ACK/NAK, to be searched for, for the data link layer.

Parameters:
<ACKNAKSequence>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:DLLP:TYPE? <SearchName>

Sets the DLLP t type to be searched for, for the data link layer.

Parameters:

<Type>	ANY | MRDLLP | ACK | NAK | INITFC1 | INITFC2 | UPDATEFC | PM | VENDOR *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:VPAT <SearchName>,<VendorBtPatt>
SEARch:TRIGger:PCIE:DLLP:VPAT? <SearchName>

Sets the vendor pattern to be searched for, for the data link layer.

Parameters:

<VendorBtPatt>	24-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:CRC <SearchName>,<CRC16>
SEARch:TRIGger:PCIE:ERRC:CRC? <SearchName>

Enables searching for 16-bit cyclic redundancy check (CRC) errors.

Parameters:

<CRC16>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:DISP <SearchName>,<Disparity>
SEARch:TRIGger:PCIE:ERRC:DISP? <SearchName>

Enables searching for disparity errors.

Parameters:

<Disparity>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:ECRC <SearchName>,<ECRC>
SEARch:TRIGger:PCIE:ERRC:ECRC? <SearchName>

Enables searching for end-to-end cyclic redundancy checksum (ECRC) errors.

Parameters:

<ECRC>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:INVP <SearchName>,<InvalidSymbol>
SEARch:TRIGger:PCIE:ERRC:INVP? <SearchName>

Enables searching for invalid symbol errors.

Parameters:

<InvalidSymbol>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:LCRC <SearchName>,<LCRC>
SEARch:TRIGger:PCIE:ERRC:LCRC? <SearchName>

Enables searching for link cyclic redundancy check (LCRC) errors.

Parameters:

<LCRC>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:COMP <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:COMP? <SearchName>

Enables searching forcompliance pattern ordered sets.

Parameters:

<Format>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:EIDE <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:EIDE? <SearchName>

Enables searching for electrical idle exit ordered sets.

Parameters:

<Format>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:EIDL <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:EIDL? <SearchName>

Enables searching for electrical idle ordered sets.

Parameters:

<Format>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:FTS <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:FTS? <SearchName>

Enables searching for fast training sequence ordered sets.

Parameters:

<Format>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:SKIP <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:SKIP? <SearchName>

Enables searching for SKP ordered sets.

Parameters:

<Format>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:TSONe <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:TSONe? <SearchName>

Enables searching for training sequence 1 ordered sets.

Parameters:

<Format>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:TSTWo <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:TSTWo? <SearchName>

Enables searching for training sequence 2 ordered sets.

Parameters:

<Format>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:ADRT <SearchName>,<AddressType>
SEARch:TRIGger:PCIE:TLP:ADRT? <SearchName>

Sets the address type to be searched for in the transaction layer type.

Parameters:

<AddressType>	ANY | X32 | X64	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CFGT <SearchName>,<CfgType>
SEARch:TRIGger:PCIE:TLP:CFGT? <SearchName>

Sets the configuration type to be searched for in the transaction layer type.

Parameters:

<CfgType>	ANY | TYPE0 | TYPE1	
	*RST:	ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CPID <SearchName>,<TLPCompleterID>
SEARch:TRIGger:PCIE:TLP:CPID? <SearchName>

Sets the completer ID to be searched for in the transaction layer type.

Parameters:

<TLPCompleterID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CPLS <SearchName>,<CplStatus>
SEARch:TRIGger:PCIE:TLP:CPLS? <SearchName>

Sets the completion status to be searched for in the transaction layer type.

Parameters:

<CplStatus>	ANY | SUCCESS | UNSUPPORTED | RETRY | ABORT *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:DEID <SearchName>,<TLPDeviceID>
SEARch:TRIGger:PCIE:TLP:DEID? <SearchName>

Sets the device ID to be searched for in the transaction layer type.

Parameters:

<TLPDeviceID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MERW <SearchName>,<MemRW>
SEARch:TRIGger:PCIE:TLP:MERW? <SearchName>

Sets the read/ write type to be searched for in the transaction layer type.

Parameters:

<MemRW>	ANY | READ | WRITE *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MSGC <SearchName>,<TLPMessageCode>
SEARch:TRIGger:PCIE:TLP:MSGC? <SearchName>

Sets the message code to be searched for in the transaction layer type.

Parameters:

<TLPMessageCode>	8-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MSGR <SearchName>,<MsgRouting>
SEARch:TRIGger:PCIE:TLP:MSGR? <SearchName>

Sets the message routing type to be searched for in the transaction layer type.

Parameters:

<MsgRouting>	ANY | ROOTCOMPLEX | ADDRESS | DEVICEID | BROADCAST | LOCAL | GATHERED *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:ORDE <SearchName>,<Ordering>
SEARch:TRIGger:PCIE:TLP:ORDE? <SearchName>

Sets the ordering type to be searched for in the transaction layer type.

Parameters:

<Ordering>	ANY | STRONG | RELAX *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:REID <SearchName>,<TLPRequesterID>
SEARch:TRIGger:PCIE:TLP:REID? <SearchName>

Sets the requester ID to be searched for in the transaction layer type.

Parameters:

<TLPRequesterID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:SNOO <SearchName>,<Snoop>
SEARch:TRIGger:PCIE:TLP:SNOO? <SearchName>

Sets the snoop state to be searched for in the transaction layer type.

Parameters:

<Snoop>	ANY | YES | NO *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:SNUM <SearchName>,<TLPSeqNo>
SEARch:TRIGger:PCIE:TLP:SNUM? <SearchName>

Sets the sequence numbe to be searched for in the transaction layer type.

Parameters:

<TLPSeqNo>	12-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:TCHN <SearchName>,<TrafficClass>
SEARch:TRIGger:PCIE:TLP:TCHN? <SearchName>

Sets the traffic class to be searched for in the transaction layer type.

Parameters:

<TrafficClass>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:TLP:TYPE? <SearchName>

Sets the transaction type to be searched for in the transaction layer type.

Parameters:

<Type>	ANY | MEM | IO | CFG | MSG | CPL | FETCH | SWAP | CAS *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:TYPE? <SearchName>

Parameters:

<Type>	TLP | DLLP | ORD | ERR *RST: TLP

Parameters for setting and query:
<SearchName>

20.17.24.6 Search Results

In all `SEARch:RESult:PCIE:PACKet<m>` commands, the suffix <m> selects the frame number in the list of search results.

In search result commands, you have to specify the `<SearchName>` parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.24.4, "Decode Results", on page 2039.

SEARch:RESult:PCIE:PACKet<m>:ADDR? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Address>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:CPID? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<CompleterID>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:CPS? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<CplStatus> RESERVED | SC | UR | CRS | CA

*RST: RESERVED

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:DFC? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<DataFC>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FCOunt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FieldCount>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:FVAL? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:
<FrameByteValue>

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:STATus? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<State>	OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated	
	*RST:	OK

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:TYPE? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:
<Type>

Usage:	Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:VAL? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<FrameByteValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

SEARch:RESult:PCIE:PACKet<m>:HFC? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<HdrFC>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

SEARch:RESult:PCIE:PACKet<m>:LEN? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Length>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage:	Query only

SEARch:RESult:PCIE:PACKet<m>:RQID? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<RequesterID>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:SEQN? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<SequenceNumber>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STATe? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<State>	OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated *RST: OK

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:TAG? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Tag>	Range: 0 to 0 Increment: 1 *RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:TYPE? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Type>	MRD32 | MRD64 | MRDLK32 | MRDLK64 | MWR32 | MWR64 | IORD | IOWR | CFGRD0 | CFGWR0 | CFGRD1 | CFGWR1 | MSG | MSGD | CPL | CPLD | CPLLK | CPLDLK | FA32 | FA64 | SWP32 | SWP64 | CAS32 | CAS64 | LPRFX | EPRFX | ACK | NAK | PMEL1 | PMEL23 | PMASRL1 | PMRA | VENDS | IFC1P | IFC1NP | IFC1CPL | IFC2P | IFC2NP | IFC2CPL | UPDFCP | UPDFCNP | UPDFCCPL | MRUPDFC | MRIFC1 | MRIFC2 | MRINIT | MRRESET | UNK | SKPOS | EIOS | FTSOS | TS1OS | TS2OS | EIEOS | COMPL | MCOMPL *RST: UNK

Usage: Query only

SEARch:RESult:PCIE:PCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

20.17.25 CXPI (Option R&S RTO-K76)

20.17.25.1 Configuration

BUS<m>:CXPI:BITRate:ENABle <BitrateEnable>

Enables the manual setting of a bit rate. You can set the bitrate value with `BUS<m>:CXPI:BITRate:VALue`.

Suffix:

<m>	1..4

Parameters:

<BitrateEnable>	ON | OFF	
	*RST:	OFF

BUS<m>:CXPI:BITRate:VALue <Bitrate>

Sets the number of transmitted bits per second. To set this value, you have to enable the bitrate first with `BUS<m>:CXPI:BITRate:ENABle`.

Suffix:

<m>	1..4

Parameters:

<Bitrate>	Range:	1000 to 100000
	Increment:	100
	*RST:	19200
	Default unit:	bps

BUS<m>:CXPI:RESult:BITRate?

Queries the measured average bit rate, which is calculated if `BUS<m>:CXPI:BITRate:ENABle` is set to `OFF`.

Suffix:

<m>	1..4

Return values:

<AverageBitrate>	Range:	1000 to 100000
	Increment:	100
	*RST:	19200
	Default unit:	bps

Usage: Query only

BUS<m>:CXPI:DORD <DisplayOrder>

Selects the order in which the signal is displayed in the honeycomb.

If `TRANsmitted` is selected, the signal is displayed in the order it occurs. If `LOGical` is selected, the signal is displayed according to the definition of the standard (MSB bit order).

Suffix:

<m>	1..4

Parameters:

<DisplayOrder>	TRANsmitted | LOGical	
	*RST:	TRANsmitted

BUS<m>:CXPI:HYSTeresis <ThresHyst>

Sets a value for the hysteresis.

Suffix:

<m>	1..4

Parameters:

<ThresHyst>	Range: -12 to 12 Increment: 0.01 *RST: 1 Default unit: V

BUS<m>:CXPI:POLarity <Polarity>

Sets the polarity of the transmitted waveform to normal (high = 1) or inverted (low = 1).

Suffix:

<m>	1..4

Parameters:

<Polarity>	NORMal | INVert *RST: NORMal

BUS<m>:CXPI:THReshold <Threshold>

Sets the threshold value for the signal.

Suffix:

<m>	1..4

Parameters:

<Threshold>	Range: -15 to 12 Increment: 0.01 *RST: 6 Default unit: V

BUS<m>:CXPI:SDATa <SourceData>

Selects the input channel for the signal.

Suffix:

<m>	1..4

Parameters:

<SourceData>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 For triggering on a serial bus, analog or digital channel sources are required.

20.17.25.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CXPI:CT <CT>

Sets the value of the counter (CT), 2 bits indicating the continuity of the frame.

Suffix:

<m>	1..3

Parameters:

<CT>

TRIGger<m>:CXPI:DATA:DCONdition <DataOperator>

Sets the condition for the data pattern. You can define no value, an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DataOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
Any data pattern is considered

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:CXPI:DATA:DMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:CXPI:DATA:DMIN` and `TRIGger<m>:CXPI:DATA:DMAX`.

*RST: OFF

TRIGger<m>:CXPI:DATA:DMAX <DataMax>

Sets the end value of a data type range if `TRIGger<m>:CXPI:DATA:DCONdition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<DataMax>

TRIGger<m>:CXPI:DATA:DMIN <DataMin>

Specifies a data bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<DataMin>

TRIGger<m>:CXPI:DATA:ICONdition <DatIdxOptor>

Set the condition for the data index value. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:CXPI:DATA:IMIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `TRIGger<m>:CXPI:DATA:IMIN` and `TRIGger<m>:CXPI:DATA:IMAX`. *RST: INRange

---

TRIGger<m>:CXPI:DATA:IMAX <DataIndexMax>

Sets the end value of a data index range if `TRIGger<m>:CXPI:DATA:ICONdition` is set to `INRange` or `RANge`.

Suffix:

<m>	1..3

Parameters:

<DataIndexMax>	Range: 1 to 0 Increment: 1 *RST: 0

TRIGger<m>:CXPI:DATA:IMIN <DataIndexMin>

Specifies a data index bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<DataIndexMin>	Range: 1 to 0 Increment: 1 *RST: 1

TRIGger<m>:CXPI:DEXTension:CONDition <DLCEXTOperator>

Set the condition for the DLC extend value. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DLCEXTOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:CXPI:DEXTension:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:CXPI:DEXTension:MIN` and `TRIGger<m>:CXPI:DEXTension:MAX`. *RST: EQUal

---

TRIGger<m>:CXPI:DEXTension:MAX <DLCEXTMax>

Sets the end value of a DLC extend range if `TRIGger<m>:CXPI:DEXTension:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<DLCEXTMax>

TRIGger<m>:CXPI:DEXTension:MIN <DLCEXTMin>

Specifies a data extension bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<DLCEXTMin>

TRIGger<m>:CXPI:DLC:CONDition <DLCOperator>

Set the condition for the DLC. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<DLCOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one DLC pattern to be set with the corresponding `TRIGger<m>:CXPI:DLC:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:CXPI:DLC:MIN` and `TRIGger<m>:CXPI:DLC:MAX`. *RST: EQUal

---

TRIGger<m>:CXPI:DLC:MAX <DLCMax>

Sets the end value of a data type range if `TRIGger<m>:CXPI:DLC:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<DLCMax>

TRIGger<m>:CXPI:DLC:MIN <DLCMin>

Specifies a DLC pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<DLCMin>

TRIGger<m>:CXPI:ERRor:CRC <ErrorCRC>

Triggers on a cyclic redundancy check error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

The transmitting node calculates the cyclic redundancy check (CRC) value of a frame and stores it into the CRC field of the frame. CRC error occurs when this CRC field value differs from the value calculated by the receiving node.

Suffix:

<m>	1..3

Parameters:

<ErrorCRC>	ON | OFF *RST: ON

TRIGger<m>:CXPI:ERRor:DLC <ErrorDLC>

Triggers on a data length code (DLC) error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

DLC error occurs when the value of the DLC field is different from the data byte field value.

Suffix:

<m>	1..3

Parameters:

<ErrorDLC>	ON | OFF	
	*RST:	ON

TRIGger<m>:CXPI:ERRor:IBS <ErrorIBS>

Triggers on an inter-byte-space (IBS) error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

Suffix:

<m>	1..3

Parameters:

<ErrorIBS>	ON | OFF	
	*RST:	ON

TRIGger<m>:CXPI:ERRor:IFS <ErrorIFS>

Triggers on an inter-frame-space (IFS) error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

Suffix:

<m>	1..3

Parameters:

<ErrorIFS>	ON | OFF	
	*RST:	ON

TRIGger<m>:CXPI:ERRor:LENGth <ErrorLength>

Triggers on a length error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

Suffix:

<m>	1..3

Parameters:

<ErrorLength>	ON | OFF	
	*RST:	ON

TRIGger<m>:CXPI:ERRor:PARity <ErrorParity>

Triggers on a parity error indicating a transmission error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

Suffix:

<m>	1..3

Parameters:

<ErrorParity>	ON | OFF *RST: ON

TRIGger<m>:CXPI:ERRor:UART <ErrorUart>

Triggers on an UART error, if `TRIGger<m>:CXPI:TYPE` is set to `ERRor`.

Suffix:

<m>	1..3

Parameters:

<ErrorUart>	ON | OFF *RST: ON

TRIGger<m>:CXPI:FID:CONDition <FrameIDOperator>

Set the condition for the frame ID. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<FrameIDOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:CXPI:FID:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:CXPI:FID:MIN` and `TRIGger<m>:CXPI:FID:MAX`. *RST: EQUal

TRIGger<m>:CXPI:FID:MAX <FrameIDMax>

Sets the end value of a frame ID range if `TRIGger<m>:CXPI:FID:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:
<FrameIDMax>

TRIGger<m>:CXPI:FID:MIN <FrameIDMin>

Specifies a frame ID pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:
<FrameIDMin>

TRIGger<m>:CXPI:NM <NM>

Sets the value of the network management (NM) field.

Suffix:

<m>	1..3

Parameters:
<NM>

TRIGger<m>:CXPI:TYPE <Type>

Selects the trigger type for the CXPI analysis.

Suffix:

<m>	1..3

Parameters:

<Type> STARt | NORMal | NPOLI | SLEEP | LONG | LPOLI | PID | PTYPe | PTPD | ERRor

STARt
Triggers on the STARt of the frame.

NORMal
Triggers on a NORMal frame. Optionally you can define a frame ID condition, an NM, a CT, a DLC condition, a data pattern condition and an index condition.

NPOLI
Triggers on a Normal POLL frame. Optionally you can define a frame ID condition, an NM, a CT, a DLC condition, a data pattern condition and an index condition.

SLEEP
Triggers on a SLEEP frame. Optionally you can define an NM, a CT, a data pattern condition and an index condition.

LONG
Triggers on a Long frame. Optionally you can define a frame ID condition, an NM, a CT, a DLC extend condition, a data pattern condition and an index condition.

LPOLI
Triggers on a Long POLL frame.

PID
Triggers on a Protected ID field. Optionally, you can define the frame ID pattern.

PTYPe
Triggers on a Protected TYPE field.

PTPID
Triggers on a Protected Type field followed by a PID field. Optionally, you can define the frame ID pattern.

ERRor
Trigger on selected error types. Define the error types with:
`TRIGger<m>:CXPI:ERRor:CRC`
`TRIGger<m>:CXPI:ERRor:DLC`
`TRIGger<m>:CXPI:ERRor:IBS`
`TRIGger<m>:CXPI:ERRor:IFS`
`TRIGger<m>:CXPI:ERRor:LENGth`
`TRIGger<m>:CXPI:ERRor:PARity`
`TRIGger<m>:CXPI:ERRor:UART`

*RST: STARt

20.17.25.3 Decode Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1496

- `BUS<m>:RESDetail` on page 1496

BUS<m>:CXPI:RESult:FCOunt?

Returns the number of frames in the acquisition.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:CXPI:RESult:FRAMe<n>:DATA?

Returns the data bytes of the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>

Usage: Query only

BUS<m>:CXPI:RESult:FRAMe<n>:DLCV?

Returns the data length code/ extension data length code field value.

Suffix:

<m>	1..4
<n>	*

Return values:

<DLC>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage:	Query only

BUS<m>:CXPI:RESult:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage:	Query only

BUS<m>:CXPI:RESult:FRAMe<n>:STATe?

Returns the state of the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<State>	OK | INComplete | ERR_IBS | ERR_IFS | ERR_LENGTH | ERR_CRC | ERR_PARITY | ERR_DLC | ERR_UART	
	*RST:	OK

Usage:	Query only

BUS<m>:CXPI:RESult:FRAMe<n>:STOP?

Returns the stop time of the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage:	Query only

BUS<m>:CXPI:RESult:FRAMe<n>:TYPE?

Returns the type of the specified frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Type>	NORMal | NPOLI | SLEEP | LONG | LPOLI | PID | PTYPe | PTPID | UNKNown | IFS **NPOLI** Normal POLI **LPOLI** Long POLI **PID** Protected ID **PTPID** Protected Type + Protected ID **IFS** Inter-Frame-Space *RST: NORMal

Usage: Query only

BUS<m>:CXPI:RESult:FRAMe<n>:WORD<o>:STATus?

Returns the status of the specified field.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<Status>	OK | INComplete | ERR_IBS | ERR_IFS | ERR_LENGTH | ERR_CRC | ERR_PARITY | ERR_DLC | ERR_UART *RST: OK

Usage: Query only

BUS<m>:CXPI:RESult:FRAMe<n>:WORD<o>:TYPE?

Returns the type (name) of the specified field.

Suffix:

<m>	1..4
<n>	*

<o>	*

Return values:

<FrameByteValue>

Usage: Query only

BUS<m>:CXPI:RESult:FRAMe<n>:WORD<o>:VALue?

Returns the numeric value of the specified field.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<FrameByteValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

20.17.25.4 Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to CXPI trigger commands.

SEARch:TRIGger:CXPI:CT <SearchName>,<CT>
SEARch:TRIGger:CXPI:CT? <SearchName>

Sets the value of the counter (CT), 2 bits indicating the continuity of the frame.

Parameters:
<CT>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:CXPI:DATA:DCONdition? <SearchName>

Sets the condition for the data pattern. You can define no value, an exact value or a value range.

Parameters:

<DataOperator>	OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **OFF = ANY** Any data pattern is considered **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:CXPI:DATA:DMIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:CXPI:DATA:DMIN` and `SEARch:TRIGger:CXPI:DATA:DCONdition`. *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:CXPI:DATA:DMAX? <SearchName>

Sets the end value of a data type range if `SEARch:TRIGger:CXPI:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:
<DataMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:CXPI:DATA:DMIN? <SearchName>

Specifies a data bit pattern, or sets the start value of a pattern range.

Parameters:
<DataMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:ICONdition <SearchName>,<DatIdxOptor>
SEARch:TRIGger:CXPI:DATA:ICONdition? <SearchName>

Set the condition for the data index value. You can define an exact value or a value range.

Parameters:

<DatIdxOptor>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:CXPI:DATA:IMIN` command. **INRange = RANGe** In range: Set the minimum and maximum value using `SEARch:TRIGger:CXPI:DATA:IMIN` and `SEARch:TRIGger:CXPI:DATA:IMAX`. *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:CXPI:DATA:IMAX? <SearchName>

Sets the end value of a data index range if `SEARch:TRIGger:CXPI:DATA:ICONdition` is set to `INRange` or `RANGe`.

Parameters:

<DataIndexMax>	Range:	1 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:CXPI:DATA:IMIN? <SearchName>

Specifies a data index bit pattern, or sets the start value of a pattern range.

Parameters:

<DataIndexMin>	Range:	1 to 0
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DEXTension:CONDition <SearchName>,<DLCEXTOperator>
SEARch:TRIGger:CXPI:DEXTension:CONDition? <SearchName>

Set the condition for the DLC extend value. You can define an exact value or a value range.

Parameters:
<DLCEXTOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:CXPI:DEXTension:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:CXPI:DEXTension:MIN` and `SEARch:TRIGger:CXPI:DEXTension:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DEXTension:MAX <SearchName>,<DLCEXTMax>
SEARch:TRIGger:CXPI:DEXTension:MAX? <SearchName>

Sets the end value of a DLC extend range if `SEARch:TRIGger:CXPI:DEXTension:CONDition` is set to `INRange` or `OORange`.

Parameters:
<DLCEXTMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DEXTension:MIN <SearchName>,<DLCEXTMin>
SEARch:TRIGger:CXPI:DEXTension:MIN? <SearchName>

Specifies a data extension bit pattern, or sets the start value of a pattern range.

Parameters:
<DLCEXTMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DLC:CONDition <SearchName>,<DLCOperator>
SEARch:TRIGger:CXPI:DLC:CONDition? <SearchName>

Set the condition for the DLC. You can define an exact value or a value range.

Parameters:

<DLCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one DLC pattern to be set with the corresponding `SEARch:TRIGger:CXPI:DLC:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:CXPI:DLC:MIN` and `SEARch:TRIGger:CXPI:DLC:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DLC:MAX <SearchName>,<DLCMax>
SEARch:TRIGger:CXPI:DLC:MAX? <SearchName>

Sets the end value of a data type range if `SEARch:TRIGger:CXPI:DLC:CONDition` is set to `INRange` or `OORange`.

Parameters:
<DLCMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:DLC:MIN <SearchName>,<DLCMin>
SEARch:TRIGger:CXPI:DLC:MIN? <SearchName>

Specifies a DLC pattern, or sets the start value of a pattern range.

Parameters:
<DLCMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:CRC <SearchName>,<ErrorCRC>
SEARch:TRIGger:CXPI:ERRor:CRC? <SearchName>

Searches for a cyclic redundancy check error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorCRC>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:DLC <SearchName>,<ErrorDLC>
SEARch:TRIGger:CXPI:ERRor:DLC? <SearchName>

Searches for a data length code error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorDLC>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:IBS <SearchName>,<ErrorIBS>
SEARch:TRIGger:CXPI:ERRor:IBS? <SearchName>

Searches for an inter-byte-space error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorIBS>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:IFS <SearchName>,<ErrorIFS>
SEARch:TRIGger:CXPI:ERRor:IFS? <SearchName>

Searches for an inter-frame-space error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorIFS>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:LENGth <SearchName>,<ErrorLength>
SEARch:TRIGger:CXPI:ERRor:LENGth? <SearchName>

Searches for a length error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorLength>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:PARity <SearchName>,<ErrorParity>
SEARch:TRIGger:CXPI:ERRor:PARity? <SearchName>

Searches for a parity error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorParity>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:ERRor:UART <SearchName>,<ErrorUart>
SEARch:TRIGger:CXPI:ERRor:UART? <SearchName>

Searches for an UART error, if `SEARch:TRIGger:CXPI:TYPE` is set to `ERRor`.

Parameters:

<ErrorUart>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CXPI:FID:CONDition <SearchName>,<FrameIDOperator>
SEARch:TRIGger:CXPI:FID:CONDition? <SearchName>

Set the condition for the frame ID. You can define an exact value or a value range.

Parameters:

<FrameIDOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange **EQUal | NEQual | LTHan | LETHan | GTHan | GETHan** Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:CXPI:FID:MIN` command. **INRange | OORange** In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:CXPI:FID:MIN` and `SEARch:TRIGger:CXPI:FID:MAX`. *RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CXPI:FID:MAX <SearchName>,<FrameIDMax>
SEARch:TRIGger:CXPI:FID:MAX? <SearchName>

Sets the end value of a frame ID range if `SEARch:TRIGger:CXPI:FID:CONDition` is set to `INRange` or `OORange`.

Parameters:

<FrameIDMax>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CXPI:FID:MIN <SearchName>,<FrameIDMin>
SEARch:TRIGger:CXPI:FID:MIN? <SearchName>

Specifies a frame ID pattern, or sets the start value of a pattern range.

Parameters:

<FrameIDMin>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CXPI:NM <SearchName>,<NM>
SEARch:TRIGger:CXPI:NM? <SearchName>

Sets the value of the network management (NM) field.

Parameters:

<NM>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CXPI:TYPE <SearchName>,<Type>
SEARch:TRIGger:CXPI:TYPE? <SearchName>

Searches for the selected CXPI frame type.

Parameters:

<Type> STARt | NORMal | NPOLI | SLEEP | LONG | LPOLI | PID | PTYPe | PTPD | ERRor

STARt
Triggers on the STARt of the frame.

NORMal
Triggers on a NORMal frame. Optionally you can define a frame ID condition, a NM, a CT, a DLC condition, a data pattern condition and an index condition.

NPOLI
Triggers on a Normal POLL frame. Optionally you can define a frame ID condition, a NM, a CT, a DLC condition, a data pattern condition and an index condition.

SLEEP
Triggers on a SLEEP frame. Optionally you can define a NM, a CT, a data pattern condition and an index condition.

LONG
Triggers on a Long frame. Optionally you can define a frame ID condition, a NM, a CT, a DLC extend condition, a data pattern condition and an index condition.

LPOLI
Triggers on a Long POLL frame.

PID
Triggers on a Protected ID field. Optionally, you can define the frame ID pattern.

PTYPe
Triggers on a Protected TYPE field.

PTPID
Triggers on a PType field followed by a PID field.Optionally, you can define the frame ID pattern.

ERRor
Trigger on selected error types. Define the error types with:
`SEARch:TRIGger:CXPI:ERRor:CRC` on page 2086
`SEARch:TRIGger:CXPI:ERRor:CRC` on page 2086
`SEARch:TRIGger:CXPI:ERRor:DLC` on page 2086
`SEARch:TRIGger:CXPI:ERRor:IBS` on page 2086
`SEARch:TRIGger:CXPI:ERRor:IFS` on page 2086
`SEARch:TRIGger:CXPI:ERRor:LENGth` on page 2087
`SEARch:TRIGger:CXPI:ERRor:PARity` on page 2087
`SEARch:TRIGger:CXPI:ERRor:UART` on page 2087

*RST: STARt

Parameters for setting and query:
<SearchName>

20.17.25.5 Search Result Settings

The search on decoded CXPI data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.25.3, "Decode Results", on page 2077.

SEARch:RESult:CXPI:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:DATA? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:DLCV? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<DLC>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:STARt? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:STATe? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<State> OK | INComplete | ERR_IBS | ERR_IFS | ERR_LENGTH | ERR_CRC | ERR_PARITY | ERR_DLC | ERR_UART

*RST: OK

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:STOP? <SearchName>

Suffix:

<m>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Type> NORMal | NPOLI | SLEEP | LONG | LPOLI | PID | PTYPe | PTPID | UNKNown | IFS

*RST: NORMal

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:STATus? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<Status> OK | INComplete | ERR_IBS | ERR_IFS | ERR_LENGTH | ERR_CRC | ERR_PARITY | ERR_DLC | ERR_UART

*RST: OK

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:TYPE? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameByteValue>

Usage: Query only

SEARch:RESult:CXPI:FRAMe<m>:WORD<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<FrameByteValue>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

20.18 Mixed Signal Option (MSO, R&S RTO-B1)

This chaptes decribes the remote commands of MSO option R&S RTO-B1.

20.18.1 Digital Channels

All `DIGital:` commands affect only the settings of the first MSO bus (Bus1). The settings of all other parallel buses (Bus 2, 3,4) remain unchanged.

DIGital<m>:DISPlay <Display>

Enables or disables the indicated digital channel, displays it, and enables the parallel Bus1 if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For Bus1, the `DIG:DISP` command has the same effect as `BUS<m>:PARallel:BIT<n>[:STATe]`. To enable digital channels for buses 2, 3 and 4, use the `BUS:PAR:BIT[:STAT]` command.

Suffix:

<m>	0..15 Number of the digital channel

Parameters:

<Display>	ON | OFF

Firmware/Software: V 1.30

DIGital<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

The setting affects only the settings of the first MSO bus (Bus1). You can set the technology value for all buses with `BUS<m>:PARallel:TECHnology`.

Suffix:

<m>	0..15 The suffix is irrelevant.

Parameters:

<Technology>	V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN See `BUS<m>:PARallel:TECHnology`

Firmware/Software: V 1.40

DIGital<m>:THReshold <Value>

Sets the logical threshold for the channel group to which the indicated digital channel belongs. The setting affects only the settings of the first MSO bus (Bus1).

The setting affects only the settings of the first MSO bus (Bus1). You can set the threshold for all buses with `BUS<m>:PARallel:TECHnology` or `BUS<m>:PARallel:THReshold<n>`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m>	0..15 Number of the digital channel. Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Value>	Range: -8.0 to 8.0 Increment: 200.0e-12 *RST: 0 Default unit: V

Firmware/Software: V 1.30

DIGital<m>:THCoupling <State>

Sets the threshold and the hysteresis for all digital channels of parallel bus 1 to the same value.

The command `BUS<m>:PARallel:THCoupling` is used to set all buses.

Suffix:

<m>	0..15 The suffix is irrelevant.

Parameters:

<State>	ON | OFF

Firmware/Software: V 1.30

DIGital<m>:HYSTeresis <Hysteresis>

Defines the size of the hysteresis to avoid the change of signal states due to noise for the channel group to which the indicated digital channel belongs.

The setting affects only the settings of the first MSO bus (Bus1). You can set the hysteresis for all buses with `BUS<m>:PARallel:HYSTeresis<n>`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m>	0..15 Number of the digital channel Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Hysteresis>	MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal **MAXIMUM = MAXimum** Maximum value that is possible and useful for the signal and its settings **ROBUST = ROBust** Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. **NORMAL = NORMal** The instrument sets a value suitable for the signal and its settings.

Firmware/Software: V 1.30

DIGital<m>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

The setting affects only the settings of the first MSO bus (Bus1). You can set the label for all buses with `BUS<m>:PARallel:BIT<n>:LABel`.

Suffix:

<m>	0..15 Number of the digital channel

Parameters:

<Label>	String containing the channel name

Firmware/Software: V 1.30

DIGital<m>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

The setting affects only the settings of the first MSO bus (Bus1). You can set the deskew for all buses with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:

<m>	0..15 Number of the digital channel

Parameters:

<Deskew>	Range: -200.0E-09 to 200.0E-09 Increment: 200.0E-12 *RST: 0 Default unit: s

20.18.2 Parallel Bus Configuration

The following commands configure the four parallel buses of R&S RTO-B1.

BUS<m>:PARallel:STATe <Enable>

Enables or disables the indicated parallel bus. The threshold settings of the bus take effect for all *active* parallel buses.

Dependencies: At least one digital channel must be enabled for the selected bus, otherwise the command does not work. The bus is enabled automatically if the first digital channel is enabled with `BUS<m>:PARallel:BIT<n>[:STATe]` or `DIGital<m>:DISPlay`.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<Enable>	ON | OFF *RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:BIT<n>[:STATe] <Assigned>

Assigns the selected digital channel to the indicated bus, displays it, and enables the bus if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For parallel bus 1, the `BUS:PAR:BIT[:STATe]` command has the same effect as `DIGital<m>:DISPlay`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	0..15 Selects the digital channel. Each digital channel provides a definite bit of the bus word.

Parameters:

<Assigned>	ON | OFF *RST: OFF

Firmware/Software: V 1.40

BUS<m>:PARallel:THReshold<n> <Threshold>

Sets the logical threshold for the indicated channel group.

Alternatively, you can set the threshold with `BUS<m>:PARallel:TECHnology`. For the parallel bus 1, you can also use `DIGital<m>:THReshold`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	1..4 Selects the channel group: 1 = dig. channels 0..3; 2 = dig. channels 4..7 3 = dig. channels 8..11 4 = dig. channels 12..15

Parameters:

<Threshold>

Range:	-8.0 to 8.0
Increment:	200.0e-12
*RST:	0
Default unit:	V

Firmware/Software: V 1.40

BUS<m>:PARallel:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15: TTL
V25: CMOS 5.0 V
V165: CMOS 3.3 V
V125: CMOS 2.5 V
V09: CMOS 1.85 V
VM13: ECL, -1.3 V
V38: PECL
V20: LVPECL
V0: Ground
MAN: Set a user-defined threshold value with `DIGital<m>:THReshold`

*RST: V165

Firmware/Software: V 1.36

BUS<m>:PARallel:THCoupling <LevelCoupling>

Sets the threshold for all digital channels of the selected bus to the same value. Also the hysteresis value is applied to all digital channels.

Tor parallel bus 1, the command `DIGital<m>:THCoupling` has the same effect.

Suffix:

<m>	1..4 The suffix is irrelevant.

Parameters:

<LevelCoupling>	ON | OFF *RST: ON

Firmware/Software: V 1.30

BUS<m>:PARallel:HYSTeresis<n> <Hysteresis>

Defines the size of the hysteresis for the channel group to avoid the change of signal states due to noise.

For the parallel bus 1, you can also use `DIGital<m>:HYSTeresis`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	1..4 Selects the channel group: 1 = dig. channels 0..3; 2 = dig. channels 4..7 3 = dig. channels 8..11 4 = dig. channels 12..15

Parameters:

<Hysteresis>	MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal **MAXIMUM = MAXimum** Maximum value that is possible and useful for the signal and its settings **ROBUST = ROBust** Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. **NORMAL = NORMal** The instrument sets a value suitable for the signal and its settings.

Firmware/Software: V 1.40

BUS<m>:PARallel:BIT<n>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

For the parallel bus 1, you can also use `DIGital<m>:DESKew`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	0..15 Number of the digital channel

Parameters:

<Deskew>

Range: -200E-9 to 200E-9
Increment: 200E-12
*RST: 0
Default unit: s

BUS<m>:PARallel:DESoffset <DeskewOffset>

Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of this general value and the individual value set with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<DeskewOffset>

Range: -200E-9 to 200E-9
Increment: 200E-12
*RST: 0
Default unit: s

BUS<m>:PARallel:BIT<n>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

For the parallel bus 1, you can also use `DIGital<m>:LABel`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	0..15 Number of the digital channel

Parameters:

<Label> String containing the channel name

Firmware/Software: V 1.40

BUS<m>:PARallel:DISPlay:SHDI <ShwDigSigns>

If enabled, the selected digital signals are shown in the diagram. Each channel is displayed as a logic signal.

See also: `DIGital<m>:DISPlay`

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<ShwDigSigns>	ON | OFF *RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:SHBU <ShowBus>

Shows or hides the indicated parallel bus. If enabled, the resulting bus signal and bus values are displayed in the diagram.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<ShowBus>	ON | OFF *RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:BTYP <BusRepres>

Selects the display type of the indicated parallel bus.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<BusRepres>	COMB | ANALog **COMB** Displays the decoded bus signal with bus values. **ANALog** Displays the bus value as amplitude, similar to an analog waveform. *RST: COMB

Firmware/Software: V 1.30

BUS<m>:PARallel:CLON <Clocked>

Defines if the bus is a clocked bus - one of the digital channels serves as clock of the bus.

Suffix:

<m>	1 | 2 Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<Clocked>	ON | OFF *RST: OFF

Firmware/Software: V 1.36

BUS<m>:PARallel:CLOCk <ClockSource>

Selects the digital channel used as clock of the indicated parallel bus.

Suffix:

<m>	1 | 2 Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<ClockSource>	D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Clock channel *RST: D1

Firmware/Software: V 1.30

BUS<m>:PARallel:CLSLope <ClockSlope>

Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Suffix:

<m>	1 | 2 Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<ClockSlope>	POSitive | NEGative | EITHer *RST: POSitive

Firmware/Software: V 1.36

BUS<m>:PARallel:CLEar

Removes all assigned digital channels from the bus

Suffix:

<m>	1..4 Selects the parallel bus.

Usage:	Event
Firmware/Software:	V 1.30

20.18.3 Digital Resolution

ACQuire:DRESolution?

Returns the current digital resolution of the digital channels.

Return values:

<DigRes>	Default unit: s
Usage:	Query only

ACQuire:POINts:DVALue?

Returns the current digital record length used by each digital channel.

Return values:

<DigReclgth>	Range: 1000 to 200E6 Increment: 2 *RST: 1000 Default unit: Sa
Usage:	Query only

20.18.4 Trigger Settings for Digital Signals and Parallel Buses

In all `TRIGger<m>:PARallel` commands, the trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on digital signals and parallel buses.

20.18.4.1 General Commands

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m>	1..3 1 = A-trigger, 2 = B-trigger, 3 = R-event Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured. For all other trigger sources, only suffix 1 is allowed. See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed>

CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input.
For this source, only the analog edge trigger is available.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTO-B1)
See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 2103

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTO-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTO-B1)

*RST: CHAN1

TRIGger<m>:PARallel:TYPE <Type>

Selects the trigger type to trigger on digital channels and parallel buses.

To trigger on analog channels or the external trigger input, use `TRIGger<m>:TYPE`.

Parameters:

<Type>	EDGE | WIDTh | TIMeout | DATatoclock | STATe | PATTern | SERPattern *RST: EDGE

TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] <ClockSource>
TRIGger<m>:PARallel:STATe:CSOurce:VALue <ClockSource>
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] <ClockSource>

Selects the digital channel of the clock signal.

Parameters:

<ClockSource>	D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: D0

TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] <LogicalExpr>

Defines a logical combination of several digital channels as trigger condition if `TRIGger<m>:SOURce` is set to LOGIC.

Parameters:

<LogicalExpr>	String with logical expression
Example:	`TRIGger:PARallel:EDGE:EXPRession 'D1 and D2'`

20.18.4.2 Edge Trigger

See also:

- `TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 2105

TRIGger<m>:PARallel:EDGE:SLOPe <Slope>

Defines the edge - the state transition - of the signal to trigger on a single digital channel (a logic bit), or a logical combination of digital channels.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

20.18.4.3 Width Trigger

See also:

- `TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 2105

TRIGger<m>:PARallel:WIDTh:POLarity <Polarity>

Sets the polarity of a pulse. When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Parameters:

<Polarity>	POSitive | NEGative | EITHer *RST: POSitive

TRIGger<m>:PARallel:WIDTh:RANGe <RangeMode>

Selects how the range of a pulse width is defined:

Parameters:

<RangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin | OUTSide** Pulses inside or outside a given time range. The time range *Width ± Delta* is defined by `TRIGger<m>:PARallel:WIDTh:WIDTh` and `TRIGger<m>:PARallel:WIDTh:DELTa`. **SHORter | LONGer** Pulses shorter or longer than a given width defined by `TRIGger<m>:PARallel:WIDTh:WIDTh` *RST: WITHin

---

TRIGger<m>:PARallel:WIDTh:WIDTh <Width>

Sets the limit for the pulse width.

The effect depends on `TRIGger<m>:PARallel:WIDTh:RANGe`.

- For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.
- For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits `TRIGger<m>:PARallel:WIDTh:DELTa`.

Parameters:

<Width>	Range: 200E-12 to 10000 Increment: 200E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:PARallel:WIDTh:DELTa <WidthDelta>

Defines a range around the given width value. the setting is relevant if `TRIGger<m>:PARallel:WIDTh:RANGe` is set to WITHin or OUTSide. The width is set with `TRIGger<m>:PARallel:WIDTh:WIDTh`.

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 600E-12 *RST: 0 Default unit: s

20.18.4.4 Timeout Trigger

See also:

- `TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 2105

TRIGger<m>:PARallel:TIMeout:RANGe <TimeoutMode>

Sets the state condition.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The level of a digital channel stays above the threshold, or the logical expression for LOGic trigger source is true.

LOW
The level of a digital channel stays below the threshold, or the logical expression for LOGic trigger source is false.

EITHer
The signal state remains unchanged.

*RST: HIGH

TRIGger<m>:PARallel:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-9 Default unit: s

20.18.4.5 Data2Clock Trigger

See also:

- `TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue]` on page 2105

TRIGger<m>:PARallel:DATatoclock:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time reference point for the setup and hold time measurement.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer *RST: POSitive

TRIGger<m>:PARallel:DATatoclock:STIMe <SetupTime>

Sets the minimum time *before* the clock edge while data should be stable and not change its state.

See also: "Setup time" on page 988

Parameters:

<SetupTime>	Range: -99.8E-9 to 100E-9 Increment: 1E-9 *RST: 0 Default unit: s

---

TRIGger<m>:PARallel:DATatoclock:HTIMe <HoldTime>

Sets the minimum time *after* the clock edge while data should be stable and not change its state.

See also: "Hold time" on page 989

Parameters:

<HoldTime>	Range: -99.8E-9 to 100E-9 Increment: 1E-9 *RST: 0 Default unit: s

20.18.4.6 State Trigger

See also:

- `TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 2105
- `TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 2105

TRIGger<m>:PARallel:STATe:CSOurce:EDGE <Slope>

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

TRIGger<m>:PARallel:STATe:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n>	0..15 Number of the digital channel

Parameters:

<Bit>	HIGH | LOW | DONTCARE | DONTcare Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

20.18.4.7 Pattern Trigger

TRIGger<m>:PARallel:PATTern:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n>	0..15 Number of the digital channel

Parameters:

<Bit>	HIGH | LOW | DONTCARE | DONTcare Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

TRIGger<m>:PARallel:PATTern:MODE <Mode>

Sets the mode of the timing condition.

Parameters:

<Mode>	OFF | TIMeout | WIDTh **OFF** No timing condition, only the logical pattern condition is relevant. **TIMeout** Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Use `TRIGger<m>:PARallel:PATTern:TIMeout:MODE` and `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` to specify the timeout. **WIDTh** Sets a pulse width as timing condition. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit. Use `TRIGger<m>:PARallel:PATTern:WIDTh:RANGe`, `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`, and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` to specify the width. *RST: OFF

TRIGger<m>:PARallel:PATTern:TIMeout:MODE <TimeoutMode>

Sets the state condition for the timeout qualification if `TRIGger<m>:PARallel:PATTern:MODE` is set to TIMeout. To set the time limit, use `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]`.

Parameters:

<TimeoutMode>	HIGH | LOW | EITHer HIGH: The pattern stays true for the specified time. LOW: The pattern stays false for the specified time. EITHER: The pattern remains unchanged for the specified time. *RST: HIGH

TRIGger<m>:PARallel:PATTern:TIMeout[:TIME] <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-9 Default unit: s

---

TRIGger<m>:PARallel:PATTern:WIDTh:RANGe <WidthRangeMode>

Selects how the range of a pulse width is defined if `TRIGger<m>:PARallel:PATTern:MODE` is set to WIDTh.

Parameters:

<WidthRangeMode>	WITHin | OUTSide | SHORter | LONGer **WITHin** Triggers when the pattern comes false inside a given time range. The time limit is defined by `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` (*Width ± Delta*). **OUTSide** Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for WITHin range. **SHORter | LONGer** Triggers when the pattern comes false before or after the given width has expired. Width is set with `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`. *RST: WITHin

---

TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh] <Width>

The effect depend on the setting of the `TRIGger<m>:PARallel:PATTern:WIDTh:RANGe`command.

For the ranges SHOrter and LONGer, the width defines the maximum and minimum time limit, respectively.

For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits "±Delta".

Parameters:

<Width>	Range:	100E-12 to 10000
	Increment:	100E-9
	*RST:	5E-9
	Default unit:	s

TRIGger<m>:PARallel:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value set with `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`.

Parameters:

<WidthDelta>	Range:	0 to 432
	Increment:	500E-12
	*RST:	0
	Default unit:	s

20.18.4.8 Serial Pattern Trigger

See also:

- `TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 2105

- `TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 2105

TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer *RST: POSitive

TRIGger<m>:PARallel:SPATtern:PATTern <Pattern>

Defines the serial bit string on which to trigger.

Parameters:

<Pattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 1175. The bit value X (don't care) is not allowed.

20.18.5 MSO Data

To export data of digital channels and parallel buses to file, use the following commands:

- `EXPort:WAVeform:SOURce` on page 1478
- `BUSFormat` on page 1497
- `EXPort:WAVeform:NAME` on page 1479
- `EXPort:WAVeform:SAVE` on page 1480

The remote export for transmission from the instrument to the controlling computer is performed using the following commands:

`FORMat[:DATA]` on page 1181

and

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:

<DataFormat>	HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG ASCII = ASCii *RST: HEX
Usage:	Asynchronous command
Firmware/Software:	FW 1.45

DIGital<m>:DATA:HEADer?

Returns the header of digital channel data

Table 20-11: Header data

Position	Meaning	Example
1	XStart, acquisition time before trigger, in s	-5E-008 = - 50 ns
2	XStop, acquisition time after trigger, in s	5E-008 = 50 ns
3	Record length of the waveform in Samples	1000
4	Number of values per sample interval. For digital data the result is 1.	1

Suffix:

<m>	0..15 Number of the digital channel
Usage:	Query only

DIGital<m>:DATA[:VALues]?

Returns the data of the indicated digital channel for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]` and `BUSFormat`.

Suffix:

<m>	0..15 Selects the digital channel.

Return values:

<Data>	List of values according to the format settings.
Usage:	Query only

BUS<m>:PARallel:DATA:HEADer?

Returns the header data of the indicated bus.

For a detailed description, see `DIGital<m>:DATA:HEADer?`.

Suffix:

<m>	1..4 Selects the parallel bus.
Usage:	Query only
Firmware/Software:	V 2.40

BUS<m>:PARallel:DATA[:VALues]?

Returns the data of the indicated parallel bus.

Requirements:

- `BUS<m>:PARallel:STATe` is set to `ON`.
- `BUS<m>:PARallel:DISPlay:SHBU` is set to `ON`.
- `FORMat[:DATA]` is set to `ASCII`.
  The data formats REAL, INT8 and INT16 are not supported.

To set the number format, use `BUSFormat`.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<Data>	List of decimal values (signed or unsigned).
Usage:	Query only
Firmware/Software:	V 2.40

20.19 Waveform Generator (Option R&S RTO-B6)

20.19.1 Waveform Generator Setup

20.19.1.1 General

WGENerator<m>:ACOPy

Copies all settings from Gen1/Gen2 and applies them to Gen2/Gen1.

Suffix:	
<m>	1..2
Usage:	Event

WGENerator<m>[:ENABle] <State>

Enables the waveform generator and outputs the waveform.

Suffix:	
<m>	1..2
Parameters:	
<State>	ON | OFF
Usage:	Asynchronous command

WGENerator<m>:SOURce <OperationMode>

Sets the operation mode for the the waveform generator.

Suffix:	
<m>	1..2
Parameters:	
<OperationMode>	FUNCgen | MODulation | SWEep | ARBGenerator *RST: FUNCgen

---

WGENerator<m>:PRESet

Sets the parameters of the waveform generator to their default values.

Suffix:	
<m>	1..2
Usage:	Event

20.19.1.2 Function Generator

WGENerator<m>:FUNCtion[:SELect] <FunctionType>

Sets the type of waveform to be generated for the function generator.

Suffix:	
<m>	1..2

Parameters:

<FunctionType>	SINusoid | SQUare | RAMP | DC | PULSe | SINC | CARDiac | GAUSs | LORNtz | EXPRise | EXPFall SINC: Cardial sine *RST: SINusoid

---

WGENerator<m>:FREQuency <Frequency>

Sets the frequency of the waveform. The available frequency range depends on the selected function type.

Suffix:

<m>	1..2

Parameters:

<Frequency>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1E+6 Default unit: Hz

---

WGENerator<m>:PERiod <Period>

Sets the period of the waveform. The available period range depends on the selected function type.

Suffix:

<m>	1..2

Parameters:

<Period>	Range: 8E-9 to 1000 Increment: 1 *RST: 1E-6 Default unit: s

---

WGENerator<m>:FUNCtion:PULSe[:WIDTh] <PulseWidth>

Sets the pulse duration for a pulse waveform.

Suffix:

<m>	1..2

Parameters:

<PulseWidth>	Range: 16.5E-9 to 90E+3 Increment: 1 *RST: 500E-9 Default unit: s

---

WGENerator<m>:FUNCtion:RAMP[:SYMMetry] <RampSymmetry>

Sets the symmetry for a ramp waveform.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:FUNCtion:SQUare:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>	Range:	0.01 to 99.99
	Increment:	1
	*RST:	50
	Default unit:	%

20.19.1.3 Modulation

WGENerator<m>:MODulation:TYPE <ModulationType>

Sets the modulation type.

Suffix:

<m>	1..2

Parameters:

<ModulationType>	AM | FM | PWM | FSK	
	*RST:	AM

WGENerator<m>:MODulation:AM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>	Range:	10 to 90
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:AM:DEPTh <Depth>

Sets the amplitude modulation depth.

Suffix:

<m>	1..2

Parameters:

<Depth>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:AM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<Frequency>	Range:	1E-3 to 1E+6
	Increment:	1
	*RST:	1000
	Default unit:	Hz

WGENerator<m>:MODulation:AM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:CARRier:FREQuency <CarrierFreq>

Sets the frequency of the carrier signal for a modulation waveform.

Suffix:

<m>	1..2

Parameters:

<CarrierFreq>	Range:	1E-3 to 100E+6
	Increment:	10
	*RST:	1E+6
	Default unit:	Hz

WGENerator<m>:MODulation:CARRier:PERiod <CarrierPeriod>

Sets the period of the carrier signal for a modulation waveform.

Suffix:

<m>	1..2

Parameters:

<CarrierPeriod>	Range:	8E-9 to 1000
	Increment:	10
	*RST:	1E-6
	Default unit:	s

WGENerator<m>:MODulation:AM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP	
	*RST:	SINusoid

WGENerator<m>:MODulation:FM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>	Range:	10 to 90
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:FM:DEViation <Deviation>

Sets the frequency modulation deviation.

Suffix:

<m>	1..2

Parameters:

<Deviation>	Range:	1E-3 to 10E+6
	Increment:	1
	*RST:	1000
	Default unit:	Hz

WGENerator<m>:MODulation:FM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m>	1..2

Parameters:

<Frequency>	Range:	1E-3 to 1E+6
	Increment:	1
	*RST:	1000
	Default unit:	Hz

WGENerator<m>:MODulation:FM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:FM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m>	1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP *RST: SINusoid

WGENerator<m>:MODulation:FSK:FONE <Frequency1>

Sets the frequency of the carrier waveform, if `WGENerator<m>:MODulation:TYPE` is set to `FSK`.

Suffix:

<m>	1..2

Parameters:

<Frequency1>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1E+6 Default unit: Hz

---

WGENerator<m>:MODulation:FSK:FTWO <Frequency2>

Sets the frequency of the modulated waveform, if `WGENerator<m>:MODulation:TYPE` is set to `FSK`.

Suffix:

<m>	1..2

Parameters:

<Frequency2>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1000 Default unit: Hz

---

WGENerator<m>:MODulation:FSK[:RATE] <Rate>

Sets the hop rate, the time before a switch from the carrier frequency set with `WGENerator<m>:MODulation:FSK:FONE` and the modulation frequency set with `WGENerator<m>:MODulation:FSK:FTWO`.

Suffix:
<m> 1..2

Parameters:
<Rate> Range: 1E-3 to 1E+6
Increment: 1
*RST: 1000
Default unit: Hz

WGENerator<m>:MODulation:PWM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:
<m> 1..2

Parameters:
<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

WGENerator<m>:MODulation:PWM:DEPTh <Depth>

Sets the modulation depth for pulse width modulation.

Suffix:
<m> 1..2

Parameters:
<Depth> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

WGENerator<m>:MODulation:PWM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:
<m> 1..2

Parameters:

<Frequency>	Range: 1E-3 to 1E+6 Increment: 1 *RST: 1000 Default unit: Hz

---

WGENerator<m>:MODulation:PWM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:PWM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP *RST: SINusoid

20.19.1.4 Sweep

WGENerator<m>:SWEep:FSTart <StartFrequency>

Sets the start frequency of the sweep range.

Suffix:

<m>	1..2

Parameters:

<StartFrequency>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1000 Default unit: Hz

---

WGENerator<m>:SWEep:TIME <Time>

Sets the duration of the sweep.

Suffix:

<m>	1..2

Parameters:

<Time>	Range: 1E-3 to 500 Increment: 1 *RST: 1E-3 Default unit: s

---

WGENerator<m>:SWEep[:FEND] <StopFrequency>

Sets the stop frequency of the sweep range.

Suffix:

<m>	1..2

Parameters:

<StopFrequency>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1E+6 Default unit: Hz

20.19.1.5 ARB

WGENerator<m>:ARBGen:COPY

Loads the waveform from the selected signal source (`WGENerator<m>:ARBGen:SELect`).

Suffix:

<m>	1..2

Usage:	Event Asynchronous command

WGENerator<m>:ARBGen:MULTichannel:IMPort <SavedWfmSrc>

Assigns a waveform from the multichannel file to the arbitrary waveform generator.

Suffix:

<m>	1..2

Parameters:

<SavedWfmSrc>	WFM1 | WFM2 | WFM3 | WFM4 *RST: WFM1

Example:

```
WGENerator1:ARBGen:MULTichannel:NAME
ArbMultichannelCurve_2017-02-16_01.bin
WGENerator1:ARBGen:MULTichannel:IMPort WF1
WGENerator1:ARBGen:MULTichannel:OPEN
```

WGENerator<m>:ARBGen:MULTichannel:NAME <FilePath>

Defines the path and the multichannel arbitrary waveform file to be imported. If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

Suffix:

<m>	1..2

Parameters:

<FilePath>

Example: See `WGENerator<m>:ARBGen:MULTichannel:IMPort` on page 2125.

WGENerator<m>:ARBGen:MULTichannel:OPEN

Loads the arbitrary waveform.

Suffix:

<m>	1..2

Example: See `WGENerator<m>:ARBGen:MULTichannel:IMPort` on page 2125.

Usage: Event
Asynchronous command

WGENerator<m>:ARBGen:NAME <FilePath>

Sets the file path and the file for an arbitrary waveform, if `WGENerator<m>:ARBGen[:SOURce]` on page 2127 is set to `ARBitrary`.

If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

This command is only relevant for files with one waveform defined. For multichannel arbitrary waveform files, see `WGENerator<m>:ARBGen:MULTichannel:OPEN`.

Suffix:

<m>	1..2

Parameters:

<FilePath>

WGENerator<m>:ARBGen:OPEN

Loads the arbitrary waveform, that is selected with the `WGENerator<m>:ARBGen:NAME` command.

This command is only relevant for files with one waveform defined. For multichannel arbitrary waveform files, see `WGENerator<m>:ARBGen:MULTichannel:OPEN`.

Suffix:

<m>	1..2
Usage:	Event Asynchronous command

WGENerator<m>:ARBGen:RUNMode <RunMode>

Sets the duration for which the signal of the arbitrary generator will be output after the trigger event.

Suffix:

<m>	1..2

Parameters:

<RunMode>	SINGle | CONTinuous *RST: CONTinuous

WGENerator<m>:ARBGen:SAMPles?

Displays the number of samples for the arbitrary waveform.

Suffix:

<m>	1..2

Return values:

<NumSamples>	Range: 0 to 128000000 Increment: 10 *RST: 0 Default unit: Sa
Usage:	Query only

WGENerator<m>:ARBGen:SELect <ScopeSignSrc>

Selects the oscilloscope source, from which the arbitrary signal is loaded, if `WGENerator<m>:ARBGen[:SOURce]` is set to `SCOPe`.

Suffix:

<m>	1..2

Parameters:

<ScopeSignSrc>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | R1 | R2 | R3 | R4 *RST: C1W1

WGENerator<m>:ARBGen:SRATe <SampleRate>

Sets the sample rate for the arbitrary waveform.

Suffix:

<m>	1..2

Parameters:

<SampleRate>	Range: 1 to 250E+6 Increment: 10 *RST: 1E+6 Default unit: Sa/s

---

WGENerator<m>:ARBGen[:SOURce] <WaveformSource>

Sets the arbitrary waveform source.

Suffix:

<m>	1..2

Parameters:

<WaveformSource>	ARBitrary | SCOPe **ARBitrary** Enables you to load an existing arbitrary file. **SCOPe** Enables you to load a scope waveform. *RST: ARBitrary

20.19.1.6 Output

WGENerator<m>:OUTPut[:LOAD] <Load>

Sets the load of the DUT at its connection.

Suffix:

<m>	1..2

Parameters:

<Load>	FIFTy | HIZ HIZ: high input impedance *RST: HIZ

WGENerator<m>:VOLTage[:VPP] <Amplitude>

Sets the amplitude, peak to peak voltage, of the output waveform. This is defined as the voltage difference between the maximum (`WGENerator<m>:VOLTage:HIGH`) and the minimum (`WGENerator<m>:VOLTage:LOW`) voltage levels.

The value is set for the currently selected load (`WGENerator<m>:OUTPut[:LOAD]`). If the load is changed, the value of the amplitude is adapted to this new setting.

Suffix:

<m>	1..2

Parameters:

<Amplitude>	Range: 0.01 to 12 Increment: 0.1 *RST: 1 Default unit: Vpp

---

WGENerator<m>:VOLTage:DCLevel <DCLevel>

Sets the DC level of the generated DC signal.

Suffix:

<m>	1..2

Parameters:

<DCLevel>	Range: -5.995 to 5.995 Increment: 0.1 *RST: 0 Default unit: V

WGENerator<m>:VOLTage:HIGH <High>

Sets the high signal level of the output waveform.

Suffix:

<m>	1..2

Parameters:

<High>	Range: -5.99 to 6 Increment: 0.1 *RST: 0.5 Default unit: V

WGENerator<m>:VOLTage:INVersion <Inversion>

Enables inversion, which swaps the two poles of the waveform.

Suffix:

<m>	1..2

Parameters:

<Inversion>	ON | OFF *RST: OFF

WGENerator<m>:VOLTage:LOW <Low>

Sets the low signal level of the output waveform.

Suffix:

<m>	1..2

Parameters:

<Low>	Range: -6 to 5.99 Increment: 0.1 *RST: -0.5 Default unit: V

WGENerator<m>:VOLTage:OFFSet <Offset>

Sets a voltage offset.

Suffix:

<m>	1..2

Parameters:

<Offset>	Range: -5.995 to 5.995 Increment: 0.1 *RST: 0 Default unit: V

20.19.1.7 Noise

WGENerator<m>:MODulation:NDCLevel <LevelDC>

Sets the DC noise level.

Suffix:

<m>	1..2

Parameters:

<LevelDC>	Range:	0 to 12
	Increment:	0.1
	*RST:	0.01
	Default unit:	Vpp

WGENerator<m>:MODulation:NLABsolute?

Queries the level of the noise in volts.

Suffix:

<m>	1..2

Return values:

<LevelAbs>	Range:	0 to 12
	Increment:	0.1
	*RST:	0
	Default unit:	Vpp

Usage: Query only

WGENerator<m>:MODulation:NLPCent <LevelPct>

Sets the noise level in percentage of the amplitude.

Suffix:

<m>	1..2

Parameters:

<LevelPct>	Range:	0 to 100
	Increment:	1
	*RST:	0
	Default unit:	%

WGENerator<m>:MODulation:NOISe <State>

Enables the adding of noise to the waveform.

Suffix:

<m>	1..2

Parameters:

<State>	ON | OFF	
	*RST:	OFF

20.19.2 Pattern Generator Setup

PGENerator:BITRate <BitRate>

Sets the number of transmitted bits per second for the pattern generator.

Parameters:

<BitRate>	Range: 1 to 40E+6 Increment: 10 *RST: 1E+6 Default unit: bps

---

PGENerator:ENABle <State>

Enables the pattern generator and outputs the waveform.

Parameters:

<State>	ON | OFF

PGENerator:FILE:OPEN

Loads the specified pattern file to the instrument.

Usage:	Event Asynchronous command

PGENerator:FILE[:NAME] <FilePath>

Specifies a file path to open a pattern generator file.

Parameters:

<FilePath>	String with the name of the file.

PGENerator:HLEVel <HighLevel>

Sets the high level of the pattern generator signal.

Parameters:

<HighLevel>	Range: 1.2 to 5 Increment: 0.1 *RST: 1.2 Default unit: V

PGENerator:PRESet

Sets the default pattern generator settings.

Usage:	Event

PGENerator:RUNMode <RunMode>

Sets the duration for which the signal of the pattern generator will be output after the trigger event.

Parameters:

<RunMode>	SINGle | CONTinuous
	*RST: CONTinuous

20.19.3 Coupling & Sync

WGENerator<m>:COUPling:ALL <CoupleAll>

Enables the coupling of all parameters of the generators, except of load and inversion.

Suffix:

<m>	1..2

Parameters:

<CoupleAll>	ON | OFF
	*RST: OFF

WGENerator<m>:COUPling:AMPLitude <CoupleAmplitude>

Enables the coupling of all amplitude parameters of the generators.

Suffix:

<m>	1..2

Parameters:

<CoupleAmplitude>	ON | OFF
	*RST: OFF

WGENerator<m>:COUPling:PHASeshift <PhaseShift>

Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Suffix:

<m>	1..2

Parameters:

<PhaseShift>
Range: -180 to 180
Increment: 1
*RST: 0
Default unit: °

WGENerator<m>:COUPling[:FREQuency] <CoupleFrequency>

Enables the coupling of all frequency parameters of the generators.

Suffix:

<m>	1..2

Parameters:

<CoupleFrequency> ON | OFF
*RST: OFF

GENerator:SYNC[:COMBination] <Combination>

Sets which signals generated from the waveform generator are synchronized.

Parameters:

<Combination> NONE | GEN12 | G1PG | G2PG | G12PG

GEN12: Gen1 and Gen 2
GEN1PG/GEN2PG: Gen1/Gen 2 and Patt Gen
GEN12PG: Gen1,Gen 2 and Patt Gen

*RST: NONE

20.19.4 DC Offset Alignment

GENerator:ALIGnment:DC:ABORt

Aborts a DC offset alignment.

Usage: Event
Asynchronous command

GENerator:ALIGnment:DC:RESult:DATE?

Queries the date of the last performed DC offset alignment.

Return values:
<Date>

Usage:	Query only

GENerator:ALIGnment:DC:RESult:TIME?

Queries the time of the last performed DC offset alignment.

Return values:
<Time>

Usage:	Query only

GENerator:ALIGnment:DC:RESult[:STATe]?

Queries the result of a DC offset alignment.

Return values:

<State>	PASSed | FAILed | NOALigndata *RST: NOALigndata
Usage:	Query only

GENerator:ALIGnment:DC[:STARt]

Starts a DC offset alignment.

Usage:	Event Asynchronous command

20.20 I/Q Software Interface (Option R&S RTO-K11)

20.20.1 I/Q Sampling Settings

To switch on input channels, use `CHANnel<m>:STATe`.

IQ:STATe <IQMode>

Activates the I/Q mode of the instrument.

Parameters:

<IQMode>	ON | OFF ON: I/Q mode OFF: normal oscilloscope mode *RST: OFF

CHANnel<m>:IQ:INPType <IQInputType>

Sets the type of the input signal.

Suffix:

<m>	1..4

Parameters:

<IQInputType>	REAL | COMPlex **REAL** Real RF signal. One real RF signal requires one input channel, thus up to four real signals can be recorded in parallel. **COMPlex** Complex I/Q signal in baseband or low IF range. One complex input signal requires two input channels. The In-Phase component must be connected to channel 1 or 3, and the Quadrature component must be connected to channel 2 or 4. Thus up to two complex input signals can be recorded in parallel. *RST: REAL

CHANnel<m>:IQ:INPMode <IQInputMode>

Selects the frequency band of a complex input signal.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<IQInputMode>	BASeband | RFIF Baseband or intermediate frequency (RFIF) *RST: BASeband

---

IQ:RBWidth <RelBw>

Sets the bandwidth factor to define the filter bandwidth.

*Filter BW = Relative BW * Sample rate*

Parameters:

<RelBw>	Range:	0.04 to 0.8
	Increment:	0.01
	*RST:	0.8

IQ:BWIDth?

Returns the filter bandwidth.

See also: `IQ:RBWidth` on page 2136

Return values:

<AbsBw>	Range:	0 to 10E+9
	Increment:	1
	*RST:	4E+9
	Default unit:	Hz

Usage: Query only

IQ:SRATe <SampleRate>

Sets the required sample rate of the output I/Q data.

Parameters:

<SampleRate>	Range:	1000 to 10E+9
	Increment:	1
	*RST:	10E+9
	Default unit:	Sa/s

IQ:RLENgth <RecordLength>

Sets the required record length of the output I/Q data. The resulting acquisition time of the I/Q data is:

Acquisition time = Record length / Sample rate

Parameters:

<RecordLength>	Range:	1000 to 10000000
	Increment:	2
	*RST:	100000
	Default unit:	Sa

CHANnel<m>:IQ:CFRequency <IQCarrierFreq>

Sets the carrier frequency of the modulated RF signal or of the complex signal in IF range.

Prerequisites:

- `CHANnel<m>:IQ:INPType` on page 2135 is set to `REAL`
  or:
- `CHANnel<m>:IQ:INPType` on page 2135 is set to `COMPlex` and `CHANnel<m>:IQ:INPMode` on page 2135 is set to `RFIF`

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<IQCarrierFreq>	Range:	100 to 5E+9
	Increment:	100
	*RST:	1E+6
	Default unit:	Hz

CHANnel<m>:IQ:SBRF <IQSidebandRF>

Defines the frequency position of the RF spectrum in the input signal: normal or inverse. The position is important for correct down-conversion and filtering.

Prerequisite: `CHANnel<m>:IQ:INPType` on page 2135 is set to `REAL`

For details, see "Sideband (real input)" on page 1030

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<IQSidebandRF>	INVerse | NORMal	
	*RST:	NORMal

CHANnel<m>:IQ:SBIF <IQSidebandIF>

Defines the sideband and the frequency position of complex modulated input signal in IF range.

Prerequisites: `CHANnel<m>:IQ:INPType` on page 2135 is set to `COMPlex` and `CHANnel<m>:IQ:INPMode` on page 2135 is set to `RFIF`

For details, see "Sideband (complex IF input)" on page 1031

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<IQSidebandIF>	NUPPer | NLOWer | IUPPer | ILOWer NUPPer: Upper sideband in normal position NLOWer: Lower sideband in normal position IUPPer: Upper sideband in inverse position ILOWer: Lower sideband in inverse position *RST: NUPPer

20.20.2 I/Q Data Output

CHANnel<m>:IQ:DATA[:VALues]?

Returns the recorded I/Q data.

Suffix:

<m>	1..4 Selects the input channel. In case of a complex input signal that requires two input channels, the results of sources Ch1 and Ch2 are identical, as well as the results of Ch3 and Ch4.

Return values:

<Data>	In-phase and and Quadrature floating values in interleaved order.

Example:

```
CHAN1:IQ:DATA?
-9.6296054835E-005, -1.5046258568E-006,
0.0001013283545, 1.5832555391E-006,
-0.00014297277085, -2.233616442E-006,
0.000192677413, 3.0105845781E-006,
-0.00020517286612, -3.2058260331E-006,
-0.002648930531, -4.1546467401E-005,
-0.0028401580639, -4.4135249482E-005,
-0.0028636774514, -4.4877564505E-005, ...
```

Usage: Query only

CHANnel<m>:IQ:DATA:HEADer?

Returns the header of I/Q data.

Table 20-12: Header data

Position	Meaning	Example
1	XStart, acquisition time before trigger, in s	-5E-008 = - 50 ns
2	XStop, acquisition time after trigger, in s	5E-008 = 50 ns

Position	Meaning	Example
3	Record length of the waveform in Samples	1000
4	Number of values per sample interval. For I/Q data the result is 1.	1

Suffix:

<m> 1..4
Selects the input channel.

Example:

```
CHAN1:IQ:DATA:HEAD?
-5E-008,5E-008,1000,1
```

Usage: Query only

20.20.3 NFC Trigger

TRIGger<m>:NFC:TECHnology <Technology>

Selects the NFC technology, the communication protocol used by the input signal.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event only

Parameters:

<Technology> NFCA | NFCB | NFCF
*RST: NFCA

TRIGger<m>:NFC:BITRate <Bitrate>

Sets the bit rate of the signal. For NFC-A and NFC-B, the bit rate is always 106 kBit per second. For NFC-F, the bit rate can be either 212 or 424 kBit per second.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event only

Parameters:

<Bitrate> KBPS106 | KBPS212 | KBPS424
*RST: KBPS106

TRIGger<m>:NFC:EVENt <Event>

Sets the event to be triggered on.

Suffix:

<m>	1..3 Event in a trigger sequence: 1 = A-event only

Parameters:

<Event> ALL | SEN | ALLB | SENB | SOS48 | SOS96

ALL | SEN
ALL_REQ and SENS_REQ commands (polling requests), only with NFC-A technology

ALLB | SENB
ALLB_REQ and SENSB_REQ commands, only with NFC-B technology

SOS48 | SOS96
Start of sequence, 48 bit 96 bit land length, only with NFC-F technology

*RST: SEN

20.21 Jitter Measurements and Clock Data Recovery (Options R&S RTO-K12/13)

This chaptes decribes the remote commands of jitter option R&S RTO-K12 and CDR option R&S RTO-K13. The options are available for R&S RTO fimware version 1.50 and higher.

20.21.1 Jitter Measurements (Option R&S RTO-K12)

The following table lists the measurement suffixes and the <MeasType> parameter value with a short description.

For a detailed description, see Chapter 16.1.2, "Jitter Measurement Types", on page 1036.

Table 20-13: Jitter measurement types

Meas. suffix	<MeasType> parameter value	Meas. type	Description/Result
37	CCJitter	Cycle-cycle jitter	Difference between the periods of two adjacent cycles. The measurement is based on the period measurement.
38	NCJitter	N-cycle jitter	Difference between the time of two adjacent groups of N cycles (periods) each.

Meas. suffix	<MeasType> parameter value	Meas. type	Description/Result
39	CCWidth	Cycle-cycle width	Difference between the pulse width of two adjacent cycles. The measurement is based on the pulse width measurement.
40	CCDutycycle	Cycle-cycle duty cycle	Difference between the duty cycle of two adjacent cycles. The measurement is based on the duty cycle measurement.
41	TIE	Time interval error	Time difference between the slope of the input signal and the slope of a reference signal. The reference signal can be a captured clock waveform, or a clock generated by clock data recovery (CDR, software algorithm or hardware generation).
42	UINTerval	Unit interval	Period of the clock signal. If no clock signal is available, it is recovered by CDR. The period is calculated as the time difference between two consecutive clock edges of the same polarity.
43	DRATe	Data rate	Frequency of the clock signal. If no clock signal is available, it is recovered by CDR. The measurement is based on the unit interval measurement.
44	SKWDelay	Skew delay	Delay between the edges of two interdependent waveforms.
45	SKWPhase	Skew phase	Phase difference between the edges of two waveforms.
1 to 36; 46	Used for amplitude/time measurements (limit checks). The jitter category uses the same limit checks as amplitude/time. See Chapter 20.12.3, "Amplitude/Time Measurement", on page 1346.		

MEASurement<m>:JITTer:CCSLope <JitterCCSlope>

Selects the slope at which the periods and thus the jitter is measured.

The command is available for the following measurements: cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types CCJitter | NCJitter | CCDutycycle).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JitterCCSlope>	FIRSt | POSitive | NEGative | EITHer **FIRSt** Measures the period from the first edge that is found, no matter of its direction. **POSitive** Measures the period at positive going edges. **NEGative** Measures the period at negative going edges. **EITHer** Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock. *RST: FIRSt

---

MEASurement<m>:JITTer:PULSe <JitterPulsePolarity>

Sets the polarity of pulses for which the pulse width is measured to obtain the cycle-cycle width and the cycle-cycle duty cycle.

The command is available for the following measurements: cycle-cycle width and cycle-cycle duty cycle (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types CCWidth | CCDutycycle).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JitterPulsePolarity>	POSitive | NEGative Pulse width of positive or negative pulses is measured, respectively. *RST: POSitive

---

MEASurement<m>:JITTer:NCYCles <JitterNofCycles>

Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.

See also: Table 16-1

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JitterNofCycles>	Range: 1 to 2147483647 Increment: 1 *RST: 2

Firmware/Software:	FW 2.60. The algorithm of N-cycle measurement has been changed and `MEASurement:JITTer:COFFset` has been removed.

MEASurement<m>:JITTer:CDRMode <JitterCDRMode>

Defines the origin of the clock signal - wether a real clock signal or a clock generated using one of the CDR methods.

The command is available for the following measurements: time-interval error, unit interval and data rate (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types TIE | UINTerval | DRATe).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JitterCDRMode> SIGNal | SW1 | SW2 | HW

SIGNal
The clock is a real clock signal.

SW1 | SW2
The clock is generated by a software algorithm. You can define two software algorithms for CDR. To configure the CDR, use the `CDR:SOFTware` commands.

HW
The clock is generated from the source signal by the integrated CDR circuitry. The HW CDR must be active to acquire the jitter data (trigger type = CDR or serial pattern with CDR)

*RST: SW1

MEASurement<m>:JITTer:SOURce<n>:TIESlope <JitterTIESlope>

Sets the clock and data edges that are used for measurements. Clock or data is defined by the SOURce suffix <n>.

The command is available for the following measurements: time-interval error, unit interval and data rate (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types TIE | UINTerval | DRATe.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.
<n>	1..2 1 = data slope (only relevant for time interval error measurements with explicit clock signal) 2 = clock slope

Parameters:

<JitterTIESlope>	POSitive | NEGative | EITHer **POSitive** The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge. **NEGative** The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge. **EITHer** For clock edges, this option can be used for double data rate (DDR) signals. For data edges, it is the most common setting. *RST: EITHer

---

MEASurement<m>:JITTer:SKWSlope <JitterSkewSlope>

Sets the edge of the first waveform from which the skew delay or phase is measured: positive, negative or both.

The command is available for the following measurement types: skew delay and skew phase (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types SKWDelay | SKWPhase).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JitterSkewSlope>	POSitive | NEGative | EITHer *RST: POSitive

---

MEASurement<m>:JITTer:SKWRelation <JittSkewRelation>

Sets the edge of the second waveform relative to the first waveform.

The command is available for the following measurement types: skew delay and skew phase (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurement types SKWDelay | SKWPhase).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1333.

Parameters:

<JittSkewRelation>	MATChing | INVerse **MATChing** Measures from positive to positive edge or from negative to negative edge. **INVerse** Measures from positive to negative edge or from negative to positive edge. *RST: MATChing

20.21.2 Clock Data Recovery (Software-based, Option R&S RTO-K12)

CDR:SOFTware<m>:ALGorithm <Algorithm>

Sets the software algorithm that is used for clock data recovery.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Algorithm>	CFRequency | PLL PLL is the phase-locked loop control system. Itcan follow slow deviations in the frequency of the data stream. CFRequency = Constant frequency. CDR uses the nominal bit rate to generate the clock signal. The method assumes that the frequency of the signal is constant during the complete acquisition. *RST: PLL

CDR:SOFTware<m>:BITRate <Bitrate>

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Bitrate>	Range: 100 to 5E+9 Increment: 10 *RST: 1E+9 Default unit: bps

---

CDR:SOFTware<m>:ESLope <Edge>

Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Edge>	POSitive | NEGative | EITHer *RST: EITHer

CDR:SOFTware<m>:SYNC <InitialSync>

Defines the phase reference for the first clock edge.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<InitialSync>	SAMPle | DATaedge **SAMPle** The first clock edge matches the first sample of the waveform at the left border of the display. **DATaedge** The first clock edge matches the first edge of the data signal. *RST: SAMPle

---

CDR:SOFTware<m>:RESults <Results>

The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Results>	ALL | AISYnc **ALL** All clock edges are used. **AISYnc** The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained. *RST: AISYnc

---

CDR:SOFTware<m>:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<PLLOrder>	FIRSt | SECond *RST: FIRSt

CDR:SOFTware<m>:PLL:BWIDth <PLLBandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<PLLBandwidth>	Range:	Nominal BITRate * Range of RELBwidth (dependent range)
	Increment:	10
	*RST:	599.88E+3
	Default unit:	Hz

CDR:SOFTware<m>:PLL:RELBwidth <PLLRelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<PLLRelBw>	Range:	10 to 5000
	Increment:	1
	*RST:	1667

CDR:SOFTware<m>:PLL:DAMPing <DampingFactor>

Sets the damping factor, which is only relevant for second order PLL.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<DampingFactor>	Range:	0.5 to 1
	Increment:	0.01
	*RST:	0.7

20.21.3 Clock Data Recovery (Hardware-based, Option R&S RTO-K13)

CDR:HARDware:SOURce <Source>

Selects the channel signal that is used for clock recovery.

The source cannot be changed if the CDR trigger is selected in the trigger setup. In this case, the instrument triggers on the recovered clock; trigger source and CDR source are the same.

Parameters:

<Source>	CHAN1 | C1 | CHAN2 | C2 | CHAN3 | C2 | CHAN4 | C4	
	*RST:	CHAN1

CDR:HARDware:BITRate <Bitrate>

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Parameters:

<Bitrate>	Range:	200E+3 to 2.5E+9 for 10 GSa/s; range depends on sample rate
	Increment:	10
	*RST:	1E+9
	Default unit:	bps

CDR:HARDware:ESLope <Edge>

Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Parameters:

<Edge>	POSitive | NEGative | EITHer	
	*RST:	EITHer

CDR:HARDware:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Parameters:

<PLLOrder>	FIRSt | SECond	
	*RST:	FIRSt

CDR:HARDware:PLL:BWIDth <PLLBandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Parameters:

<PLLBandwidth>	Range:	Nominal BITRate * Range of RELBwidth (dependent range)
	Increment:	10
	*RST:	599.88E+3
	Default unit:	Hz

CDR:HARDware:PLL:RELBwidth <PLLRelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Parameters:

<PLLRelBw>	Range:	500 to 3000
	Increment:	1
	*RST:	1667

CDR:HARDware:PLL:DAMPing <DampingFactor>

Sets the damping factor, which is only relevant for second order PLL.

Parameters:

<DampingFactor>	Range:	0.5 to 1
	Increment:	0.01
	*RST:	0.7

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m>
1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

<n>
1..27
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...11 = not available
12...27 = R&S RT-ZVC input channels (R&S RTO2000 only)

Parameters:

<Level>
Voltage for the trigger level.

Range:	Depends on vertical scale, channel offset and other settings. The trigger level must be within the current display range.
Increment:	1E-3
*RST:	0
Default unit:	V

Example:

```
TRIG:LEV5 0.01
```

Sets the trigger level for the external trigger signal to 10 mV.

```
TRIG2:LEV3 0.2
```

Sets the trigger level for the B-event and B-trigger source channel 3 to 200 mV.

20.21.4 CDR Trigger

CDR:HARDware:UIOFfset <UntIntvlOffs>

Defines an offset for the bit start, the beginning of the unit interval. The trigger point corresponds to the clock edge that indicates the bit start. The UI offset is a number between 0 and 1. Value 0 matches sets the clock edge to the beginning of the bit period; value 0.5 sets the clock edge to the middle of the bit period.

Parameters:

<UntIntvlOffs>
Range: 0 to 1
Increment: 0.01
*RST: 0

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m>
1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

<n>
1..27
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...11 = not available
12...27 = R&S RT-ZVC input channels (R&S RTO2000 only)

Parameters:

<Level>
Voltage for the trigger level.
Range: Depends on vertical scale, channel offset and other settings. The trigger level must be within the current display range.
Increment: 1E-3
*RST: 0
Default unit: V

Example:

`TRIG:LEV5 0.01`
Sets the trigger level for the external trigger signal to 10 mV.
`TRIG2:LEV3 0.2`
Sets the trigger level for the B-event and B-trigger source channel 3 to 200 mV.

20.21.5 Serial Pattern Trigger Using CDR

TRIGger<m>:SPATtern:CDR <CdrInUse>

Disables the clock source and enables the recovered clock signal generated by hardware CDR.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<CdrInUse>	ON | OFF *RST: OFF

CDR:HARDware:UIOFfset <UntIntvlOffs>

Defines an offset for the bit start, the beginning of the unit interval. The trigger point corresponds to the clock edge that indicates the bit start. The UI offset is a number between 0 and 1. Value 0 matches sets the clock edge to the beginning of the bit period; value 0.5 sets the clock edge to the middle of the bit period.

Parameters:

<UntIntvlOffs>	Range: 0 to 1 Increment: 0.01 *RST: 0

20.21.6 Eye Mask Testing

The eye mask testing is available if option R&S RTO-K12 is activated on the instrument.

MTESt:EYEMask:TYPE <MaskTestName>,<Type>
MTESt:EYEMask:TYPE? <MaskTestName>

Defines the outline of the eye mask.

Parameters:

<Type>	SQUare | DIAMond | HEXagon | OCTagon *RST: DIAMond

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:HEIGht<m>[:VALue] <MaskTestName>, <value>

Defines the main heigth af all eye mask shapes and the minor height for octagon mask shapes.

Suffix:

<m>	1..2 1 - main width 2 - minor width

Parameters:

<value>	Default unit: s

Setting parameters:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:WIDTh<m>[:VALue] <MaskTestName>, <value>

Defines the main width af all eye mask shapes and the minor width for hexagon and octagon mask shapes.

Suffix:

<m>	1..2 1 - main width 2 - minor width

Parameters:

<value>	Default unit: s

Setting parameters:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:MSKRight <MaskTestName>,<Copy>
MTESt:EYEMask:MSKRight? <MaskTestName>
MTESt:EYEMask:MSKLeft <MaskTestName>,<Copy>
MTESt:EYEMask:MSKLeft? <MaskTestName>

Copies the eye shape to the right and left, respectively.

The distance of the copy is defined using `MTESt:EYEMask:HPERiod`.

Parameters:

<Copy>	ON | OFF *RST: OFF

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:HPERiod <MaskTestName>,<InterpattLength>
MTESt:EYEMask:HPERiod? <MaskTestName>

Defines the time distance between the shape centers if `MTESt:EYEMask:MSKLeft` and/or `MTESt:EYEMask:MSKRight` are ON.

Parameters:

<InterpattLength>	Range: 0 to 100 Increment: 0.01 *RST: 0.5 Default unit: s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:MSKTop <MaskTestName>,<Add>
MTESt:EYEMask:MSKTop? <MaskTestName>
MTESt:EYEMask:MSKBottom <MaskTestName>,<Add>
MTESt:EYEMask:MSKBottom? <MaskTestName>

Enable the upper (top) and lower (bottom) mask region, respectively.

Parameters:

<Add>	ON | OFF *RST: OFF

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:TOFFset <MaskTestName>,<Offset>
MTESt:EYEMask:TOFFset? <MaskTestName>
MTESt:EYEMask:BOFFset <MaskTestName>,<Offset>
MTESt:EYEMask:BOFFset? <MaskTestName>

Voltage distance from the eye shape center that limit the upper (TOFFset) and lower (BOFFset) regions.

Parameters:

<Offset>	Range: 0 to 100 Increment: 0.01 *RST: 0.5 Default unit: V

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:TBSYmmetric <MaskTestName>,<Symmetry>
MTESt:EYEMask:TBSYmmetric? <MaskTestName>

Sets bottom and top offsets to the same value so that the outer regions are symmetric to the eye shape.

Parameters:

<Symmetry>	ON | OFF	
	*RST:	ON

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:TBWidth <MaskTestName>,<RectangleLength>
MTESt:EYEMask:TBWidth? <MaskTestName>

Sets the time width of the outer regions, symmetric to the eye shape center.

Parameters:

<RectangleLength>	Range:	0 to 100
	Increment:	0.01
	*RST:	0.5
	Default unit:	s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:HPOSition <MaskTestName>,<PatOffsetX>
MTESt:EYEMask:HPOSition? <MaskTestName>

Sets the horizontal (time) value of the eye shape enter and thus defines the horizontal position of the eye shape on the display.

Parameters:

<PatOffsetX>	Range:	-100 to 100
	Increment:	0.01
	*RST:	0
	Default unit:	s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:VPOSition <MaskTestName>,<PatOffsetY>
MTESt:EYEMask:VPOSition? <MaskTestName>

Sets the vertical (voltage) value of the eye shape enter and thus defines the vertical position of the eye shape on the display.

Parameters:

<PatOffsetY>	Range: -100 to 100 Increment: 0.01 *RST: 0 Default unit: V

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

20.22 Power Analysis (Option R&S RTO-K31)

20.22.1 General

POWer:ENABle

Activates the power mode and initializes the power measurements. If the power mode is disabled, the instrument does not accept any `POWer` command.

Use `POWer:ENABle` after each `*RST`.

Example:	See Chapter 20.3.7.1, "Auto Deskew", on page 1169
Usage:	Event

POWer:SOURce:CURRent<1..2> <CurrentSource>

Sets the channel for the current source.

Parameters:

<CurrentSource>	CHAN1 | CHANnel1 | CHAN2 | CHANnel2 | CHAN3 | CHANnel3 | CHAN4 | CHANnel4 CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4
Usage:	Asynchronous command

POWer:SOURce:VOLTage<1..4> <VoltageSource>

Sets the channel for the voltage source input.

Parameters:

<VoltageSource>	CHAN1 | CHANnel1 | CHAN2 | CHANnel2 | CHAN3 | CHANnel3 | CHAN4 | CHANnel4 CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4
Usage:	Asynchronous command

20.22.2 Deskew

Programming example: Chapter 20.3.7.1, "Auto Deskew", on page 1169

POWer:DESKew:CURRent

Applies the result of the auto deskew to the "Skew offset" value.

Usage: Event

POWer:DESKew:EXECute

Starts the auto deskew.

Usage: Event

POWer:DESKew:RESet <OverwriteCurrSkew>

Overwrites the present skew setup.

Parameters:

<OverwriteCurrSkew>	ON | OFF *RST: ON

POWer:DESKew:TIME?

Queries the result of the auto deskew.

Return values:

<AutoDeskewOffs>	Range:	-100E-9 to 100E-9
	*RST:	0
	Default unit:	s

Usage: Query only

POWer:DESKew:UDPReset <UsrDefinedPreset>

Activates or deactivates a user defined setup. If ON, the instrument setup including probe setup and the deskew values are written to a user defined preset file (saveset) that can be loaded using `MMEMory:RCL` on page 1475.

The default path is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTO\SaveSets\`

Parameters:

<UsrDefinedPreset>	ON | OFF	
	*RST:	ON

20.22.3 Report

POWer:REPort:CONTent:HSETup <ContentHorizSet>
POWer:REPort:CONTent:MSETup <ContentMeasSet>
POWer:REPort:CONTent:MSIGnal <ContentMeasuredSigns>
POWer:REPort:CONTent:RESU <ContentResults>
POWer:REPort:CONTent:SETTings <ContentSettings>
POWer:REPort:CONTent:TSETup <ContentTrigSet>
POWer:REPort:CONTent:VSETup <ContentVertSet>

Sets how often the respective content is shown in the final report.

Parameters:

<ContentVertSet>	ALWAYS | NEVER | ONCE
	*RST: ONCE

POWer:REPort:CONTent:TITLe <ContentTitle>

Includes the title page in the report.

Parameters:

<ContentTitle>	ON | OFF
	*RST: ON

POWer:REPort:DESCription <String>
POWer:REPort:DUT <String>
POWer:REPort:SITE <String>
POWer:REPort:TEMPerature <String>
POWer:REPort:USER <String>

The content of the strings is shown at the title page of a report if the title page is included in the report.

Parameters:
<String>

POWer:REPort:FONT:COLO <FontColor>

Sets the font color.

Parameters:

<FontColor>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

POWer:REPort:FONT:FAMI <FontFamily>

Selects the font family. You can choose between Arial and Helvetica.

Parameters:

<FontFamily>	ARIAL | HELV	
	*RST:	ARIAL

POWer:REPort:FONT:SIZE <FontSize>

Sets the font size.

Parameters:

<FontSize>	Range:	10 to 30
	Increment:	1
	*RST:	12

POWer:REPort:LOGO <LogoFile>

Selects a path to a logo picture file.

Parameters:

<LogoFile>

POWer:REPort:PAPersize <PaperSize>

Set the layout of your report.

Parameters:

<PaperSize>	A4 | USL	
	*RST:	A4

POWer:REPort:FILE:NAME <Path>

Defines the path and file name of the report file that is to be created, saved, or deleted.

Parameters:

<Path>	String containing path and file name

POWer:REPort:FILE:DELete

Deletes the selected report file.

Usage:	Event

POWer:REPort:FILE:NEW

Creates a new report file.

Usage: Event

POWer:REPort:FILE:SAVE

Saves the report file.

Usage: Event

POWer:REPort:TEST:ADD <MeasType>
POWer:REPort:TEST:INSert <MeasType>, <Index>
POWer:REPort:TEST:REMove <MeasType>, <Index>

Manage reports.

Setting parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

QUAL
Power Quality

RUSH
Inrush Current

HARM
Current Harmonic

MODU
Modulation Analysis

DONR
Dynamic ON Resistance

SLEW
Slew Rate

SOA
Safe Operating Area (S.O.A.)

TURN
Turn On/Off

SWIT
Switching Loss

EFF
Power Efficiency

RIPP
Ripple

TRANS
Transient Response

SPEC
Spectrum

<Index>

Usage: Setting only

POWer:REPort:INVert <InvertScreenshotClr>
POWer:REPort:TEST:DSEA <MeasType>
POWer:REPort:TEST:ISE <MeasType>
POWer:REPort:TEST:SEA <MeasType>
POWer:REPort:TEST:RSE <MeasType>

Manage the selection of reports.

Parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

QUAL
Power Quality

RUSH
Inrush Current

HARM
Current Harmonic

MODU
Modulation Analysis

DONR
Dynamic ON Resistance

SLEW
Slew Rate

SOA
Safe Operating Area (S.O.A.)

TURN
Turn On/Off

SWIT
Switching Loss

EFF
Power Efficiency

RIPP
Ripple

TRANS
Transient Response

SPEC
Spectrum

POWer:REPort:TEST:DIRectory <MeasType>, <DirectoryPath>
POWer:REPort:TEST:DIRectory? <MeasType>

Selects the directory, in which the reports are saved.

Setting parameters:
<DirectoryPath>

Parameters for setting and query:

<MeasType>	QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

POWer:REPort:TEST:COMMent <MeasType>, <Comment>
POWer:REPort:TEST:COMMent? <MeasType>

Sets a comment for the report.

Setting parameters:
<Comment>

Parameters for setting and query:

<MeasType>	QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

POWer:REPort:TEST:COUNt <MeasType>

Parameters:

<MeasType>	QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

Return values:
<Count>

POWer:REPort:TEST:LSENd? <MeasType>

Query parameters:

<MeasType>	QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC
Usage:	Query only

20.22.4 Power Quality

POWer:QUALity:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL *RST: MANUAL

POWer:QUALity:EXECute

Starts the power quality measurement.

Usage: Event

POWer:QUALity:FREQ <Frequency>

Sets the input frequency of the source signal in Hz.

Parameters:

<Frequency>	F50 | F60 | F360 | F400 | F650 | F800 | NFF650 | WFF800 | FCUS NFF650: 360 to 650 Hz WFF800: 360 to 800 Hz FCUS: user-defined frequency to be set using `POWer:QUALity:FCUS`. *RST: F50

POWer:QUALity:FCUS <CustomFrequency>

Sets the user-defined frequency if `POWer:QUALity:FREQ` is set to `FCUS`.

Parameters:

<CustomFrequency>	Range: 1 to 5000 Increment: 1 *RST: 16.666 Default unit: Hz

Firmware/Software: Version 2.70

POWer:QUALity:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:QUALity:RESult:CURRent:CRESTfactor?
POWer:QUALity:RESult:CURRent:FREQuency?
POWer:QUALity:RESult:CURRent:PEAK?
POWer:QUALity:RESult:CURRent:RMS?
POWer:QUALity:RESult:POWer:APParent?
POWer:QUALity:RESult:POWer:PFACtor?
POWer:QUALity:RESult:POWer:PHASe?
POWer:QUALity:RESult:POWer:REACtive?
POWer:QUALity:RESult:POWer:REALpower?
POWer:QUALity:RESult:VOLTage:CRESTfactor?
POWer:QUALity:RESult:VOLTage:FREQuency?
POWer:QUALity:RESult:VOLTage:PEAK?
POWer:QUALity:RESult:VOLTage:RMS?

Returns the value of the respective result.

Return values:

<Value>	Range:	Depends on the measured quantity.
	Default unit:	Depends on the measured quantity.

Usage:	Query only

20.22.5 Inrush Current

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:INRush:ADD

Adds a gate.

Usage:	Event

POWer:INRush:INSert <GateIndex>

Inserts a gate.

Setting parameters:
<GateIndex>

Usage:	Setting only

POWer:INRush:REMove <GateIndex>

Removes a gate

Setting parameters:
<GateIndex>

Usage:	Setting only

POWer:INRush:COUNt?

Queiries the number of inrush current gates.

Return values:
<Count>

Usage:	Query only

POWer:INRush:EXECute

Starts the inrush current measurement.

Usage:	Event

POWer:INRush:GATE<m>:STARt <StartTime>
POWer:INRush:GATE<m>:STOP <StopTime>

Sets the measuring time for the selected gate.

Suffix:

<m>	*

Parameters:

<StopTime>	Range:	0 to 10
	Increment:	0
	*RST:	100E-6
	Default unit:	s

POWer:INRush:GATE<m>:VALue <Value>

Returns the value of the inrush current.

Suffix:

<m>	*

Parameters:

<Value>	Range: -1000 to 1000 Increment: 0 *RST: 0 Default unit: A

POWer:INRush:MAXCurrent <MaxExpCurr>

Sets the maximum expected current for the vertical scale.

Parameters:

<MaxExpCurr>	Range: -1000 to 1000 Increment: 0 *RST: 10 Default unit: A

POWer:INRush:TRIGger <CurrentValue>

Sets the current value for the trigger.

Parameters:

<CurrentValue>	Range: -1000 to 1000 Increment: 0 *RST: 1 Default unit: A

POWer:INRush:REPort:ADD

Adds the result to the report list.

Usage: Event

20.22.6 Current Harmonic

POWer:HARMonics:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:HARMonics:DOFR <FrequencyDOA160>

Selects the frequency of the input signal.

Parameters:

<FrequencyDOA160>	F360 | F400 | F650 | F800	
	*RST:	F400

POWer:HARMonics:ENFR <FreqEN61000>

Selects the frequency of the input signal.

Parameters:

<FreqEN61000>	F50 | F60	
	*RST:	F50

POWer:HARMonics:MIFR <FreqMIL1399>

Selects the frequency of the input signal.

Parameters:

<FreqMIL1399>	F400 | F60	
	*RST:	F400

POWer:HARMonics:EVAL <AnalysisRevised>

Sets the evaluation of the results for "Standard" > "RTCA DO-160".

Parameters:

<AnalysisRevised>	REVISED | NOREVISED	
	*RST:	NOREVISED

POWer:HARMonics:EXECute

Starts the current harmonic measurement.

Usage: Event

POWer:HARMonics:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:HARMonics:RESult<m>:STDinuse?

Returns the used standard.

Suffix:

<m>	1..2

Return values:

<StandardInUse>	ENA | ENB | ENC | END | MIL | RTC *RST: ENA
Usage:	Query only

POWer:HARMonics:RESult<m>:FREQuency<n>:VALue?
POWer:HARMonics:RESult<m>:MAXValue<n>:VALue?
POWer:HARMonics:RESult<m>:STDValue<n>:VALue?
POWer:HARMonics:RESult<m>:VALue<n>:VALue?

Returns the value of the respective result.

Suffix:

<m>	1..2
<n>	*

Return values:

<Value>	Range: -1000 to 1000 *RST: 0 Default unit: A
Usage:	Query only

POWer:HARMonics:STAN <StandardInUse>

Sets a standard for the current harmonic measurement.

Parameters:

<StandardInUse>	ENA | ENB | ENC | END | MIL | RTC *RST: ENA

POWer:HARMonics:VOLT <DOADisplayResult>

Selects if the voltage results are displayed or not for "Standard" > "RTCA DO-160" and enabled "Evaluation with voltage source and revised current law".

Parameters:

<DOADisplayResult>	VOLTDISP | NOVOLTDISP *RST: NOVOLTDISP

Example:

```
POW:HARM:STAN RTC
POW:HARM:EVAL REVISED
POW:HARM:VOLT NOVOLTDISP
```

Selects an evaluation with the revised current law and no voltage display.

20.22.7 Modulation Analysis

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:MODulation:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:MODulation:DHIStogram <DispHistg>

Activates or deactivates the display of a histogram.

Parameters:

<DispHistg> ON | OFF

*RST: ON

POWer:MODulation:EXECute

Starts the modulation analysis measurement.

Usage: Event

Asynchronous command

POWer:MODulation:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:MODulation:RESult:ACTual? <MeasType>
POWer:MODulation:RESult:AVG? <MeasType>
POWer:MODulation:RESult:EVTCount? <MeasType>
POWer:MODulation:RESult:NPEak? <MeasType>
POWer:MODulation:RESult:PPEak? <MeasType>
POWer:MODulation:RESult:RMS? <MeasType>
POWer:MODulation:RESult:STDDev? <MeasType>
POWer:MODulation:RESult:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType>	FREQ | DUTY
Usage:	Query only

POWer:MODulation:SOURce <Source>

Selects the source for the measurement.

Parameters:

<Source>	CURRENT | VOLTAGE
	*RST: VOLTAGE

POWer:MODulation:TYPE <AnalysisType>

Sets the type of measurement.

Parameters:

<AnalysisType>	TURNON | CONT
	*RST: CONT

20.22.8 Dynamic ON Resistance

POWer:DONRes:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:DONRes:AVG <Average>

Enables/disables averaging.

Parameters:

<Average>	ON | OFF	
	*RST:	ON

POWer:DONRes:EXECute

Starts the dynamic on resistance measurement.

Usage:	Event Asynchronous command

POWer:DONRes:GATE<m>:STARt <Start>
POWer:DONRes:GATE<m>:STOP <Stop>

Sets the value for the cursor.

Suffix:

<m>	1..2

Parameters:

<Stop>

POWer:DONRes:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:DONRes:RESult:RESistance?

Returns the the dynamic on resistance value.

Return values:

<Resistance>	Range:	-100E+24 to 100E+24
	*RST:	0
	Default unit:	\x2126

Usage:	Query only

20.22.9 Slew Rate

POWer:SLEWrate:SOURce <Source>

Selects the source for the slew rate measurement.

Parameters:

<Source>	CURRENT | VOLTAGE	
	*RST:	VOLTAGE

POWer:SLEWrate:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:SLEWrate:AVGDeriv <AvgDerivative>

Activates or deactivates average.

Parameters:

<AvgDerivative>	ON | OFF	
	*RST:	ON

POWer:SLEWrate:EXECute

Starts the slew rate measurement.

Usage: Event

ACQuire:ARESet:MODE <ArtmRst>

Defines when the envelope and average evaluation restarts.

Parameters:

<ArtmRst> NONE | TIME | WFMS

TIME
Restarts the envelope and average calculation after the time defined with `ACQuire:ARESet:TIME`.

WFMS
Restarts the envelope and average calculation after a number of acquired waveforms defined with `ACQuire:ARESet:COUNt` on page 1214.

*RST: NONE

Firmware/Software: V 1.36

ACQuire:ARESet:TIME <EnvelopeTimeout>

Defines the time after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `TIME`.

Parameters:

<EnvelopeTimeout>	Range:	0.1 to 10000
	Increment:	0.01
	*RST:	0.1
	Default unit:	s

Firmware/Software: V 1.36

ACQuire:ARESet:COUNt <NofWaveforms>

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `WFMS`.

Parameters:

<NofWaveforms>	Range:	2 to 16777215
	Increment:	10
	*RST:	1000

Firmware/Software:	V 2.70 Replaces the command `ACQuire:ARESet:WFMCount`

POWer:SLEWrate:GATE:STARt <T0>
POWer:SLEWrate:GATE:STOP <T1>

Sets the value for the cursor.

Parameters:
<T1>

POWer:SLEWrate:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SLEWrate:RESult:ACTual? <MeasType>
POWer:SLEWrate:RESult:AVG? <MeasType>
POWer:SLEWrate:RESult:EVTCount? <MeasType>
POWer:SLEWrate:RESult:NPEak? <MeasType>
POWer:SLEWrate:RESult:PPEak? <MeasType>
POWer:SLEWrate:RESult:RMS? <MeasType>
POWer:SLEWrate:RESult:STDDev? <MeasType>
POWer:SLEWrate:RESult:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType>	MIN | MAX

Usage: Query only

20.22.10 S.O.A

POWer:SOA:EXECute

Starts the safe operating area measurement.

Usage: Event

POWer:SOA:LINear:ADD
POWer:SOA:LOGarithmic:ADD

Adds a point.

Usage: Event

POWer:SOA:LINear:COUNt?
POWer:SOA:LOGarithmic:COUNt?

Queries the number of points.

Return values:
<Count>

Usage: Query only

POWer:SOA:LINear:REMove <GateIndex>
POWer:SOA:LOGarithmic:REMove <GateIndex>

Removes a point.

Setting parameters:
<GateIndex>

Usage: Setting only

POWer:SOA:LINear:INSert <GateIndex>
POWer:SOA:LOGarithmic:INSert <GateIndex>

Inserts a point.

Setting parameters:
<GateIndex>

Usage:	Setting only

POWer:SOA:LINear:POINt<m>:CURRent <Amp>
POWer:SOA:LOGarithmic:POINt<m>:CURRent <Amp>

Sets the current value for the respective point.

Suffix:

<m>	*

Parameters:

<Amp>	Range:	0.01 to 1000
	Increment:	0
	*RST:	0.01
	Default unit:	A

POWer:SOA:LINear:POINt<m>:VOLTage <Volt>
POWer:SOA:LOGarithmic:POINt<m>:VOLTage <Volt>

Sets the voltage value for the respective point.

Suffix:

<m>	*

Parameters:

<Volt>	Range:	1E-3 to 1000
	Increment:	0
	*RST:	1E-3
	Default unit:	V

POWer:SOA:MASK <EnableMaskTest>

Activates or deactivates a mask.

Parameters:

<EnableMaskTest>	ON | OFF	
	*RST:	OFF

POWer:SOA:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:SOA:SCALe <Scale>

Sets the scale for the measurement.

Parameters:

<Scale>	LOG | LINEAR *RST: LOG

POWer:SOA:SWITch <Switch>

Switches between linear and logarithmic scale.

Parameters:

<Switch>	LOGLINEAR | LINEARLOG *RST: LOGLINEAR

20.22.11 Turn On/Off

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:ONOFf:ATOFf <ACTrigLevOff>
POWer:ONOFf:ATON <ACTrigLevOn>

Triggers the beginning of the measurements at the moment the AC input voltage reaches the set value.

Parameters:

<ACTrigLevOn>	Range:	-1E+6 to 1E+6
	Increment:	1E-3
	*RST:	10
	Default unit:	V

POWer:ONOFf:DTOFf <ACTrigLevOff>
POWer:ONOFf:DTON <ACTrigLevOn>

POWer:ONOFf:DSOFf <StateLevelOff>
POWer:ONOFf:DSON <StateLevelOn>

Sets the percentage of the steady state level of the DC output that has to be reached.

Parameters:

<StateLevelOn>	Range:	0 to 100
	Increment:	1
	*RST:	90
	Default unit:	%

POWer:ONOFf:EXECute

Starts the turn on/off measurement.

Usage: Event

POWer:ONOFf:INPut <InputType>

Sets the input type.

Parameters:

<InputType>	AC | DC	
	*RST:	AC

POWer:ONOFf:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:ONOFf:RESult:TOFF?
POWer:ONOFf:RESult:TON?

Returns the result time.

Return values:

<TurnOnTime>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

POWer:ONOFf:TIME <Time>

Sets the time, the start of the measurement of the turn off time is delay with, after the trigger point.

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 0.1 Default unit: s

---

POWer:ONOFf:TYPE <MeasType>

Selects the measurement type.

Parameters:

<MeasType>	TON | TOFF TON - "Turn on" measurement TOFF - "Turn off" measurement *RST: TON

20.22.12 Switching Loss

POWer:SWITching:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:SWITching:EXECute

Starts the switching loss measurement.

Usage:	Event Asynchronous command

POWer:SWITching:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:SWITching:SWIFrequency <SwitchingFreq>

Sets the switching frequency.

Parameters:

<SwitchingFreq>	Range:	1 to 500E+9
	Increment:	1000
	*RST:	10E+6
	Default unit:	Hz

POWer:SWITching:SWIT <MeasureSwitchingFreq>

Activates or deactivates the measurements of the switching frequency.

Parameters:

<MeasureSwitchingFreq>	ON | OFF	
	*RST:	ON

POWer:SWITching:COND <MeasureConduction>
POWer:SWITching:NCON <MeasureNonConduction>
POWer:SWITching:TON <MeasureTurnOn>
POWer:SWITching:TOFF <MeasureTurnOff>
POWer:SWITching:TOTal <MeasureTotal>

Enables the measurement during the respective period.

Parameters:

<MeasureTotal>	ON | OFF *RST: ON

POWer:SWITching:GATE:COND:STARt <T1>
POWer:SWITching:GATE:COND:STOP <T2>
POWer:SWITching:GATE:NCON:STARt <T3>
POWer:SWITching:GATE:TOFF:STARt <T2>
POWer:SWITching:GATE:TOFF:STOP <T3>
POWer:SWITching:GATE:TON:STARt <T0>
POWer:SWITching:GATE:TON:STOP <T1>

Sets the value for the respective cursor.

Parameters:
<T1>

POWer:SWITching:RESult:ENERgy:ACTual? <MeasType>
POWer:SWITching:RESult:ENERgy:AVG? <MeasType>
POWer:SWITching:RESult:ENERgy:EVTCount? <MeasType>
POWer:SWITching:RESult:ENERgy:NPEak? <MeasType>
POWer:SWITching:RESult:ENERgy:PPEak? <MeasType>
POWer:SWITching:RESult:ENERgy:RMS? <MeasType>
POWer:SWITching:RESult:ENERgy:STDDev? <MeasType>
POWer:SWITching:RESult:ENERgy:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType>	SWF | TON | TOF | CON | NCO | TOT
Usage:	Query only

POWer:SWITching:RESult:POWer:ACTual? <MeasType>
POWer:SWITching:RESult:POWer:AVG? <MeasType>
POWer:SWITching:RESult:POWer:EVTCount? <MeasType>
POWer:SWITching:RESult:POWer:NPEak? <MeasType>
POWer:SWITching:RESult:POWer:PPEak? <MeasType>
POWer:SWITching:RESult:POWer:RMS? <MeasType>

POWer:SWITching:RESult:POWer:STDDev? <MeasType>
POWer:SWITching:RESult:POWer:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType>	SWF | TON | TOF | CON | NCO | TOT
Usage:	Query only

20.22.13 Power Efficiency

POWer:EFFiciency:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:EFFiciency:EXECute

Starts the power efficiency measurement.

Usage:	Event

POWer:EFFiciency:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:EFFiciency:RESult<m>:ACTual?
POWer:EFFiciency:RESult<m>:AVG?
POWer:EFFiciency:RESult<m>:EVTCount?
POWer:EFFiciency:RESult<m>:NPEak?
POWer:EFFiciency:RESult<m>:PPEak?
POWer:EFFiciency:RESult<m>:RMS?
POWer:EFFiciency:RESult<m>:STDDev?
POWer:EFFiciency:RESult<m>:WFMCount?

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Suffix:

<m>	1..3

Return values:

<WaveformsCount>	Range:	0 to 4E+9
	*RST:	0

Usage:	Query only

20.22.14 Ripple

POWer:RIPPle:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:RIPPle:CURRent <TwoChMeas>

Activates or deactivates the input current.

Parameters:

<TwoChMeas>	ON | OFF	
	*RST:	ON

POWer:RIPPle:EXECute

Starts the ripple measurement.

Usage:	Event

POWer:RIPPle:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency>	Range:	1 to 100E+9
	Increment:	1
	*RST:	1E+6
	Default unit:	Hz

POWer:RIPPle:REPort:ADD

Adds the result to the report list.

Usage:	Event

POWer:RIPPle:RESult:FREQuency[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:RMS? [<VoltageMeasType>]

POWer:RIPPle:RESult:FREQuency:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:FREQuency:WFMCount? [<VoltageMeasType>]

Return the specified statistic result of the frequency of the signal. The result is based on the period measurement.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result of the frequency
Usage:	Query only

POWer:RIPPle:RESult:MAXimum[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:MAXimum:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the maximum value of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result
Usage:	Query only

POWer:RIPPle:RESult:MINimum[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:MINimum:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the minimum value of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result
Usage:	Query only

POWer:RIPPle:RESult:NDCYcle[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:NDCYcle:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the negative duty cycle. The measurement requires at least one complete period of a triggered signal.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result

Usage: Query only

POWer:RIPPle:RESult:PDCYcle[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDCYcle:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the positive duty cycle. The measurement requires at least one complete period of a triggered signal.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result

Usage: Query only

POWer:RIPPle:RESult:PDEL[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:PDEL:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the peak to peak measurement.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result

Usage: Query only

POWer:RIPPle:RESult:PERiod[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:PPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:PERiod:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the period, the length of the left-most signal period of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent *RST: VOLTage

Return values:

<Result>	Statistic result

Usage: Query only

POWer:RIPPle:RESult:STDDev[:ACTual]? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:AVG? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:EVTCount? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:NPEak? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:PPEak? [<VoltageMeasType>]

POWer:RIPPle:RESult:STDDev:RMS? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:STDDev? [<VoltageMeasType>]
POWer:RIPPle:RESult:STDDev:WFMCount? [<VoltageMeasType>]

Return the specified statistic result for the standard deviation of the long-term measurement results.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<VoltageMeasType>	VOLTage | CURRent
	*RST: VOLTage

Return values:

<Result>	Statistic result

Usage:	Query only

20.22.15 Transient Response

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

Progragramming example: Chapter 20.3.7.2, "Transient Response Measurement", on page 1170

POWer:TRANsient:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:TRANsient:EXECute

Starts the transient response measurement.

Usage: Event

POWer:TRANsient:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency>	Range:	1 to 100E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	Hz

POWer:TRANsient:HYSTeresis <ToleranceTube>

Specifies a tolerated error band for the signal level.

Parameters:

<ToleranceTube>	Range:	0 to 50
	Increment:	1
	*RST:	10
	Default unit:	%

POWer:TRANsient:INPut <ThreeChMeas>

Activates or deactivates the input voltage.

Parameters:

<ThreeChMeas>	ON | OFF	
	*RST:	OFF

POWer:TRANsient:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:TRANsient:RESult[:ACTual]? <MeasType>

Returns the results of the transient response measurement.

Query parameters:

<MeasType>	OVERshoot | RTIMe | DELay | PEAKtime | SETTling

Usage: Query only

POWer:TRANsient:SIGHigh <ExpHighOutputSignLev>

Sets the expected signal high voltage value.

Parameters:

<ExpHighOutputSignLev> Range: -1000 to 1000
Increment: 1E-3
*RST: 1
Default unit: V

POWer:TRANsient:SIGLow <ExpLowOutputSignLev>

Sets the expected signal low voltage value.

Parameters:

<ExpLowOutputSignLev> Range: -1000 to 1000
Increment: 1E-3
*RST: 0
Default unit: V

POWer:TRANsient:TRGChannel <TriggerSource>

Sets the source channel of the trigger.

Parameters:

<TriggerSource> CHAN1 | CHANnel1 | CHAN2 | CHANnel2 | CHAN3 | CHANnel3 | CHAN4 | CHANnel4

CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4
Only the measurement source channels can be used as trigger source.

*RST: CHAN1

POWer:TRANsient:TRGLevel <TriggerLevel>

Parameters:

<TriggerLevel> Range: -1000 to 1000
Increment: 1E-3
*RST: 0
Default unit: V

POWer:TRANsient:TRGSlope <TriggerSlope>

Sets the edge type for the trigger event.

Parameters:

<TriggerSlope>	POSitive | NEGative | EITHer	
	*RST:	POSitive

20.22.16 Spectrum

POWer:SPECtrum:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:SPECtrum:EXECute

Starts the spectrum measurement.

Usage: Event

POWer:SPECtrum:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency>	Range:	1 to 100E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	Hz

POWer:SPECtrum:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SPECtrum:RCOunt?

Returns the total number of harmonics.

Return values:
<ResultCount>

Usage: Query only

POWer:SPECtrum:RESult<m>:FREQuency?

Returns the result frequency of the m-th result value.

Suffix:

<m>	1..*

Return values:
<Frequency>

Usage: Query only

POWer:SPECtrum:RESult<m>:LEVel?

Returns the result level of the m-th result value.

Suffix:

<m>	1..*

Return values:
<Level>

Usage: Query only

20.23 Maintenance

DIAGnostic:SERVice:WFAModel?

Returns the model name of the oscilloscope.

Return values:

<WFAModel>	RTO1012 | RTO1014 | RTO1022 | RTO1024 | RTO1044 | RTO1002 | RTO1004 | RTO1094 | RTO2012 | RTO2014 | RTO2022 | RTO2024 | RTO2032 | RTO2034 | RTO2044 | RTO2062 | RTO2004 | RTE1022 | RTE1024 | RTE1032 | RTE1034 | RTE1052 | RTE1054 | RTE1102 | RTE1104 | RTE1102N | RTE1104N | RTE1152 | RTE1154 | RTE1202 | RTE1204 *RST: RTO1024

Usage:	Query only

DIAGnostic:SERVice:WFASeries?

Returns the model series of the oscilloscope.

Return values:

<WFASeries>	RTO | RTE *RST: RTO
Usage:	Query only

DIAGnostic:SERVice:WFAType?

Returns the instrument family of the oscilloscope.

Return values:

<WFAType>	RTO | RTO2000 | RTE *RST: RTO2000
Usage:	Query only

DIAGnostic:SERVice:STST:EXECute

Starts the selftest.

Usage:	Event Asynchronous command

DIAGnostic:SERVice:STST:STATe?

Returns the summary result of the selftest.

Return values:

<State>	PSSD | FAILed | UNDefined *RST: UNDefined
Usage:	Query only

DIAGnostic:SERVice:PWD <Password>

Sets the password to enter the service mode.

Setting parameters:

<Password>	Password string
Usage:	Setting only

20.24 Status Reporting

This chapter describes the remote commands that are used to read the status registers.

For information on structure, hierarchy, and contents of the status registers, see Chapter C, "Remote Control - Status Reporting System", on page 2232.

20.24.1 STATus:OPERation Register

`STATus:OPERation` commands provide information on the activity of the instrument.

See also: Chapter C.3.4, "STATus:OPERation Register", on page 2237

STATus:OPERation:CONDition?
STATus:OPERation[:EVENt]?

The CONDition command returns information on actions the instrument is currently executing. The contents of the register is retained.

The EVENt command returns information on actions the instrument has executed since the last reading. Reading the EVENt register deletes its contents.

Bits:

- 0 = ALIGnment
- 2 = AUToset
- 3= WTRIgger (wait for trigger)
- 4= MEASuring

Usage: Query only

STATus:OPERation:ENABle <Enable>

Controls the ENABle part of the STATus:OPERation register. The ENABle defines which events in the EVENt part of the status register are forwarded to the OPERation summary bit (bit 7) of the status byte. The status byte can be used to create a service request.

Parameters:

<Enable>	Range:	1 to 65535
	Increment:	1

Example: `STATus:OPERation:ENABle 5`
The ALIGnment event (bit 0) and AUToset event (bit 2) are forwarded to the OPERation summary bit of the status byte.

20.24.2 STATus:QUEStionable Registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the STATus:QUEStionable registers.

See also: Chapter C.3.5, "STATus:QUEStionable Register", on page 2238

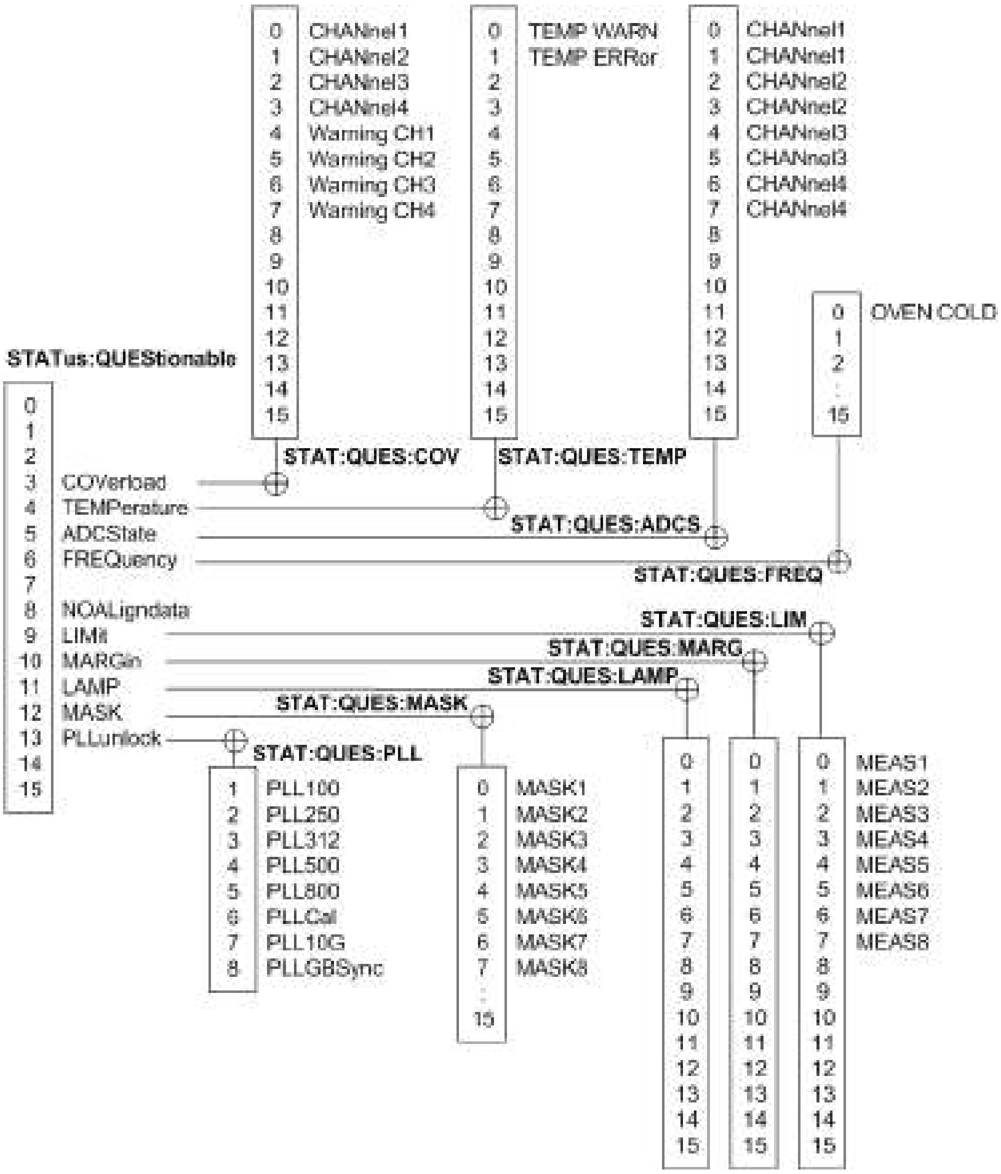


Figure 20-1: Overview of the STATus:QUEStionable register

The following commands are available:

STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?
STATus:QUEStionable:ADCState:CONDition?
STATus:QUEStionable:LIMit:CONDition?
STATus:QUEStionable:MARGin:CONDition?
STATus:QUEStionable:FREQuency:CONDition?
STATus:QUEStionable:LAMPlitude:CONDition?

STATus:QUEStionable:ZVCoverload:CONDition?
STATus:QUEStionable:MASK:CONDition?

Returns the contents of the CONDition part of the status register to check for questionable instrument or measurement states. Reading the CONDition registers does not delete the contents.

Usage: Query only

STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>
STATus:QUEStionable:ADCState:ENABle <Value>
STATus:QUEStionable:LIMit:ENABle <Value>
STATus:QUEStionable:MARGin:ENABle <Value>
STATus:QUEStionable:FREQuency:ENABle <Value>
STATus:QUEStionable:LAMPlitude:ENABle <Value>
STATus:QUEStionable:ZVCoverload:ENABle <Value>
STATus:QUEStionable:MASK:ENABle <Value>

Sets the ENABle part that allows true conditions in the EVENt part to be reported in the summary bit. If a bit is set to 1 in the enable part and its associated event bit transitions to true, a positive transition occurs in the summary bit and is reported to the next higher level.

Parameters:

<Value>	Bit mask in decimal representation
Example:	`STATus:QUEStionable:MASK:ENABle 24` Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:ENABle register part: *24* = *8* + *16* = $2^3 + 2^4$

STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?
STATus:QUEStionable:ADCState[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]?
STATus:QUEStionable:MARGin[:EVENt]?
STATus:QUEStionable:FREQuency:EVENt?
STATus:QUEStionable:LAMPlitude[:EVENt]?
STATus:QUEStionable:ZVCoverload[:EVENt]?
STATus:QUEStionable:MASK[:EVENt]?

Returns the contents of the EVENt part of the status register to check whether an event has occurred since the last reading. Reading an EVENt register deletes its contents.

Usage: Query only

STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>
STATus:QUEStionable:ADCState:NTRansition <Value>
STATus:QUEStionable:LIMit:NTRansition <Value>

STATus:QUEStionable:MARGin:NTRansition <Value>
STATus:QUEStionable:FREQuency:NTRansition <Value>
STATus:QUEStionable:LAMPlitude:NTRansition <Value>
STATus:QUEStionable:ZVCoverload:NTRansition <Value>
STATus:QUEStionable:MASK:NTRansition <Value>

Sets the negative transition filter. If a bit is set, a 1 to 0 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value>	Bit mask in decimal representation
Example:	`STATus:QUEStionable:MASK:NTRansition 24` Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:NTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>
STATus:QUEStionable:ADCState:PTRansition <Value>
STATus:QUEStionable:LIMit:PTRansition <Value>
STATus:QUEStionable:MARGin:PTRansition <Value>
STATus:QUEStionable:FREQuency:PTRansition <Value>
STATus:QUEStionable:LAMPlitude:PTRansition <Value>
STATus:QUEStionable:ZVCoverload:PTRanstition <Value>
STATus:QUEStionable:MASK:PTRansition <Value>

Sets the positive transition filter. If a bit is set, a 0 to 1 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value>	Bit mask in decimal representation
Example:	`STATus:QUEStionable:MASK:PTRansition 24` Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:PTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

20.25 Remote Trace

The commands in this section configure tracing of the remote control interface and of events. They also configure the display of the SCPI remote trace.

Before you start tracing, configure all settings as desired. Modifying settings while tracing is active may result in loss of already traced data. Useful exception: Selecting a new target file while tracing is allowed. For start mode `EXPLicit` a restart of the instrument resets the settings to the documented default values.

If you want to start tracing already during startup of the instrument, configure all settings (including start mode `AUTO`). Then restart your instrument. Tracing will be started automatically during the restart, using the already configured settings.

If you use an XML file as trace file, ensure that tracing is stopped properly. If tracing is aborted instead of stopped, for example by shutting down the instrument for stop mode `EXPLicit`, the XML file will be invalid, because some tags are not closed.

When the maximum file size is reached (except for stop mode `BUFFerfull`) or if tracing is started with an already existing trace file, a backup of the trace file is created and the file itself is reset and overwritten. When the file is full for the second time or when tracing is started the next time, the first backup file is lost because it is overwritten by the next backup. In order to prevent loss of data, set a sufficient file size, select an appropriate stop mode and archive/copy completed trace files if you want to keep them.

20.25.1 Standard Commands

TRACe:REMote:MODE:FILE:NAME <FilePath>

Sets the directory and file name where the remote trace file is stored.

Parameters:

<FilePath>	String parameter

TRACe:REMote:MODE:FILE:FORMat <Format>

Sets the file format of the remote trace file.

Parameters:

<Format>	ASCii | XML

TRACe:REMote:MODE:FILE:SIZE <FileSize>

Sets the maximum size of the remote trace file.

Parameters:

<FileSize>	Integer value

TRACe:REMote:MODE:FILE:STARtmode <StartMode>

Defines how the remote trace is started.

Parameters:

<StartMode>	AUTO | EXPLicit **AUTO** Starts the remote trace immediately. **EXPLicit** Starts remote trace with `TRACe:REMote:MODE:FILE:ENABle ON`

TRACe:REMote:MODE:FILE:STOPmode <StopMode>

Defines when the remote trace is stopped.

Parameters:

<StopMode>	AUTO | EXPLicit | ERRor | BUFFerfull **AUTO** Ends the remote trace on device shutdown. **EXPLicit** Ends remote trace with `TRACe:REMote:MODE:FILE:ENABle OFF` **ERRor** Ends remote trace when a SCPI error occurs. **BUFFerfull** Ends remote trace when the maximum file size is reached.

TRACe:REMote:MODE:FILE:ENABle <Enable>

Enables and disables the remote trace to file.

Parameters:

<Enable>	ON | OFF

TRACe:REMote:MODE:FILE:FILTer <Input>, <Output>, <Error>, <Trigger>, <DeviceClear>, <StatusRegister>, <Connection>, <RemoteLocalEvents>, <Locking>

Defines the content of the remote trace file.

Parameters:

<Input>	ON | OFF Input data
<Output>	ON | OFF Output data
<Error>	ON | OFF New SCPI error queue entries
<Trigger>	ON | OFF Trigger events

<DeviceClear>	ON | OFF Device clear events
<StatusRegister>	ON | OFF Status register conditions
<Connection>	ON | OFF Open/close connection events
<RemoteLocalEvents>	ON | OFF Local/remote transition events
<Locking>	ON | OFF Remote locking events

20.25.2 Diagnostic Remote Trace Commands

TRACe:REMote:MODE:FILE:DEXecution:DURation <Enable>

Traces the device execution time of a command

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:RPC <Enable>

Enables and disables output of rpc calls to remote trace.

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:PARSer <Enable>

Enables and disables output of parser transitions to remote trace.

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:FUNCtions <Enable>

Enables and disables output of function names to remote trace.

Parameters:
<Enable> ON | OFF

20.26 Deprecated Commands

The following commands are provided for compatibility to previous oscilloscope versions only. For new remote control programs, use the specified alternative commands.

ACQuire:ARESet:WFMCount <MaxAcqCnt>

The command is obsolete and replaced by `ACQuire:ARESet:COUNt` on page 1214.

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `WFMS`.

Parameters:

<MaxAcqCnt>	Range:	1 to 16777215
	Increment:	10
	*RST:	1

Firmware/Software: V 1.36

BUS<m>:SWIRe:MINGap <MinGapTime>

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range:	1E-9 to 10E-6
	Increment:	100E-9
	*RST:	200E-9
	Default unit:	s

BUS<m>:SWIRe:THRCoupling <ThresCoup>

Enables coupling, i.e. the same threshold and hysteresis value is used for the strob and the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresCoup>	ON | OFF	
	*RST:	ON

BUS<m>:SWIRe:THRPreset <ThresholdPreset>

Prests the threshold and hysteresis value of the strobe and data signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset>	V01 | V03 | V2 | MAN *RST: V01

MEASurement<m>:SPECtrum:NREJect <NoiseReject>

Defines the threshold beneath which values are rejected as noise.

Replaced by `MEASurement<m>:SPECtrum:ATHReshold`.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<NoiseReject>	Range: 0 to 100 Increment: 1 *RST: 0 Default unit: dB

MEASurement<m>:SPECtrum:THReshold <Value>

Defines a threshold relative to the reference level as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<Value>	Threshold in dB
Firmware/Software:	Version 2.70 The command has been replaced by `MEASurement<m>:SPECtrum:ATHReshold`.

SEARch:TRIGger:INTerval:POLarity <SearchName>,<Slope>
SEARch:TRIGger:INTerval:POLarity? <SearchName>

Sets the edge for the interval detection.

Parameters:

<Slope>	POSitive | NEGative | EITHer POSitive = rising edge, NEGative = falling edge *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

Replaced by `SEARch:TRIGger:INTerval:SLOPe`

TRIGger<m>:INTerval:POLarity <Slope>

Sets the edge for the interval detection.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Slope>	POSitive | NEGative POSitive = rising edge, NEGative = falling edge *RST: POSitive

Replaced by `TRIGger<m>:INTerval:SLOPe`

21 Maintenance

The instrument does not need periodic maintenance. Only the cleaning of the instrument is essential.

To protect the front panel and to transport the instrument to another workplace safely and easily, accessories are provided:

- Front cover (R&S RTO-Z1, order number 1317.6970.02)
- Soft case (R&S RTO-Z3, order number 1304.9118.02)

The adjustment of the OCXO oscillator is described in the service manual.

The addresses of Rohde & Schwarz support centers can be found at www.customer-support.rohde-schwarz.com. A list of all service centers is available on www.services.rohde-schwarz.com.

21.1 Cleaning

⚠ **WARNING**

Risk of electric shock

If moisture enters the casing, for example if you clean the instrument using a moist cloth, contact with the instrument can lead to electric shock. Before cleaning the instrument other than with a dry cloth, make sure that the instrument is switched off and disconnected from all power supplies.

NOTICE

Instrument damage caused by cleaning agents

Cleaning agents contain substances such as solvents (thinners, acetone, etc.), acids, bases, or other substances. Solvents can damage the front panel labeling, plastic parts, or screens, for example.

Never use cleaning agents to clean the outside of the instrument. Use a soft, dry, lint-free dust cloth instead.

NOTICE

Risk of instrument damage due to obstructed fans

If the instrument is operated in dusty areas, the fans become obstructed by dust or other particles over time. Check and clean the fans regularly to ensure that they always operate properly. If the instrument is run with obstructed fans for a longer period, the instrument overheats, which can disturb the operation and even cause damage.

1. Clean the outside of the instrument using a soft, dry, lint-free dust cloth.
2. Check and clean the fans regularly to ensure that they always operate properly.
3. Clean the touchscreen as follows:
    a) Apply a small amount of standard screen cleaner to a soft cloth.
    b) Wipe the screen gently with the moist, but not wet, cloth.
    c) If necessary, remove any excess moisture with a dry, soft cloth.

21.2 Information for Technical Support

If you encounter problems that you cannot solve yourself, contact your Rohde & Schwarz support center at www.customersupport.rohde-schwarz.com. The staff of our support center is optimally trained to assist you in solving the problems. The support center finds solutions more quickly and efficiently if you provide them with information on the instrument and an error description.

To create, collect and save the required information, you can use the RTxServiceReporter. The RTxServiceReporter creates a ZIP file with a complete bug report, all relevant setup information, reporting and log files, and the instrument configuration (device footprint).

1. Open the App Cockpit: tap ▦.
2. On the "R&S Apps" tab, tap "Service".

    The RTxServiceReporter creates the report and saves it as ZIP file directly on the Windows desktop.
3. Attach the report file to an email in which you describe the problem. Send the email to the customer support address for your region as listed in the Internet

On the instrument, you can find log files, the device footprint and report files, and other information in the "AppData" folder on the Windows desktop (`C:\ProgramData\Rohde-Schwarz\RTx`).

The "Board Detection/Maintenance" dialog box also provides information on your instrument configuration which may be helpful in case you need support.

21.3 Data Security

If you have to send the instrument to the service, or if the instrument is used in a secured environment, consider the document "Instrument Security Procedures" that is delivered on the R&S RTO web page.

Instrument configuration data and user data are stored on a removable hard disk only. Thus it is sufficient to remove the hard disk before the instrument leaves a secured environment. Details are given in the document mentioned above.

21.4 Storing and Packing

The storage temperature range of the instrument is given in the data sheet. If the instrument is to be stored for a longer period of time, it must be protected against dust.

Repack the instrument as it was originally packed when transporting or shipping. The two protective foam plastic parts prevent the control elements and connectors from being damaged. The antistatic packing foil avoids any undesired electrostatic charging to occur.

If you do not use the original packaging, use a sturdy cardboard box of suitable size and provide for sufficient padding to prevent the instrument from slipping inside the package. Wrap antistatic packing foil around the instrument to protect it from electrostatic charging.

21.5 Performing a Self-test

The instrument self-test checks the hardware for correct operation. Perform the self-test if you suspect problems in hardware operation.

1. From the "File" menu, select "Selftest".
2. Tap "Selftest".

   The test can take several minutes. The summary result is shown in the "State" field. If you require support, you may be asked to provide this information.

21.6 Reference for Maintenance Settings

21.6.1 Board Detection/Maintenance

The "Board Detection/Maintenance" dialog box in the "File" menu provides service information for your R&S RTO. In case you require support, you may be asked to provide this information.

21.6.1.1 System Info

This tab provides general information on the hardware configuration, and indicates where system information can be found on the instrument.

21.6.1.2 Mainboard

This tab provides information on the mainboard configuration in your instrument.

21.6.1.3 Frontend

This tab provides information on the frontend configuration in your instrument.

21.6.1.4 Frontpanel

This tab provides information on the frontpanel module installed in your instrument.

21.6.1.5 MSO Option

This tab is only relevant if the MSO option R&S RTO-B1 is installed. The tab provides information on the MSO hardware module that is installed in your instrument.

21.6.1.6 Service

This tab allows the service personnel to enter a password that activates further service functions.

Remote command:

- `DIAGnostic:SERVice:PWD` on page 2196

21.6.2 Selftest

The instrument selftest checks the hardware for correct operation. Perform the selftest if you suspect problems in hardware operation.

Selftest
Starts the selftest.

Remote command:
`*TST?` on page 1180

State
Shows the summary result of the selftest: Pass or Fail.

Remote command:
`DIAGnostic:SERVice:STST:STATe?` on page 2196

Result
Opens a log file with detailed information on the selftest steps and hardware components operation. In case you require support, you may be asked to provide this information.

Annex

A Menu Overview

This section provides an overview of the menus together with a short description or link to the description.

A.1 File Menu

Menu item	Description	Corresponding key
File	Chapter 11.2, "Waveforms and Results", on page 449	SAVE RECALL
Setup	Chapter 3, "Instrument Setup", on page 99	SETUP
Print	Chapter 11.3, "Screenshots", on page 468 Chapter 11.3.2, "Printing Screenshots", on page 472	CAMERA
Help	Chapter 2.4.10, "Getting Information and Help", on page 96	HELP
Mode	Chapter 3.6.5, "Options in Beta State", on page 134	Only R&S RTO1000: MODE
Maintenance	Chapter 21.6.1, "Board Detection/Maintenance", on page 2210	
Selfalignment	Chapter 3.5, "Self-Alignment", on page 128	
Selftest	Chapter 21.6.2, "Selftest", on page 2211	
Demo Board	For internal use only. Opens a setup dialog box for the demo board If a demo board is connected to the instrument.	

Menu item	Description	Corresponding key
Minimize Application	Shows the Windows desktop with the application icon of the R&S RTO firmware.	
Exit	Shuts down the firmware.	

A.2 Horizontal Menu

Menu item	Description	Corresponding key
Setup	Chapter 4.2.1, "Setup", on page 147	HORIZONTAL
Acquisition	Chapter 4.2.2, "Acquisition", on page 151	ACQUISITION
Ultra Segmentation	Chapter 4.2.3, "Ultra Segmentation", on page 156	
Skew	Chapter 4.8.2, "Skew", on page 196	

A.3 Trigger Menu

Menu item	Description	Corresponding key
Setup	Chapter 5.3, "Trigger Types", on page 206	TRIGGER
Qualification	Chapter 5.4, "Qualification", on page 233	
Noise Reject	Chapter 5.6, "Noise Reject", on page 236	
Holdoff	Chapter 5.5, "Holdoff", on page 235	
Ctrl/Action	Chapter 5.7, "Control / Action", on page 237	
Digital Filter	Chapter 4.7, "Digital Filter Setup", on page 193	
Acquisition Info	Shows the current number of acquisitions that have been acquired.	

A.4 Vertical Menu

Menu item	Description	Corresponding key
Channels	Chapter 4.3.1, "Channels", on page 158	CH <N>
Coupled Channels		
Power Calculation	Chapter 4.3.3, "Power Calculation", on page 161	
Probe Setup	Chapter 4.5, "Probes", on page 166	
Probe Attributes	Chapter 4.5.9, "Probe Attributes", on page 184	

Menu item	Description	Corresponding key
Calibration Results	Chapter 4.5.10, "Calibration Results", on page 185	
Digital Filter	Chapter 4.7, "Digital Filter Setup", on page 193	

A.5 Math Menu

Menu item	Description	Key / Icon
Math Setup	Chapter 6.3.4, "Math Setup - General Settings", on page 278	MATH
FFT Setup	Chapter 8.1.3.1, "FFT Setup", on page 378	FFT
FFT Overlap		
FFT Gating	Chapter 8.1.3.3, "FFT Gating", on page 384	
FFT Y-Units		
Reference Waveform	Submenu: Setup, Scaling, Original Attributes: Chapter 6.2.2, "Settings for Reference Waveforms", on page 262	Ref 1

A.6 Cursor Menu

Menu item	Description	Key / Icon
Setup	Chapter 7.1.3.1, "Cursor Setup", on page 297	CURSOR
Style and Label	Chapter 7.1.3.2, "Cursor Labels", on page 301	
Peak Search	Chapter 7.1.3.3, "Peak Search ", on page 301	

A.7 Meas Menu

Menu item	Description	Key / Icon
Setup	Chapter 7.2.1.1, "General Measurement Settings", on page 305	MEAS
Long Term/Track	Chapter 7.2.9.2, "Long Term/Track Settings", on page 357	

Menu item	**Description**	**Key / Icon**
Gate/Display	Chapter 7.2.3.1, "Gate Settings for Measurements", on page 315 Chapter 7.2.2.2, "Result Display Settings", on page 313	
Limit Check	Chapter 7.2.12.2, "Actions on Limit Check Results", on page 366	
Histogram	Chapter 7.2.8.2, "Histogram Setup", on page 350	
Reference Level	Chapter 7.2.4.1, "Level Settings", on page 319	

A.8 Masks Menu

Menu item	**Description**	**Key / Icon**
Test Definition	Chapter 9.2.1, "Test Definition", on page 398	MASKS Opens the last selected tab in the "Masks" dialog box.
Mask Definition	Chapter 9.2.2.1, "Mask Definition: User Mask", on page 400	
Event Actions / Reset	Chapter 9.2.3, "Event Actions /Reset ", on page 406	
Mask Display	Chapter 9.2.4, "Mask Display", on page 408	

A.9 Search Menu

Menu item	**Description**	**Key / Icon**
Setup	Chapter 10.2, "Search Setup", on page 421	SEARCH Opens the last selected tab in the "Search" dialog box.
Gate	Chapter 10.3.1, "Gate Settings", on page 435	
Result Presentation	Chapter 10.4.1, "Result Presentation Settings", on page 437	
Noise Reject	Chapter 10.5.1, "Noise Reject Settings", on page 440	

A.10 Analysis Menu

The content of the menu depends on the installed options.

Menu item	**Description**	**Corresponding key**
Power	Chapter 17, "Power Analysis (Option R&S RTO-K31)", on page 1059	
Serial Bus		
Configuration	Chapter 12.1.1, "Configuration - General Settings", on page 481	PROTOCOL
Display	Chapter 12.1.2, "Display", on page 482	
Label List	Chapter 12.1.3, "Label Lists", on page 484	
Parallel bus		
Configuration	Chapter 13.1.1, "Parallel Buses - Configuration", on page 973	LOGIC
Digital Probes	Chapter 13.1.2, "Parallel Buses - Digital Probes", on page 978	
CDR Setup		
SW	Chapter 16.2.1, "Software CDR ", on page 1047	
HW	Chapter 16.2.2, "Hardware CDR (Option R&S RTO-K13)", on page 1049	
Jitter Wizard	Chapter 16.1.1, "Jitter Wizard", on page 1035	
External Apps		
Start Compliance Test	Chapter 18, "Compliance Tests", on page 1128	

A.11 Display Menu

Menu item	**Description**	**Key / Icon**
Signal Colors / Persistence	Chapter 3.4.2.1, "Colors / Persistence", on page 110	DISPLAY Opens the last selected tab in the "Display" dialog box.
Color Tables	Chapter 3.4.2.2, "Color Tables", on page 113	
Diagram Layout	Chapter 3.4.2.3, "Diagram Layout", on page 114	
XY-Diagram	Chapter 6.5, "XY-diagram", on page 288	
Labels		🏷
Zoom	Chapter 6.1, "Zoom", on page 248	ZOOM 🔍
Show History	Enables the history mode and opens the quick-access "History" dialog box. Chapter 6.4, "History", on page 281	HISTORY

Menu item	Description	Key / Icon
History Setup	Opens the "History" configuration dialog box without starting the history mode. Chapter 6.4.2, "History Setup", on page 283	
Show Performance	Displays the current performance values of the instrument.	
Clear Screen Results	Deletes all measurement results including long term measurement and statistic results. Also deletes the current measurement and channel waveforms.	🧹
Toolbar	Chapter 2.4.5.2, "Configuring the Toolbar", on page 85	

A.12 Tutorials Menu

Menu item	Description	Corresponding key
Getting Started	Opens a dialog box with tutorial videos that explain how to use the instrument..	

B Remote Control - Basics

B.1 Messages

B.1.1 Instrument Messages

Instrument messages are employed in the same way for all interfaces, if not indicated otherwise in the description.

There are different types of instrument messages, depending on the direction they are sent:

- Commands
- Instrument responses

Structure and syntax of the instrument messages are described in Chapter B.2, "SCPI Command Structure", on page 2220.

Commands

Commands (program messages) are messages that the controller sends to the instrument. They operate the instrument functions and request information. The commands are subdivided according to two criteria:

- According to the effect on the instrument:
  - **Setting commands** cause instrument settings such as a reset of the instrument or setting the frequency.
  - **Queries** cause data to be provided for remote control, e.g. for identification of the instrument or polling a parameter value. Queries are formed by directly appending a question mark to the command header.
- According to their definition in standards:
  - **Common commands**: their function and syntax are precisely defined in standard IEEE 488.2. They are employed identically on all instruments (if implemented). They refer to functions such as management of the standardized status registers, reset and self-test.
  - **Instrument control commands** refer to functions depending on the features of the instrument such as frequency settings. Many of these commands have also been standardized by the SCPI committee. These commands are marked as "SCPI compliant" in the command reference chapters. Commands without this SCPI label are device-specific, however, their syntax follows SCPI rules as permitted by the standard.

Instrument responses

Instrument responses (response messages and service requests) are messages that the instrument sends to the controller after a query. They can contain measurement results, instrument settings and information on the instrument status.

B.1.2 Interface Massages

Interface messages are transmitted to the instrument on the data lines. They are used to communicate between the controller and the instrument.

B.1.2.1 GPIB Interface Messages

Interface messages are transmitted to the instrument on the data lines, with the attention line (ATN) being active (LOW). They are used for communication between the controller and the instrument and can only be sent by a computer which has the function of a GPIB bus controller. GPIB interface messages can be further subdivided into:

- **Universal commands**: act on all instruments connected to the GPIB bus without previous addressing
- **Addressed commands**: only act on instruments previously addressed as listeners

Universal Commands

Universal commands are encoded in the range 10 through 1F hex. They affect all instruments connected to the bus and do not require addressing.

Command	Effect on the instrument
DCL (Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument settings.
IFC (Interface Clear) *)	Resets the interfaces to the default setting.
LLO (Local Lockout)	The "Local" softkey is disabled. Manual operation is no longer available until `GTL` is executed.
SPE (Serial Poll Enable)	Ready for serial poll.
SPD (Serial Poll Disable)	End of serial poll.
PPU (Parallel Poll Unconfigure)	End of the parallel-poll state.
*) IFC is not a real universal command, it is sent via a separate line; however, it also affects all instruments connected to the bus and does not require addressing	

Addressed Commands

Addressed commands are encoded in the range 00 through 0F hex. They only affect instruments addressed as listeners.

Command	Effect on the instrument
GET (Group Execute Trigger)	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
GTL (Go to Local)	Transition to the "local" state (manual control).
GTR (Go to Remote)	Transition to the "remote" state (remote control).
PPC (Parallel Poll Configure)	Configures the instrument for parallel poll.
SDC (Selected Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.

B.1.2.2 LAN Interface Messages

In the LAN connection, the interface messages are called low–level control messages. These messages can be used to emulate interface messages of the GPIB bus.

Command	Long term	Effect on the instrument
&ABO	Abort	Aborts processing of the commands just received.
&DCL	Device Clear	Aborts processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
&GTL	Go to Local	Transition to the "local" state (manual control). (The instrument automatically returns to remote state when a remote command is sent UNLESS `&NREN` was sent before.)
&GTR	Go to Remote	Enables automatic transition from local state to remote state by a subsequent remote command (after `&NREN` was sent).
&GET	Group Execute Trigger	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
&LLO	Local Lockout	Disables transition from remote control to manual control by means of the front panel keys.
&NREN	Not Remote Enable	Disables automatic transition from local state to remote state by a subsequent remote command. (To re-activate automatic transition use `&GTR`.)
&POL	Serial Poll	Starts a serial poll.

B.2 SCPI Command Structure

SCPI commands consist of a header and, in most cases, one or more parameters. The header and the parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). The headers may consist of several mnemonics (keywords). Queries are formed by appending a question mark directly to the header.

The commands can be either device-specific or device-independent (common commands). Common and device-specific commands differ in their syntax.

B.2.1 Syntax for Common Commands

Common (= device-independent) commands consist of a header preceded by an asterisk (*), and possibly one or more parameters.

Table B-1: Examples of common commands

*RST	RESET	Resets the instrument.
*ESE	EVENT STATUS ENABLE	Sets the bits of the event status enable registers.
*ESR?	EVENT STATUS QUERY	Queries the contents of the event status register.
*IDN?	IDENTIFICATION QUERY	Queries the instrument identification string.

B.2.2 Syntax for Device-Specific Commands

Not all commands used in the following examples are necessarily implemented in the instrument. For demonstration purposes only, assume the existence of the following commands for this section:

- `DISPlay[:WINDow<1...4>]:MAXimize <Boolean>`
- `FORMat:READings:DATA <type>[,<length>]`
- `HCOPy:DEVice:COLor <Boolean>`
- `HCOPy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>`
- `HCOPy[:IMMediate]`
- `HCOPy:ITEM:ALL`
- `HCOPy:ITEM:LABel <string>`
- `HCOPy:PAGE:DIMensions:QUADrant[<N>]`
- `HCOPy:PAGE:ORIentation LANDscape | PORTrait`
- `HCOPy:PAGE:SCALe <numeric value>`
- `MMEMory:COPY <file_source>,<file_destination>`
- `SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>`
- `SENSe:FREQuency:STOP <numeric value>`
- `SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}`

B.2.2.1 Long and short form

The mnemonics feature a long form and a short form. The short form is marked by upper case letters, the long form corresponds to the complete word. Either the short form or the long form can be entered; other abbreviations are not permitted.

Example:

`HCOPy:DEVice:COLor ON` is equivalent to `HCOP:DEV:COL ON`.

Case-insensitivity

Upper case and lower case notation only serves to distinguish the two forms in the manual, the instrument itself is case-insensitive.

B.2.2.2 Numeric Suffixes

If a command can be applied to multiple instances of an object, e.g. specific channels or sources, the required instances can be specified by a suffix added to the command. Numeric suffixes are indicated by angular brackets (<1...4>, <n>, <i>) and are replaced by a single value in the command. Entries without a suffix are interpreted as having the suffix 1.

Example:

Definition: `HCOPy:PAGE:DIMensions:QUADrant[<N>]`

Command: `HCOP:PAGE:DIM:QUAD2`

This command refers to the quadrant 2.

Different numbering in remote control

For remote control, the suffix may differ from the number of the corresponding selection used in manual operation. SCPI prescribes that suffix counting starts with 1. Suffix 1 is the default state and used when no specific suffix is specified.

Some standards define a fixed numbering, starting with 0. If the numbering differs in manual operation and remote control, it is indicated for the corresponding command.

B.2.2.3 Optional Mnemonics

Some command systems permit certain mnemonics to be inserted into the header or omitted. These mnemonics are marked by square brackets in the description. The instrument must recognize the long command to comply with the SCPI standard. Some commands are considerably shortened by these optional mnemonics.

Example:

Definition: `HCOPy[:IMMediate]`

Command: `HCOP:IMM` is equivalent to `HCOP`

Optional mnemonics with numeric suffixes

Do not omit an optional mnemonic if it includes a numeric suffix that is relevant for the effect of the command.

Example:

Definition:`DISPlay[:WINDow<1...4>]:MAXimize <Boolean>`

Command: `DISP:MAX ON` refers to window 1.

In order to refer to a window other than 1, you must include the optional `WINDow` parameter with the suffix for the required window.

`DISP:WIND2:MAX ON` refers to window 2.

B.2.3 SCPI Parameters

Many commands are supplemented by a parameter or a list of parameters. The parameters must be separated from the header by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank).

The parameters required for each command and the allowed range of values are specified in the command description.

Allowed parameters are:

B.2.3.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point and exponent. Values exceeding the resolution of the instrument are rounded up or down. The mantissa may comprise up to 255 characters, the exponent must lie inside the value range -32000 to 32000. The exponent is introduced by an "E" or "e". Entry of the exponent alone is not allowed.

Example:

`SENS:FREQ:STOP 1500000` = `SENS:FREQ:STOP 1.5E6`

Units

For physical quantities, the unit can be entered. If the unit is missing, the basic unit is used. Allowed unit prefixes are:

- G (giga)
- MA (mega), MOHM, MHZ
- K (kilo)

- M (milli)
- U (micro)
- N (nano)

Example:

`SENSe:FREQ:STOP 1.5GHz` = `SENSe:FREQ:STOP 1.5E9`

Some settings allow relative values to be stated in percent. According to SCPI, this unit is represented by the `PCT` string.

Example:

`HCOP:PAGE:SCAL 90PCT`

B.2.3.2 Special Numeric Values

The following mnemonics are special numeric values. In the response to a query, the numeric value is provided.

- **MIN and MAX**: denote the minimum and maximum value.
- **DEF**: denotes a preset value which has been stored in the EPROM. This value conforms to the default setting, as it is called by the *RST command.
- **UP and DOWN**: increases or reduces the numeric value by one step. The step width can be specified via an allocated step command for each parameter which can be set via UP and DOWN.
- **INF and NINF**: INFinity and negative INFinity (NINF) represent the numeric values 9.9E37 or -9.9E37, respectively. INF and NINF are only sent as instrument responses.
- **NAN**: Not A Number (NAN) represents the value 9.91E37. NAN is only sent as a instrument response. This value is not defined. Possible causes are the division of zero by zero, the subtraction of infinite from infinite and the representation of missing values.

Example:

Setting command: `SENSe:LIST:FREQ MAXimum`

Query: `SENS:LIST:FREQ?`

Response: `3.5E9`

Queries for special numeric values

The numeric values associated to `MAXimum/MINimum/DEFault` can be queried by adding the corresponding mnemonic after the quotation mark.

Example: `SENSe:LIST:FREQ? MAXimum`

Returns the maximum numeric value as a result.

B.2.3.3 Boolean Parameters

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0. The numeric values are provided as the response for a query.

Example:

Setting command: `HCOPy:DEV:COL ON`

Query: `HCOPy:DEV:COL?`

Response: `1`

B.2.3.4 Text Parameters

Text parameters observe the syntactic rules for mnemonics, i.e. they can be entered using a short or long form. Like any parameter, they have to be separated from the header by a white space. In the response to a query, the short form of the text is provided.

Example:

Setting command: `HCOPy:PAGE:ORIentation LANDscape`

Query: `HCOP:PAGE:ORI?`

Response: `LAND`

B.2.3.5 Character Strings

Strings must always be entered in quotation marks (' or ").

Example:

```
HCOP:ITEM:LABel "Test1"
HCOP:ITEM:LABel 'Test1'
```

B.2.3.6 Block Data

Block data is a format which is suitable for the transmission of large amounts of data. For example, a command using a block data parameter has the following structure:

```
FORMat:READings:DATA #45168xxxxxxxx
```

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted.

#0 specifies a data block of indefinite length. The use of the indefinite format requires a `NL^END` message to terminate the data block. This format is useful when the length of

the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

B.2.4 Overview of Syntax Elements

The following tables provide an overview of the syntax elements and special characters.

Table B-2: Syntax elements

:	The colon separates the mnemonics of a command.
;	The semicolon separates two commands of a command line. It does not alter the path.
,	The comma separates several parameters of a command.
?	The question mark forms a query.
*****	The asterisk marks a common command.
' ' **"**	Quotation marks introduce a string and terminate it (both single and double quotation marks are possible).
#	The hash symbol introduces binary, octal, hexadecimal and block data. ● Binary: #B10110 ● Octal: #O7612 ● Hexa: #HF3A7 ● Block: #21312
	A "white space" (ASCII-Code 0 to 9, 11 to 32 decimal, e.g. blank) separates the header from the parameters.

Table B-3: Special characters

|	**Parameters**
	A vertical stroke in parameter definitions indicates alternative possibilities in the sense of "or". The effect of the command differs, depending on which parameter is used.
	Example:
	Definition:`HCOPy:PAGE:ORIentation LANDscape | PORTrait`
	Command `HCOP:PAGE:ORI LAND` specifies landscape orientation
	Command `HCOP:PAGE:ORI PORT` specifies portrait orientation
	Mnemonics
	A selection of mnemonics with an identical effect exists for several commands. These mnemonics are indicated in the same line; they are separated by a vertical stroke. Only one of these mnemonics needs to be included in the header of the command. The effect of the command is independent of which of the mnemonics is used.
	Example:
	Definition`SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>`
	The two following commands with identical meaning can be created:
	`SENS:BAND:RES 1`
	`SENS:BWID:RES 1`

[ ]	Mnemonics in square brackets are optional and may be inserted into the header or omitted. Example: `HCOPy[:IMMediate]` `HCOP:IMM` is equivalent to `HCOP`

{ }	Parameters in curly brackets are optional and can be inserted once or several times, or omitted.
	Example: `SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}`
	The following are valid commands:
	`SENS:LIST:FREQ 10`
	`SENS:LIST:FREQ 10,20`
	`SENS:LIST:FREQ 10,20,30,40`

B.2.5 Structure of a Command Line

A command line may consist of one or several commands. It is terminated by one of the following:

- <New Line>
- <New Line> with EOI
- EOI together with the last data byte

Several commands in a command line must be separated by a semicolon ";".

Example:

```
MMEM:COPY "Test1","MeasurementXY";:HCOP:ITEM ALL
```

This command line contains two commands. The first command belongs to the MMEM system, the second command belongs to the HCOP system. If the next command belongs to a different command system, the semicolon is followed by a colon.

Example:

`HCOP:ITEM ALL;:HCOP:IMM`

This command line contains two commands. Both commands are part of the `HCOP` command system, i.e. they have one level in common.

If the successive commands belong to the same system, having one or several levels in common, the command line can be abbreviated. When abbreviating the command line, the second command begins with the level below HCOP. The colon after the semicolon is omitted. The abbreviated form of the command line reads as follows:

`HCOP:ITEM ALL;IMM`

Example:

`HCOP:ITEM ALL`

`HCOP:IMM`

A new command line always begins with the complete path.

B.2.6 Responses to Queries

A query is defined for each setting command unless explicitly specified otherwise. It is formed by adding a question mark to the associated setting command. According to SCPI, the responses to queries are partly subject to stricter rules than in standard IEEE 488.2.

- The requested parameter is transmitted without a header.
  Example: `HCOP:PAGE:ORI?`, Response: `LAND`
- Maximum values, minimum values and all other quantities that are requested via a special text parameter are returned as numeric values.
  Example: `SENSe:FREQuency:STOP? MAX`, Response: `3.5E9`
- Numeric values are output without a unit. Physical quantities are referred to the basic units or to the units set using the `Unit` command. The response `3.5E9` in the previous example stands for 3.5 GHz.
- Truth values (Boolean values) are returned as `0` (for OFF) and `1` (for ON).
  Example:
  Setting command: `HCOPy:DEV:COL ON`
  Query: `HCOPy:DEV:COL?`
  Response: `1`
- Text (character data) is returned in a short form.
  Example:
  Setting command: `HCOPy:PAGE:ORIentation LANDscape`
  Query: `HCOP:PAGE:ORI?`
  Response: `LAND`
- Invalid numerical results
  In some cases, particularly when a result consists of multiple numeric values, invalid values are returned as 9.91E37 (not a number).

B.3 Command Sequence and Synchronization

IEEE 488.2 defines a distinction between overlapped (asynchronous) and sequential commands:

- A sequential command finishes executing before the next command starts executing. Commands that are processed quickly are usually implemented as sequential commands.
- An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. Usually, overlapping commands take longer to process and allow the program to do other tasks while being executed. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially. This method is called synchronization between the controller and the instrument.

As a rule, send commands and queries in different program messages, i.e. in separate command lines.

Do not combine queries with commands that affect the queried value in one program message because the response to the query is not predictable.

The following messages always return correct results:

```
:CHAN:SCAL 0.01;POS 1
```

```
:CHAN:SCAL?
```

Result: `0.01` (10 mV/div)

Reason: Setting commands within one command line, even though they are implemented as sequential commands, are not necessarily serviced in the order in which they have been received.

For further information, refer to:

- rohde-schwarz.com/rckb: Rohde & Schwarz web page that provides information on instrument drivers and remote control.
- "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00). The book offers detailed information on concepts and definitions of SCPI.

B.3.1 Preventing Overlapping Execution

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used. All three commands cause a certain action only to be carried out after the hardware has been set. The controller can be forced to wait for the corresponding action to occur.

*Table B-4: Synchronization using *OPC, *OPC? and *WAI*

Command	Action	Programming the controller
*OPC	Sets the Operation Complete bit in the ESR after all previous commands have been executed.	• Setting bit 0 in the ESE • Setting bit 5 in the SRE • Waiting for service request (SRQ)
*OPC?	Stops command processing until 1 is returned. This occurs when all pending operations are completed.	Send *OPC? directly after the command whose processing must be terminated before other commands can be executed.
*WAI	Stops further command processing until all commands sent before *WAI have been executed.	Send *WAI directly after the command whose processing must be terminated before other commands are executed.

Command synchronization using `*WAI` or `*OPC?` is a good choice if the overlapped command takes only little time to process. The two synchronization commands simply block overlapped execution of the command. Append the synchronization command to the overlapping command, for example:

```
SINGle; *OPC?
```

For time consuming overlapped commands, you can allow the controller or the instrument to do other useful work while waiting for command execution. Use one of the following methods:

*OPC with a service request

1. Set the OPC mask bit (bit no. 0) in the ESE: *ESE 1
2. Set bit no. 5 in the SRE: `*SRE 32` to enable ESB service request.
3. Send the overlapped command with `*OPC` .
4. Wait for a service request.

   The service request indicates that the overlapped command has finished.

*OPC? with a service request

1. Set bit no. 4 in the SRE: `*SRE 16` to enable MAV service request.
2. Send the overlapped command with `*OPC?`.
3. Wait for a service request.

   The service request indicates that the overlapped command has finished.

Event status register (ESE)

1. Set the OPC mask bit (bit no. 0) in the ESE: `*ESE 1`
2. Send the overlapped command without `*OPC`, `*OPC?` or `*WAI`.

3. Poll the operation complete state periodically (with a timer) using the sequence:
   `*OPC; *ESR?`

   A return value (LSB) of 1 indicates that the overlapped command has finished.

B.4 General Programming Recommendations

Initial instrument status before changing settings

Manual operation is designed for maximum possible operating convenience. In contrast, the priority of remote control is the "predictability" of the instrument status. Thus, when a command attempts to define incompatible settings, the command is ignored and the instrument status remains unchanged, i.e. other settings are not automatically adapted. Therefore, control programs should always define an initial instrument status (e.g. using the *RST command) and then implement the required settings.

Command sequence

As a general rule, send commands and queries in different program messages. Otherwise, the result of the query may vary depending on which operation is performed first (see also Preventing Overlapping Execution).

Reacting to malfunctions

The service request is the only possibility for the instrument to become active on its own. Each controller program should instruct the instrument to initiate a service request in case of malfunction. The program should react appropriately to the service request.

Error queues

The error queue should be queried after every service request in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C Remote Control - Status Reporting System

The status reporting system stores all information on the current operating state of the instrument, and on errors which have occurred. This information is stored in the status registers and in the error queue. Both can be queried via GPIB bus or LAN interface (`STATus`... commands).

C.1 Structure of a SCPI Status Register

Each standard SCPI register consists of 5 parts. Each part has a width of 16 bits and has different functions. The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is valid for all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus the contents of the register parts can be processed by the controller as positive integers.

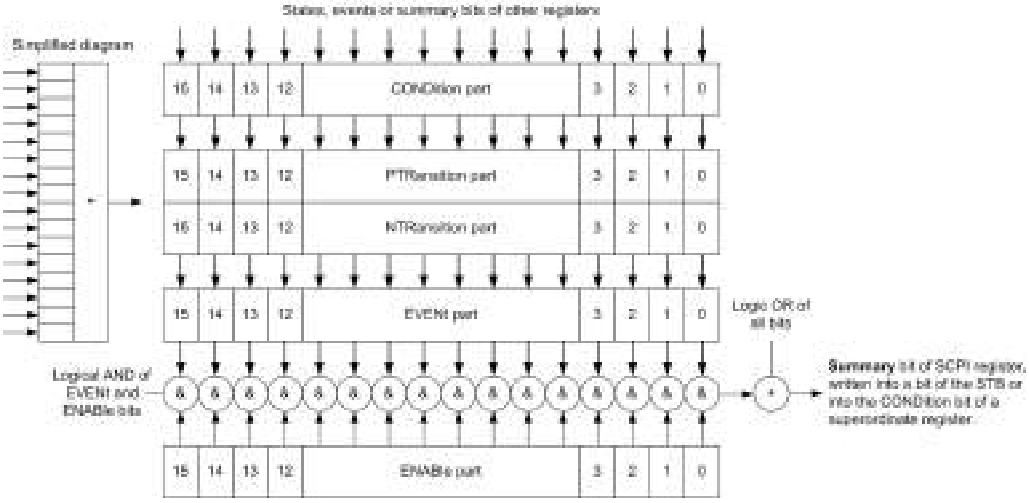


Figure C-1: The status-register model

Description of the five status register parts

The five parts of a SCPI register have different properties and functions:

- **CONDition**
  The `CONDition` part is written into directly by the hardware or the sum bit of the next lower register. Its contents reflect the current instrument status. This register part can only be read, but not written into or cleared. Its contents are not affected by reading.
- **PTRansition / NTRansition**
  The two transition register parts define which state transition of the `CONDition` part (none, 0 to 1, 1 to 0 or both) is stored in the `EVENt` part.
  The **Positive-TRansition** part acts as a transition filter. When a bit of the `CONDition` part is changed from 0 to 1, the associated `PTR` bit decides whether the `EVENt` bit is set to 1.

- PTR bit =1: the `EVENt` bit is set.
- PTR bit =0: the `EVENt` bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.
The **Negative-TRansition** part also acts as a transition filter. When a bit of the `CONDition` part is changed from 1 to 0, the associated `NTR` bit decides whether the `EVENt` bit is set to 1.

- NTR bit =1: the `EVENt` bit is set.
- NTR bit =0: the `EVENt` bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.

- **EVENt**
  The `EVENt` part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the transition filters. It is permanently updated by the instrument. This part can only be read by the user. Reading the register clears it. This part is often equated with the entire register.
- **ENABle**
  The `ENABle` part determines whether the associated `EVENt` bit contributes to the sum bit (see below). Each bit of the `EVENt` part is "ANDed" with the associated `ENABle` bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an "OR" function (symbol '+').
  `ENABle` bit = 0: the associated `EVENt` bit does not contribute to the sum bit
  `ENABle` bit = 1: if the associated `EVENt` bit is "1", the sum bit is set to "1" as well.
  This part can be written into and read by the user as required. Its contents are not affected by reading.

Sum bit

The sum bit is obtained from the `EVENt` and `ENABle` part for each register. The result is then entered into a bit of the `CONDition` part of the higher-order register.

The instrument automatically generates the sum bit for each register. Thus an event can lead to a service request throughout all levels of the hierarchy.

C.2 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

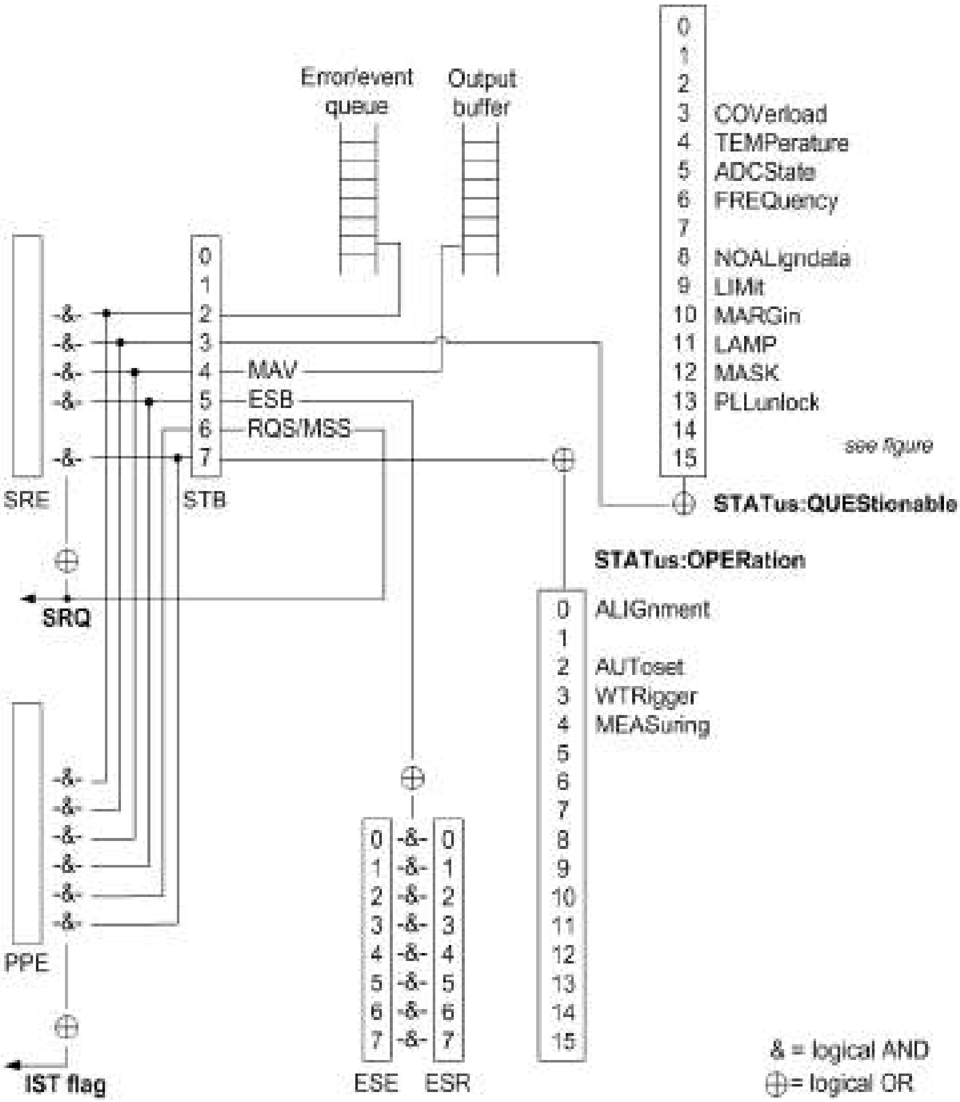


Figure C-2: Overview of the status registers hierarchy

- **STB, SRE**
  The STatus Byte (`STB`) register and its associated mask register Service Request Enable (`SRE`) form the highest level of the status reporting system. The `STB` provides a rough overview of the instrument status, collecting the information of the lower-level registers.
- **ESR, SCPI registers**
  The STB receives its information from the following registers:
  - The Event Status Register (`ESR`) with the associated mask register standard Event Status Enable (`ESE`).
  - The `STATus:OPERation` and `STATus:QUEStionable` registers which are defined by SCPI and contain detailed information on the instrument.
- **IST, PPE**

The `IST` flag ("Individual STatus"), like the `SRQ`, combines the entire instrument status in a single bit. The `PPE` fulfills the same function for the `IST` flag as the `SRE` for the service request.

- **Output buffer**
  The output buffer contains the messages the instrument returns to the controller. It is not part of the status reporting system but determines the value of the `MAV` bit in the `STB` and thus is represented in the overview.

All status registers have the same internal structure.

SRE, ESE

The service request enable register `SRE` can be used as `ENABle` part of the `STB` if the `STB` is structured according to SCPI. By analogy, the `ESE` can be used as the `ENABle` part of the `ESR`.

C.3 Contents of the Status Registers

In the following sections, the contents of the status registers are described in more detail.

C.3.1 Status Byte (STB) and Service Request Enable Register (SRE)

The `STatus Byte` (STB) is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STB can thus be compared with the `CONDition` part of an SCPI register and assumes the highest level within the SCPI hierarchy.

The STB is read using the command `*STB?` or a serial poll.

The `STatus Byte` (STB) is linked to the `Service Request Enable` (SRE) register. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated. The SRE can be set using the command `*SRE` and read using the command `*SRE?`.

Table C-1: Meaning of the bits used in the status byte

Bit No.	Meaning
0...1	Not used
2	Error Queue not empty The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a service request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with remote control.

Bit No.	Meaning
3	QUEStionable status register summary bit The bit is set if an `EVENt` bit is set in the `QUEStionable` status register and the associated `ENABle` bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by querying the `STATus:QUEStionable` status register.
4	MAV bit (message available) The bit is set if a message is available in the output queue which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller.
5	ESB bit Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in greater detail by polling the event status register.
6	MSS bit (master status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	`STATus:OPERation` status register summary bit The bit is set if an `EVENt` bit is set in the `OPERation` status register and the associated `ENABle` bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by querying the `STATus:OPERation` status register.

C.3.2 IST Flag and Parallel Poll Enable Register (PPE)

As with the SRQ, the IST flag combines the entire status information in a single bit. It can be read by means of a parallel poll (see Chapter C.4.3, "Parallel Poll", on page 2244) or using the command `*IST?`.

The parallel poll enable register (PPE) determines which bits of the STB contribute to the IST flag. The bits of the STB are "ANDed" with the corresponding bits of the PPE, with bit 6 being used as well in contrast to the SRE. The IST flag results from the "ORing" of all results. The PPE can be set using commands `*PRE` and read using command *PRE?.

C.3.3 Event Status Register (ESR) and Event Status Enable Register (ESE)

The ESR is defined in IEEE 488.2. It can be compared with the `EVENt` part of a SCPI register. The event status register can be read out using command *ESR?.

The ESE corresponds to the `ENABle` part of a SCPI register. If a bit is set in the ESE and the associated bit in the ESR changes from 0 to 1, the ESB bit in the STB is set. The ESE register can be set using the command `*ESE` and read using the command `*ESE?`.

Table C-2: Meaning of the bits used in the event status register

Bit No.	Meaning
0	Operation Complete This bit is set on receipt of the command *OPC exactly when all previous commands have been executed.
1	Not used
2	Query Error This bit is set if either the controller wants to read data from the instrument without having sent a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	Device-dependent Error This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue.
4	Execution Error This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue.
5	Command Error This bit is set if a command is received, which is undefined or syntactically incorrect. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue.
6	User Request This bit is set when the instrument is switched over to manual control.
7	Power On (supply voltage on) This bit is set on switching on the instrument.

C.3.4 STATus:OPERation Register

In the `CONDition` part, this register contains information on which actions the instrument is executing. In the `EVENt` part, it contains information on which actions the instrument has executed since the last reading.

It can be read using the commands `STATus:OPERation:CONDition?` or `STATus:OPERation[:EVENt]?`, see also Chapter 20.24.1, "STATus:OPERation Register", on page 2197.

Table C-3: Bits in the STATus:OPERation register

Bit No.	Meaning
0	`ALIGnment` This bit is set as long as the instrument is performing a self-alignment.
1	Not used
2	`AUToset` This bit is set while the instrument is performing an auto setup.

Bit No.	Meaning
3	`WTRIgger` This bit is set while the instrument is waiting for the trigger.
4	`MEASuring` The bit is set as long as an acquisition - sampling and postprocessing - is running. In run continuous mode, the bit is always set.
5 - 15	Not used

C.3.5 STATus:QUEStionable Register

This register contains information about indefinite states which may occur if the unit is operated without meeting the specifications. It can be read using the commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`

The remote commands for the STATus:QUEStionable register are described in Chapter 20.24.2, "STATus:QUEStionable Registers", on page 2198.

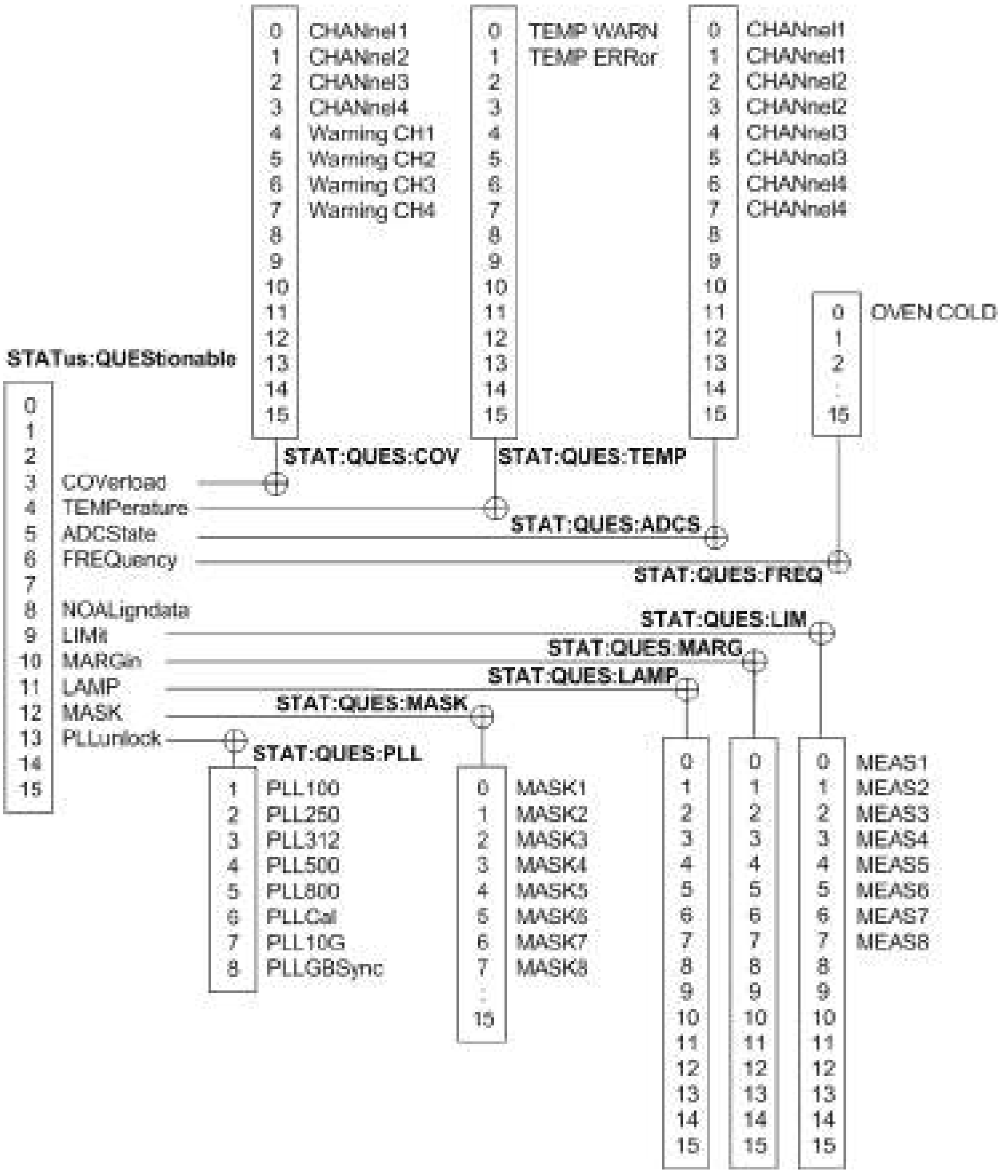


Figure C-3: Overview of the STATus:QUEStionable register

Table C-4: Bits in the STATus:QUEStionable register

Bit No.	Meaning
0 to 2	not used
3	`COVerload` This bit is set if a questionable channel overload occurs (see Chapter C.3.5.1, "STATus:QUEStionable:COVerload register", on page 2240).
4	`TEMPerature` This bit is set if a questionable temperature occurs (see Chapter C.3.5.2, "STATus:QUEStionable:TEMPerature register", on page 2241).

Bit No.	Meaning
5	`ADCState` The bit is set if the signal is clipped on the upper or lower edge of the screen - an overflow of the ADC occurs (see Chapter C.3.5.3, "STATus:QUEStionable:ADCState Register", on page 2241).
6	`FREQuency` This bit is set if there is anything wrong with the frequency of the local oscillator or the reference frequency (see Chapter C.3.5.4, "STATus:QUEStionable:FREQuency Register", on page 2242).
7	Not used
8	`NOALigndata` This bit is set if no alignment data is available - the instrument is uncalibrated.
9	`LIMit` This bit is set if a limit value is violated (see Chapter C.3.5.5, "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers", on page 2242).
10	`MARGin` This bit is set if a margin value is violated, and the limit value is not violated (see Chapter C.3.5.5, "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers", on page 2242).
11	`LAMP` (Low AMPlitude) This bit is set if the magnitude of the signal is too low to get reliable measurement results. See Chapter C.3.5.6, "STATus:QUEStionable:LAMP Register", on page 2242.
12	`MASK` This bit is set if a mask value is violated (see Chapter C.3.5.7, "STATus:QUEStionable:MASK register", on page 2243
13	`PLLunlock` Only relevant if option R&S RTO-K13 is installed. See Chapter C.3.5.8, "STATus:QUEStionable:PLLunlock Register", on page 2243.
14	Not used
15	This bit is always 0.

C.3.5.1 STATus:QUEStionable:COVerload register

This register contains all information about overload of the channels. The bit is set if the assigned channel is overloaded, or if an overload risk occured (overload warning).

Table C-5: Bits in the STATus:QUEStionable:COVerload register

Bit No.	Meaning
0	Overload on `CHANnel1`
1	Overload on `CHANnel2`
2	Overload on `CHANnel3`
3	Overload on `CHANnel4`
4	Overload warning for `CHANnel1`

Bit No.	Meaning
5	Overload warning for `CHANnel2`
6	Overload warning for `CHANnel3`
7	Overload warning for `CHANnel4`

C.3.5.2 STATus:QUEStionable:TEMPerature register

This register contains information about the instrument's temperature.

Table C-6: Bits in the STATus:QUEStionable:TEMPerature register

Bit No.	Meaning
0	`TEMP WARN` This bit is set if a temperature warning on channel 1, 2, 3 or 4 occured.
1	`TEMP ERRor` This bit is set if a temperature error on channel 1, 2, 3 or 4 occured.

C.3.5.3 STATus:QUEStionable:ADCState Register

This register contains all information about overflow of the ADC.

The bit is set if the assigned channel signal is clipped on the upper or lower edge of the screen. In this case, the signal does not fit in the range of the ADC and an overflow occurs.

Table C-7: Bits in the STATus:QUEStionable:ADCState register

Bit No.	Meaning
0	`CHANnel1`, clipping on the upper limit
1	`CHANnel1`, clipping on the lower limit
2	`CHANnel2`, clipping on the upper limit
3	`CHANnel2`, clipping on the lower limit
4	`CHANnel3`, clipping on the upper limit
5	`CHANnel3`, clipping on the lower limit
6	`CHANnel4`, clipping on the upper limit
7	`CHANnel4`, clipping on the lower limit

C.3.5.4 STATus:QUEStionable:FREQuency Register

Table C-8: Bits in the STATus:QUEStionable:FREQuency register

Bit No.	Meaning
0	Oven cold. This bit is set if the reference oscillator has not yet attained its operating temperature.

C.3.5.5 STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers

These registers contain information about the observance of the limits or margins of measurements.

The LIMit bit is set if the limit of the assigned measurement is violated. The MARGin bit is set if the margin of the assigned measurement is violated but not the limit (the limit bit is not set).

The status bits are set if the limits or margins of the main or additional measurement are violated.

If multiple measurements are active, all measurement results affect the status bits. Statistical results do not change the status bits.

Table C-9: Bits in the STATus:QUEStionable:LIMit and STATus:QUEStionable.MARGin registers

Bit No.	Meaning
0	`MEAS1`
1	`MEAS2`
2	`MEAS3`
3	`MEAS4`
4	`MEAS5`
5	`MEAS6`
6	`MEAS7`
7	`MEAS8`

C.3.5.6 STATus:QUEStionable:LAMP Register

The LAMP (Low AMPlitude) bit is set if the magnitude of the signal is too low to get reliable measurement results.

Table C-10: Bits in the STATus:QUEStionable:LAMP register

Bit No.	Meaning
0	`MEAS1`
1	`MEAS2`
2	`MEAS3`
3	`MEAS4`

Bit No.	Meaning
4	`MEAS5`
5	`MEAS6`
6	`MEAS7`
7	`MEAS8`

C.3.5.7 STATus:QUEStionable:MASK register

This register contains information about the violation of masks. This bit is set if the assigned mask is violated.

Table C-11: Bits in the STATus:QUEStionable:MASK register

Bit No.	Meaning
0	`MASK1`
1	`MASK2`
2	`MASK3`
3	`MASK4`
4	`MASK5`
5	`MASK6`
6	`MASK7`
7	`MASK8`

C.3.5.8 STATus:QUEStionable:PLLunlock Register

This register contains information on the phase-locked loop process status.

Table C-12: Bits in the STATus:QUEStionable:PLLunlock register

Bit No.	Meaning
1	`PLL100`
2	`PLL250`
3	`PLL312`
4	`PLL500`
5	`PLL800`
6	`PLLCal`
7	`PLL10G`
8	`PLLGBSync`

C.4 Application of the Status Reporting System

The purpose of the status reporting system is to monitor the status of one or several devices in a measuring system. To do this and react appropriately, the controller must receive and evaluate the information of all devices. The following standard methods are used:

- **Service request** (SRQ) initiated by the instrument
- **Serial poll** of all devices in the bus system, initiated by the controller in order to find out who sent a SRQ and why
- **Parallel poll** of all devices
- Query of a **specific instrument status** by means of commands
- Query of the **error queue**

C.4.1 Service Request

Under certain circumstances, the instrument can send a service request (SRQ) to the controller. Usually this service request initiates an interrupt at the controller, to which the control program can react appropriately. As evident from Figure C-2, an SRQ is always initiated if one or several of bits 2, 3, 4, 5 or 7 of the status byte are set and enabled in the SRE. Each of these bits combines the information of a further register, the error queue or the output buffer. The `ENABle` parts of the status registers can be set such that arbitrary bits in an arbitrary status register initiate an SRQ. In order to make use of the possibilities of the service request effectively, all bits should be set to "1" in enable registers SRE and ESE.

The SRQ is the only possibility for the instrument to become active on its own. Each controller program should cause the instrument to initiate a service request if errors occur. The program should react appropriately to the service request.

C.4.2 Serial Poll

In a serial poll, just as with command `*STB`, the status byte of an instrument is queried. However, the query is realized via interface messages and is thus clearly faster.

The serial poll method is defined in IEEE 488.1 and used to be the only standard possibility for different instruments to poll the status byte. The method also works for instruments which do not adhere to SCPI or IEEE 488.2.

The serial poll is mainly used to obtain a fast overview of the state of several instruments connected to the controller.

C.4.3 Parallel Poll

In a parallel poll, up to eight instruments are simultaneously requested by the controller using a single command to transmit 1 bit of information each on the data lines, i.e., to set the data line allocated to each instrument to a logical "0" or "1".

In addition to the SRE register, which determines the conditions under which an SRQ is generated, there is a Parallel Poll Enable register (PPE) which is ANDed with the STB bit by bit, considering bit 6 as well. This register is ANDed with the STB bit by bit, considering bit 6 as well. The results are ORed, the result is possibly inverted and then sent as a response to the parallel poll of the controller. The result can also be queried without parallel poll using the command `*IST?`.

The instrument first has to be set for the parallel poll using the command `PPC`. This command allocates a data line to the instrument and determines whether the response is to be inverted. The parallel poll itself is executed using `PPE`.

The parallel poll method is mainly used to find out quickly which one of the instruments connected to the controller has sent a service request. To this effect, SRE and PPE must be set to the same value.

C.4.4 Query of an instrument status

Each part of any status register can be read using queries. There are two types of commands:

- The common commands `*ESR?`, `*IDN?`, `*IST?`, `*STB?` query the higher-level registers.
- The commands of the `STATus` system query the SCPI registers (`STATus:QUEStionable`...)

The returned value is always a decimal number that represents the bit pattern of the queried register. This number is evaluated by the controller program.

Queries are usually used after an SRQ in order to obtain more detailed information on the cause of the SRQ.

C.4.4.1 Decimal representation of a bit pattern

The STB and ESR registers contain 8 bits, the SCPI registers 16 bits. The contents of a status register are specified and transferred as a single decimal number. To make this possible, each bit is assigned a weighted value. The decimal number is calculated as the sum of the weighted values of all bits in the register that are set to 1.

Bits	0	1	2	3	4	5	6	7	...
Weight	1	2	4	8	16	32	64	128	...

Example:

The decimal value 40 = 32 + 8 indicates that bits no. 3 and 5 in the status register (e.g. the `QUEStionable` status summary bit and the `ESB` bit in the `STatus` Byte) are set.

C.4.5 Error Queue

Each error state in the instrument leads to an entry in the error queue. The entries of the error queue are detailed plain text error messages that can be looked up in the Error Log or queried via remote control using `SYSTem:ERRor[:NEXT]?`. Each call of `SYSTem:ERRor[:NEXT]?` provides one entry from the error queue. If no error messages are stored there any more, the instrument responds with 0, "No error".

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C.5 Reset Values of the Status Reporting System

The following table contains the different commands and events causing the status reporting system to be reset. None of the commands, except `*RST` and `SYSTem:PRESet`, influence the functional instrument settings. In particular, `DCL` does not change the instrument settings.

Table C-13: Resest of the status reporting system

Event	**Switching on supply voltage** **Power-On-Status-Clear**		**DCL, SDC** **(Device Clear, Selected Device Clear)**	***RST or SYSTem:PRESet**	**STATus:PRESet**	***CLS**
Effect	**0**	**1**				
Clear STB, ESR	-	yes	-	-	-	yes
Clear SRE, ESE	-	yes	-	-	-	-
Clear PPE	-	yes	-	-	-	-
Clear EVENt parts of the registers	-	yes	-	-	-	yes
Clear ENABle parts of all OPERation and QUEStionable registers; Fill ENABle parts of all other registers with "1".	-	yes	-	-	yes	-
Fill PTRansition parts with "1"; Clear NTRansition parts	-	yes	-	-	yes	-
Clear error queue	yes	yes	-	-	-	yes
Clear output buffer	yes	yes	yes	1)	1)	1)

Event	**Switching on supply voltage** **Power-On-Status-Clear**		**DCL, SDC** **(Device Clear, Selected Device Clear)**	***RST or SYSTem:PRESet**	**STATus:PRESet**	***CLS**
Effect	**0**	**1**				
Clear command processing and input buffer	yes	yes	yes	-	-	-
1) The first command in a command line that immediately follows a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.						

List of Commands

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