Serial Triggering and Analysis Application Modules

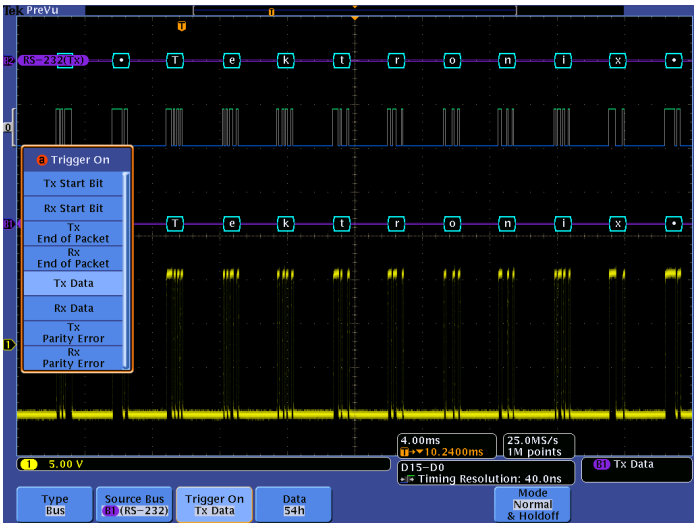
AERO • AUDIO • AUTO • AUTOMAX • COMP • EMBD • FLEX Data Sheet

Features & Benefits

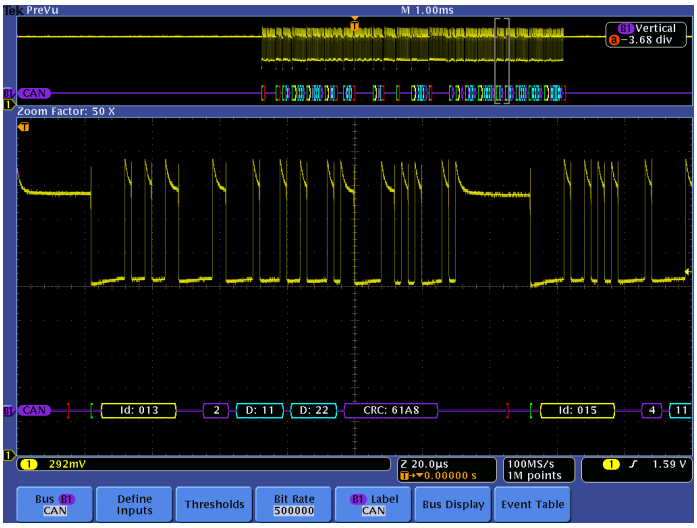
- Automated Serial Triggering, Decode, and Search options for I²C, SPI, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I²S/LJ/RJ/TDM.*1
- Trigger on all the critical elements of a serial bus such as address, data, etc.
- Decode all the critical elements of each message. No more counting 1s and 0s!
- Search through long acquisitions using user-defined criteria to find specific messages.
- Event table shows decoded serial bus activity in a tabular, time-stamped format for quick summary of system activity.
- Export Event table data to .csv format.

*1 Ethernet and USB information available in separate data sheet.

Tektronix®



Triggering on a specific transmit data packet going across an RS-232 bus. A complete set of triggers, including triggers for specific serial packet content, ensures you quickly capture your event of interest.



Color-coded display of a CAN bus, showing Start, DLC, Data, CRC, and Stop components of the serial signal.

Serial Triggering and Analysis Application Modules

On a serial bus, a single signal often includes address, control, data, and clock information. This can make isolating events of interest difficult. The Serial Application modules for the MDO4000, MSO/DPO4000, MSO/DPO3000, and MSO/DPO2000 Series transform the oscilloscopes into a robust tool for debugging serial buses with automatic trigger, decode, and search for I²C, SPI, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I²S/LJ/RJ/TDM.

Serial Triggering

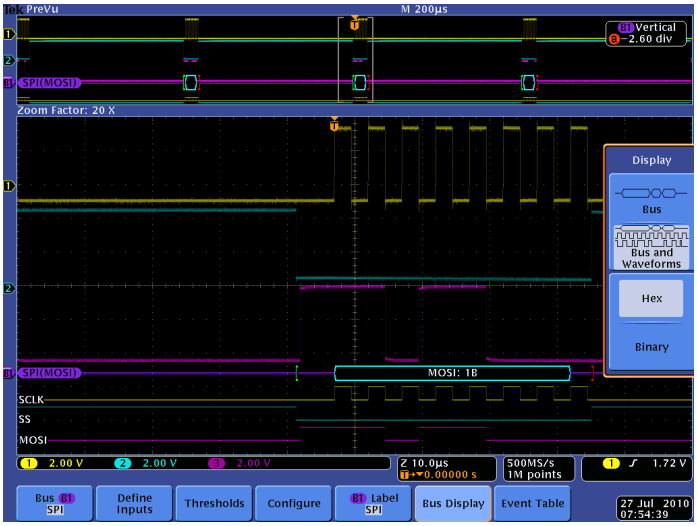
Trigger on packet content such as start of packet, specific addresses, specific data content, unique identifiers, etc. on popular serial interfaces such as I²C, SPI, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I²S/LJ/RJ/TDM.

Bus Display

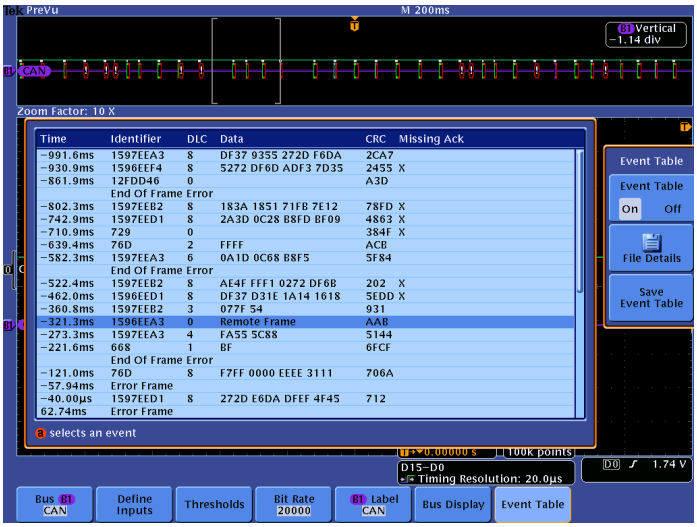
Provides a higher-level, combined view of the individual signals (clock, data, chip enable, etc.) that make up your bus, making it easy to identify where packets begin and end and identifying subpacket components such as address, data, identifier, CRC, etc.

Bus Decoding

Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex value? Let the oscilloscope with a Serial Application module do it for you! Once you've set up a bus, the MDO4000, MSO/DPO4000, MSO/DPO3000, or MSO/DPO2000 Series will decode each packet on the bus, and display the value in hex, binary, decimal (LIN, MIL-STD-1553, and FlexRay only), signed decimal (I²S/LJ/RJ/TDM only), or ASCII (RS-232/422/485/UART only) in the bus waveform.



Simultaneously display the bus and digital waveforms. Digital waveforms show how the bus translates the individual signals based on the threshold settings (useful for making analog channels look like just 1s and 0s).



Event table showing decoded Identifier, DLC, DATA, and CRC for every CAN packet in a long acquisition.

Search – I²C decode showing results from a Wave Inspector® search for Address value 50. Wave Inspector® controls provide unprecedented efficiency in viewing and navigating waveform data.

Event Table

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, etc.).

Search

Serial triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do? In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. With a Serial Application module, you can enable the MDO4000, MSO/DPO4000, MSO/DPO3000, and MSO/DPO2000 Series oscilloscopes to automatically search through the acquired data for user-defined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the oscilloscope front panel.

Characteristics

I²C Characteristics

Bus Setup Options

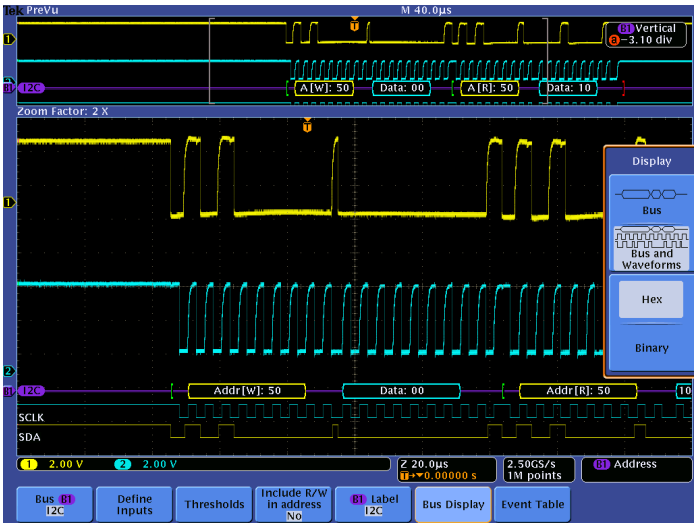
Characteristic	Description
Sources (Clock and Data)	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single Ended
Include R/W in Address	Yes or No
Formats Available	Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

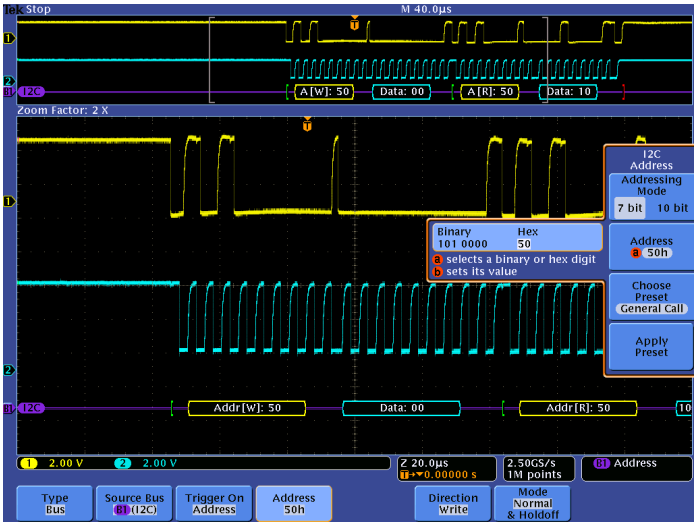
Characteristic	Description
Trigger and/or Search On	Start Stop Repeated Start Missing Ack Address (7 or 10 bit) Data (number of bytes 1-5) Address and Data

Bus Decode

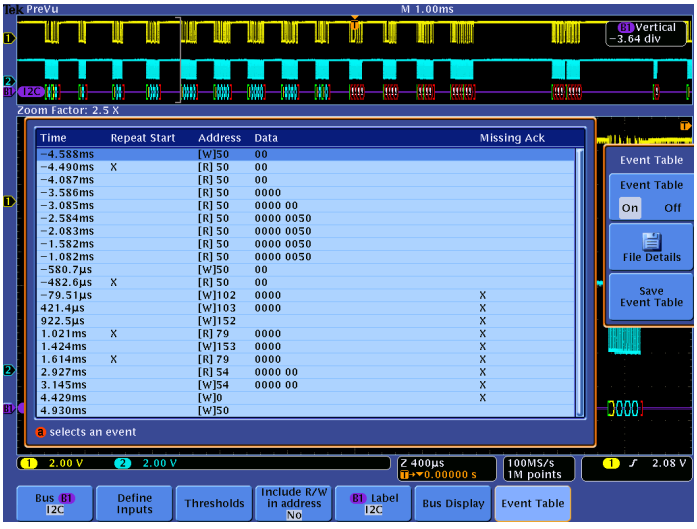
Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	Start (green bracket) Address (yellow box) Missing Ack (red ! symbol) Data (cyan box) Stop (red bracket)



I²C bus setup, showing selection of bus display modes.



Triggering on a specific address value on the I²C bus.



Event table for I²C bus with all captured packets time stamped and in a tabular view.

SPI Characteristics

Bus Setup Options

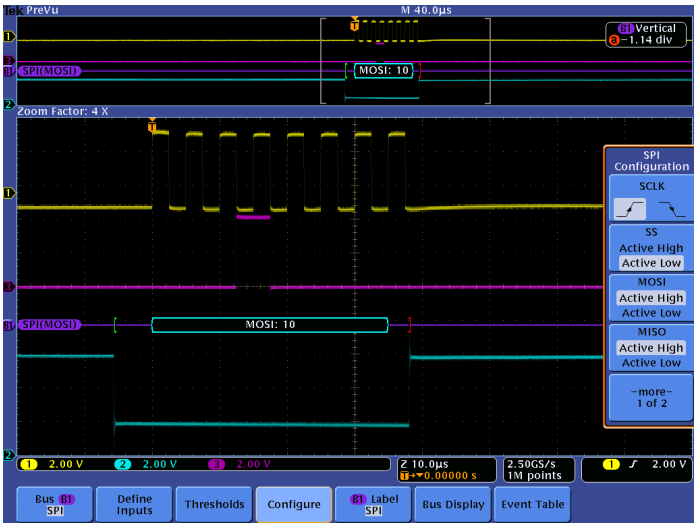
Characteristic	Description
Sources (Clock, Data, Slave Select, and MISO)	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single Ended
Decode Configuration	
Framing	Idle Time (2-wire SPI) Slave Select (3-wire or 4-wire SPI)
Clock	Rising or Falling Edge
Slave Select	Active High or Active Low
MOSI	Active High or Active Low
MISO	Active High or Active Low
Word Size	4-32 bits
Bit Order	Most Significant (MS) First Least Significant (LS) First
Formats Available	Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

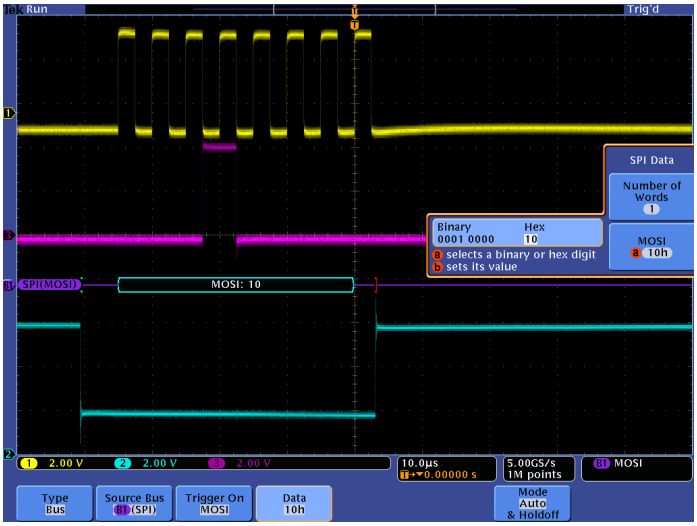
Characteristic	Description
Trigger and/or Search On	SS Start of Frame MOSI MISO MOSI and MISO Data (number of words 1-16)

Bus Decode

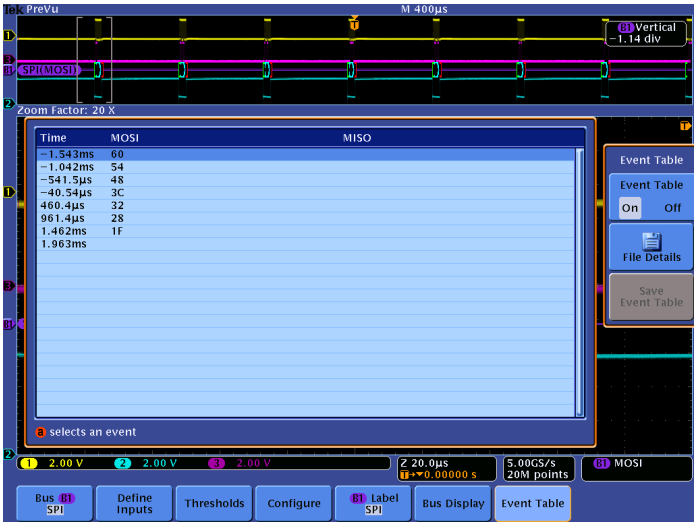
Characteristic	Description
Maximum Clock/Data Rate	Up to 50 Mb/s (for automated decoding of bus)
Decode Display	Start (green bracket) Data (cyan box) Stop (red bracket)



SPI bus setup, showing configuration options for bus sources.



Triggering on a specific MOSI data value on the SPI bus.



Event table for SPI bus with all captured packets time stamped and in a tabular view.

RS-232/UART/RS-422/RS-485 Characteristics

Bus Setup Options

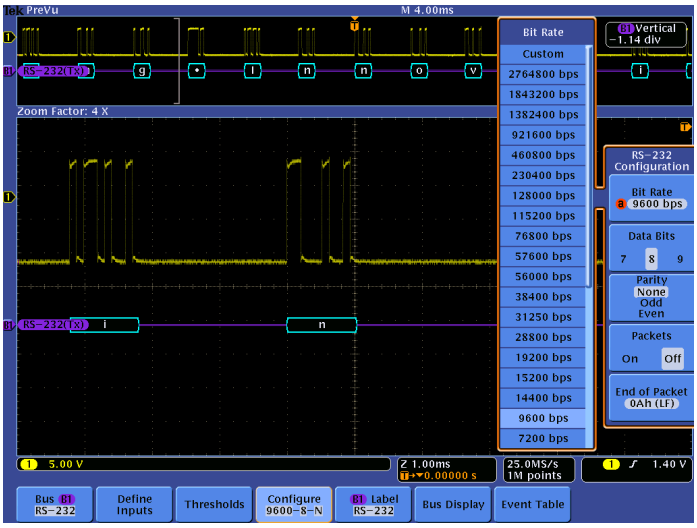
Characteristic	Description
RS-232/UART Sources (Transmit and Receive)	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
RS-422/RS-485 Sources (Transmit and Receive)	Analog channels 1-4
Thresholds	Per-channel thresholds
Recommended Probing	
RS-232/UART	Single Ended
RS-422/RS-485	Differential
Polarity	Normal (RS-232) Inverted (UART, RS-422/RS-485)
Decode Configuration	
Bit rate	
Pre-defined list of rates	50 b/s - 2.8 Mb/s
Custom	50 b/s - 10 Mb/s
Data bits	7, 8, or 9
Parity	None, Odd, or Even
Packets	On or Off
End of packet	00h (NUL) 0Ah (LF) 0Dh (CR) 20h (SP) FFh
Formats Available	Hex Binary ASCII
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

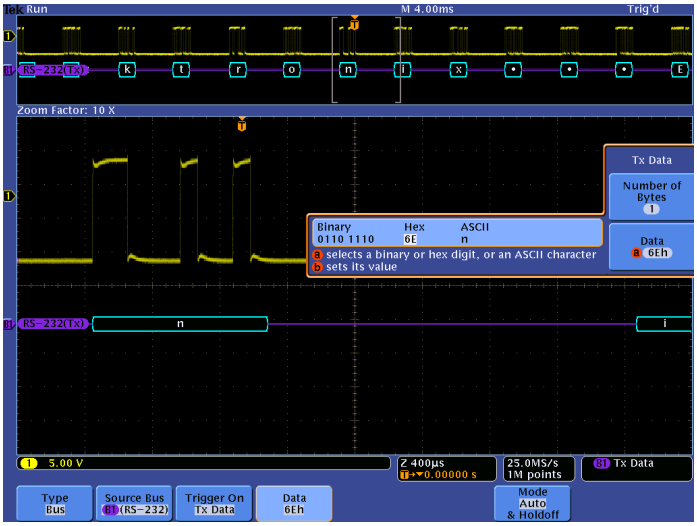
Characteristic	Description
Trigger and/or Search On	Tx Start Bit Rx Start Bit Tx End of Packet Rx End of Packet Tx Data (number of bytes 1-10) Rx Data (number of bytes 1-10) Tx Parity Error Rx Parity Error

Bus Decode

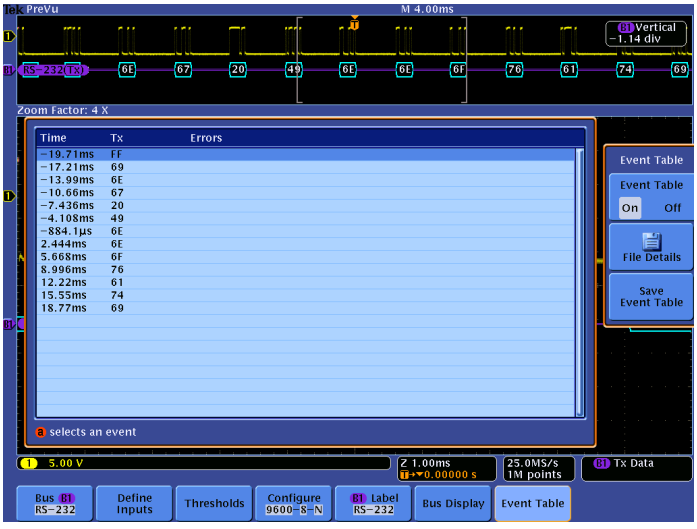
Characteristic	Description
Maximum Bit Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	Data (cyan box) Errors (red box) - Parity - Framing



RS-232 bus setup, showing bit rate options for RS-232 bus.



Triggering on a specific Tx data value on the RS-232 bus.



Event table for RS-232 bus with all captured packets time stamped and in a tabular view.

CAN Characteristics

Bus Setup Options

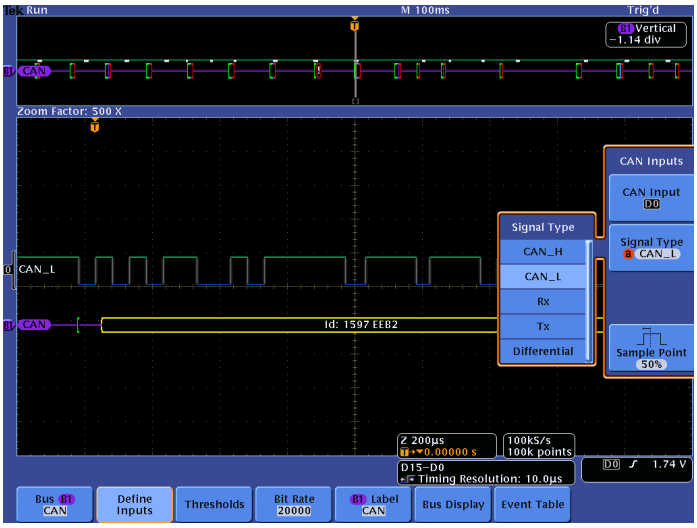
Characteristic	Description
Source for CAN_H, CAN_L, Rx, or Tx Probing	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Source for Differential Probing	Analog channels 1-4
Thresholds	Per-channel thresholds
Recommended Probing	
CAN_H, CAN_L, Rx, Tx	Single Ended
Differential	Differential
Bit Rate	
Pre-defined list of rates	10 Kb/s - 1 Mb/s
Custom	10 Kb/s - 1 Mb/s
Sample Point	Position at 5% to 95% within bit period or unit interval
Formats Available	Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

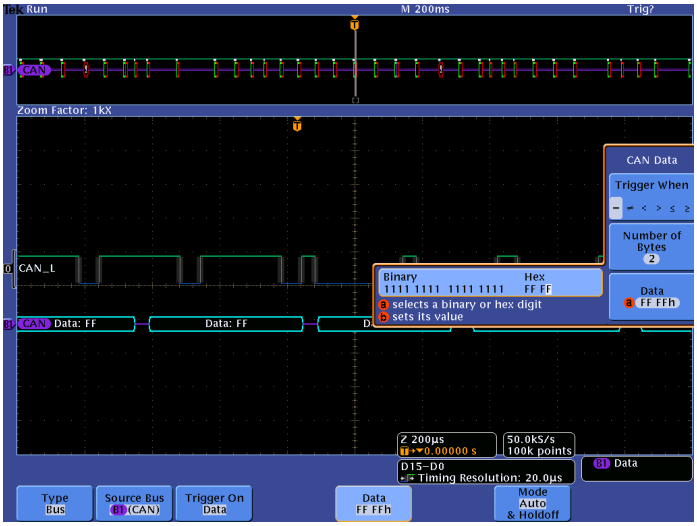
Characteristic	Description
Trigger and/or Search On	Start of Frame Type of Frame (Data, Remote, Error, Overload) Identifier (Standard or Extended) Data (number of bytes 1-8, trigger or search when =, ≠, <, >, ≤, ≥) ID and Data End of Frame Missing Ack Bit Stuffing Error

Bus Decode

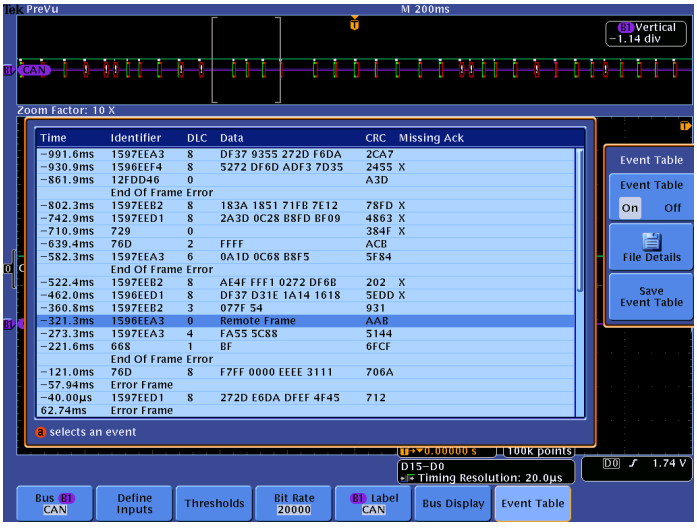
Characteristic	Description
Maximum Bit Rate	Up to 1 Mb/s (for automated decoding of bus)
Decode Display	Start (green bracket) Identifier (yellow box) DLC, CRC (purple box) Missing Ack (red ! symbol) Data (cyan box) Stop (red bracket) Errors (red box) - End of Frame - Bit Stuffing



CAN bus setup, showing signal type options for CAN bus.



Triggering on a specific data value on the CAN bus.



Event table for CAN bus with all captured packets time stamped and in a tabular view.

LIN Characteristics

Bus Setup Options

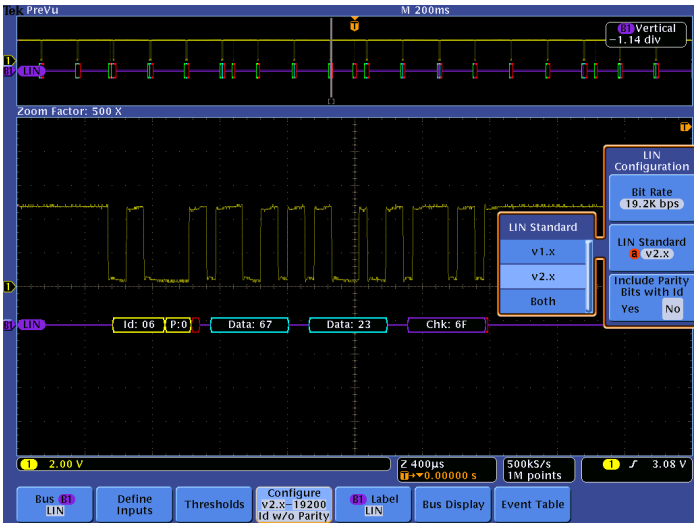
Characteristic	Description
Source	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single Ended
Sample Point	Position at 5% to 95% within bit period or unit interval
Decode Configuration	
Polarity	Normal or Inverted
Bit rate	
Pre-defined list of rates	1.2 Kb/s - 19.2 Kb/s
Custom	800 b/s - 100 Kb/s
LIN standard	v1.x, v2.x, or Both
Include parity bits with ID	Yes or No
Formats Available	Decimal: ID and Parity; Hex: Data and Checksum Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

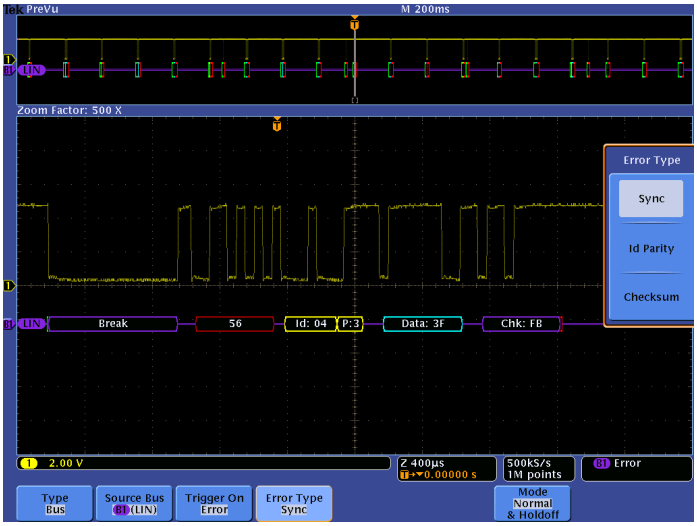
Characteristic	Description
Trigger and/or Search On	Sync Identifier Data (number of bytes 1-8; trigger or search when =, ≠, <, >, ≤, ≥, inside range, outside range) ID and Data Wakeup Frame Sleep Frame Error (Sync, ID Parity, Checksum)

Bus Decode

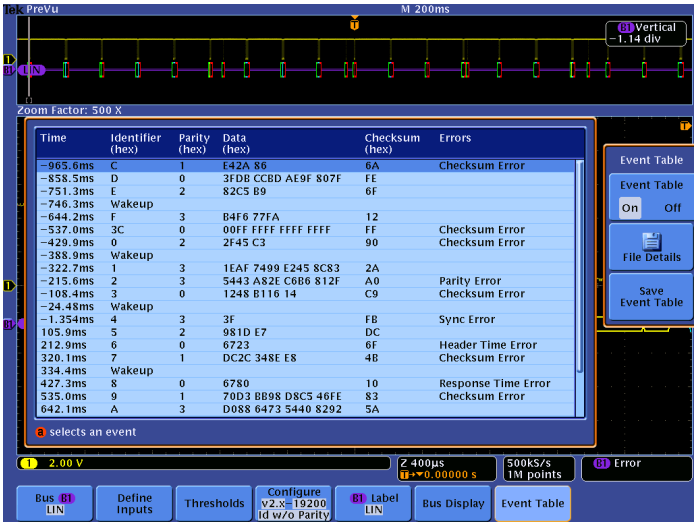
Characteristic	Description
Maximum Bit Rate	Up to 1 Mb/s, by LIN definition up to 20 Kb/s (for automated decoding of bus)
Decode Display	Start (green bracket) Sync, Break (purple box) Identifier, Parity (yellow box) Data (cyan box) Checksum, Wakeup (purple box) End of frame (red bracket) Errors (red box) - Sync - Parity - Checksum - Header Time - Response Time - Frame Time - Response and Frame Time



LIN bus setup, showing source configuration options for LIN bus.



Triggering on a Sync Error on the LIN bus.



Event table for LIN bus with all captured packets time stamped and in a tabular view.

FlexRay Characteristics

Bus Setup Options

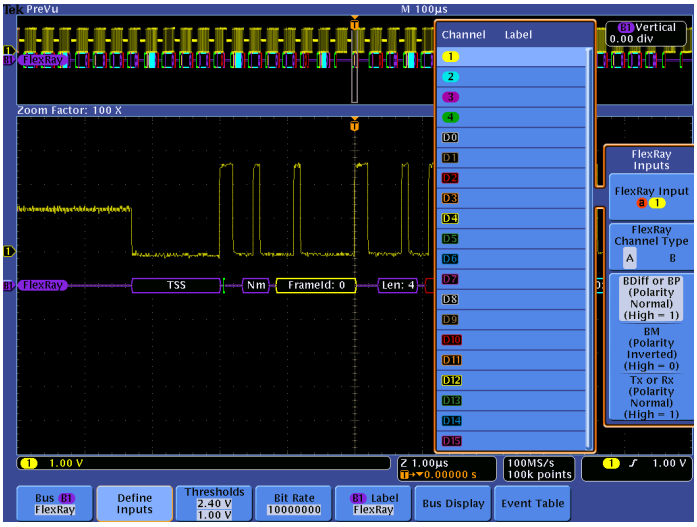
Characteristic	Description
Source for Single-ended Probing	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Source for Differential Probing	Analog channels 1-4
Thresholds	High and Low thresholds per channel
Recommended Probing	Single Ended or Differential
Decode Configuration	
Bit rate	2.5 Mb/s, 5 Mb/s, 10 Mb/s, or Custom (1 Mb/s - 100 Mb/s)
Channel type	A or B
Polarity	BDiff or BP, BM, Tx or Rx
Formats Available	Decimal: ID, Len and Count; Hex: CRCs and Data Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Decode

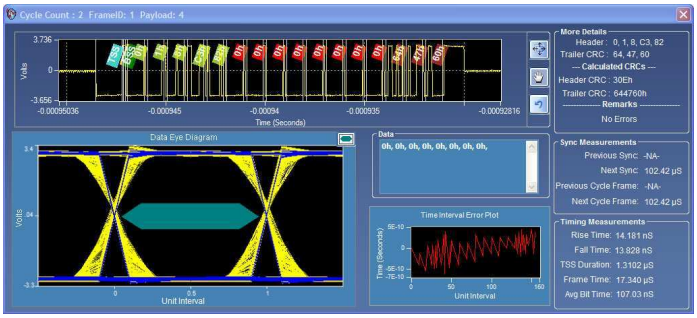
Characteristic	Description
Maximum Bit Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	TTS (purple box) Start (green bracket) Frame ID (yellow box) Payload Length (purple box) Headers (purple box) - Null - Normal - Sync - Payload - Startup - Unknown - Null Sync - Payload Sync - Null Startup - Payload Startup - CRC Cycle Count (yellow box) Data (cyan box) CRC, DTS, CID (purple box) Stop (red bracket) - TSS - Header CRC - Trailer CRC - Null Frame - Sync Frame - Startup Frame - BSS - FSS

Bus Trigger and Search Options

Characteristic	Description
Trigger and/or Search On	Start of Frame Indicator Bits (Normal, Null, Payload, Sync, Startup) Identifier (trigger when =, ≠, <, >, ≤, ≥, inside range, outside range) Cycle Count (trigger when =, ≠, <, >, ≤, ≥, inside range, outside range) Header Fields (Indicator Bits, Identifier, Payload Length, Header CRC, and Cycle Count) Data (number of bits 1-16; byte offset 'don't care' – 253; trigger when =, ≠, <, >, ≤, ≥, inside range, outside range) ID and Data End of Frame (Static, Dynamic (DTS), All) Error (Header CRC, Trailer CRC, Null Frame, Sync Frame, Startup Frame)



FlexRay bus setup, showing input options for FlexRay bus.



PC-based, eye-diagram analysis software built an eye-diagram from the entire acquisition and plotted it against TP1 mask.

I²S/LJ/RJ/TDM Characteristics

Bus Setup Options

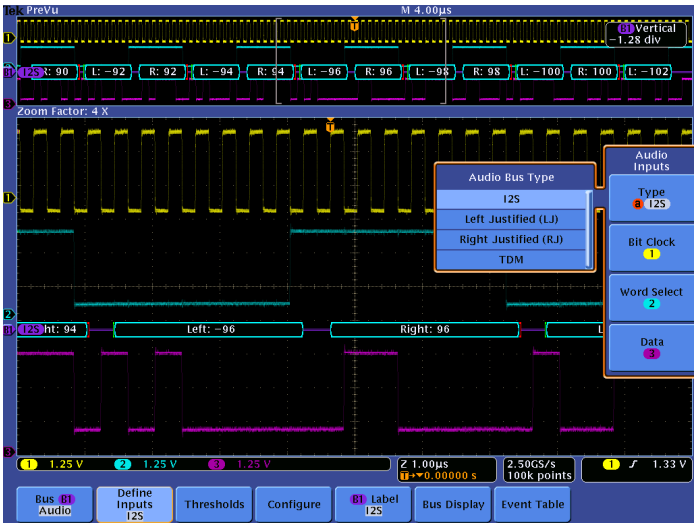
Characteristic	Description
Sources (Clock, Word, Data)	Analog channels 1-4 Digital channels D0-D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single Ended
Decode Configuration	
Word size	4-32 bits
Clock	Rising or falling edge
Word Select polarity	Normal or High
Data High	1 or 0
Bit order	Most Significant (MS) First Least Significant (LS) First
Formats Available	Signed Decimal Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

Characteristic	Description
Trigger and/or Search On	Word Select Frame Sync Data (select either word, left word, or right word; trigger or search when =, ≠, <, >, ≤, ≥, inside range, outside range)

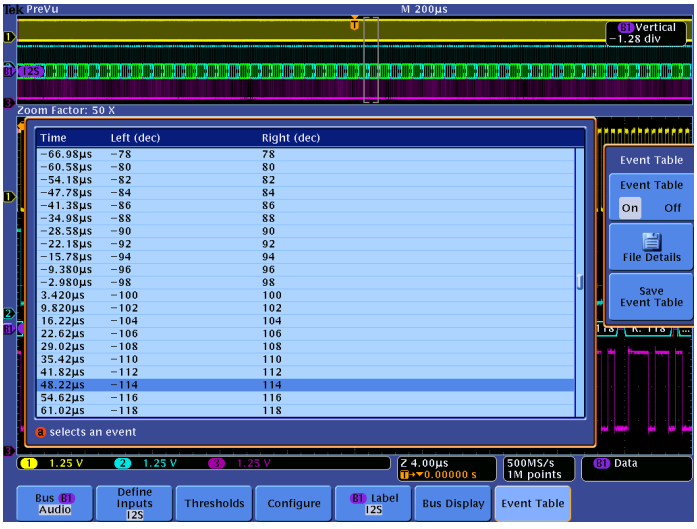
Bus Decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 12.5 Mb/s (for automated decoding of I²S/LJ/RJ bus) Up to 25 Mb/s (for automated decoding of TDM bus)
Decode Display	Start (green bracket) Data (cyan box) Stop (red bracket)



I²S bus setup, showing input configuration options for I²S bus.

Triggering on a specific data value on the I²S bus.



Event table for I²S bus with all captured packets time stamped and in a tabular view.

MIL-STD-1553 Characteristics

Bus Setup Options

Characteristic	Description
Source	Analog channels 1-4 Reference waveforms 1-4 Math waveform
Thresholds	High and Low threshold per source
Recommended Probing	Differential or Single Ended (only one single-ended signal required)
Decode Configuration	
Polarity	Normal or Inverted
Bit rate	1 Mb/s per the standard
Formats Available	Mixed1: Hex (data), Decimal (addresses and count), Binary (bits) Mixed2: ASCII (data), Decimal (addresses and count), Binary (bits) Block Hex Hex and Binary Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

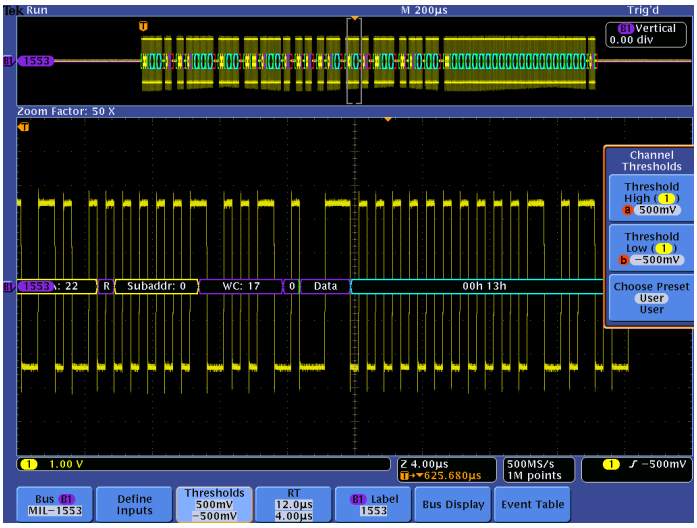
Characteristic	Description
Trigger and/or Search On	Sync Word Type*2 (Command, Status, Data) Command Word*2 (set RT Address (=, ≠, <, >, ≤, ≥, inside range, outside range), T/R, Sub-address/Mode, Data Word Count/Mode Code, and Parity individually) Status Word*2 (set RT Address (=, ≠, <, >, ≤, ≥, inside range, outside range), Message Error, Instrumentation, Service Request Bit, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance (DBCA), Terminal Flag, and Parity individually) Data Word (user-specified 16-bit data value) Error (Sync, Parity, Manchester, Non-contiguous data) Idle Time (minimum time selectable from 4 µs to 100 µs; maximum time selectable from 12 µs to 100 µs; trigger on < minimum, > maximum, inside range, outside range)

Bus Decode

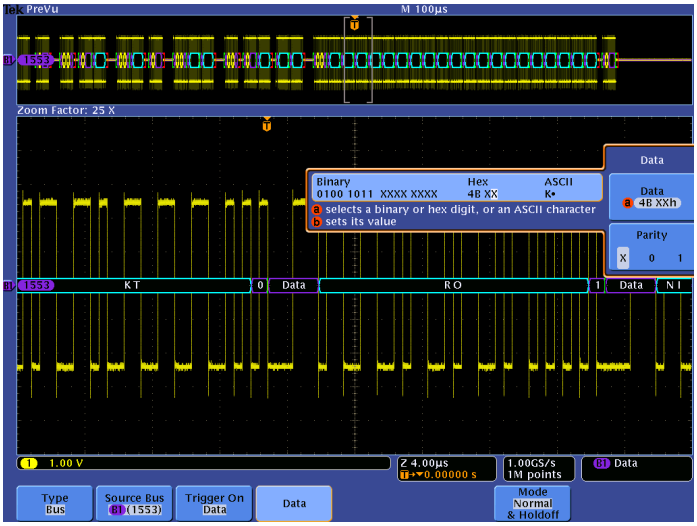
Characteristic	Description
Maximum Clock/Data Rate	Up to 1 Mb/s (for automated decoding of bus)
Decode Display	Start (green bracket) Sync*3 (purple box) with Word Type identified Address (yellow box) R/T (purple box) Word Count (purple box) Status Bits (purple box) Data (cyan box) Parity (purple box) Stop (red bracket) Errors (red box)

*2 Trigger selection of Command Word will trigger on Command and ambiguous Command/Status words. Trigger selection of Status Word will trigger on Status and ambiguous Command/Status words.

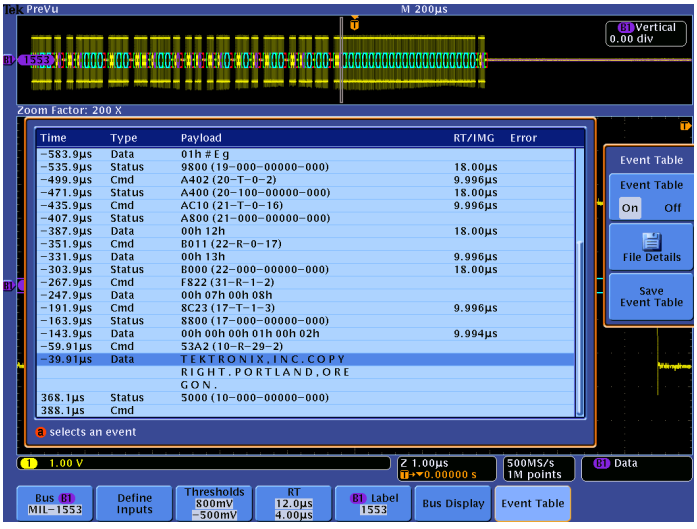
*3 Ambiguous Command and Status words will be labeled with C/S and a generic bit decode will be displayed.



MIL-1553 bus setup, showing threshold setup for MIL-1553 bus.



Triggering on a specific data value on the MIL-1553 bus.



Event table for MIL-1553 bus with all captured packets time stamped and in a tabular view.

Ordering Information

Serial Bus	MDO4000*4 MSO/DPO4000B*4 MSO/DPO4000*5 Series Module	MSO/DPO3000 Series Module	MSO/DPO2000 Series Module	Description
I2C, SPI	DPO4EMBD*6, 7	DPO3EMBD*8	DPO2EMBD*9	Embedded Serial Triggering and Analysis Module. Enables triggering on packet-level information on I2C and SPI buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information
RS-232/422/485/UART	DPO4COMP*10	DPO3COMP	DPO2COMP	Computer Serial Triggering and Analysis Module. Enables triggering on packet-level information on RS-232/422/485/UART buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information
CAN, LIN	DPO4AUTO*11	DPO3AUTO	DPO2AUTO	Automotive Serial Triggering and Analysis Module. Enables triggering on packet-level information on CAN and LIN buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information
CAN, LIN, FlexRay	DPO4AUTOMAX*12	—	—	Extended Automotive Serial Triggering and Analysis Module. Enables triggering on packet-level information on CAN, LIN, and FlexRay buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, packet decode tables with time stamp information and eye-diagram analysis software
FlexRay	—	DPO3FLEX	—	FlexRay Serial Triggering and Analysis Module. Enables triggering on packet-level information on FlexRay buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information
I2S/LJ/RJ/TDM	DPO4AUDIO*13, 14	DPO3AUDIO*15	—	Audio Serial Triggering and Analysis Module. Enable triggering on packet-level information on I2S, LJ, RJ, and TDM audio buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode table with time stamp information
MIL-STD-1553	DPO4AERO	DPO3AERO	—	Aerospace Serial Triggering and Analysis Module. Enables triggering on packet-level information on MIL-STD-1553 serial buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information

*4 Ethernet and USB serial triggering and analysis application modules available.

*5 USB serial triggering and analysis application module available.

*6 For DPO4000 (non-B) Series with serial numbers lower than C020000, contact Tektronix for a serial triggering hardware update to enable 2-wire SPI triggering.

*7 For SPI, only 2-wire support is available on DPO4032, DPO4102B, and DPO4102B-L models.

*8 For SPI, only 2-wire support is available on DPO3012, DPO3032, and DPO3052 models.

*9 For SPI, only 2-wire support is available on DPO2012 model.

*10 For DPO4000 (non-B) Series with serial numbers lower than C020000, contact Tektronix for a serial triggering hardware update to enable RS-232/422/485/UART parity error triggering.

*11 For DPO4000 (non-B) Series with serial numbers lower than C020000, contact Tektronix for a serial triggering hardware update to enable LIN triggers.

*12 For DPO4000 (non-B) Series with serial numbers lower than C020000, contact Tektronix for a serial triggering hardware update to enable FlexRay and LIN triggers.

*13 Not available on DPO4032, DPO4102B, and DPO4102B-L models.

*14 For DPO4000 (non-B) Series with serial numbers lower than C020000, contact Tektronix for a serial triggering hardware update to enable I2S, LJ, RJ, TDM triggers.

*15 Not available on DPO3012, DPO3032, and DPO3052 models.

Recommended Probes

Please refer to www.tek.com/probes for further information on the recommended models of probes and any necessary probe adapters.

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Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

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For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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