Tektronix®

2 Series Mixed Signal Oscilloscopes
MSO22 and MSO24

Specifications and Performance Verification

Warning: The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

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- In North America, call 1-800-833-9200.
- Worldwide, visit to *www.tek.com* find contacts in your area.

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Important safety information

This manual contains information and warnings that must be followed by the user for safe operation and to keep the product in a safe condition.

To safely perform service on this product, see the *Service safety summary* that follows the *General safety summary*.

General safety summary

Use the product only as specified. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

This product shall be used in accordance with local and national codes.

For correct and safe operation of the product, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only.

Only qualified personnel who are aware of the hazards involved should remove the cover for repair, maintenance, or adjustment.

Before use, always check the product with a known source to be sure it is operating correctly.

This product is not intended for detection of hazardous voltages.

Use personal protective equipment to prevent shock and arc blast injury where hazardous live conductors are exposed.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

To avoid fire or personal injury

Use proper power cord

Use only the power cord specified for this product and certified for the country of use. Do not use the provided power cord for other products.

Ground the product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded. Do not disable the power cord grounding connection.

Power disconnect

The power cord disconnects the product from the power source. See instructions for the location. Do not position the equipment so that it is difficult to operate the power cord; it must remain accessible to the user at all times to allow for quick disconnection if needed.

Use proper AC adapter

Use only the AC adapter specified for this product.

Connect and disconnect properly

Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Use only insulated voltage probes, test leads, and adapters supplied with the product, or indicated by Tektronix to be suitable for the product.

Connect the probe output to the measurement instrument before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement instrument.

De-energize the circuit under test before connecting or disconnecting the current probe.

Observe all terminal ratings

To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of a product, probe, or accessory. Use caution when using 1:1 test leads because the probe tip voltage is directly transmitted to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not float the common terminal above the rated voltage for that terminal.

The measurement terminals on this product are not rated for connection to Category III or IV circuits.

Do not connect a current probe to any wire that carries voltages above the current probe voltage rating.

Do not operate without covers

Do not operate this product with covers or panels removed, or with the case open. Hazardous voltage exposure is possible.

Avoid exposed circuitry

Do not touch exposed connections and components when power is present.

Do not operate with suspected failures

If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Disable the product if it is damaged. Do not use the product if it is damaged or operates incorrectly. If in doubt about safety of the product, turn it off and disconnect the power cord. Clearly mark the product to prevent its further operation.

Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged, if there is exposed metal, or if a wear indicator shows.

Examine the exterior of the product before you use it. Look for cracks or missing pieces.

Use only specified replacement parts.

Replace batteries properly

Replace batteries only with the specified type and rating.

Recharge batteries for the recommended charge cycle only.

Wear eye protection

Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do not operate in wet/damp conditions

Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere

Keep product surfaces clean and dry

Remove the input signals before you clean the product.

Provide proper ventilation

Refer to the installation instructions in the manual for details on installing the product so it has proper ventilation.

Slots and openings are provided for ventilation and should never be covered or otherwise obstructed. Do not push objects into any of the openings.

Provide a safe working environment

Always place the product in a location convenient for viewing the display and indicators.

Avoid improper or prolonged use of keyboards, pointers, and button pads. Improper or prolonged keyboard or pointer use may result in serious injury.

Be sure your work area meets applicable ergonomic standards. Consult with an ergonomics professional to avoid stress injuries.

Use only the Tektronix rackmount hardware specified for this product.

Probes and test leads

Before connecting probes or test leads, connect the power cord from the power connector to a properly grounded power outlet.

Keep fingers behind the protective barrier, protective finger guard, or tactile indicator on the probes. Remove all probes, test leads and accessories that are not in use.

Use only correct Measurement Category (CAT), voltage, temperature, altitude, and amperage rated probes, test leads, and adapters for any measurement.

Beware of high voltages

Understand the voltage ratings for the probe you are using and do not exceed those ratings. Two ratings are important to know and understand:

- The maximum measurement voltage from the probe tip to the probe reference lead.
- The maximum floating voltage from the probe reference lead to earth ground.

These two voltage ratings depend on the probe and your application. Refer to the Specifications section of the manual for more information.

WARNING: To prevent electrical shock, do not exceed the maximum measurement or maximum floating voltage for the oscilloscope input BNC connector, probe tip, or probe reference lead.

Connect and disconnect properly.

Connect the probe output to the measurement product before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement product.

De-energize the circuit under test before connecting or disconnecting the current probe.

Connect the probe reference lead to earth ground only.

Do not connect a current probe to any wire that carries voltages or frequencies above the current probe voltage rating.

Inspect the probe and accessories

Before each use, inspect probe and accessories for damage (cuts, tears, or defects in the probe body, accessories, or cable jacket). Do not use if damaged.

Ground-referenced oscilloscope use

Do not float the reference lead of this probe when using with ground-referenced oscilloscopes. The reference lead must be connected to earth potential (0 V).

Floating measurement use

Do not float the reference lead of this probe above the rated float voltage.

Service safety summary

The *Service safety summary* section contains additional information required to safely perform service on the product. Only qualified personnel should perform service procedures. Read this *Service safety summary* and the *General safety summary* before performing any service procedures.

To avoid electric shock

Do not touch exposed connections.

Do not service alone

Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

Disconnect power

To avoid electric shock, switch off the product power and disconnect the power cord from the mains power before removing any covers or panels, or opening the case for servicing.

Use care when servicing with power on

Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

Verify safety after repair

Always recheck ground continuity and mains dielectric strength after performing a repair.

Terms in this manual

These terms may appear in this manual:

WARNING: Warning statements identify conditions or practices that could result in injury or loss of life.

CAUTION: Caution statements identify conditions or practices that could result in damage to this product or other property.

Terms on the product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

Symbols on the product

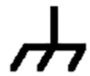
When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which have to be taken to avoid them. (This symbol may also be used to refer the user to ratings in the manual.)

The following symbols(s) may appear on the product.

CAUTION: Refer to Manual

Protective Ground (Earth) Terminal

Earth Terminal



Chassis Ground

WARNING: High Voltage

Breakable. Do not drop.

Standby

Functional Earth Terminal

Use only on an insulated wire.

Connection and disconnection to hazardous bare wire permitted.

Do not connect to or remove from an uninsulated conductor that is HAZARDOUS LIVE.

Specifications

This chapter contains specifications for the instrument. All specifications are typical unless noted as guaranteed. Typical specifications are provided for your convenience but are not guaranteed. Specifications that are marked with the ✓ symbol are guaranteed and checked in Performance Verification.

To meet specifications, these conditions must first be met:

- The instrument must have been calibrated in an ambient temperature between 18 °C and 28 °C (64 °F and 82 °F).
- The instrument must be operating within the environmental limits. (See *Environmental characteristics*).
- The instrument must be powered from a source that meets the specifications. (See *Power supply system* on page 19).
- The instrument must have been operating continuously for at least 20 minutes within the specified operating temperature range.
- You must perform the Signal path compensation procedure after the warmup period. See the Signal path compensation procedure for how to perform signal path compensation. If the ambient temperature changes more than 5 °C (9 °F), repeat the procedure.

Analog signal acquisition system

Number of analog input channels	2 Series MSO offers 2 and 4 channel models.
Input coupling	AC, DC
Input termination selection	1 MΩ only
Input termination, 1 MΩ DC-coupled	1 MΩ ± 1%
Input capacitance, 1 MΩ DC-coupled	14 pF ± 3 pF
Number of digitized bits	8 bits Displayed vertically with 25 digitization levels (DL[1]) per division, 10.24 divisions dynamic range.
Sensitivity range (coarse), 1 MΩ	1 mV/Div to 10 V/Div in a 1-2-5 sequence
Sensitivity range (fine)	Continuous adjustment from 1 mV/DIV to 10 V/DIV, 1 MΩ 1x
Sensitivity resolution (fine)	≤10% of current setting
Maximum input voltage, 1 MΩ DC-coupled	The maximum input voltage at the BNC, 300 V_{rms}. Installation category II Derate at 20 dB/decade between 4.5 MHz to 45 MHz Derate at 14 dB between 45 MHz to 450 MHz; above 450 MHz, 5 V_{rms} Maximum peak input voltage at the BNC: ± 424 V
✓ **DC gain accuracy**	Guaranteed for 2 mV/div and above, typical otherwise. <2 mV/div: ±3.0%, typical, derated at 0.100%/°C above 30 °C ≥2 mV/div: ±2.0%, derated at 0.100%/°C above 30 °C
Offset ranges	1 mV/div to 63.8 mV/div : ±1 V 63.9 mV/div to 999.5 mV/div : ±10 V 1 V/div to 10 V/div : ±100 V
Position range	±5 divisions
Offset accuracy	All terms must be converted to volts by multiplying by the current volts/div setting. >2 mV/div: ± (0.005 X |offset – position | + 0.2 div) ≤2 mV/div: ± (0.005 X |offset – position | + 0.3 div)
Number of waveforms for average acquisition mode	2 to 10.24 k waveforms, default of 16 waveforms
DC voltage measurement accuracy, average acquisition mode	The basic accuracy specification applies directly to any sample and to the following measurements: high, low, maximum, minimum, mean, cycle mean, RMS, and cycle RMS. The delta volts accuracy specification applies to subtractive calculations involving two of these measurements. The delta volts (difference voltage) accuracy specification applies directly to the following measurements; positive overshoot, negative overshoot, Pk-Pk, and amplitude. Offset, position, and the constant offset term must be converted to volts by multiplying by the appropriate volts/div term. The limits are as follows:

[1] DL is the abbreviation for digitization level. A converter can resolve the smallest voltage level change by using an 8-bit A–D converter. This value is also known as the Least Significant Bit (LSB).

Measurement type	DC accuracy (in volts)
Average of > 16 waveforms	± ((DC Gain accuracy) X |reading -(offset - position)| + Offset accuracy + 0.1 div + 1 mV)
Delta volts between any two averages of ≥16 waveforms acquired with the same oscilloscope setup and ambient conditions	± (DC Gain accuracy X |reading| + 0.08 div + 1.4 mV)

Analog bandwidth

Bandwidth selections

20 MHz, 70 MHz, 100 MHz, 200 MHz, 350 MHz, and 500 MHz (when equal to or less than instrument's rated bandwidth)

✓ Analog bandwidth

Below 5 mV/div, 500 MHz bandwidth is specified as typical.

The limits stated below are for an ambient temperature of ≤30 °C. For each degree above 30 °C, reduce the upper bandwidth frequency by 1%.

Instrument bandwidth	Volts/div setting	Bandwidth
70 MHz	1 mV/div – 10 V/div	DC – 70 MHz
100 MHz	1 mV/div – 10 V/div	DC – 100 MHz
200 MHz	1 mV/div – 10 V/div	DC – 200 MHz
350 MHz	1 mV/div – 10 V/div	DC – 350 MHz
500 MHz	<5 mV/div	DC – 500 MHz
500 MHz	≥5 mV/div - 10 V/div	DC – 500 MHz

Lower frequency limit, AC-coupled

<10 Hz

The AC-coupled lower frequency limits are reduced by a factor of 10 (<1 Hz) when 10X passive probes are used.

Upper frequency limit, 20 MHz bandwidth-limited

20 MHz, ± 25%, DC-coupled

Calculated rise time

Measurements made using the oscilloscope's automated measurement feature may read slower rise time values than those determined by the above equation. This is because the automated measurements do not take interpolation into account. Measuring using cursors on the interpolated waveform gives a more accurate result.

The formula is calculated by measuring the –3 dB bandwidth of the oscilloscope. The formula accounts for the rise time contribution of the oscilloscope independent of the rise time of the signal source.

Calculated rise time (10% to 90%, in ps) equals 0.35/BW except from 1000 to 2100 mentioned in below table.

Bandwidth	Rise time (ps)
500 MHz	1000
350 MHz	1400
200 MHz	2100
100 MHz	3500
70 MHz	5000

Peak detect or envelope mode pulse response

Peak detect response indicates how effective the oscilloscope is at picking up a single narrow pulse and determining its amplitude.

The minimum single pulse widths for peak detect or envelope mode is at least:

Bandwidth (MHz)	Minimum pulse width
500	> 2 ns
350	> 3 ns
200	> 5 ns
100	> 10 ns
70	> 14 ns
50	> 20 ns

Skew and delay

Deskew range

-95 ns to +95 ns

Crosstalk (channel isolation)

	≤ 100 MHz	> 100 MHz
1 MΩ	100:1	30:1

Timebase system

Sample rate range

Maximum 1.25 GS/s - All channels

Maximum 2.5 GS/s - Half channel

Record length range

10 M Standard

Seconds/Division range

1 ns/div to 1000 s/div when in half channel mode

2 ns/div to 1000 s/div when in full channel mode

Maximum triggered acquisition rate

>5 k wfm/s

Timebase accuracy

± 25 x 10^{-6} over any over any ≥1 ms interval

Timebase delay time range

-10 divisions to 5000 s

Delta time measurement accuracy (DTA)

The formula to calculate delta-time measurement accuracy (DTA) for a given instrument setting and input signal is as follows (assumes insignificant signal content above the Nyquist frequency).SR_1 = Slew rate (1st Edge) around 1st point in measurement

SR_2 = Slew rate (2nd Edge) around 2nd point in measurement

N = Input-referred noise (V_{rms})

TBA = Timebase accuracy

tp = Delta-time measurement duration (sec)

RD = (Record length)/(Sample rate)

(assume edge shape that results from Gaussian filter response)

$$DTApp = \pm 5 \times \sqrt{2 \cdot \left(\frac{N}{SR_1}\right)^2 + 2 \cdot \left(\frac{N}{SR_2}\right)^2 + \left(5ps + 1 \cdot 10^{-6} \cdot RD\right)^2} + 2 \cdot t_{sr} + TBA \cdot t_p$$

$$DTArms = \sqrt{2 \cdot \left(\frac{N}{SR_1}\right)^2 + 2 \cdot \left(\frac{N}{SR_2}\right)^2 + \left(5ps + 1 \cdot 10^{-6} \cdot RD\right)^2 + \left(\frac{2 \cdot t_{sr}}{\sqrt{12}}\right)^2} + TBA \cdot t_p$$

(Assumes insignificant error due to aliasing)

The term under the square root sign is stability and is due to Time Interval Error (TIE). The errors due to this term occur throughout a single-shot measurement. The second term is due to both the absolute center-frequency accuracy and the center-frequency stability of the time base and varies between multiple single-shot measurements over the observation interval (the amount of time from the first single-shot measurement to the final single-shot measurement).

Triggering system

Number of Aux In (external) trigger channels

One channel

Aux In (external) trigger input impedance

1 MΩ ± 1% in parallel with 14 pF ± 3 pF

Aux In (external) trigger maximum input voltage

300 V_{rms}, Installation category II

Derate at 20 dB/decade above 3 MHz to 30 V_{rms} at 30 MHz; 10 dB/decade above 30 MHz.

Based upon a sinusoidal or DC input signal. The excursion above 300 V should be less than 100 ms in duration, and the duty factor is limited to < 44%. The RMS signal level must be limited to 300 V. If these values are exceeded, damage to the instrument may result.

Edge-type trigger sensitivity, DC-coupled

The greater of 2 mV or 0.4 div from DC to 20 MHz

The greater of 3 mV or 0.5 div from >20 MHz to 70 MHz

The greater of 4 mV or 0.5 div from >70 MHz to 100 MHz

The greater of 4 mV or 0.6 div from >100 MHz to 200 MHz

The greater of 5 mV or 0.7 div from >200 MHz to 350 MHz

The greater of 6 mV or 0.8 div from >350 MHz to instrument bandwidth

Edge trigger sensitivity, AC-coupled

The minimum sensitivities are as follows:

Trigger coupling	Typical sensitivity
AC	1.0 times the DC coupled limits for frequencies above 10 Hz. Attenuates signals below 10 Hz
NOISE REJ	2.5 times the DC coupled limits
HF REJ	1.0 times the DC coupled limits from DC to 50 kHz. Attenuates signals above 50 kHz
LF REJ	1.0 times the DC Coupled limits for frequencies above 50 kHz. Attenuates signals below 50 kHz

Trigger types

Analog channels: Edge, pulse width, timeout, runt, logic, setup and hold, and Rise/Fall time.

Aux In: Edge

Lowest frequency for successful operation of "Set level to 50%" function

50 Hz

Logic trigger minimum logic or rearm time

For logic, time between channels refers to the length of time a logic state derived from more than one channel must exist to be recognized. For events, the time is the minimum time between a main and delayed event that will be recognized if more than one channel is used.

For all vertical settings, the minimums are:

Triggering type	Pulse width	Rearm time	Time between channels
Logic	Not applicble	2 ns	2 ns
Time qualified logic	4 ns	2 ns	2 ns

Setup/hold violation trigger, setup and hold time ranges

Input coupling on the clock and data channels must be the same.

For setup time, positive numbers mean a data transition before the clock.

For hold time, positive numbers mean a data transition after the clock edge.

Setup + hold time is the algebraic sum of the setup time and the hold time programmed by the user.

The limits are as follows:

Feature	Minimum	Maximum
Setup time	0 ns	20 s
Hold time	0 ns	20 s
Setup + hold time	400 ps	21 s

Minimum pulse width, rearm time, and transition time

For trigger class width and runt, pulse width refers to the width of the pulse being measured. Rearm time refers to the time between pulses.

For trigger class slew rate, pulse width refers to the delta time being measured. Rearm time refers to the time it takes the signal to cross the two trigger thresholds again.

For Slew rate triggering, the minimum transition time defined as the time signal spends between the two trigger threshold settings.

Pulse class	Minimum pulse width	Minimum rearm time
Runt	4 ns	2 s
Width	4 ns	2 ns + 5% of width upper limit setting
Slew rate	4 ns	8.5 ns + 5% of delta time setting

Rise/fall time trigger, delta time range

800 ps to 20 s

Pulse width, or time-qualified runt trigger time range

800 ps to 20 s

Trigger holdoff range

0 s minimum to 10 s maximum.

Hold off may not function correctly in sequence trigger mode.

Arbitrary function generator

Function types

Arbitrary, sine, square, pulse, ramp, DC level, Gaussian, Lorentz, exponential rise/fall, sin(x)/x, random noise, Haversine, and Cardiac.

Amplitude range Values are peak-to-peak voltages.

Waveform	Amplitude range 50 Ω	Amplitude range 1 MΩ
Arbitrary	10 mV to 2.5 V	20 mV to 5 V
Sine	10 mV to 2.5 V	20 mV to 5 V
Square	10 mV to 2.5 V	20 mV to 5 V
Pulse	10 mV to 2.5 V	20 mV to 5 V
Ramp	10 mV to 2.5 V	20 mV to 5 V
Gaussian	10 mV to 1.25 V	20 mV to 2.5 V
Lorentz	10 mV to 1.2 V	20 mV to 2.4 V
Exponential rise	10 mV to 1.25 V	20 mV to 2.5 V
Exponential decay	10 mV to 1.25 V	20 mV to 2.5 V
Sin(X)/X	10 mV to 1.5 V	20 mV to 3.0 V
Random noise	10 mV to 2.5 V	20 mV to 5 V
Haversine	10 mV to 1.25 V	20 mV to 2.5 V
Cardiac	10 mV to 2.5 V	20 mV to 5 V

Maximum sample rate 250 MS/s

Arbitrary function length 128 K sample

Sine waveform

Frequency range 0.1 Hz to 50 MHz

Frequency setting resolution 0.1 Hz

Amplitude flatness ±0.5 dB at 1 kHz

±1.5 dB at 1 kHz for <20 mV_{pp} amplitudes with 50 Ω termination

Total harmonic distortion 1% into 50 Ω for amplitude > 100 mV

Spurious-free dynamic range 40 dB (V_{pp} ≥ 0.1 V) 50 Ω load

Square and pulse waveform

Frequency range 0.1 Hz to 25 MHz

Frequency setting resolution 0.1 Hz

Duty cycle range 10% - 90% or 10 ns minimum pulse, whichever is larger

Minimum pulse time applies to both on and off time, so maximum duty cycle will be reduced at higher frequencies to maintain 10 ns of off time.

Minimum pulse width, typical 10 ns. This is the minimum time for either on or off duration.

Rise/fall time 5.5 ns, 10% - 90% with 50 Ω termination

Pulse width resolution 100 ps

Overshoot <5% for signal steps > 100 mV_{pp} and frequency settings ≥100 kHz with 50 Ω termination

<7% for signal steps > 100 mV_{pp} and frequency settings < 100 kHz with 50 Ω termination

This applies to the overshoot of the positive-going transition (+overshoot) and the negative-going (-overshoot) transition.

Asymmetry	± 1% ± 5 ns, at 50% duty cycle with 50 Ω termination
Jitter	<500 ps TIE_{rms} <60 ps TIE_{rms}, ≥100 mV_{pp} amplitude, 40% - 60% duty cycle (Square and pulse waveforms, 5 GHz measurement bandwidth)

Ramp and triangle waveform

Frequency range	0.1 Hz to 500 kHz
Frequency setting resolution	0.1 Hz
Variable symmetry	0% - 100%
Symmetry resolution	0.1%
DC level range	±2.5 V into Hi-Z ±1.25 V into 50 Ω
Gaussian pulse, lorentz pulse, and haversine maximum frequency	5 MHz
Exponential rise/fall maximum frequency	5 MHz
Sine(X)/X maximum frequency	2 MHz
Random noise amplitude range	20 mV_{pp} to 5 V_{pp} in to Hi-Z 10 mV_{pp} to 2.5 V_{pp} into 50 Ω For both isolated noise signal and additive noise signal. Additive noise is 0% to 100% of the peak-to-peak amplitude specified. The additive noise range is restricted in favor of amplitude in order not to exceed the maximum output limits. There is currently a linear reduction from 100% to 0% above 50% amplitude.
Sine and ramp frequency accuracy	130 ppm (frequency ≤10 kHz); 50 ppm (frequency > 10 kHz)
Square and pulse frequency accuracy	130 ppm (frequency ≤10 kHz); 50 ppm (frequency > 10 kHz)
Signal amplitude resolution	500 µV (50 Ω) 1 mV (Hi-Z)
Signal amplitude accuracy	±[(1.5% of peak-to-peak amplitude setting) + (1.5% of absolute DC offset setting) + 1 mV] (frequency = 1 kHz)
DC offset Range	±2.5 V into Hi-Z ±1.25 V into 50 Ω
DC offset Resolution	500 µV (50 Ω) 1 mV (Hi-Z)
✓ **DC offset accuracy**	± [(1.5% of absolute offset voltage setting) + 1 mV] Add 3 mV of uncertainty per 10 °C change from 25 °C ambient
Cardiac maximum frequency	500 kHz

Digital channel acquisition

Number of input channels	16 Digital Inputs
Input resistance, typical	101 KΩ to ground

Input capacitance, typical	8 pF Specified at the input to the P6316 probe with all 8 ground inputs connected to the user's ground. Use of leadsets, grabber clips, ground extenders, or other connection accessories may compromise this specification.
Minimum input signal swing, typical	500mV peak-to-peak Specified at the input to the P6316 probe with all 8 ground inputs connected to the user's ground. Use of leadsets, grabber clips, ground extenders, or other connection accessories may compromise this specification.
Maximum input signal swing, typical	+30 V, -20 V
DC input voltage range	+30 V, -20 V
Maximum input dynamic range	50 V_{pp} (threshold setting dependent)
Channel to channel skew (typical)	500 ps Digital Channel to Digital Channel only This is the propagation path skew, and ignores skew contributions due to bandpass distortion, threshold inaccuracies (see Threshold Accuracy), and sample binning (see Digital Channel Timing Resolution).
Threshold voltage range	–15 V to +25 V
Digital channel timing resolution	Minimum: 2 ns
Threshold accuracy	± [180 mV + 2% of threshold setting after calibration]. Requires valid SPC.
Minimum detectable pulse	2.0 ns Specified at the input to the P6316 probe with all eight ground inputs connected to the user's ground. Use of lead sets, grabber clips, ground extenders, or other connection accessories may compromise this specification.

Digital pattern generator

Number of channels	4
Pattern memory length	4 K bits
Output amplitude	2.5 V, 3.3 V, 5 V (Continuous Mode) 5 V (Burst Mode) Typical voltages are 10% below the nominal settings to allow for voltage differentials and tolerances
Bit Rate	1 bps to 25 Mbps
Pattern type	Square, counter, user defined, and manual

Processor system

Host processor	Application processing unit: Dual-core Arm Cortex-A53 MPCore with CoreSight; NEON and single/double precision floating point; 32 KB/32 KB L1 cache, 1 MB L2 cache Real-time processing unit Dual-core Arm Cortex-R5F with CoreSight; single/double precision floating point; 32 KB/32 KB L1 cache, and TCM

Display system

Display type	Display area – 217 mm (H) x 135 mm (V), TFT active matrix, and Liquid Crystal Display (LCD) with capacitive touch.

Display resolution	1,280 horizontal × 800 vertical pixels
Luminance	260 cd/m² Display luminance is specified for a new display set at full white brightness.
Color support	16,777,216 (8-bit RGB) colors

Interfaces, input, and output ports

Ethernet Interface An 8-pin RJ-45 connector that supports 10/100 Mb/s and 1000 Mbps Ethernet (in full duplex mode only).

Video signal output

USB interface Two USB 2.0 high speed host ports on the side of the instrument.
One USB 2.0 high speed device port on the side of the instrument.

Probe compensator output

Probe compensator, output voltage and frequency

Characteristic	Value
Output voltage	Normal: 0-2.5 V amplitude
Source impedance	Normal: 1 kΩ
Frequency	1 kHz

Auxiliary output (Aux out)

Aux out connector and functional modes A single BNC connector
Acquisition (main) trigger out and AFG out

Aux out output voltage Non-AFG voltage thresholds are listed in the following table:

Characteristic	Limits
V_{out} (HI)	≥ 2.5 V open circuit; ≥ 1.0 V into a 50 Ω load to ground
V_{out} (LO)	≤ 0.7 V into a load of ≤ 4 mA; ≤ 0.25 V into a 50 Ω load to ground

Data handling characteristics

Real-time clock	A programmable clock maintains and reports the current time in the units of years, months, days, hours, minutes, and seconds.
Non-volatile memory capacity	One eMMC device (limited to 2 GB of usable space in SLC mode) contains the bootloader, operating system, application software, calibration constants, and user data storage.
Mass storage device capacity	Linux: ≥4 GB. The form factor is an embedded eMMC BGA. It provides storage for saved customer data, all calibration constants and the Linux operating system. Not customer serviceable. Partition on the user device, with a nominal capacity of 2 GB, is available for the storage of saved customer data. The physical capacity is larger, but in SLC mode it is 2 GB only for the longevity of the NAND flash.

Power supply system

Power consumption	60 W maximum
Source voltage	100 – 240 VAC ±10% (50/60 Hz)
Source frequency	50 – 60 Hz (100 – 240 VAC)
Fuse rating	T3.15 A, 250 V The fuse is not customer replaceable. The line lead is fused, but the neutral lead is not fused.
Operating time on battery	4 hours- 1 battery 7 hours - 2 batteries Battery life is measured under following conditions: • Only one channel is turned on • Lowest timebase setting selected • Lowest record length is selected • Fastest sample rate is selected • All analysis or interpolation capabilities are turned off • Edge trigger is selected • Back-light set to low

Safety characteristics

Safety certification	The following certifications and compliance are applicable: UL/CSA/EN 61010-2-030. US NRTL Listed - UL61010-1. Canadian Certification - CAN/CSA-C22.2 No. 61010.1. EU Compliance – Low Voltage Directive 2014-35-EU and EN61010-1. International Compliance – IEC 61010-1.
Pollution degree	Pollution degree 2, indoor, and dry location use only.

Mechanical characteristics

Weight

Type	Weight
MSO2x (all bandwidths)	4 lbs (1.8 kg)
MSO2x (all bandwidths), battery module with 1 battery	7 lb (3.2 kg)
MSO2x (all bandwidths), battery module with 2 batteries)	8 lb (3.6 kg)

Overall dimensions	MSO2x (all bandwidths): 344 x 210 x 40.4 mm MSO2x (all bandwidths, with battery module): 344 x 210 x 78 mm
Clearance requirements	The clearance requirement for adequate cooling is 13 mm (0.5 in) on the rear of the instrument along the bottom edge (inlet vents) and top edge (exhaust vents).

Electromagnetic compatibility

Regional certifications, classifications, and standards list

European union	EC Council EMC Directive 2014/30/EU Demonstrated using: EN 61326-2-1:2006 Electrical equipment for measurement, control, and laboratory, part 2-1. Emissions that exceed the levels required by this standard may occur when this equipment is connected to a test object. Compliance is demonstrated using high-quality, shielded interface cables. EN IEC 61326-1:2021 and EN IEC 61326-2-1:2021 EMC requirements for Class A electrical equipment. Emissions: EN 55011, Class A Immunity: IEC 61000-4-2 IEC 61000-4-3 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6 IEC 61000-4-11 EN 61000-3-2 EN 61000-3-3
Australia	EMC Framework, demonstrated per emission standard CISPR 11 in accordance with EN 61326-2-1.
United Kingdom	Electromagnetic Compatibility Regulations 2016-UK SI 2016 No.1091 Demonstrated using: EN 61326-2-1:2013 Electrical equipment for measurement, control, and laboratory, Part 2-1. Emissions that exceed the levels required by this standard may occur when this equipment is connected to a test object. Use high quality shielded cables to maintain compliance. Emissions: EN 55011, Class A Immunity: IEC 61000-4-2 IEC 61000-4-3 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6 IEC 61000-4-11 EN 61000-3-2 EN 61000-3-3
Ukraine	Technical Regulations on Electromagnetic Equipment Compatibility TR 1077 DSTU EN 61326-1: 2016 (EN 61326-1: 2013. IDT) and DSTU EN 61326-2-1: 2016 (EN 61326-2-1: 2013. IDT): Electrical equipment for measuring control and laboratory use. Requirements for electromagnetic compatibility Part 1 consists of general requirements, and Part 2-1 consists of additional requirements. Test configurations, working conditions, and quality criteria for the operation of an accurate test. Emissions: DSTU EN 55011: 2019 (EN 55011: 2009. IDT. CISPR 11: 2009. MOD) / Amendment № 1: 2019 (EN 55011: 2009 / A1: 2010. IDT.

	CISPR 11: 2009 / A1: 2010. IDT) - Industrial equipment, scientific, and medical radio frequency. Characteristics of electromagnetic interference, norms, and methods of measurement. Immunity DSTU EN 61000-4-11: 2019 (EN 61000-4-11: 2004. IDT. IEC 61000-4-11: 2004. IDT) - Electromagnetic compatibility Part 4-11 consists of test and measurement methods. Tests for immunity to voltage dips, short-term interruptions, and voltage changes. DSTU EN 61000-4-2: 2018 (EN 61000-4-2: 2009. IDT. IEC 61000-4-2: 2008. IDT) - Electromagnetic compatibility Part 4-2 consists of test and measurement methods. Tests for resistance to electrostatic discharges. DSTU EN 61000-4-3: 2019 (EN 61000-4-3: 2006. IDT. IEC 61000-4-3: 2006. IDT) / Amendment № 2: 2019 (EN 61000-4-3: 2006 / A2: 2010 IDT IEC 61000-4-3: 2006 / A2: 2010 IDT) - Electromagnetic compatibility. Part 4-3. Test and measurement methods. Tests for immunity to radio frequency electromagnetic fields of radiation. DSTU EN 61000-4-4: 2019 (EN 61000-4-4: 2012. IDT. IEC 61000-4-4: 2012. IDT) - Electromagnetic compatibility Part 4-4 consists of test methods for testing and measurement. Tests for susceptibility to electrical rapid transition processes or pulse packets. DSTU EN 61000-4-5: 2019 (EN 61000-4-5: 2014. IDT. IEC 61000-4-5: 2014. IDT) - Electromagnetic compatibility Part 4-5 consists of test and measurement methods. Tests for immunity to voltage and current surges. DSTU EN 61000-4-6: 2019 (EN 61000-4-6: 2014. IDT. IEC 61000-4-6: 2013. IDT) - Electromagnetic compatibility Part 4 consists of test and measurement methods. Tests for immunity to conductive perturbations induced by radio frequency fields Emissions that exceed the levels required by this standard may occur when this equipment is connected to a test object. Compliance demonstrated using high quality, shielded interface cables.
Korea	EC Council EMC Directive 2014/30/EU Demonstrated using: EN 61326-2-1:2013 Electrical equipment for measurement, control, and laboratory, Part 2-1. Emissions that exceed the levels required by this standard may occur when this equipment is connected to a test object. Use high quality shielded cables to maintain compliance. EN IEC 61326-1:2021 and EN IEC 61326-2-1:2021 EMC Requirements for Class A electrical equipment Emissions EN 55011, Class A Immunity IEC 61000-4-2 IEC 61000-4-3 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6 IEC 61000-4-11 EN 61000-3-2 EN 61000-3-3

Immunity

Electrostatic discharge (ESD), and enclosure port	IEC 61000-4-2

Radiated radio frequency electromagnetic field, and enclosure port	IEC 61000-4-3 Triggering when the trigger threshold is offset by less than 4 minor divisions from ground reference is allowed.
Electrical fast Transient/burst, and common-mode	IEC 61000-4-4
Surge/electrical slow transient	IEC 61000-4-5
Conducted radio frequency	IEC 61000-4-6 Ambient fields may induce triggering when the trigger threshold is offset by less than 1 major division from ground reference.
Voltage dips and short interruptions, and AC power port	IEC 61000-4-11

Environmental compliance

Product recycling information and documentation

User information should include an explanation of the recycling mark and direct the customer to the appropriate resources for recycling the product via one of the following methods:

1. Operator manual boilerplate; or
2. Pack-in errata sheet (only use this method if manual has been finalized); or
3. Online help file (if no other documentation is shipped with the product).

Environmental characteristics

Temperature	
Operating	0 °C to +50 °C
Non-operating	-20 °C to +60 °C
Humidity	
Operating	5% to 90% relative humidity at temperatures up to +30 °C, 5% to 60% relative humidity at temperatures greater than +30 °C and up to +50 °C
Non-operating	5% to 90% relative humidity at temperatures up to +30 °C 5% to 60% relative humidity at temperatures greater than +30 °C and up to +60 °C
Altitude	
Operating	up to 3,000 meters
Non-operating	up to 12,000 meters

Dynamics

Random vibration: Non-operating

MIL-PRF-28800F, class 3,4 for standard product:

- 0.015 G2/Hz from 5 Hz to 100 Hz, rolling off at -6 dB/octave from 100 to 137 Hz;
- 0.0075 G2/Hz from 137 to 350 Hz, rolling off at -6 dB/octave from 350 to 500 Hz;
- 10 minutes per axis, in all 3 axes. (30 minutes total)

MIL-PRF-28800F, class 2 for product with protective accessory: 0.03 G2/Hz from 10 Hz to 500 Hz (3.83 Grms) for 30 minutes per axis, in all 3 axes. (90 minutes total)

Sine vibration: operating	Military Standard MIL-PRF-28800F (Class 3)
Mechanical shock: operating	Half-sine mechanical shocks, 30 g peak amplitude, 11 ms duration, 3 drops in each direction of each axis (18 total).

Performance verification procedures

This chapter contains performance verification procedures for the specifications marked with the ✓ symbol. The following equipment, or a suitable equivalent, is required to complete these procedures.

The performance verification procedures verify the performance of your instrument. They do not adjust your instrument. If your instrument fails any of the performance verification tests, repeat the failing test, verifying that the test equipment and settings are correct. If the instrument continues to fail a test, contact Tektronix Customer Support for assistance.

These procedures cover all 2 Series MSO instruments. Completion of the performance verification procedure does not update the instrument time and date.

Print the test records on the following pages and use them to record the performance test results for your oscilloscope. Disregard checks and test records that do not apply to the specific model you are testing.

The following table lists the required equipment. You might need additional cables and adapters, depending on the actual test equipment you use.

Required equipment	Minimum requirements	Examples
DC voltage source	3 mV to 4 V, ±0.1% accuracy	Fluke 9500B Oscilloscope Calibrator with a 9530 Output Module
Leveled sine wave generator	50 kHz to 2 GHz, ±4% amplitude accuracy	
Time mark generator	80 ms period, $\pm 1.0 \times 10^{-6}$ accuracy, rise time <50 ns	

Test records

DC Gain Accuracy test record

DC Gain Accuracy					
Performance checks	**Bandwidth**	**Vertical scale**	**Low limit**	**Test result**	**High limit**
Channel 1 DC Gain Accuracy, 0 V offset, 0 V vertical position	20 MHz	2 mV/div	-2%		2%
		4.98 mV/div	-2%		2%
		5 mV/div	-2%		2%
		10 mV/div	-2%		2%
		20 mV/div	-2%		2%
		49.8 mV/div	-2%		2%
		50 mV/div	-2%		2%
		100 mV/div	-2%		2%
		200 mV/div	-2%		2%
		500 mV/div	-2%		2%
		1 V/div	-2%		2%
	FULL	100 mV/div	-2%		2%
Channel 2 DC Gain Accuracy, 0 V offset, 0 V vertical position	20 MHz	2 mV/div	-2%		2%
		4.98 mV/div	-2%		2%
		5 mV/div	-2%		2%
		10 mV/div	-2%		2%
		20 mV/div	-2%		2%
		49.8 mV/div	-2%		2%
		50 mV/div	-2%		2%
		100 mV/div	-2%		2%
		200 mV/div	-2%		2%
		500 mV/div	-2%		2%
		1 V/div	-2%		2%
	FULL	100 mV/div	-2%		2%

Table continued…

DC Gain Accuracy					
Performance checks	**Bandwidth**	**Vertical scale**	**Low limit**	**Test result**	**High limit**
Channel 3 DC Gain Accuracy, 0 V offset, 0 V vertical position	20 MHz	2 mV/div	-2%		2%
		4.98 mV/div	-2%		2%
		5 mV/div	-2%		2%
		10 mV/div	-2%		2%
		20 mV/div	-2%		2%
		49.8 mV/div	-2%		2%
		50 mV/div	-2%		2%
		100 mV/div	-2%		2%
		200 mV/div	-2%		2%
		500 mV/div	-2%		2%
		1 V/div	-2%		2%
	FULL	100 mV/div	-2%		2%
Channel 4 DC Gain Accuracy, 0 V offset, 0 V vertical position	20 MHz	2 mV/div	-2%		2%
		4.98 mV/div	-2%		2%
		5 mV/div	-2%		2%
		10 mV/div	-2%		2%
		20 mV/div	-2%		2%
		49.8 mV/div	-2%		2%
		50 mV/div	-2%		2%
		100 mV/div	-2%		2%
		200 mV/div	-2%		2%
		500 mV/div	-2%		2%
		1 V/div	-2%		2%
	FULL	100 mV/div	-2%		2%

Analog Bandwidth test record

Analog Bandwidth performance checks					
Bandwidth at Channel	**Vertical scale**	**$V_{in\text{-}AC\ RMS}$**	**$V_{bw\text{-}AC\ RMS}$**	**Limit**	**Test result Gain = $V_{bw\text{-}AC\ RMS}/V_{in\text{-}AC\ RMS}$**
Channel 1	1 mV/div			≥ 0.707	
	2 mV/div			≥ 0.707	
	5 mV/div			≥ 0.707	
	10 mV/div			≥ 0.707	
	20 mV/div			≥ 0.707	
	200 mV/div			≥ 0.707	
	700 mV/div			≥ 0.707	
	3 V/div			≥ 0.707	
	5 V/div			≥ 0.707	
Channel 2	1 mV/div			≥ 0.707	
	2 mV/div			≥ 0.707	
	5 mV/div			≥ 0.707	
	10 mV/div			≥ 0.707	
	20 mV/div			≥ 0.707	
	200 mV/div			≥ 0.707	
	700 mV/div			≥ 0.707	
	3 V/div			≥ 0.707	
	5 V/div			≥ 0.707	
Channel 3	1 mV/div			≥ 0.707	
	2 mV/div			≥ 0.707	
	5 mV/div			≥ 0.707	
	10 mV/div			≥ 0.707	
	20 mV/div			≥ 0.707	
	200 mV/div			≥ 0.707	
	700 mV/div			≥ 0.707	
	3 V/div			≥ 0.707	
	5 V/div			≥ 0.707	

Table continued…

Analog Bandwidth performance checks					
Bandwidth at Channel	Vertical scale	$V_{in\text{-}AC\ RMS}$	$V_{bw\text{-}AC\ RMS}$	Limit	Test result Gain = $V_{bw\text{-}AC\ RMS}/V_{in\text{-}AC\ RMS}$
Channel 4	1 mV/div			≥ 0.707	
	2 mV/div			≥ 0.707	
	5 mV/div			≥ 0.707	
	10 mV/div			≥ 0.707	
	20 mV/div			≥ 0.707	
	200 mV/div			≥ 0.707	
	700 mV/div			≥ 0.707	
	3 V/div			≥ 0.707	
	5 V/div			≥ 0.707	

Digital threshold accuracy tests with 2-MSO option

Digital threshold accuracy performance checks						
Digital channel	Threshold	V_{s-}	V_{s+}	Low limit	Test result V_{sAvg} = $(V_{s-} + V_{s+})/2$	High limit
D0	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D1	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D2	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D3	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D4	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D5	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D6	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D7	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D8	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D9	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V

Table continued…

Digital threshold accuracy performance checks						
Digital channel	Threshold	V_{s-}	V_{s+}	Low limit	Test result V_{sAvg} = $(V_{s-} + V_{s+})/2$	High limit
D10	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D11	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D12	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D13	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D14	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V
D15	0 V			-0.18 V		0.18 V
	4 V			3.74 V		4.26 V

Long term sample rate test records

Long Term Sample Rate			
Performance checks	Low limit	Test result	High limit
Long Term Sample Rate	-2 divisions		+2 divisions

AFG DC Offset Accuracy Tests

AFG DC Offset Accuracy				
Performance checks		Low limit	Test result	High limit
All models	20 mV DC offset @ 50 Ω	18.7 mV		21.3 mV
	1 V DC offset @ 50 Ω	984 mV		1.016 V
	- 1 V DC offset @ 50 Ω	-1.016 V		-984 mV

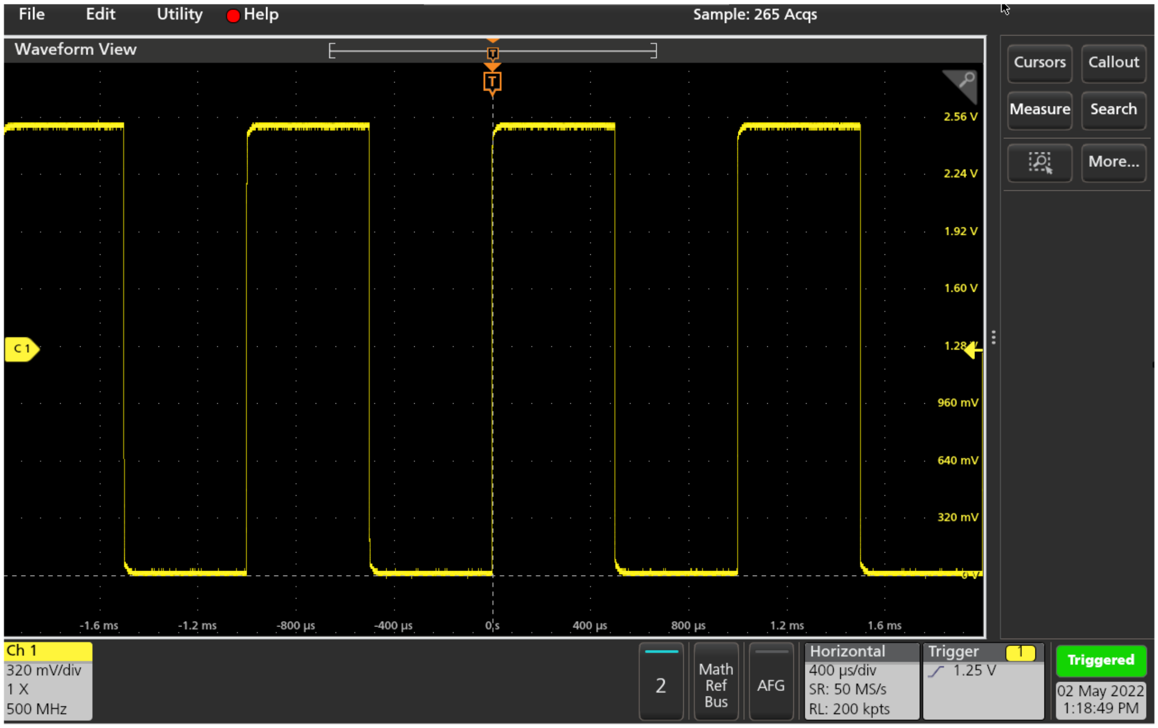
Check probe compensation

Procedure to check the probe compensation.

Procedure

1. Connect the probe compensation to **Ch 1**.
2. Turn on the Ch 1 and turn off all other channels.
3. Tap **File** > **Default Setup**.
4. Push **Autoset** button on the front-panel or tap **File** > **Autoset** from the menu bar.

   The screen displays a square wave. The levels should be approximately 0 V - 2.5 V and 1 kHz.



Check Aux In

Procedure to check the Aux In.

Procedure

1. Connect probe compensation to **Aux In**.
2. Tap **File** > **Default Setup**.
3. Double-tap the trigger badge on the settings bar and set the trigger **Source** to **Aux In**.
4. Set **Trigger Level** to **1 V**.
5. Tap **Trigger** on the settings bar and verify the oscilloscope is **Triggering**.

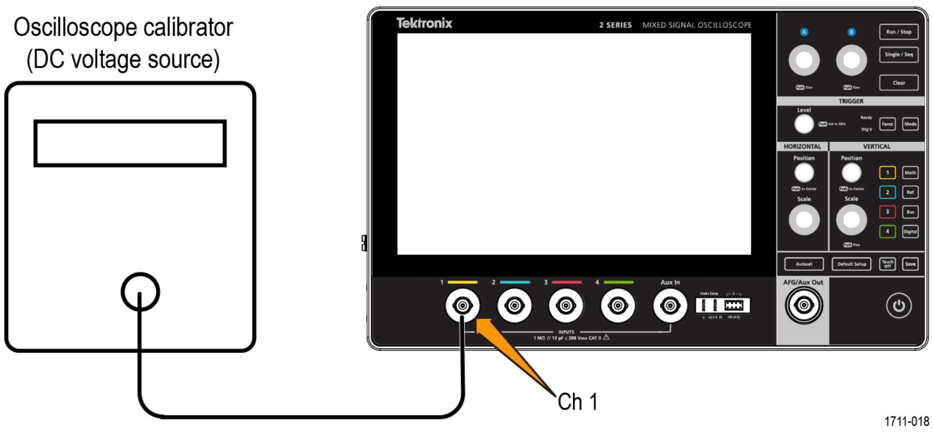
Check DC gain accuracy

Procedure to test the DC gain accuracy.

Procedure

⚠ **WARNING:** Set the generator output to Off or 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure. The generator is capable of providing dangerous voltages.

1. Connect the oscilloscope to a calibrated DC voltage source. If you are using the Fluke 9500 calibrator, connect the calibrator head to the oscilloscope channel to test.



2. Tap **File** > **Default Setup**.
3. Double-tap the **Acquisition** badge and set **Acquisition Mode** to **Average**.
4. Set the **Number of Waveforms** to **16**.
5. Tap outside the menu to close the menu.
6. Double-tap the **Trigger** badge and set the trigger **Source** to **Internal**.
7. Tap outside the menu to close it.
8. Add the **Mean** measurement to the Results bar:
   a) Tap the **Measure** button to open the **Add Measurements** menu.
   b) Set the **Source** to **Ch 1**.
   c) In the **Amplitude Measurements** panel, double-tap the **Mean** button to add the Mean measurement badge to the Results bar.
9. Tap outside the menu to close it.
10. Double-tap the **Mean** results badge.
11. Tap **Show Statistics in Badge**.
12. Tap outside the menu to close it.
13. Tap the channel button of the channel to test, to add the channel badge to the Settings bar.
14. Double tap the channel to test badge to open its menu and set the channel settings:
    a) Set **Vertical Scale** to **2 mV/div**.
    b) Tap **Bandwidth Limit** and set to **20 MHz**.
    c) Tap outside the menu to close it.
15. Record the negative-measured and positive-measured mean readings in the *Expected gain worksheet* as follows:
    a) On the calibrator, set the DC Voltage Source to the $V_{negative}$ value as listed in the 2 mV row of the worksheet.
    b) Double-tap the **Acquisition** badge and tap **Clear** to reset the measurement statistics.
    c) Enter the **Mean** reading in the worksheet as $V_{negative-measured}$.
    d) On the calibrator, set the DC Voltage Source to $V_{positive}$ value as listed in the 2 mV row of the worksheet.
    e) Double-tap the **Acquisition** badge (if not open) and tap **Clear**.
    f) Enter the **Mean** reading in the worksheet as $V_{positive-measured}$.

Table 1: Expected gain worksheet

Oscilloscope vertical scale setting	$V_{diffExpected}$	$V_{negative}$	$V_{positive}$	$V_{negative-measured}$	$V_{positive-measured}$	V_{diff}	Test result (Gain accuracy)
2 mV/div							
4.98 mV/div							
5 mV/div							
10 mV/div							
20 mV/div							
49.8 mV/div							
50 mV/div							
100 mV/div							
200 mV/div							
500 mV/div							
1.0 V/div							
100 mV/div at Full BW							

16. Calculate Gain Accuracy as follows:

a) Calculate V_{diff} as follows:

$V_{diff} = | V_{negative\text{-}measured} - V_{positive\text{-}measured} |$

b) Enter V_{diff} in the worksheet.

c) Calculate *Gain Accuracy* as follows:

Gain Accuracy $= ((V_{diff} - V_{diffExpected})/V_{diffExpected}) \times 100\%$

d) Enter the *Gain Accuracy* value in the worksheet and in the test record.

17. Repeat steps *14* on page 31 through *16* on page 32 for all vertical scale settings in the work sheet and the test record.

18. Repeat the procedure for all remaining channels:

a) Set the calibrator to **0** volts.

b) Move the calibrator output to the next channel input to be tested.

c) Double-tap the channel badge of the channel that you have finished testing and set **Display** to **Off**.

d) Double-tap the **Mean** measurement badge.

e) Tap the **Configure** panel.

f) Tap the **Source 1** field and select the next channel to test.

g) Starting from step *14* on page 31, set the values from the test record for the channel under test, and repeat the above steps until all channels have been tested.

19. Touch outside a menu to close the menu.

Check analog bandwidth

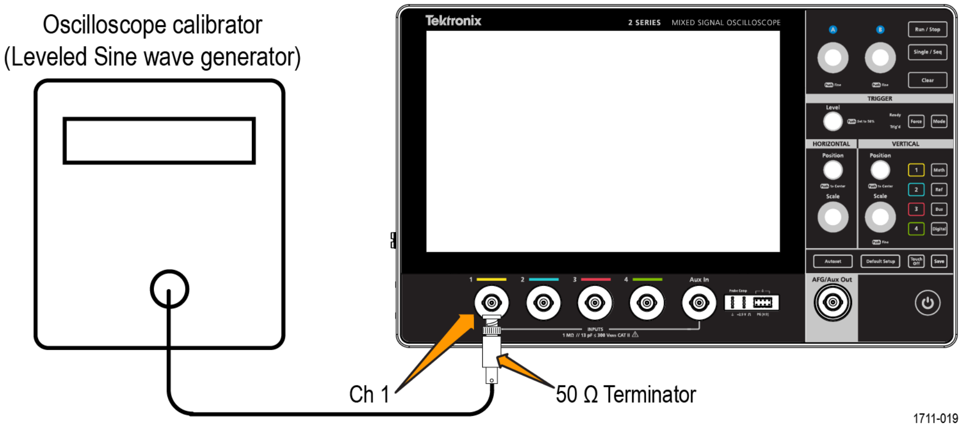
Procedure to check the bandwidth for each channel.

Procedure

⚠ **WARNING:** Set the generator to off or 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure. The generator is capable of providing dangerous voltages.

1. Connect the output of the calibrated leveled sine wave generator to the 50 Ω terminator (Tektronix Part Number 011-0049-02) on Channel 1 as shown in the following illustration.

   If using the Fluke 9500 calibrator as the sine wave generator, connect the calibrator head to the 50 Ω terminator with the Fluke 9500 in 50 Ω output mode. Do not connect the Fluke 9500 calibrator head directly to the oscilloscope channel.



2. Tap **File** > **Default Setup** to reset the instrument and add the channel 1 badge and signal to the display.
3. Add the AC RMS measurement as follows:
   a) Tap the **Measure** button.
   b) Set the **Source** to the channel under test.
   c) In the **Amplitude Measurements** panel, double-tap the **AC RMS** measurement button to add the measurement badge to the Results bar.
4. Set the channel under test settings:
   a) Double-tap the badge of the channel under test to open its configuration menu.
   b) Set **Vertical Scale** to **1 mV/div**.
   c) Tap outside the menu to close it.
5. Adjust the leveled sine wave signal source to display a waveform of 8 vertical divisions at the selected vertical scale with a set frequency of **1 kHz**.

   For example, at 5 mV/div, use a ≥40 $mV_{p\text{-}p}$ signal; at 2 mV/div, use a ≥16 $mV_{p\text{-}p}$ signal.

   At some V/div settings, the generator may not provide 8 vertical divisions of signal. Set the generator output to obtain as many vertical divisions of signal as possible.
6. Double-tap the **Horizontal** badge in the Settings bar.
7. Set the **Horizontal Scale** to **1 ms/division**.
8. Tap outside the menu to close it.
9. Record the **AC RMS** measurement in the $\mathbf{V}_{in\text{-}AC\ RMS}$ entry of the test record.
10. Double-tap the **Horizontal** badge in the Settings bar.
11. Set the **Horizontal Scale** to **4 ns/division**.
12. Adjust the signal source to the maximum bandwidth frequency for the bandwidth and model being tested.
13. Record the **AC RMS** measurement at the new frequency in the $\mathbf{V}_{bw\text{-}pp}$ entry of the test record.
14. Use the values of *V bw-pp* and *V in-pp* recorded in the test record, and the following equation, to calculate the Gain at bandwidth.

    Gain = *Vbw-pp* / *Vin-pp*.

    To pass the performance measurement test, Gain should be ≥ 0.707. Enter *Gain* in the test record.
15. Repeat steps from *4* on page 33 to *14* on page 33 for all combinations of Vertical Scale and Horizontal Scale settings listed in the test record.
16. Repeat the test for all remaining channels as follows:

a) Turn **Off** the generator.
b) Move the calibrator output to the next channel input to be tested.
c) Turn **On** the generator.
d) Tap the channel button on the oscilloscope Settings bar of the next channel to test.
e) Double-tap the **AC RMS** measurement badge.
f) Tap the **Configure** panel.
g) Tap the **Source 1** field and select the next channel to test.
h) Starting from step *4* on page 33, repeat the procedure until all channels have been tested.

Check digital threshold accuracy with 2-MSO option

This procedure checks the threshold accuracy of the digital channels and is for models with the 2-MSO option only.

About this task

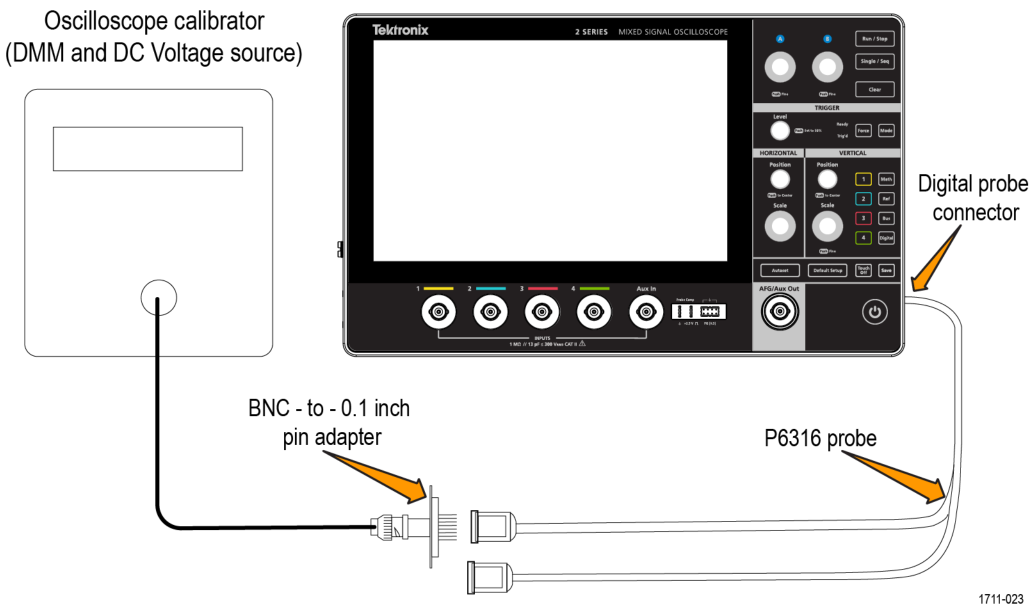
This procedure applies to digital channels D0 through D15, and to channel threshold values of 0 V and 4 V.

Procedure

1. Connect the P6316 digital probe to the instrument.

2. Connect the P6316 Group 1 pod to the DC voltage source to run this test.

You will need a BNC-to-0.1 inch pin adapter to complete the connection. If using the Fluke 9500 calibrator as the DC voltage source, connect the calibrator head to the P6316 Group 1 pod. You will need a BNC-to-0.1 inch pin adapter to complete the connection.



3. Push **Default Setup** on the front panel to set the instrument to the factory default settings.

4. Display the digital channels and set the thresholds as follows:

a) Tap the **D15-D0** button on the Settings bar.
b) Double-tap the **D15-D0** badge on the Settings bar.
c) Tap the **D15-D8 Turn All On** button to turn all bits on.
d) Tap the **D7-D0 Turn All On** button to turn all bits on.
e) Tap the D15-D8 **Thresholds** field at the bottom of the menu and set the value to **0 V**.
f) Tap the D7-D0 field at the bottom of the menu and set the value to **0 V**. The thresholds are set for the 0 V threshold check.

g) Tap outside the menu to close it.

5. You need to record the test values in the test record row for 0 V for each digital channel. See *Digital threshold accuracy performance checks table*.
6. Double-tap the **Trigger** badge.
7. Tap **Slope** and change the slope to rising edge.
8. Set the **Source** to the appropriate channel, such as D0.

   By default, the Type is set to Edge, Coupling is set to DC, Slope is set to Rising, Mode is set to Auto, and Level is set to match the threshold of the channel being tested.
9. Tap outside the menu to close it.
10. Set the DC voltage source (Vs) to -400 mV. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

    If the channel is a static logic level high (green), change the DC voltage source Vs to -500 mV.
11. Increment Vs by +20 mV. Wait 3 seconds and check the logic level of the corresponding digital channel in the display. If the channel is at a static logic level high (green), record the Vs value as in the 0 V row of the test record.

    If the channel is a logic level low (blue) or is alternating between high and low, repeat this step (increment Vs by 20 mV, wait 3 seconds, and check for a static logic high). Continue until a value for **Vs-** is found. In this procedure, the channel might not change state until after you pass the set threshold level.
12. Double-tap the **Trigger** badge.
13. Tap **Slope** and change the slope to falling edge.
14. Tap outside the menu to close it.
15. Set the DC voltage source (Vs) to +400 mV. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

    If the channel is a static logic level low (blue), change the DC voltage source Vs to +500 mV.
16. Decrement Vs by -20 mV. Wait 3 seconds and check the logic level of the corresponding digital channel in the display. If the channel is at a static logic level low, record the Vs value as **Vs+** in the 0 V row of the test record.

    If the channel is a logic level high (green) or is alternating between high and low, repeat this step (decrement Vs by 20 mV, wait 3 seconds, and check for a static logic low). Continue until a value for **Vs+** is found.
17. Find the average, V_{sAvg} = (Vs- + Vs+)/2. Record the average as the test result in the test record.

    Compare the test result to the limits. If the result is between the limits, continue with the procedure to test the channel at the +4 V threshold value.
18. Repeat the procedure starting with step *6* on page 35 for each remaining digital channel.
19. Double-tap the **Trigger** badge.
20. Set the **Source** to the appropriate channel, such as D0.
21. Tap **Slope** and change the slope to falling edge.
22. The remaining part of this procedure is for the +4 V threshold test.

    a) Double-tap the **D15-D0** badge on the Settings bar.

    b) Tap the **D15-D8 Turn All On** button to turn all bits on.

    c) Tap the **D7-D0 Turn All On** button to turn all bits on.

    d) Tap the D15-D8 **Thresholds** field at the bottom of the menu and set the value to **4.00 V**.

    e) Tap the D7-D0 **Thresholds** field at the bottom of the menu and set the value to **4.00 V**.

    f) Tap outside the menu to close it.
23. Set the DC voltage source (Vs) to +4.4 V. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

    If the channel is a static logic level low (blue), change the DC voltage source Vs to +4.5 V.
24. Decrement Vs by -20 mV. Wait 3 seconds and check the logic level of the corresponding digital channel in the display. If the channel is at a static logic level low, record the Vs value as **Vs+** in the 4 V row of the test record.

    If the channel is a logic level high (green) or is alternating between high and low, repeat this step (decrement Vs by 20 mV, wait 3 seconds, and check for a static logic low). Continue until a value for **Vs+** is found.

25. Double-tap the **Trigger** badge.

26. Tap **Slope** and change the slope to rising edge.

27. Tap outside the menu to close it.

28. Set the DC voltage source (Vs) to +3.6 V. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

If the channel is a static logic level high (green), change the DC voltage source Vs to +3.5 V.

29. Increment Vs by +20 mV. Wait 3 seconds and check the logic level of the corresponding digital channel in the display. If the channel is at a static logic level high, record the Vs value as in the 4 V row of the test record.

If the channel is a logic level low (blue) or is alternating between high and low, repeat this step (increment Vs by 20 mV, wait 3 seconds, and check for a static logic high). Continue until a value for **Vs-** is found.

30. Find the average, V_{sAvg} = (Vs- + Vs+)/2. Record the average as the test result in the test record.

Compare the test result to the limits. If the result is between the limits, the channel passes the test.

31. Repeat the procedure starting with step *19* on page 35 for each digital channel.

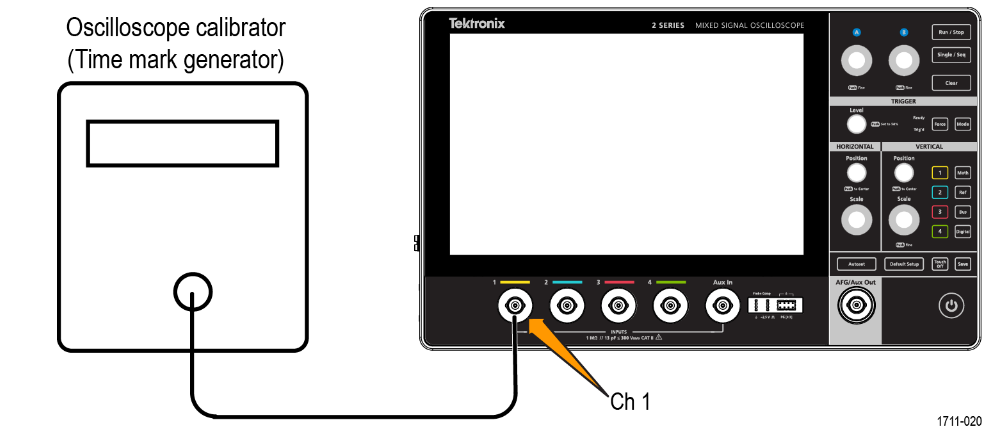
Check long term sample rate

This procedure checks the sample rate and delay time accuracy (time base).

Procedure

WARNING: Set the generator to off or 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure. The generator is capable of providing dangerous voltages.

1. Connect the output of a time mark generator to the oscilloscope channel 1 input.



2. Set the time mark generator period to **80 ms**. Use a time mark waveform with a fast rising edge.

3. If it is adjustable, set the time mark amplitude to approximately **1 V_{P-P}**.

4. Tap **File** > **Default Setup**.

5. Tap the channel **1** button on the Settings bar.

6. Double-tap the Channel 1 badge to open its Configuration menu.

7. Set **Vertical Scale** to **500 mV**.

8. Set the **Position** value to center the time mark signal on the screen.

9. Tap outside the menu area to close it.

10. Double-tap the **Horizontal** settings badge.

11. Set the **Horizontal Scale** to **1 us/div**.

12. Tap outside the menu area to close it.

13. Double-tap the **Trigger** settings badge.

14. Set **Source** to the channel being tested.
15. Set the **Level** as necessary for a triggered display.
16. Tap outside the menu area to close it.
17. Double-tap the **Horizontal** settings badge.
18. Adjust the **Position** value to move the trigger point to the center of the screen.
19. Turn **Delay** to **On** and set **Position** to **80 ms**.
20. Set the **Horizontal Scale** to **1 us/div**.
21. Observe where the rising edge of the marker crosses the center horizontal graticule line. The rising edge should cross within ±2 divisions of the vertical center graticule. Enter the deviation in the test record.

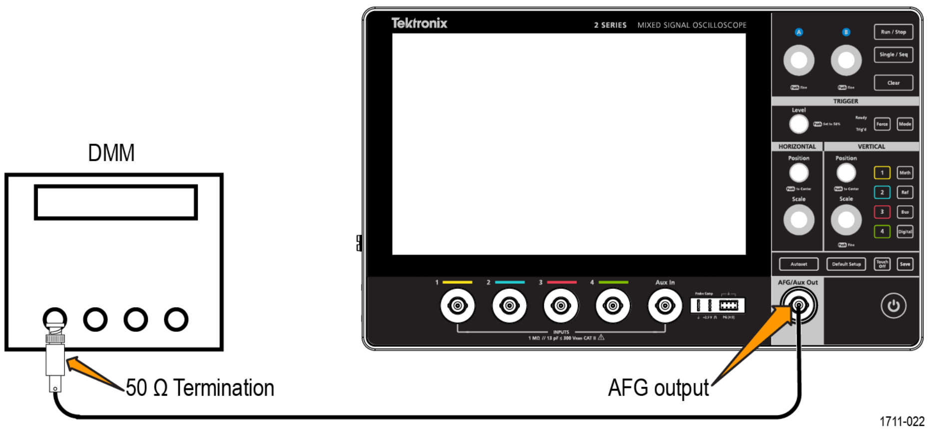
    A 2.5 x 10^{-6} time base error is 2 divisions of displacement.

Check AFG DC offset accuracy

This procedure checks the AFG DC Offset Accuracy.

Procedure

1. Connect the AFG output to the DMM through a 50 Ω termination.



2. Push the **Default Setup** button on the oscilloscope front panel.
3. Tap the **AFG** button.
4. Tap **Waveform Type** and select **DC** from the drop down list.
5. Tap **Amplitude** and set amplitude to the value shown in the test record.
6. Set DMM to measure DC Voltage.
7. Measure voltage on the DMM. Compare the result to the limits in the test record.
8. Repeat steps from *3* on page 37 to *7* on page 37 above for each line in the test record. This completes the procedure.