MDO4000 Series
Mixed Domain Oscilloscopes
Specifications and Performance Verification

Technical Reference

077-0583-01

Tektronix

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Technical Reference

This document supports firmware version 2.94 and above for MDO4000 Series instruments.

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.

Revision A

www.tektronix.com

077-0583-01

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

Table of Contents

List of Tables

General safety summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

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.

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

Connect and disconnect properly. De-energize the circuit under test before connecting or disconnecting the current probe.

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.

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

Connect the probe reference lead to earth ground only.

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

Power disconnect. The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

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

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

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

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.

Symbols and 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.

The following symbol(s) may appear on the product:

Specifications

This chapter contains specifications for the MDO4000 Series oscilloscopes. All specifications are guaranteed unless noted as "typical." Typical specifications are provided for your convenience but are not guaranteed. Specifications that are marked with the ✓ symbol are checked in *Performance Verification*.

All specifications apply to all MDO4000 models unless noted otherwise. To meet specifications, two conditions must first be met:

- The oscilloscope must have been operating continuously for twenty minutes within the specified operating temperature range. (See Table 12 on page 23.)
- You must perform the Signal Path Compensation (SPC) operation described in step 2 of the *Self Test* before evaluating specifications. (See page 62, *Self Test*.) If the operating temperature changes by more than 10 °C (18 °F), you must perform the SPC operation again.

Analog Signal Acquisition System Specifications

The following table shows the specifications for the analog signal acquisition system.

Table 1: Analog signal acquisition system specifications

Characteristic	Description		
Number of input channels	4 analog channels, digitized simultaneously		
Input coupling	DC or AC		
Input resistance selection	1 MΩ or 50 Ω 250 kΩ (to be selected for performance verification only).		
✓ Input impedance, DC coupled	1 MΩ	1 MΩ ±1%	
	50 Ω	50 Ω ±1%	
		MDO4104-X	VSWR ≤1.5:1 from DC to 1 GHz, typical
		MDO4054-X	VSWR ≤1.5:1 from DC to 500 MHz, typical
		MDO4034-3	VSWR ≤1.5:1 from DC to 350 MHz, typical
		MDO4014-3	VSWR ≤1.5:1 from DC to 100 MHz, typical
Input Capacitance, 1 MΩ DC coupled, typical	13 pF ± 2 pF		

Table 1: Analog signal acquisition system specifications (cont.)

Characteristic	Description		
Maximum input voltage	1 MΩ	300 V_{RMS} at the BNC	
		Installation Category II	
		Derate at 20 dB/decade between 4.5 MHz and 45 MHz	
		Derate 14 dB/decade between 45 MHz and 450 MHz	
		Above 450 MHz, 5 V_{RMS}.	
		Maximum peak input voltage at the BNC, ±424 V	
	250 KΩ	75 V_{RMS} at the BNC	
		Installation Category II	
		Derate at 20 dB/decade between 1.3 MHz and 13 MHz	
		Derate 10 dB/decade between 13 MHz and 130 MHz	
		Above 130 MHz, 5 V_{RMS}.	
		Maximum peak input voltage at the BNC, ±106 V	
	50 Ω	5 V_{RMS} with peaks ≤±20 V (Duty Factor ≤ 6.25%)	
		Overvoltage trip is intended to protect against overloads that might damage termination resistors. A sufficiently large impulse might cause damage regardless of the overvoltage protection circuitry because of the finite time required to detect and respond.	
DC Balance	0.1 div with the input DC coupled, set to 50 Ω termination, and input terminated with 50 Ω BNC terminator		
	0.2 div at 1 mV/div with the input DC coupled, set to 50 Ω termination, and input terminated with 50 Ω BNC terminator		
	0.2 div with the input DC coupled, set to 1 MΩ termination, and input terminated with 50 Ω BNC terminator		
Number of digitized bits	8 bits		
	Displayed vertically with 25 digitization levels (DL) per division, 10.24 divisions dynamic range.		
	"DL" is the abbreviation for "digitization level." A DL is the smallest voltage level change that can be resolved by an 8-bit A-D Converter. This value is also known as the least significant bit (LSB).		
Sensitivity range (coarse)	*1 MΩ*	1 mV/div to 10 V/div in a 1-2-5 sequence	
	50 Ω	1 mV/div to 1 V/div in a 1-2-5 sequence	
Sensitivity range (fine)	*1 MΩ*	1 mV/div to 5 V/div	< –50% to > +50% of selected setting
		10 V/div	< –50% to 0%
		Allows continuous adjustment from 1 mV/div to 10 V/div	
	50 Ω	1 mV/div to 500 mV/div	< –50% to > +50% of selected setting
		1 V/div	< –50% to 0%
		Allows continuous adjustment from 1 mV/div to 1 V/div	
Sensitivity resolution (fine), typical	≤1% of current setting		

Table 1: Analog signal acquisition system specifications (cont.)

Characteristic	Description		
✓ DC gain accuracy	*For 50 Ω, 1 MΩ, and 250 kΩ (250 kΩ checked indirectly):* ±1.5%, derated at 0.100%/°C above 30 °C ±2.0%, derated at 0.100%/°C above 30 °C, 1 mV/Div setting ±3.0% variable gain, derated at 0.100%/°C above 30 °C		
Offset ranges, minimum	*Volts/div setting*	*Offset range*	
		1 MΩ input	50 Ω input
	1 mV/div to 50 mV/div	±1 V	±1 V
	50.5 mV/div to 99.5 mV/div	±0.5 V	±0.5 V
	100 mV/div to 500 mV/div	±10 V	±10 V
	505 mV/div to 995 mV/div	±5 V	±5 V
	1 V/div to 5 V/div	±100 V	±5 V
	5.05 V/div to 10 V/div	±50 V	Not applicable
	For 50 Ω path, 1 V/div is the maximum vertical setting. The input signal cannot exceed Max Input Voltage for the 50 Ω input path. Refer to the Max Input Voltage specification for more information.		
Position range	±5 divisions		
✓ Offset accuracy	±[0.005 × | offset – position | + DC Balance] Both the position and the constant offset term must be converted to volts by multiplying by the appropriate volts/div term.		
Number of waveforms for average acquisition mode	2 to 512 waveforms Default of 16 waveforms		
DC voltage measurement accuracy average acquisition mode	Measurement type	DC Accuracy (in Volts)	
	Average of ≥ 16 waveforms	±[DC Gain Accuracy × | reading – (offset - position) | + offset accuracy + 0.1 division] Refer to DC Gain Accuracy for temperature derating information.	
	Delta Volts between any two averages of ≥16 waveforms acquired with the same oscilloscope setup and ambient conditions	±[DC gain accuracy × | reading | + 0.05 div] Refer to DC Gain Accuracy for temperature derating information.	
	Offset, position, and the constant offset term must be converted to volts by multiplying by the appropriate volts/div term. The basic accuracy specification applies directly to any sample and to the following measurements: High, Low, Max, Min, Mean, Cycle Mean, RMS, and Cycle RMS. The delta volt 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.		

Table 1: Analog signal acquisition system specifications (cont.)

Characteristic	Description	
DC voltage measurement accuracy Sample acquisition mode, typical	*Measurement type*	*DC Accuracy (in volts)*
	Any sample	±[DC gain accuracy × | reading – (offset – position) | + Offset Accuracy + 0.15 div + 0.6 mV] Refer to DC Gain Accuracy for temperature derating information.
	Delta volts between any two samples acquired with the same oscilloscope setup and ambient conditions	±[DC gain accuracy × | reading | + 0.15 div + 1.2 mV] Refer to DC Gain Accuracy for temperature derating information.
	Offset, position, and the constant offset term must be converted to volts by multiplying by the appropriate volts/div term.	

Table 1: Analog signal acquisition system specifications (cont.)

Characteristic	Description			
Analog bandwidth selections	MDO4104-6, MDO4104-3, MDO4054-6, MDO4054-3, MDO4034-3: 20 MHz, 250 MHz, and Full MDO4014-3: 20 MHz and Full			
✓ Analog bandwidth, DC coupled	These limits are for ambient temperature of ≤30°C and the bandwidth selection set to FULL. Reduce the upper bandwidth frequency by 1% for each °C above 30°C			
			Volts/Div setting	*Bandwidth*
	50 Ω	MDO4104-X	5 mV/div — 1 V/div	DC to 1.00 GHz
			2 mV/div — 4.98 mV/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4054-X	5 mV/div — 1 V/div	DC to 500 MHz
			2 mV/div — 4.98 mV/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4034-3	2 mV/div — 1 V/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4014-3	1 mV/div — 1 V/div	DC to 100 MHz
	1 MΩ, typical	MDO4104-X	5 mV/div — 10 V/div	DC to 500 MHz
			2 mV/div — 4.98 mV/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4054-X	5 mV/div — 10 V/div	DC to 500 MHz
			2 mV/div — 4.98 mV/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4034-3	2 mV/div — 10 V/div	DC to 350 MHz
			1 mV/div — 1.99 mV/div	DC to 175 MHz
		MDO4014-3	1 mV/div — 10 V/div	DC to 100 MHz
	With TPPXX00 10X probes, typical	MDO4104-X (TPP1000 probe)	50 mV/div — 100 V/div	DC to 1 GHz
			20 mV/div — 49.8 mV/div	DC to 350 MHz
			10 mV/div — 19.9 mV/div	DC to 175 MHz
		MDO4054-X (TPP0500 probe)	50 mV/div — 100 V/div	DC to 500 MHz
			20 mV/div — 49.8 mV/div	DC to 350 MHz
			10 mV/div — 19.9 mV/div	DC to 175 MHz
		MDO4034-3 (TPP0500)	20 mV/div — 100 V/div	DC to 350 MHz
			10 mV/div — 19.9 mV/div	DC to 175 MHz
		MDO4014-3 (TPP0500)	10 mV/div — 100 V/div	DC to 100 MHz
Lower frequency limit, AC coupled, typical	< 10 Hz when AC, 1 MΩ coupled The AC coupled lower frequency limits are reduced by a factor of 10 when 10X passive probes are used.			
Upper frequency limit, 250 MHz bandwidth limited, typical	250 MHz, ±20%, all models except MDO4014-3			

Table 1: Analog signal acquisition system specifications (cont.)

Upper frequency limit, 20 MHz bandwidth limited, typical	20 MHz, ±20%, all models			
Calculated rise time at 0.350/BW = t_r, typical	The formula is calculated by measuring -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.			
	Model	*50 Ω 1 mV/div to 1.99 mV/div*	*50 Ω 2 mV/div to 4.99 mV/div*	*50 Ω 5 mV/div to 1 V/div*
	MDO4104-X	2 ns	1 ns	350 ps
	MDO4054-X	2 ns	1 ns	700 ps
	MDO4034-3	2 ns	1 ns	1 ns
	MDO4014-3	3.5 ns	3.5 ns	3.5 ns
	Model	*TPP1000 probe 10 mV/div to 19.9 mV/div*	*TPP1000 probe 20 mV/div to 49.8 mV/div*	*TPP1000 probe 50 mV/div to 10 V/div*
	MDO4104-X	2 ns	1 ns	350 ps
	MDO4054-X	2 ns	1 ns	700 ps
	MDO4034-3	2 ns	1 ns	1 ns
	MDO4014-3	3.5 ns	3.5 ns	3.5 ns
	Model	*TPP0500 probe 10 mV/div to 19.9 mV/div*	*TPP0500 probe 20 mV/div to 49.8 mV/div*	*TPP0500 probe 50 mV/div to 10 V/div*
	MDO4104-X	2 ns	1 ns	700 ps
	MDO4054-X	2 ns	1 ns	700 ps
	MDO4034-3	2 ns	1 ns	1 ns
	MDO4014-3	3.5 ns	3.5 ns	3.5 ns
Peak Detect or Envelope mode pulse response, typical	*Model (Sample Rate Maximum)*		*Minimum pulse width*	
	MDO4104-X (≤2 channels enabled)		>800 ps	
	MDO4104-X (≥3 channels enabled), MDO4054-X, MDO4034-3, MDO4014-3		>1.6 ns	

Table 1: Analog signal acquisition system specifications (cont.)

✓ Random Noise, Sample Acquisition Mode	*Model*	*Bandwidth limit*	*RMS noise (mV)*	
			1 M Ω	*50 Ω*
	MDO4104-X	Full Bandwidth	≤ (300 µV + 8.0% of Volts/div setting)	≤ (75 µV + 6.0% of Volts/div setting)
		250 MHz bandwidth	≤ (100 µV + 5.0% of Volts/div setting)	≤ (50 µV + 4.0% of Volts/div setting)
		20 MHz bandwidth	≤ (100 µV + 5.0% of Volts/div setting)	≤ (50 µV + 4.0% of Volts/div setting)
	MDO4054-X, MDO4034-3, MDO4014-3	Full Bandwidth	≤ (130 µV + 8.0% of Volts/div setting)	≤ (130 µV + 8.0% of Volts/div setting)
		250 MHz bandwidth (except MDO4014-3)	≤ (100 µV + 6.0% of Volts/div setting)	≤ (100 µV + 6.0% of Volts/div setting)
		20 MHz bandwidth	≤ (100 µV + 4.0% of Volts/div setting)	≤ (100 µV + 4.0% of Volts/div setting)
Delay between channels, full bandwidth, typical	≤100 ps between any two analog or digital channels with input impedance set to 50 Ω, DC coupling, with equal volts/division setting or above 10 mV/div All settings in the instrument can be manually time aligned using the Probe Deskew function from –125 ns to +125 ns with a resolution of 20 ps This specification does not pertain to the RF channel. For RF channel delay, see the RF Input Specifications.			
Deskew range	–125 ns to +125 ns with a resolution of 20 ps			
Crosstalk (channel isolation), typical	≥100:1 at ≤100 MHz and ≥30:1 at >100 MHz up to the rated bandwidth for any two channels having equal Volts/Div settings			
TekVPI Interface	The probe interface allows installing, powering, compensating, and controlling a wide range of probes offering a variety of features. The interface is available on all front panel inputs. (RF channel requires TPA-N-VPI adapter.)			
Total probe power	FiveTektronix VPI-compliant probe interfaces (one per channel). (RF channel requires TPA-N-VPI adapter.) 50 W maximum internal probe power (total for all 5 VPI ports)			
Probe power per channel	*Voltage*	*Max Amperage*	*Voltage Tolerance*	
	5 V	50 mA (250 mW)	±5%	
	12 V	2 A (24 W)	±10%	

Time Base System Specifications

The following table shows the horizontal and acquisition system specifications for the MDO4000 Series oscilloscopes.

Table 2: Time base system specifications

Characteristic	Description			
Sample-rate range	MDO4104-X	2.5 S/s – 5 GS/s (1 – 2 analog channels enabled)		
		2.5 S/s – 2.5 GS/s (3 – 4 analog channels enabled)		
	MDO4054-X, MDO4034-3, MDO4014-3	2.5 S/s – 2.5 GS/s		
Record Length Range	20 M, 10 M, 1 M, 100 k, 10 k, 1 k			
Seconds/Division range	*Instrument*	*1 k*	*10 k*	*100 k – 20 M*
	MDO4104-X (2 channels enabled)	400 ps – 40 s	400 ps – 400 s	400 ps – 1,000 s
	MDO4104-X (4 channels enabled), MDO4054-X, MDO4034-3, MDO4014-3	1 ns – 40 s	1 ns – 400 s	1 ns – 1,000 s
Maximum triggered acquisition rate	> 50,000 wfm/s			
Aperture Uncertainty	≤(3 ps + 0.1 ppm × record duration)$_{RMS}$, for records having ≤1 minute duration			
Long-term sample rate and delay time accuracy	±5 ppm over any ≥1 ms time interval			

Table 2: Time base system specifications (cont.)

Characteristic	Description
Delta-time measurement accuracy	The formula to calculate the delta-time measurement accuracy (DTA) for a given instrument setting and input signal is given in the following table. (See Table 3.) The formula assumes insignificant signal content above Nyquist and insignificant error due to aliasing. The abbreviations used in the formula are as follows: SR_1 = slew rate around 1st point in measurement (1st edge) SR_2 = slew rate around 2nd point in measurement (2nd edge) N =input-referred noise (V_{RMS}) (Refer to *Random Noise* and *Sample Acquisition Mode* specifications.) TBA = time base accuracy (5 ppm) (Refer to *Long-term Sample Rate* and *Delay Time Accuracy* specifications.) t_p = delta-time measurement duration (sec) RD = (record length)/(sample rate) t_{sr} = 1/(sample rate) assume edge shape that results from Gaussian filter response
	The term under the squareroot sign is the stability and is due to TIE (Time Interval Error). 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).

Table 3: Delta-Time measurement accuracy formula

The terms used in these formulas are defined under *Delta-time measurement accuracy*, in the preceding table. (See Table 2.)

$$DTA_{pk-pk} = \pm 5 \times \sqrt{2\left[\frac{N}{SR_1}\right]^2 + 2\left[\frac{N}{SR_2}\right]^2 + (3ps + 1 \times 10^{-7} \times RD)^2} + 2t_{sr} + TBA \times t_p$$

$$DTA_{rms} = \sqrt{2\left[\frac{N}{SR_1}\right]^2 + 2\left[\frac{N}{SR_2}\right]^2 + (3ps + 1 \times 10^{-7} \times RD)^2 + \left(\frac{2 \times t_{sr}}{\sqrt{12}}\right)^2} + TBA \times t_p$$

Triggering System Specifications

The following table shows the trigger specifications for analog and digital channels on the MDO4000 Series oscilloscopes. These specifications do not apply to the RF input channel.

NOTE. *For RF, please see the analog to RF trigger skew specification.* *(See page 17, RF Input Specifications.)*

Table 4: Trigger specifications

Characteristic	Description		
Trigger bandwidth, Edge, typical	MDO4104-X	1 GHz	
	MDO4054-X	500 MHz	
	MDO4034-3	350 MHz	
	MDO4014-3	100 MHz	
Trigger bandwidth, Pulse and Logic, typical	MDO4104-X	1 GHz	
	MDO4054-X	500 MHz	
	MDO4034-3	350 MHz	
	MDO4014-3	100 MHz	
Edge-type trigger sensitivity, DC coupled, typical	*Model*	*Trigger Source*	*Sensitivity*
	MDO4104-X	Any input channel	50 Ω path: 0.40 div from DC to 50 MHz, increasing to 1 div at oscilloscope bandwidth
	MDO4054-X, MDO4034-3, MDO4014-3	Any input channel	50 Ω path: 1 mV/div to 4.98 mV/div — 0.75 div from DC to 50 MHz, increasing to 1.3 div at oscilloscope bandwidth. ≥5 mV/div — 0.40 div from DC to 50 MHz, increasing to 1 div at oscilloscope bandwidth.
	All models	Any input channel	1 MΩ path: 1 mV/div to 4.98 mV/div – 0.75 div from DC to 50 MHz, increasing to 1.3 div at oscilloscope bandwidth. ≥5 mV/div – 0.40 div from DC to 50 MHz, increasing to 1 div at oscilloscope bandwidth.
	All models	Line	Fixed
Trigger jitter, typical	≤10 ps_{RMS} for edge-type trigger ≤100 ps_{RMS} for non edge-type trigger modes		

Table 4: Trigger specifications (cont.)

Characteristic	Description			
Edge-type trigger sensitivity, not DC coupled, typical	*Trigger Coupling*	*Typical Sensitivity*		
	AC Coupling	1 div for frequencies above 45 Hz. Attenuates signals below 45 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	1.5 times the DC-coupled limits for frequencies above 50 kHz. Attenuates signals below 50 kHz		
Video-type trigger formats and field rates	Triggers from negative sync composite video, field 1, or field 2 for interlaced systems, on any field, specific line, or any line for interlaced or noninterlaced systems. Supported systems include NTSC, PAL, and SECAM.			
Video-type trigger sensitivity, typical	*Delayed and main trigger*			
	Source	*Sensitivity*		
	Any input channel	0.6 to 2.5 divisions of video sync tip		
Lowest frequency for successful operation of "Set Level to 50%" function, typical	45 Hz			
Logic-type or logic qualified trigger or events-delay sensitivities, DC coupled, typical	1.0 division from DC to maximum bandwidth			
Pulse-type runt trigger sensitivities, typical	1.0 division from DC to maximum bandwidth			
Pulse-type trigger width and glitch sensitivities, typical	1.0 division			
Logic-type triggering, minimum logic or rearm time, typical	For all vertical settings, the minimums are:			
	Trigger type	*Pulse width*	*Re-arm time*	*Time between channels*
	Logic	Not applicable	2 ns	1 ns
	Time Qualified Logic	4 ns	2 ns	1 ns
	For logic, the 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.			
Minimum clock pulse widths for setup/hold time violation trigger, typical	*For all vertical settings, the minimums are:*			
	Clock active	*Clock inactive*		
	User hold time + 2.5 ns	2 ns		
	An active pulse width is the width of the clock pulse from its active edge (as defined in the Clock Edge lower-bezel menu item) to its inactive edge. An inactive pulse width is the width of the pulse from its inactive edge to its active edge. The user hold time is the number selected by the user.			

Table 4: Trigger specifications (cont.)

Setup/hold violation trigger, setup and hold time ranges	*Feature*	*Min*	*Max*
	Setup time	–0.5 ns	1.0 ms
	Hold time	1 ns	1.0 ms
	Setup + Hold time	0.5 ns	2.0 ms
	Input coupling on 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 Hold Time that you programmed.		
Pulse type trigger, minimum pulse, rearm time, transition time	*Pulse class*	*Minimum pulse width*	*Minimum rearm time*
	Glitch	4 ns	2 ns + 5% of glitch width setting
	Runt	4 ns	2 ns
	Time-qualified runt	4 ns	8.5 ns + 5% of width setting
	Width	4 ns	2 ns + 5% of width upper limit setting
	Slew rate (transition time)	4 ns	8.5 ns + 5% of delta time setting
	For the trigger class width and the trigger class runt, the pulse width refers to the width of the pulse being measured. The rearm time refers to the time between pulses. For the trigger class slew rate, the pulse width refers to the delta time being measured. The rearm time refers to the time it takes the signal to cross the two trigger thresholds again.		
Transition time trigger, delta time range	4 ns to 8 s		
Time range for glitch, pulse width, timeout, time-qualified runt, or time-qualified window triggering	4 ns to 8 s		
Time Accuracy for Pulse, Glitch, Timeout, or Width Triggering	*Time Range*	*Accuracy*	
	1 ns to 500 ns	±(20% of setting + 0.5 ns)	
	520 ns to 1 s	±(0.01% of setting + 100 ns)	
B trigger after events, minimum pulse width and maximum event frequency, typical	4 ns, 500 MHz		
B trigger, minimum time between arm and trigger, typical	4 ns For trigger after time, this is the time between the end of the time period and the B trigger event. For trigger after events, this is the time between the last A trigger event and the first B trigger event.		
B trigger after time, time range	4 ns to 8 seconds		
B trigger after events, event range	1 to 4,000,000		

Table 4: Trigger specifications (cont.)

Trigger level ranges	*Source*	*Range*
	Any input channel	±8 divisions from center of screen ±8 divisions from 0 V when vertical LF reject trigger coupling is selected
	Line	Not applicable
	Line trigger level is fixed at about 50% of the line voltage. This specification applies to logic and pulse thresholds.	
Trigger level accuracy, DC coupled, typical	For signals having rise and fall times ≥10 ns.	
	Source	*Range*
	Any input channel	±0.20 div
	Line	Not applicable
Trigger holdoff range	20 ns minimum to 8 s maximum	
Maximum serial trigger bits	128 bits	
Standard serial bus interface triggering		
I^{2}C	**Address Triggering:** 7 and 10 bit user specified addresses, as well as General Call, START byte, HS-mode, EEPROM, and CBUS **Data Trigger:** 1 to 5 bytes of user specified data **Trigger On:** Start, Repeated Start, Stop, Missing Ack, Address, Data, or Address and Data **Maximum Data Rate:** 10 Mbps	
SPI	**Data Trigger:** 1 to 16 bytes of user-specified data **Trigger On:** SS Active, MOSI, MISO, or MOSI & MISO **Maximum Data Rate:** 50 Mbps	
CAN	**Data Trigger:** 1 to 8 bytes of user-specified data, including qualifiers of equal to (=), not equal to (<>), less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=) **Trigger On:** Start of Frame, Type of Frame, Identifier, Data, Identifier and Data, End of Frame, Missing Ack, or Bit Stuffing Errors **Frame Type:** Data, Remote, Error, Overload **Identifier:** Standard (11 bit) and Extended (29 bit) identifiers **Maximum Data Rate:** 1 Mbps	
LIN	**Identifier Trigger:** 6 bits of user-specified data, equal to (=) **Data Trigger:** 1 to 8 bytes of user-specified data, including qualifiers of equal to (=), not equal to (<>), less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, or outside range **Error:** Sync, Identifier Parity, Checksum **Trigger On:** Sync, Identifier, Data, Identifier & Data, Wakeup Frame, Sleep Frame, or Error **Maximum Data Rate:** 100 kbps	

Table 4: Trigger specifications (cont.)

FlexRay	**Indicator bits**: Normal Frame, Payload Frame, Null Frame, Sync Frame, Startup Frame **Identifier Trigger**: 11 bits of user-specified data, equal to (=), not equal to (<>), less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), Inside Range, or Outside Range **Cycle Count Trigger**: 6 bits of user-specified data, equal to (=) **Header Fields Trigger**: 40 bits of user-specified data comprising Indicator Bits, Identifier, Payload Length, Header CRC, Cycle Count, or equal to (=) **Data Trigger:** 1 to 16 Bytes of user-specified data, with 0 to 253, or "don't care" bytes of data offset, including qualifiers of equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), Inside Range, Outside Range **End Of Frame:** User-chosen types Static, Dynamic (DTS), and All **Error:** Header CRC, Trailer CRC, Null Frame-static, Null Frame-dynamic, Sync Frame, Startup Frame **Trigger On:** Start of Frame, Indicator Bits, Identifier, Cycle Count, Header Fields, Data, Identifier & Data, End of Frame, or Error **Maximum Data Rate:** 100 Mbps
Audio	
I^{2}S	**Data Trigger:** 32 bits of user-specified data in a left word, right word, or either, including qualifiers of equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, outside range **Trigger on:** Word Select, Data **Maximum Data Rate:** 12.5 Mbps
Left Justified	**Data Trigger:** 32 bits of user-specified data in a left word, right word, or either, including qualifiers of equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, outside range **Trigger on:** Word Select, Data **Maximum Data Rate:** 12.5 Mbps
Right Justified	**Data Trigger:** 32 bits of user-specified data in a left word, right word, or either, including qualifiers of equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, outside range **Trigger on:** Word Select, Data **Maximum Data Rate:** 12.5 Mbps
TDM	**Data Trigger:** 32 bits of user-specified data in a channel 0-7, including qualifiers of equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, outside range **Trigger on:** Frame Sync, Data **Maximum Data Rate:** 25 Mbps
RS-232	**Bit Rate:** 50 bps to 10 Mbps **Data Bits:** 7, 8, or 9 **Parity:** None, Odd, or Even **Trigger on:** Tx Start bit, Rx Start bit, Tx End of Packet, Rx End of Packet, Tx Data, Rx Data, Tx Parity Error, Rx Parity Error **End of Packet:** 00 (NUL), OA (LF), OD (CR), 20 (SP), FF

Table 4: Trigger specifications (cont.)

MIL-STD-1553	**Bit Rate:** 1 Mb/s **Trigger on:** Sync, Word Type (Command, Status, Data), Command Word (set RT Address (=, ≠, <, >, ≤, ≥, inside range, outside range), T/R, Sub-address/Mode, Data Word Count/Mode Code, and Parity individually), Status Word (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)
USB	**Data Rates Supported:** HS: 480 Mbps, Full: 12 Mbps, Low: 1.5 Mbps **Trigger On:** Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error ***NOTE.*** *HIGH SPEED support available only on MDO4104-3 and MDO4104-6 models.*
Ethernet	**Bit Rate:** 10BASE-T, 10 Mbps; 100BASE-TX, 100 Mbps **Trigger On:** Start Frame Delimiter (SFD), MAC Address, MAC Length/Type, IP Header, TCP Header, TCP/IPv4/MAC Client Data, End of Packet, Idle, FCS (CRC) Error, MAC Q-Tag control Information.

Digital Acquisition System Specifications

The following table shows the digital acquisition specifications for the MDO4000 Series oscilloscopes.

Table 5: Digital acquisition specifications

Characteristic	Description
Threshold voltage range	–40 V to +40 V
Digital channel timing resolution	2 ns main memory, 60.6 ps for MagniVu memory
✓ Logic threshold accuracy	±(100 mV + 3% of threshold setting after calibration) Requires valid SPC, as described in step 2 of the *Self Test*. (See page 62, *Self Test*.)
Minimum detectable pulse width, typical	1 ns Using MagniVu memory. Requires the use of 342-1140-00 ground clip on each channel.

P6616 Digital Probe Input Specifications

The following table shows the P6616 Digital Probe specifications.

Table 6: P6616 digital probe input specifications

Characteristic	Description
Number of channels	16 digital inputs
Input resistance, typical	100 kΩ to ground
Input capacitance, typical	3.0 pF Measured at the podlet input. Requires the use of 342-1140-00 ground clip on each channel
Minimum input signal swing, typical	400 mV_{p-p} Requires the use of 342-1140-00 ground clip on each channel
Maximum input signal swing, typical	30 V_{p-p} for f_{in} ≤ 200 MHz (centered around the DC threshold voltage) at the P6616 probe tip. 10 V_{p-p} for f_{in} >200 MHz (centered around the DC threshold voltage) at the P6616 probe tip. Failure to meet this input signal requirement will compromise the AC performance of the digital channel. It might also damage the input circuitry. See the Absolute maximum input voltage specification.
Maximum Input Toggle Rate, typical	500 MHz Maximum frequency sine wave input (at the minimum signal swing amplitude) that can accurately be reproduced as a logic square wave. Requires the use of a 342-1140-00 ground clip on each channel. Higher toggle rates can be achieved with higher amplitudes.
Absolute maximum input voltage, typical	±42 V peak at the P6616 input (not at the instrument input) Probe input voltages beyond this limit could permanently damage the instrument and the P6616 probe.
Channel-to-channel skew, typical	200 ps Digital channel to digital channel only. This is the propagation path skew and ignores skew contributions due to threshold inaccuracies (see Threshold accuracy) and sample binning (see Digital channel timing resolution). Factory calibration/deskew is required to achieve this number.

RF Input Specifications

The following table shows the RF input specifications for the MDO4000 Series oscilloscopes.

Table 7: RF input specifications

Characteristic	Description	
Center frequency range	MDO4104-6, MDO4054-6	50 kHz to 6 GHz
	MDO4104-3, MDO4054-3, MDO4034-3, MDO4014-3	50 kHz to 3 GHz
Frequency measurement resolution	1 Hz	
Span	Span adjustable in 1-2-5 sequence Variable resolution = 1% of the next span setting The MDO4XX4-6 Span is adjustable from 1 kHz to 6 GHz The MDO4XX4-3 Span is adjustable from 1 kHz to 3 GHz	
Resolution bandwidth (RBW)	Adjustable in 1-2-3-5 sequence. Maximum of 10 MHz RBW Minimum RBW for Windowing functions as follows: 30 Hz Kaiser, Blackman-Harris 20 Hz Rectangular, Hamming, Hanning 50 Hz Flat-Top 60 dB/3 dB shape factor (Kaiser, Blackman-Harris) 4:1 ratio	
Input vertical range	Vertical measurement range +30 dBm to DANL. Vertical setting of 1 dB/div to 20 dB/div in a 1-2-5 sequence Attenuator settings from 0 to 45 dB, in 5 dB steps	
Level display range	**Log scale and units:** dBm, dBmV, dBµV, dBµW, dBmA, dBµA **Measurement points:** 1000 **Marker level readout resolution:** Log scale: 0.1 dB **Maximum number of RF traces:** 4 **Trace functions:** maximum hold, average, minimum hold, normal, spectrogram slice (uses normal trace) **Detection methods:** Positive-Peak, negative-peak, sample, average	
Reference level	**Setting range:** –140 dBm to +30 dBm, in steps of 5 dBm **Default setting:** 0 dBm	
Vertical position	–10 divisions to +10 divisions (displayed in dB)	
Maximum operating input level	**Average continuous power:** +30 dBm (1W) **DC maximum before damage:** ±40 Vdc **Maximum "no damage"** 33 dBm (2W) CW **Peak pulse power:** +45 dBm (32W)	
	Peak Pulse Power is defined as: <10 us pulse width, <1% duty cycle, and a reference level of ≥ +10 dBm.	

Table 7: RF input specifications (cont.)

Characteristic	Description	
Frequency measurement accuracy	**Marker Frequency** All models: ±(Reference Frequency Error * MarkerFrequency + .001 * span + 2) Hz. Marker Frequency with Span/RBW ≤ 1000:1 Reference frequency error = ±5 ppm	
✓ Phase noise	10 kHz offset: < –90 dBc/Hz (< –95 dBc/Hz, typical) 100 kHz offset: < –95 dBc/Hz (< –98 dBc/Hz, typical) 1 MHz offset: < –113 dBc/Hz (< –118 dBc/Hz, typical)	
Residual FM, typical	≤100 Hz peak-to-peak in 100 ms	
Resolution bandwidth (RBW) accuracy	Max RBW % Error = (0.5/(25 x WF)) * 100	
	WF = Rectangular: 0.89 Hamming: 1.30 Hanning: 1.44 Blackman-Harris: 1.90 Kaiser: 2.23 Flat-Top: 3.77	
✓ Displayed average noise level (DANL)	MDO4104-6 MDO4054-6	50 kHz to 5 MHz: < –130 dBm/Hz (< –134 dBm/Hz, typical) 5 MHz to 3 GHz: < –148 dBm/Hz (< –152 dBm/Hz, typical) 3 GHz to 6 GHz: < –140 dBm/Hz (< –143 dBm/Hz, typical)
	MDO4104-3, MDO4054-3, MDO4034-3, MDO4014-3	50 kHz to 5 MHz: < –130 dBm/Hz (< –134 dBm/Hz, typical) 5 MHz to 3 GHz: < –148 dBm/Hz (< –152 dBm/Hz, typical)
1 dB gain compression	>5 dBm	
	With reference level set to –10 dBm	
✓ Level measurement uncertainty	< ±1 dB (<±0.5 dB typical) 20 °C to 30 °C temperature range, reference level 10 dBm to –25 dBm. Input level ranging from reference level to 30 dB below reference level. < ±1.5 dB, Ta > 30 °C and Ta < 20 °C temperature range, reference level 10 dBm to –25 dBm. Input level ranging from reference level to 30 dB below reference level.	

Table 7: RF input specifications (cont.)

Characteristic	Description
Spurious response	**2nd and 3rd harmonic distortion >100 MHz:** < –55 dBc (< –60 dBc Typical) With auto settings on, signals –5 dB below reference level
	2nd and 3rd harmonic distortion: >50 kHz: < –55 dBc (< –60 dBc Typical) With auto settings on, signals –5 dB below reference level, and reference level ≤ -15 dBm
	2nd order intermodulation distortion: >200 MHz: < –55 dBc (< –60 dBc Typical) With auto settings on and signals –5 dB below reference level
	2nd order intermodulation distortion: >50 kHz: < –55 dBc (< –60 dBc Typical) With auto settings on, signals –5 dB below reference level, and reference level ≤ –15 dBm
	Other A/D spurs: < –55 dBc (< –60 dBc Typical)
✓ Third order intermodulation distortion	**3rd order intermodulation distortion >15 MHz:** < –60 dBc (< –63 dBc Typical) With auto settings on, signals –5 dB below reference level
	3rd order intermodulation distortion >50 kHz: < –60 dBc (< –63 dBc Typical) With auto settings on, signals –5 dB below reference level, and reference level ≤ –15 dBm
Image and IF rejection	< –50 dBc (< –55 dBc typical)
	With –10 dBm reference level
✓ Residual spurious response	< –78 dBm
	With ≤ –25 dBm reference level and RF input terminated with 50 Ω.
Power level trigger frequency and amplitude range	Frequency range: 1 MHz to 6 GHz (MDO4XX4-6 models) 1 MHz to 3 GHz (MDO4XX4-3 models) Amplitude range: 30 dBm to -40 dBm
RF to analog channel skew, typical	Maximum time between analog channels triggered and RF channel: < 5 ns
Power level trigger limits	Center frequency 1 MHz to 3.25 GHz: –35 dB from reference level Center frequency >3.25 GHz: –13 dB from reference level Minimum pulse duration: 10 µs ON time with a minimum settling OFF time of 10 µs.
✓ Crosstalk to RF channel from analog channels	< -68 dB from reference level (≤1 GHz oscilloscope input frequencies) < -48 dB from reference level (>1 GHz to 2 GHz oscilloscope input frequencies)
	Full scale amplitude with 50 Ω input and 100 mV/div vertical setting with direct input (no probes).
Channel power accuracy, Typical	< ±1 dB (<±0.5 dB Typical) 20-30 °C temperature range < ±1.5 dB, Ta >30 °C and Ta <20 °C temperature range
Occupied bandwidth accuracy, Typical	± Span/1000
Adjacent channel power ratio, Typical	-58 dBc

Display System Specifications

The following table shows the display specifications for the MDO4000 Series oscilloscopes.

Table 8: Display system specifications

Characteristic	Description
Display type	Display area: 210.4 mm (8.28 in) (H) x 157.8 mm (6.21 in) (V), 264 mm (10.4 in) diagonal, 6-bit RGB full color, XGA (1024 x 768) TFT liquid crystal display (LCD).
Display resolution	1024 X 768 XGA display resolution
Luminance, typical	400 cd/m^2
Waveform display color scale	The TFT display can support up to 262,144 colors. A subset of these colors is used for the oscilloscope display. The colors that are used are fixed and not changeable by the user.

Interfaces and Input/Output Port Specifications

The following table shows the interfaces and input/output port specifications for the MDO4000 Series oscilloscopes.

Table 9: Interfaces and Input/Output port specifications

Characteristic	Description	
Ethernet interface	Standard on all models: 10/100/1000 Mbps	
GPIB interface	Available as an optional accessory (TEK-USB-488 GPIB to USB Adapter), which connects to the USB Device and USB Host port. The control interface is incorporated into the instrument user interface.	
Video signal output	A 15-pin D-sub VGA connector.	
USB interface	4 USB host connectors (2.0 HS), two on the instrument front and two on the rear. 1 USB device connector (2.0 HS), on the instrument rear panel. All are standard on all models.	
Probe compensator output voltage and frequency, typical	*Output Voltage* Default: 0 – 2.5 V amplitude, ± 2% (Source Impedance of 1kΩ) TPPXX00 Cal Mode: 0 – 2.5 V amplitude, ± 5% (Source Impedance of ≤25Ω) *Frequency* 1 kHz, ± 25%	
Auxiliary output (AUX OUT) Trigger Out or Reference Clock Out	You can set the Auxiliary output to Trigger Out or Reference Clock Out. Reference Clock Out: Outputs the 10 MHz oscilloscope reference clock. Trigger Out: A HIGH to LOW transition indicates that the trigger occurred.	
	Trigger output logic levels	
	Characteristic	*Limits*
	Vout (HI)	≥2.5 V open circuit ≥1.0 V into a 50 Ω load to ground
	Vout (LO)	≤0.7 V into a load of ≤4 mA ≤0.25 V into a 50 Ω load to ground
External Reference nominal input frequency	10 MHz You must select either the internal reference (default) or 10 MHz external.	
External Reference input frequency variation tolerance, typical	9.9 MHz to 10.1 MHz You must run SPC, described in step 2 of the *Self Test*, whenever the external reference is more than 0.2% (2000 ppm) different than the nominal reference frequency or reference at which SPC was last run. (See page 62, *Self Test*.) The time base changes in correspondence to the fluctuations in the external reference.	
External Reference input sensitivity, typical	1.5 V_{p-p} for input frequencies between 9.9 MHz and 10.1 MHz	
External Reference input maximum input signal	7 V_{p-p}	
External Reference input impedance, typical	Rin = 1.5 kΩ ±20% in parallel with 15 pF ±5 pF at 10 MHz	

Data Handling Specifications

The following table shows the data handling specifications for the MDO4000 Series oscilloscopes.

Table 10: Data handling specifications

Characteristic	Description
Nonvolatile memory retention time, typical	No time limit for front-panel settings, saved waveforms, setups, or calibration constants. 10 M and 20 M records saved as Reference waveforms are not saved in the nonvolatile memory and they will not be saved across a power cycle.
Real-time clock	A programmable clock providing time in years, months, days, hours, minutes, and seconds

Power Supply System Specifications

The following table shows the power supply system specifications for the MDO4000 Series oscilloscopes.

Table 11: Power supply system specifications

Characteristic	Description
Operating line frequency and voltage range	Volts: 100 – 240; Hz: 50 – 60 Volts: 115: Hz: 400
Maximum power consumption:	225 W
Source voltage	100 V to 240 V ±10%
Source frequency	(85 to 264 V) 45 Hz to 66 Hz (100 V to 132 V) 360 Hz to 440 Hz
Fuse rating	T6.3AH, 250 VAC The fuse cannot be replaced by the user.

Environmental Specifications

The following table shows the environmental specifications for the MDO4000 Series oscilloscopes.

Table 12: Environmental specifications

Characteristic	Description
Temperature	Operating: 0 °C to +50 °C (32 °F to +122 °F) Nonoperating: -20 °C to +60 °C (-4 °F to +140 °F)
Humidity	Operating: High: 40 °C to 50 °C (104 °F to 122 °F), 10% to 60% relative humidity Low: 0 °C to 40 °C (32 °F to 104 °F), 10% to 90% relative humidity Nonoperating: High: 40 °C to 60 °C (104 °F to 140 °F), 5% to 60% relative humidity Low: 0 °C to 40 °C (32 °F to 104 °F), 5% to 90% relative humidity
Altitude	Operating: 3,000 m (9,843 ft) Nonoperating: 12,000 m (39,370 ft)
Pollution Degree	Pollution Degree 2, indoor use only

Mechanical Specifications

The following table shows the mechanical specifications for the MDO4000 Series oscilloscopes.

Table 13: Mechanical specifications

Characteristic	Description
Weight	*Benchtop configuration (oscilloscope only)* Requirements that follow are nominal: 11.0 lbs (5.0 kg), stand-alone instrument, without front cover. 18.8 lbs (8.5 kg), instrument with rackmount, without front cover 23.6 lbs (10.7 kg), when packaged for domestic shipment (without rackmount)
Dimensions	*Benchtop configuration (oscilloscope only)* Requirements that follow are nominal and unboxed Height: 9.0 in (229 mm) feet folded in, handle folded down 9.8 in (249 mm) feet folded out, handle folded down 11.5 in (292 mm) feet folded in, handle folded up 12.3 in (312 mm) feet folded out, handled folded up Width: 17.3 in (439 mm) from handle hub to handle hub Depth: 5.8 in (147 mm) from back of feet to front of knobs 6.1 in (155 mm) from back of feet to front of front cover 9.8 in (249 mm) from handle to front of knobs (handle folded to back side of unit) Box Dimensions: Height: 15.7 in (399 mm) Width: 15.6 in (396 mm) Length: 22.2 in (564 mm) *Rackmount configuration* Requirements that follow are nominal and unboxed (5U rack sizes): Height: 8.6 in (218 mm) Width: 19.2 in (488 mm), from outside of handle to outside of handle Depth: 15.1 in (384 mm), from outside of handle to back of slide
Clearance Requirements	0 mm (0 in), top 0 in (0 mm), bottom, on feet, with flip stands down 2 in (50.8 mm), left side (facing the front of the instrument) 0 in (0 mm), right side (facing the front of the instrument) 2 in (50.8 mm), rear (where the power cord is plugged in)

TPA-N-PRE Specifications

The following tables shows the TPA-N-PRE Preamplifier specifications.

Table 14: TPA-N-PRE specifications

Characteristic	Description
Frequency range	Preamp: 9 kHz to 6 GHz MDO4XX4-6 with preamp: 50 kHz to 6 GHz MDO4XX4-3 with preamp: 50 kHz to 3 GHz
Preamp gain	Amplifying state: 12 dB (nominal) Bypass state: –1.5 dB (nominal)
Displayed average noise level (DANL) of the MDO4000 with the preamp attached to the MDO's RF input	With the preamp mode set to "Auto" and the reference level set to -40 dBm MDO4XX4-6: 50 kHz to 5 MHz: < –140 dBm/Hz (–144 dBm/Hz typical) 5 MHz to 3 GHz: < –158 dBm/Hz (–162 dBm/Hz typical) 3 GHz to 6 GHz: < –150 dBm/Hz (–153 dBm/Hz typical) MDO4XX4-3: 50 kHz to 5 MHz: < –140 dBm/Hz (–144 dBm/Hz typical) 5 MHz to 3 GHz: < –158 dBm/Hz (–162 dBm//Hz typical)
Level measurement uncertainty of the MDO4000 with the preamp attached to the MDO's RF input	With the preamp mode set to "Auto", reference level 10 dBm to –40 dBm and input level ranging from reference level to 30 dB below reference level. Specifications exclude mismatch error at the preamp input and applies to both amplifying and bypass states. < ±1.5 dB (typical), 20 °C to 30 °C temperature range. ≤ ±2.3 dB (typical), over full operating range.
Maximum operating input level of the MDO4000 with the preamp attached to the MDO's RF input	Average continuous power: +30 dBm (1 W) DC maximum before damage: ±20 V DC Maximum power before damage (CW): +30 dBm (1 W) Maximum power before damage (pulse): +45 dBm (32 W) (<10 μs pulse width, <1% duty cycle, and reference level of ≥ +10 dBm)
Reference level range of the MDO4000 with the preamp attached to the MDO's RF input	Amplifying state: –30 dBm to DANL Bypass state: +30 dBm to DANL
Connector type	SMA – female (outside threads)
Temperature	Operating: 0 °C to +50 °C Non-operating: –20 °C to +60 °C
Humidity	Operating: High: 40 °C to 50 °C (104 °F to 122 °F), 10% to 60% RH Low: 0 °C to 40 °C (32 °F to 104 °F), 5% to 90% RH Non-operating: High: 40 °C to 50 °C (104 °F to 122 °F), 10% to 60% RH Low: 0 °C to 40 °C (32 °F to 104 °F), 5% to 90% RH

Characteristic	Description
Altitude	Operating: Up to 3,000 meters Non-operating: Up to 12,000 meters
Power requirements	The TPA-N-PRE is powered directly from the RF input on the MDO4000 Series oscilloscope
Regulatory	Compliance labeling: WEEE (European Union)
Recommended oscilloscopes	MDO4000 Mixed Domain Oscilloscopes ***NOTE.*** *For best probe support, download and install the latest version of the oscilloscope firmware from www.tektronix.com*

Performance Verification

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, you should contact Tektronix to have the factory adjustment performed. See the contact information on the back of the title page of this manual.

This section contains performance verification procedures for the specifications marked with the ✓ symbol. These procedures cover all MDO4000 Series models. Please ignore checks that do not apply to the specific model you are testing.

Print the test record on the following pages and use it to record the performance test results for your oscilloscope.

NOTE. *Completion of the performance verification procedure does not update the stored time and date of the latest successful adjustment. The date and time are updated only when the instrument is adjusted by Tektronix.*

The following equipment, or a suitable equivalent, is required to complete these procedures. You might need additional cables and adapters, depending on the actual test equipment you use.

Table 15: Required equipment

Description	Minimum requirements	Examples
DC voltage source	3 mV to 4 V, ±0.1% accuracy	Fluke 9500B Oscilloscope Calibrator with a 9510 Output Module
Leveled sine wave generator	50 kHz to 1000 MHz, ±4% amplitude accuracy	
Time mark generator	80 ms period, ±1 ppm accuracy, rise time < 50 ns	
Signal generator	Frequency: to at least 6 GHz Frequency accuracy: 5 ppm	Anritsu MG3692B Options 2A, 3A, 4, 15A, 16, 22, SM5821 Rohde & Schwarz SMT06 (Two generators are needed for checking Third Order Intermodulation Distortion)
Hybrid coupler (power combiner)	Connects the output of two generators to the oscilloscope RF input	Krytar 3005070
Logic probe	Low capacitance digital probe, 16 channels.	P6616 probe; standard accessory shipped with MDO4000 Series oscilloscopes.
BNC-to-0.1 inch pin adapter to connect the logic probe to the signal source.	BNC-to-0.1 inch pin adapter; female BNC to 2x16. 01 inch pin headers.	Tektronix adapter part number 679-6240-00; to connect the Fluke 9500B to the P6616 probe.
Digital multimeter (DMM)	0.1% accuracy or better	Fluke 177 Series Digital Multimeter
Power meter		Agilent N1913A Single-Channel Power Meter
Power head	Frequency range at least 50 kHz – 6 GHz	Agilent E9304A Average Power Sensor
Power splitter		Agilent 11667A Power Splitter
Male N-N adapter		For connecting between the power splitter ad the oscilloscope RF Input
One 50 Ω terminator	Impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0049-02
One 50 Ω terminator	Impedance 50 Ω; Male N connector	For terminating the RF Input
One 50 Ω BNC coaxial cable	Male-to-male connectors	Tektronix part number 012-0057-01
One 50 Ω SMA coaxial cable	N connector to SMA	
Three SMA cables	With the correct connector to fit your generator output.	Tektronix part number 174-6025-00 (6 ft) Tektronix part number 174-6026-00 (2 ft)

Test Record

Model	Serial	Procedure performed by	Date

Test	Passed	Failed
Self Test		

Input Impedance

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 1 Input Impedance, 1 MΩ	10 mV/div	990 kΩ		1.01 MΩ
	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 1 Input Impedance, 250 kΩ	100 mV/div	245 kΩ		255 kΩ
Channel 1 Input Impedance, 50 Ω	10 mV/div	49.5 Ω		50.5 Ω
	100 mV/div	49.5 Ω		50.5 Ω
Channel 2 Input Impedance, 1 MΩ	10 mV/div	990 kΩ		1.01 MΩ
	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 2 Input Impedance, 250 kΩ	100 mV/div	245 kΩ		255 kΩ
Channel 2 Input Impedance, 50 Ω	10 mV/div	49.5 Ω		50.5 Ω
	100 mV/div	49.5 Ω		50.5 Ω
Channel 3 Input Impedance, 1 MΩ	10 mV/div	990 kΩ		1.01 MΩ
	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 3 Input Impedance, 250 kΩ	100 mV/div	245 kΩ		255 kΩ
Channel 3 Input Impedance, 50 Ω	10 mV/div	49.5 Ω		50.5 Ω
	100 mV/div	49.5 Ω		50.5 Ω
Channel 4 Input Impedance, 1 MΩ	10 mV/div	990 kΩ		1.01 MΩ
	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 4 Input Impedance, 250 kΩ	100 mV/div	245 kΩ		255 kΩ
Channel 4, Input Impedance, 50 Ω	10 mV/div	49.5 Ω		50.5 Ω
	100 mV/div	49.5 Ω		50.5 Ω

DC Balance

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 1 DC Balance, 50 Ω, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.2 mV		0.2 mV
	5 mV/div	-0.5 mV		0.5 mV
	10 mV/div	-1 mV		1 mV
	20 mV/div	-2 mV		2 mV
	49.8 mV/div	-4.98 mV		4.98 mV
	50 mV/div	-5 mV		5 mV
	100 mV/div	-10 mV		10 mV
	200 mV/div	-20 mV		20 mV
	500 mV/div	-50 mV		50 mV
	1 V/div	-100 mV		100 mV
Channel 1 DC Balance, 1 MΩ, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.4 mV		0.4 mV
	5 mV/div	-1 mV		1 mV
	10 mV/div	-2 mV		2 mV
	20 mV/div	-4 mV		4 mV
	100 mV/div	-20 mV		20 mV
	500 mV/div	-100 mV		100 mV
	1 V/div	-200 mV		200 mV
	10 V/div	-2 V		2 V
Channel 1 DC Balance, 50 Ω, 250 MHz BW	20 mV/div	-2 mV		2 mV
Channel 1 DC Balance, 1 MΩ, 250 MHz BW	20 mV/div	-4 mV		4 mV
Channel 1 DC Balance, 50 Ω, Full BW	20 mV/div	-2 mV		2 mV
Channel 1 DC Balance, 1 MΩ, Full BW	20 mV/div	-4 mV		4 mV

DC Balance

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 2 DC Balance, 50 Ω, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.2 mV		0.2 mV
	5 mV/div	-0.5 mV		0.5 mV
	10 mV/div	-1 mV		1 mV
	20 mV/div	-2 mV		2 mV
	49.8 mV/div	-4.98 mV		4.98 mV
	50 mV/div	-5 mV		5 mV
	100 mV/div	-10 mV		10 mV
	200 mV/div	-20 mV		20 mV
	500 mV/div	-50 mV		50 mV
	1 V/div	-100 mV		100 mV
Channel 2 DC Balance, 1 MΩ, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.4 mV		0.4 mV
	5 mV/div	-1 mV		1 mV
	10 mV/div	-2 mV		2 mV
	20 mV/div	-4 mV		4 mV
	100 mV/div	-20 mV		20 mV
	500 mV/div	-100 mV		100 mV
	1 V/div	-200 mV		200 mV
	10 V/div	-2 V		2 V
Channel 2 DC Balance, 50 Ω, 250 MHz BW	20 mV/div	-2 mV		2 mV
Channel 2 DC Balance, 1 MΩ, 250 MHz BW	20 mV/div	-4 mV		4 mV
Channel 2 DC Balance, 50 Ω, Full BW	20 mV/div	-2 mV		2 mV
Channel 2 DC Balance, 1 MΩ, Full BW	20 mV/div	-4 mV		4 mV

DC Balance

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 3 DC Balance, 50 Ω, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.2 mV		0.2 mV
	5 mV/div	-0.5 mV		0.5 mV
	10 mV/div	-1 mV		1 mV
	20 mV/div	-2 mV		2 mV
	49.8 mV/div	-4.98 mV		4.98 mV
	50 mV/div	-5 mV		5 mV
	100 mV/div	-10 mV		10 mV
	200 mV/div	-20 mV		20 mV
	500 mV/div	-50 mV		50 mV
	1 V/div	-100 mV		100 mV
Channel 3 DC Balance, 1 MΩ, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.4 mV		0.4 mV
	5 mV/div	-1 mV		1 mV
	10 mV/div	-2 mV		2 mV
	20 mV/div	-4 mV		4 mV
	500 mV/div	-100 mV		100 mV
	100 mV/div	-20 mV		20 mV
	1 V/div	-200 mV		200 mV
	10 V/div	-2 V		2 V
Channel 3 DC Balance, 50 Ω, 250 MHz BW	20 mV/div	-2 mV		2 mV
Channel 3 DC Balance, 1 MΩ, 250 MHz BW	20 mV/div	-4 mV		4 mV
Channel 3 DC Balance, 50 Ω, Full BW	20 mV/div	-2 mV		2 mV
Channel 3 DC Balance, 1 MΩ, Full BW	20 mV/div	-4 mV		4 mV

DC Balance

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 4 DC Balance, 50 Ω, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.2 mV		0.2 mV
	5 mV/div	-0.5 mV		0.5 mV
	10 mV/div	-1 mV		1 mV
	20 mV/div	-2 mV		2 mV
	49.8 mV/div	-4.98 mV		4.98 mV
	50 mV/div	-5 mV		5 mV
	100 mV/div	-10 mV		10 mV
	200 mV/div	-20 mV		20 mV
	500 mV/div	-50 mV		50 mV
	1 V/div	-100 mV		100 mV
Channel 4 DC Balance, 1 MΩ, 20 MHz BW	1 mV/div	-0.2 mV		0.2 mV
	2 mV/div	-0.4 mV		0.4 mV
	5 mV/div	-1 mV		1 mV
	10 mV/div	-2 mV		2 mV
	20 mV/div	-4 mV		4 mV
	500 mV/div	-100 mV		100 mV
	100 mV/div	-20 mV		20 mV
	1 V/div	-200 mV		200 mV
	10 V/div	-2 V		2 V
Channel 4 DC Balance, 50 Ω, 250 MHz BW	20 mV/div	-2 mV		2 mV
Channel 4 DC Balance, 1 MΩ, 250 MHz BW	20 mV/div	-4 mV		4 mV
Channel 4 DC Balance, 50 Ω, Full BW	20 mV/div	-2 mV		2 mV
Channel 4 DC Balance, 1 MΩ, Full BW	20 mV/div	-4 mV		4 mV

DC Gain Accuracy

Performance checks	Bandwidth	Vertical scale	Low limit	Test result	High limit
MDO4104-3, MDO4104-6					
Channel 1 DC Gain Accuracy, 0 V offset, 0 V vertical position, 50 Ω	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		49.8 mV/div	-3.0%		3.0%
		50 mV/div	-1.5%		1.5%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
	250 MHz	20 mV/div	-1.5%		1.5%
	Full	20 mV/div	-1.5%		1.5%
Channel 2 DC Gain Accuracy, 0 V offset, 0 V vertical position, 50 Ω	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		49.8 mV/div	-3.0%		3.0%
		50 mV/div	-1.5%		1.5%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
	250 MHz	20 mV/div	-1.5%		1.5%
	Full	20 mV/div	-1.5%		1.5%

DC Gain Accuracy

Performance checks	Bandwidth	Vertical scale	Low limit	Test result	High limit
MDO4104-3, MDO4104-6					
Channel 3 DC Gain Accuracy, 0 V offset, 0 V vertical position, 50 Ω	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		49.8 mV/div	-3.0%		3.0%
		50 mV/div	-1.5%		1.5%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
	250 MHz	20 mV/div	-1.5%		1.5%
	Full	20 mV/div	-1.5%		1.5%
Channel 4 DC Gain Accuracy, 0 V offset, 0 V vertical position, 50 Ω	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		49.8 mV/div	-3.0%		3.0%
		50 mV/div	-1.5%		1.5%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
	250 MHz	20 mV/div	-1.5%		1.5%
	Full	20 mV/div	-1.5%		1.5%

DC Gain Accuracy

Performance checks	Bandwidth	Vertical scale	Low limit	Test result	High limit
All Models					
Channel 1 DC Gain Accuracy, 0 V offset, 0 V vertical position, 1 MΩ	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		50 mV/div	-1.5%		1.5%
		63.5 mV/div	-3.0%		3.0%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
		5 V/div	-1.5%		1.5%
	250 MHz (Not applicable for the MDO4014-3)	20 mV/div	-1.5%		1.5%
	FULL	20 mV/div	-1.5%		1.5%
Channel 2 DC Gain Accuracy, 0 V offset, 0 V vertical position, 1 MΩ	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		50 mV/div	-1.5%		1.5%
		63.5 mV/div	-3.0%		3.0%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
		5 V/div	-1.5%		1.5%
	250 MHz (Not applicable for the MDO4014-3)	20 mV/div	-1.5%		1.5%
	FULL	20 mV/div	-1.5%		1.5%

DC Gain Accuracy

Performance checks	Bandwidth	Vertical scale	Low limit	Test result	High limit
All Models					
Channel 3 DC Gain Accuracy, 0 V offset, 0 V vertical position, 1 MΩ	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		50 mV/div	-1.5%		1.5%
		63.5 mV/div	-3.0%		3.0%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
		5 V/div	-1.5%		1.5%
	250 MHz (Not applicable for the MDO4014-3)	20 mV/div	-1.5%		1.5%
	FULL	20 mV/div	-1.5%		1.5%
Channel 4 DC Gain Accuracy, 0 V offset, 0 V vertical position, 1 MΩ	20 MHz	1 mV/div	-2.0%		2.0%
		2 mV/div	-1.5%		1.5%
		5 mV/div	-1.5%		1.5%
		10 mV/div	-1.5%		1.5%
		20 mV/div	-1.5%		1.5%
		50 mV/div	-1.5%		1.5%
		63.5 mV/div	-3.0%		3.0%
		100 mV/div	-1.5%		1.5%
		200 mV/div	-1.5%		1.5%
		500 mV/div	-1.5%		1.5%
		1 V/div	-1.5%		1.5%
		5 V/div	-1.5%		1.5%
	250 MHz (Not applicable for the MDO4014-3)	20 mV/div	-1.5%		1.5%
	FULL	20 mV/div	-1.5%		1.5%

DC Offset Accuracy

Performance checks	Vertical scale	Vertical offset [1]	Low limit	Test result	High limit
All models:					
Channel 1 DC Offset Accuracy, 20 MHz BW, 50 Ω	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	5.0 V	4.965 V		5.035 V
	100 mV/div	-5.0 V	-5.035 V		-4.965 V
Channel 1 DC Offset Accuracy, 20 MHz BW, 1 MΩ	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	9.0 V	8.935 V		9.065 V
	100 mV/div	- 9.0 V	-9.065 V		-8.935 V
	500 mV/div	9.0 V	8.855 V		9.145 V
	500 mV/div	- 9.0 V	-9.145 V		-8.855 V
	1.01 V/div	99.5 V	98.80 V		100.2 V
	1.01 V/div	-99.5 V	-100.2 V		-98.80 V
	3 V/div	99.5 V	98.40 V		100.6 V
	3 V/div	-99.5 V	-100.6 V		-98.4 V
	5 V/div	99.5 V	98.00 V		101.0 V
	5 V/div	-99.5 V	-101.0 V		-98.00 V
Channel 2 DC Offset Accuracy, 20 MHz BW, 50 Ω	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	5.0 V	4.965 V		5.035 V
	100 mV/div	-5.0 V	-5.035 V		-4.965 V
Channel 2 DC Offset Accuracy, 20 MHz BW, 1 MΩ	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	9.0 V	8.935 V		9.065 V
	100 mV/div	-9.0 V	-9.065 V		-8.935 V
	500 mV/div	9.0 V	8.855 V		9.145 V
	500 mV/div	- 9.0 V	-9.145 V		-8.855 V
	1.01 V/div	99.5 V	98.80 V		100.2 V
	1.01 V/div	-99.5 V	-100.2 V		-98.80 V
	3 V/div	99.5 V	98.40 V		100.6 V
	3 V/div	-99.5 V	-100.6 V		-98.4 V
	5 V/div	99.5 V	98.00 V		101.0 V
	5 V/div	-99.5 V	-101.0 V		-98.00 V

DC Offset Accuracy

Performance checks	Vertical scale	Vertical offset [1]	Low limit	Test result	High limit
Channel 3 DC Offset Accuracy, 20 MHz BW, 50 Ω	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	5.0 V	4.965 V		5.035 V
	100 mV/div	-5.0 V	-5.035 V		-4.965 V
Channel 3 DC Offset Accuracy, 20 MHz BW, 1 MΩ	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	9.0 V	8.935 V		9.065 V
	100 mV/div	-9.0 V	-9.065 V		-8.935 V
	500 mV/div	9.0 V	8.855 V		9.145 V
	500 mV/div	- 9.0 V	-9.145 V		-8.855 V
	1.01 V/div	99.5 V	98.80 V		100.2 V
	1.01 V/div	-99.5 V	-100.2 V		-98.80 V
	3 V/div	99.5 V	98.40 V		100.6 V
	3 V/div	-99.5 V	-100.6 V		-98.4 V
	5 V/div	99.5 V	98.00 V		101.0 V
	5 V/div	-99.5 V	-101.0 V		-98.00 V
Channel 4 DC Offset Accuracy, 20 MHz BW, 50 Ω	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	5.0 V	4.965 V		5.035 V
	100 mV/div	-5.0 V	-5.035 V		-4.965 V
Channel 4 DC Offset Accuracy, 20 MHz BW, 1 MΩ	1 mV/div	900 mV	895.3 mV		904.7 mV
	1 mV/div	-900 mV	-904.7 mV		-895.3 mV
	100 mV/div	9.0 V	8.935 V		9.065 V
	100 mV/div	-9.0 V	-9.065 V		-8.935 V
	500 mV/div	9.0 V	8.855 V		9.145 V
	500 mV/div	- 9.0 V	-9.145 V		-8.855 V
	1.01 V/div	99.5 V	98.80 V		100.2 V
	1.01 V/div	-99.5 V	-100.2 V		-98.80 V
	3 V/div	99.5 V	98.40 V		100.6 V
	3 V/div	-99.5 V	-100.6 V		-98.4 V
	5 V/div	99.5 V	98.00 V		101.0 V
	5 V/div	-99.5 V	-101.0 V		-98.00 V

1 Use this value for both the calibrator output and the oscilloscope offset setting.

Sample Rate and Delay Time Accuracy

Performance checks	Low limit	Test result	High limit
	-1 divisions		+1 divisions

Analog Bandwidth

Performance checks

Bandwidth at Channel	Impedance	Vertical scale	Horizontal scale	V_{in-pp}	V_{bw-pp}	Limit	Test result Gain = V_{bw-pp}/V_{in-pp}
All Models							
Channel 1	50 Ω	1 mV/div	4 ns/div (175 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		5 mV/div	1 ns/div (Full BW)			≥ 0.707	
		10 mV/div	1 ns/div (Full BW)			≥ 0.707	
		50 mV/div	1 ns/div (Full BW)			≥ 0.707	
		100 mV/div	1 ns/div (Full BW)			≥ 0.707	
		1 V/div	1 ns/div (Full BW)			≥ 0.707	
MDO4104-3, MDO4104-6 Models Only							
Channel 1	1 MΩ	1 mV/div	4 ns/div (175 MHz)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz)			≥ 0.707	
		5 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		10 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		50 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		100 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		1 V/div	1 ns/div (500 MHz)			≥ 0.707	

Analog Bandwidth

Performance checks

Bandwidth at Channel	Impedance	Vertical scale	Horizontal scale	V_{in-pp}	V_{bw-pp}	Limit	Test result Gain = V_{bw-pp}/V_{in-pp}
All Models							
Channel 2	50 Ω	1 mV/div	4 ns/div (175 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		5 mV/div	1 ns/div (Full BW)			≥ 0.707	
		10 mV/div	1 ns/div (Full BW)			≥ 0.707	
		50 mV/div	1 ns/div (Full BW)			≥ 0.707	
		100 mV/div	1 ns/div (Full BW)			≥ 0.707	
		1 V/div	1 ns/div (Full BW)			≥ 0.707	
MDO4104-3, MDO4104-6 Models Only							
Channel 2	1 MΩ	1 mV/div	4 ns/div (175 MHz)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz)			≥ 0.707	
		5 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		10 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		50 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		100 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		1 V/div	1 ns/div (500 MHz)			≥ 0.707	

Analog Bandwidth							
Performance checks							
Bandwidth at Channel	**Impedance**	**Vertical scale**	**Horizontal scale**	V_{in-pp}	V_{bw-pp}	**Limit**	**Test result Gain = V_{bw-pp}/V_{in-pp}**
All Models							
Channel 3	50 Ω	1 mV/div	4 ns/div (175 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		5 mV/div	1 ns/div (Full BW)			≥ 0.707	
		10 mV/div	1 ns/div (Full BW)			≥ 0.707	
		50 mV/div	1 ns/div (Full BW)			≥ 0.707	
		100 mV/div	1 ns/div (Full BW)			≥ 0.707	
		1 V/div	1 ns/div (Full BW)			≥ 0.707	
MDO4104-3, MDO4104-6 Models Only							
Channel 3	1 MΩ	1 mV/div	4 ns/div (175 MHz)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz)			≥ 0.707	
		5 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		10 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		50 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		100 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		1 V/div	1 ns/div (500 MHz)			≥ 0.707	

Analog Bandwidth

Performance checks

Bandwidth at Channel	Impedance	Vertical scale	Horizontal scale	V_{in-pp}	V_{bw-pp}	Limit	Test result Gain = V_{bw-pp}/V_{in-pp}
All Models							
Channel 4	50 Ω	1 mV/div	4 ns/div (175 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz for all models except the 100 MHz MDO4014-3)			≥ 0.707	
		5 mV/div	1 ns/div (Full BW)			≥ 0.707	
		10 mV/div	1 ns/div (Full BW)			≥ 0.707	
		50 mV/div	1 ns/div (Full BW)			≥ 0.707	
		100 mV/div	1 ns/div (Full BW)			≥ 0.707	
		1 V/div	1 ns/div (Full BW)			≥ 0.707	
MDO4104-3, MDO4104-6 Models Only							
Channel 4	1 MΩ	1 mV/div	4 ns/div (175 MHz)			≥ 0.707	
		2 mV/div	2 ns/div (350 MHz)			≥ 0.707	
		5 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		10 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		50 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		100 mV/div	1 ns/div (500 MHz)			≥ 0.707	
		1 V/div	1 ns/div (500 MHz)			≥ 0.707	

Random Noise, Sample Acquisition Mode

Performance checks		Vertical sensitivity = 100 mV/div			
		1 MΩ		50 Ω	
	Bandwidth	Test result (mV)	High limit (mV)	Test result (mV)	High limit (mV)
MDO4104-3, MDO4104-6					
Channel 1	Full		8.30		6.08
	250 MHz limit		5.10		4.05
	20 MHz limit		5.10		4.05
Channel 2	Full		8.30		6.08
	250 MHz limit		5.10		4.05
	20 MHz limit		5.10		4.05
Channel 3	Full		8.30		6.08
	250 MHz limit		5.10		4.05
	20 MHz limit		5.10		4.05
Channel 4	Full		8.30		6.08
	250 MHz limit		5.10		4.05
	20 MHz limit		5.10		4.05
MDO4054-3, MDO4054-6					
Channel 1	Full		8.13		8.13
	250 MHz limit		6.10		6.10
	20 MHz limit		4.10		4.10
Channel 2	Full		8.13		8.13
	250 MHz limit		6.10		6.10
	20 MHz limit		4.10		4.10
Channel 3	Full		8.13		8.13
	250 MHz limit		6.10		6.10
	20 MHz limit		4.10		4.10
Channel 4	Full		8.13		8.13
	250 MHz limit		6.10		6.10
	20 MHz limit		4.10		4.10

Delta Time Measurement Accuracy

Performance checks			
MDO4104-3, MDO4104-6			
Channel 1			
MDO = 4 ns/div, Source freq = 240 MHz			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		118 ps
100 mV	800 mV		117 ps
500 mV	4 V		117 ps
1 V	4 V		122 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		464 ps
5 mV	40 mV		276 ps
100 mV	800 mV		234 ps
500 mV	4 V		232 ps
1 V	4 V		417 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		4.50 ns
5 mV	40 mV		2.52 ns
100 mV	800 mV		2.05 ns
500 mV	4 V		2.03 ns
1 V	4 V		4.01 ns
MDO = 4 µs/div, Source freq = 240 kHz			
1 mV	8 mV		45.0 ns
5 mV	40 mV		25.2 ns
100 mV	800 mV		20.5 ns
500 mV	4 V		20.3 ns
1 V	4 V		40.1 ns
MDO = 40 µs/div, Source freq = 24 kHz			
1 mV	8 mV		450 ns
5 mV	40 mV		252 ns
100 mV	800 mV		205 ns
500 mV	4 V		203 ns
1 V	4 V		401 ns
MDO = 400 µs/div, Source freq = 2.4 kHz			
1 mV	8 mV		4.50 µs
5 mV	40 mV		2.52 µs
100 mV	800 mV		2.05 µs
500 mV	4 V		2.03 µs
1 V	4 V		4.01 µs

Delta Time Measurement Accuracy

MDO4104-3, MDO4104-6			
Channel 2			
MDO = 4 ns/div, Source freq = 240 MHz			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		118 ps
100 mV	800 mV		117 ps
500 mV	4 V		117 ps
1 V	4 V		122 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		464 ps
5 mV	40 mV		276 ps
100 mV	800 mV		234 ps
500 mV	4 V		232 ps
1 V	4 V		417 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		4.50 ns
5 mV	40 mV		2.52 ns
100 mV	800 mV		2.05 ns
500 mV	4 V		2.03 ns
1 V	4 V		4.01 ns
MDO = 4 μs/div, Source freq = 240 kHz			
1 mV	8 mV		45.0 ns
5 mV	40 mV		25.2 ns
100 mV	800 mV		20.5 ns
500 mV	4 V		20.3 ns
1 V	4 V		40.1 ns
MDO = 40 μs/div, Source freq = 24 kHz			
1 mV	8 mV		450 ns
5 mV	40 mV		252 ns
100 mV	800 mV		205 ns
500 mV	4 V		203 ns
1 V	4 V		401 ns
MDO = 400 μs/div, Source freq = 2.4 kHz			
1 mV	8 mV		4.50 μs
5 mV	40 mV		2.52 μs
100 mV	800 mV		2.05 μs
500 mV	4 V		2.03 μs
1 V	4 V		4.01 μs

Delta Time Measurement Accuracy

MDO4104-3, MDO4104-6			
Channel 3			
MDO = 4 ns/div, Source freq = 240 MHz			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		118 ps
100 mV	800 mV		117 ps
500 mV	4 V		117 ps
1 V	4 V		122 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		464 ps
5 mV	40 mV		276 ps
100 mV	800 mV		234 ps
500 mV	4 V		232 ps
1 V	4 V		417 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		4.50 ns
5 mV	40 mV		2.52 ns
100 mV	800 mV		2.05 ns
500 mV	4 V		2.03 ns
1 V	4 V		4.01 ns
MDO = 4 µs/div, Source freq = 240 kHz			
1 mV	8 mV		45.0 ns
5 mV	40 mV		25.2 ns
100 mV	800 mV		20.5 ns
500 mV	4 V		20.3 ns
1 V	4 V		40.1 ns
MDO = 40 µs/div, Source freq = 24 kHz			
1 mV	8 mV		450 ns
5 mV	40 mV		252 ns
100 mV	800 mV		205 ns
500 mV	4 V		203 ns
1 V	4 V		401 ns
MDO = 400 µs/div, Source freq = 2.4 kHz			
1 mV	8 mV		4.50 µs
5 mV	40 mV		2.52 µs
100 mV	800 mV		2.05 µs
500 mV	4 V		2.03 µs
1 V	4 V		4.01 µs

Delta Time Measurement Accuracy

MDO V/div	Source V_{pp}	Test result	High limit
MDO4104-3, MDO4104-6			
Channel 4			
MDO = 4 ns/div, Source freq = 240 MHz			
5 mV	40 mV		118 ps
100 mV	800 mV		117 ps
500 mV	4 V		117 ps
1 V	4 V		122 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		464 ps
5 mV	40 mV		276 ps
100 mV	800 mV		234 ps
500 mV	4 V		232 ps
1 V	4 V		417 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		4.50 ns
5 mV	40 mV		2.52 ns
100 mV	800 mV		2.05 ns
500 mV	4 V		2.03 ns
1 V	4 V		4.01 ns
MDO = 4 μs/div, Source freq = 240 kHz			
1 mV	8 mV		45.0 ns
5 mV	40 mV		25.2 ns
100 mV	800 mV		20.5 ns
500 mV	4 V		20.3 ns
1 V	4 V		40.1 ns
MDO = 40 μs/div, Source freq = 24 kHz			
1 mV	8 mV		450 ns
5 mV	40 mV		252 ns
100 mV	800 mV		205 ns
500 mV	4 V		203 ns
1 V	4 V		401 ns
MDO = 400 μs/div, Source freq = 2.4 kHz			
1 mV	8 mV		4.50 μs
5 mV	40 mV		2.52 μs
100 mV	800 mV		2.05 μs
500 mV	4 V		2.03 μs
1 V	4 V		4.01 μs

Delta Time Measurement Accuracy

MDO4054-3, MDO4054-6, MDO4034-3, MDO4014-3			
Channel 1			
MDO = 4 ns/div, Source freq = 240 MHz (except for the MDO4014-3)			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		234 ps
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		736 ps
5 mV	40 mV		423 ps
100 mV	800 mV		357 ps
500 mV	4 V		354 ps
1 V	4 V		581 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		6.99 ns
5 mV	40 mV		3.54 ns
100 mV	800 mV		2.73 ns
500 mV	4 V		2.69 ns
1 V	4 V		5.34 ns
MDO = 4 µs/div, Source freq = 240 kHz			
1 mV	8 mV		69.9 ns
5 mV	40 mV		35.4 ns
100 mV	800 mV		27.3 ns
500 mV	4 V		26.9 ns
1 V	4 V		53.4 ns
MDO = 40 µs/div, Source freq = 24 kHz			
1 mV	8 mV		699 ns
5 mV	40 mV		354 ns
100 mV	800 mV		273 ns
500 mV	4 V		269 ns
1 V	4 V		534 ns
MDO = 400 µs/div, Source freq = 2.4 kHz			
1 mV	8 mV		6.99 µs
5 mV	40 mV		3.54 µs
100 mV	800 mV		2.73 µs
500 mV	4 V		2.69 µs
1 V	4 V		5.34 µs

Delta Time Measurement Accuracy

MDO V/div	Source V_{pp}	Test result	High limit
MDO4054-3, MDO4054-6, MDO4034-3, MDO4014-3			
Channel 2			
MDO = 4 ns/div, Source freq = 240 MHz (except for the MDO4014-3)			
5 mV	40 mV		234 ps
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		736 ps
5 mV	40 mV		423 ps
100 mV	800 mV		357 ps
500 mV	4 V		354 ps
1 V	4 V		581 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		6.99 ns
5 mV	40 mV		3.54 ns
100 mV	800 mV		2.73 ns
500 mV	4 V		2.69 ns
1 V	4 V		5.34 ns
MDO = 4 μs/div, Source freq = 240 kHz			
1 mV	8 mV		69.9 ns
5 mV	40 mV		35.4 ns
100 mV	800 mV		27.3 ns
500 mV	4 V		26.9 ns
1 V	4 V		53.4 ns
MDO = 40 μs/div, Source freq = 24 kHz			
1 mV	8 mV		699 ns
5 mV	40 mV		354 ns
100 mV	800 mV		273 ns
500 mV	4 V		269 ns
1 V	4 V		534 ns
MDO = 400 μs/div, Source freq = 2.4 kHz			
1 mV	8 mV		6.99 μs
5 mV	40 mV		3.54 μs
100 mV	800 mV		2.73 μs
500 mV	4 V		2.69 μs
1 V	4 V		5.34 μs

Delta Time Measurement Accuracy

MDO4054-3, MDO4054-6, MDO4034-3, MDO4014-3			
Channel 3			
MDO = 4 ns/div, Source freq = 240 MHz (except for the MDO4014-3)			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		234 ps
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		736 ps
5 mV	40 mV		423 ps
100 mV	800 mV		357 ps
500 mV	4 V		354 ps
1 V	4 V		581 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		6.99 ns
5 mV	40 mV		3.54 ns
100 mV	800 mV		2.73 ns
500 mV	4 V		2.69 ns
1 V	4 V		5.34 ns
MDO = 4 μs/div, Source freq = 240 kHz			
1 mV	8 mV		69.9 ns
5 mV	40 mV		35.4 ns
100 mV	800 mV		27.3 ns
500 mV	4 V		26.9 ns
1 V	4 V		53.4 ns
MDO = 40 μs/div, Source freq = 24 kHz			
1 mV	8 mV		699 ns
5 mV	40 mV		354 ns
100 mV	800 mV		273 ns
500 mV	4 V		269 ns
1 V	4 V		534 ns
MDO = 400 μs/div, Source freq = 2.4 kHz			
1 mV	8 mV		6.99 μs
5 mV	40 mV		3.54 μs
100 mV	800 mV		2.73 μs
500 mV	4 V		2.69 μs
1 V	4 V		5.34 μs

Delta Time Measurement Accuracy

MDO4054-3, MDO4054-6, MDO4034-3, MDO4014-3			
Channel 4			
MDO = 4 ns/div, Source freq = 240 MHz (except for the MDO4014-3)			
MDO V/div	**Source V_{pp}**	**Test result**	**High limit**
5 mV	40 mV		234 ps
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/div, Source freq = 24 MHz			
1 mV	8 mV		736 ps
5 mV	40 mV		423 ps
100 mV	800 mV		357 ps
500 mV	4 V		354 ps
1 V	4 V		581 ps
MDO = 400 ns/div, Source freq = 2.4 MHz			
1 mV	8 mV		6.99 ns
5 mV	40 mV		3.54 ns
100 mV	800 mV		2.73 ns
500 mV	4 V		2.69 ns
1 V	4 V		5.34 ns
MDO = 4 μs/div, Source freq = 240 kHz			
1 mV	8 mV		69.9 ns
5 mV	40 mV		35.4 ns
100 mV	800 mV		27.3 ns
500 mV	4 V		26.9 ns
1 V	4 V		53.4 ns
MDO = 40 μs/div, Source freq = 24 kHz			
1 mV	8 mV		699 ns
5 mV	40 mV		354 ns
100 mV	800 mV		273 ns
500 mV	4 V		269 ns
1 V	4 V		534 ns
MDO = 400 μs/div, Source freq = 2.4 kHz			
1 mV	8 mV		6.99 μs
5 mV	40 mV		3.54 μs
100 mV	800 mV		2.73 μs
500 mV	4 V		2.69 μs
1 V	4 V		5.34 μs

Digital Threshold Accuracy

Performance checks:

Digital channel	Threshold	V_{slow}	V_{shigh}	Low limit	Test result	High limit
D0	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D1	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D2	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D3	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D4	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D5	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D6	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D7	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D8	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D9	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D10	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D11	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D12	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D13	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D14	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V
D15	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V

Phase Noise

Performance checks		Low limit	Test result	High limit
Center Frequency 2 GHz	10 kHz	N/A		-90 dBc/Hz
	100 kHz	N/A		-95 dBc/Hz
	1 MHz	N/A		-113 dBc/Hz

Displayed Average Noise Level (DANL)

Performance checks		Low limit	Test result	High limit
All models	50 kHz – 5 MHz	N/A		- 130 dBm/Hz
	5 MHz – 3 GHz	N/A		- 148 dBm/Hz
MDO4104-6 and MDO4054-6 only	3 GHz – 4 GHz	N/A		- 140 dBm/Hz
	4 GHz – 6 GHz	N/A		- 140 dBm/Hz

Level Measurement Uncertainty

Performance checks			Low limit	Test result	High limit
+10 dBm	All models	50 kHz	-1 dBm		+1 dBm
		100 kHz – 900 kHz	-1 dBm		+1 dBm
		1 MHz – 9 MHz	-1 dBm		+1 dBm
		10 MHz – 90 MHz	-1 dBm		+1 dBm
	MDO4104-3, MDO4054-3, MDO4034-3, MDO4014-3	100 MHz – 3 GHz	-1 dBm		+1 dBm
	MDO4104-6, MDO4054-6	100 MHz – 6 GHz	-1 dBm		+1 dBm
0 dBm	All models	50 kHz	-1 dBm		+1 dBm
		100 kHz – 900 kHz	-1 dBm		+1 dBm
		1 MHz – 9 MHz	-1 dBm		+1 dBm
		10 MHz – 90 MHz	-1 dBm		+1 dBm
	MDO4104-3, MDO4054-3, MDO4034-3, MDO4014-3	100 MHz – 3 GHz	-1 dBm		+1 dBm
	MDO4104-6, MDO4054-6	100 MHz – 6 GHz	-1 dBm		+1 dBm
–15 dBm	All models	50 kHz	-1 dBm		+1 dBm
		100 kHz – 900 kHz	-1 dBm		+1 dBm
		1 MHz – 9 MHz	-1 dBm		+1 dBm
		10 MHz – 90 MHz	-1 dBm		+1 dBm
	MDO4104-3, MDO4054-3, MDO4034-3, MDO4014-3	100 MHz – 3 GHz	-1 dBm		+1 dBm
	MDO4104-6, MDO4054-6	100 MHz – 6 GHz	-1 dBm		+1 dBm

Third Order Intermodulation Distortion

Performance checks			Low limit	Test result	High limit
All models	Center Frequency 2.745 GHz	Generator 1 signal	N/A		-60 dBc
		Generator 2 signal	N/A		-60 dBc
MDO4XX4-6	Center Frequency 4.5 GHz	Generator 1 signal	N/A		-60 dBc
		Generator 2 signal	N/A		-60 dBc

Residual Spurious Response

Performance checks		Low limit	Test result	High limit
All models	50 kHz to 3 GHz	N/A		-80 dBm
MDO4XX4-6	2.75 GHz to 4.5 GHz	N/A		-78 dBm
	3.5 GHz to 6.0 GHz	N/A		-78 dBm

Crosstalk to RF channel from analog channels				
Performance checks				
Channel 1 crosstalk		**Low limit**	**Test result**	**High limit**
Generator signal frequency and Oscilloscope Center Frequency setting	100 MHz	N/A		-68 dBm
	200 MHz	N/A		-68 dBm
	300 MHz	N/A		-68 dBm
	400 MHz	N/A		-68 dBm
	500 MHz	N/A		-68 dBm
	600 MHz	N/A		-68 dBm
	700 MHz	N/A		-68 dBm
	800 MHz	N/A		-68 dBm
	900 MHz	N/A		-68 dBm
	1 GHz	N/A		-68 dBm
	1.1 GHz	N/A		-48 dBm
	1.2 GHz	N/A		-48 dBm
	1.3 GHz	N/A		-48 dBm
	1.4 GHz	N/A		-48 dBm
	1.5 GHz	N/A		-48 dBm
	1.6 GHz	N/A		-48 dBm
	1.7 GHz	N/A		-48 dBm
	1.8 GHz	N/A		-48 dBm
	1.9 GHz	N/A		-48 dBm
	2 GHz	N/A		-48 dBm

Crosstalk to RF channel from analog channels

Channel 2 crosstalk		Low limit	Test result	High limit
Generator signal frequency and Oscilloscope Center Frequency setting	100 MHz	N/A		-68 dBm
	200 MHz	N/A		-68 dBm
	300 MHz	N/A		-68 dBm
	400 MHz	N/A		-68 dBm
	500 MHz	N/A		-68 dBm
	600 MHz	N/A		-68 dBm
	700 MHz	N/A		-68 dBm
	800 MHz	N/A		-68 dBm
	900 MHz	N/A		-68 dBm
	1 GHz	N/A		-68 dBm
	1.1 GHz	N/A		-48 dBm
	1.2 GHz	N/A		-48 dBm
	1.3 GHz	N/A		-48 dBm
	1.4 GHz	N/A		-48 dBm
	1.5 GHz	N/A		-48 dBm
	1.6 GHz	N/A		-48 dBm
	1.7 GHz	N/A		-48 dBm
	1.8 GHz	N/A		-48 dBm
	1.9 GHz	N/A		-48 dBm
	2 GHz	N/A		-48 dBm

Crosstalk to RF channel from analog channels

Channel 3 crosstalk		Low limit	Test result	High limit
Generator signal frequency and Oscilloscope Center Frequency setting	100 MHz	N/A		-68 dBm
	200 MHz	N/A		-68 dBm
	300 MHz	N/A		-68 dBm
	400 MHz	N/A		-68 dBm
	500 MHz	N/A		-68 dBm
	600 MHz	N/A		-68 dBm
	700 MHz	N/A		-68 dBm
	800 MHz	N/A		-68 dBm
	900 MHz	N/A		-68 dBm
	1 GHz	N/A		-68 dBm
	1.1 GHz	N/A		-48 dBm
	1.2 GHz	N/A		-48 dBm
	1.3 GHz	N/A		-48 dBm
	1.4 GHz	N/A		-48 dBm
	1.5 GHz	N/A		-48 dBm
	1.6 GHz	N/A		-48 dBm
	1.7 GHz	N/A		-48 dBm
	1.8 GHz	N/A		-48 dBm
	1.9 GHz	N/A		-48 dBm
	2 GHz	N/A		-48 dBm

Crosstalk to RF channel from analog channels

Channel 4 crosstalk		Low limit	Test result	High limit
Generator signal frequency and Oscilloscope Center Frequency setting	100 MHz	N/A		-68 dBm
	200 MHz	N/A		-68 dBm
	300 MHz	N/A		-68 dBm
	400 MHz	N/A		-68 dBm
	500 MHz	N/A		-68 dBm
	600 MHz	N/A		-68 dBm
	700 MHz	N/A		-68 dBm
	800 MHz	N/A		-68 dBm
	900 MHz	N/A		-68 dBm
	1 GHz	N/A		-68 dBm
	1.1 GHz	N/A		-48 dBm
	1.2 GHz	N/A		-48 dBm
	1.3 GHz	N/A		-48 dBm
	1.4 GHz	N/A		-48 dBm
	1.5 GHz	N/A		-48 dBm
	1.6 GHz	N/A		-48 dBm
	1.7 GHz	N/A		-48 dBm
	1.8 GHz	N/A		-48 dBm
	1.9 GHz	N/A		-48 dBm
	2 GHz	N/A		-48 dBm

Auxiliary (Trigger) Output

Performance checks		Low limit	Test result	High limit
Trigger Output	High 1 MΩ	≥ 2.5 V		–
	Low 1 MΩ	–		≤ 0.7 V
Trigger Output	High 50 Ω	≥ 1.0 V		–
	Low 50 Ω	–		≤ 0.25 V

With TPA-N-PRE Attached:

With TPA-N-PRE attached: Displayed Average Noise Level (DANL)

Performance checks		Low limit	Test result	High limit
All models (with TPA-N-PRE attached)	50 kHz – 5 MHz	N/A		- 140 dBm/Hz
	5 MHz – 3 GHz	N/A		- 158 dBm/Hz
MDO4XX4-6 only (with TPA-N-PRE attached)	3 GHz – 4 GHz	N/A		- 150 dBm/Hz
	4 GHz – 6 GHz	N/A		- 150 dBm/Hz

Performance Verification Procedures

The Performance Verification Procedures consist of a self test and several check steps, which check the oscilloscope performance to specifications. The following three conditions must be met before performing these procedures:

1. The oscilloscope must have been operating continuously for twenty (20) minutes in an environment that meets the operating range specifications for temperature and humidity.
2. You must perform the Signal Path Compensation (SPC) operation described in step 2 of the *Self Test* before evaluating specifications. (See page 62, *Self Test*.) If the operating temperature changes by more than 10 °C (18 °F), you must perform the SPC operation again.
3. You must connect the oscilloscope and the test equipment to the same AC power circuit. Connect the oscilloscope and test instruments to a common power strip if you are unsure of the AC power circuit distribution. Connecting the oscilloscope and test instruments to separate AC power circuits can result in offset voltages between the equipment, which can invalidate the performance verification procedure.

The time required to complete the entire procedure is more than one hour. To ensure instrument performance to the Level Measurement Uncertainty specification, it is necessary to check at many points, which can add significant time to the procedure.

⚠ ***WARNING.*** *Some procedures use hazardous voltages. To prevent electrical shock, always set voltage source outputs to 0 V before making or changing any interconnections.*

Self Test

This procedure uses internal routines to verify that the oscilloscope functions and passes its internal self tests. No test equipment or hookups are required.

1. *Run the System Diagnostics (may take several minutes):*

   a. Disconnect everything from the oscilloscope inputs.

   b. Push the front-panel **Default Setup** button.

   c. Push the **Utility** menu button.

   d. Push the **Utility Page** lower-bezel button.

   e. Select **Self Test**.

   f. Push the **Self Test** lower-bezel button. The Loop X Times side-bezel menu will be set to **Loop 1 Times**.

   g. Push the **OK Run Self Test** side-bezel button.

   h. Wait. The internal diagnostics perform an exhaustive verification of proper instrument function. This verification may take several minutes.

   i. Verify that the status of all tests on the readout is **Pass**.

   j. Push the **Menu** button twice to clear the dialog box and Self Test menu.

2. *Run the signal path compensation routine (may take 5 to 15 minutes):*

   a. Push the front-panel **Default Setup** button.

   b. Push the **Utility** menu button.

   c. Push the **Utility Page** lower-bezel button.

   d. Select **Calibration**.

   e. Push the **Signal Path** lower-bezel button.

   f. Push the **OK-Compensate Signal Paths** side bezel button.

   g. When the signal path compensation is complete, push the **Menu** button twice to clear the dialog box and Self Test menu.

   h. Check the lower-bezel **Signal Path** button to verify that the status is **Pass**.

Check Input Impedance (Resistance)

This test checks the Input Impedance.

1. Connect the output of the oscilloscope calibrator (for example, the Fluke 9500) to the oscilloscope channel 1 input, as shown below.

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

2. Push the front-panel **Default Setup** button.
3. *Set the impedance to 1 MΩ as follows:*
   a. Push the channel 1 button.
   b. Set the **Termination** (input impedance) to **1 MΩ**.
4. Set the Vertical **Scale** to **10 mV/division**.
5. Measure the input resistance of the oscilloscope with the calibrator. Record this value in the test record.
6. Repeat steps 4 and 5 for each vertical scale setting in the test record.
7. *Repeat the tests at 250 kΩ as follows:*
   a. Set the calibrator impedance to 1 MΩ.
   b. Push the **Utility** front-panel button.
   c. Push the **Utility Page** lower-bezel button.
   d. Select **Self Test**.
   e. Push the **250 kΩ Impedance Verification** lower-bezel button to set the oscilloscope input impedance to **250 kΩ**.
   f. Push the channel **1** side-bezel button to enable channel 1.
   g. Set the Vertical **Scale** to 100 **mV/division**.
   h. Measure the input resistance of the oscilloscope with the calibrator. Record this value in the test record.

8. *Repeat the tests at 50 Ω as follows:*

   a. Set the calibrator impedance to 50 Ω.

   b. Set the **Termination** (input impedance) to **50 Ω**.

   c. Repeat steps 4 through 6.

9. *Repeat the procedure for all remaining channels as follows:*

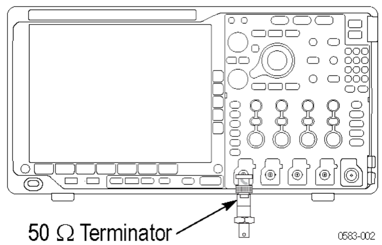
   a. Push the front-panel channel button to deselect the channel that you already tested.

   b. Connect the calibrator to the input for the next channel to be tested.

   c. Starting from step 3, repeat the procedure for each channel.

Check DC Balance

This test checks the DC balance. You do not need to connect any equipment (other than a 50Ω terminator) to the oscilloscope to perform this check.



1. Attach a 50 Ω terminator to the oscilloscope channel 1 input.
2. Push the front-panel **Default Setup** button.
3. *Set the input impedance to 50 Ω as follows:*
   a. Push the channel 1 button.
   b. Set the **Termination** (input impedance) to **50 Ω**.
4. Set the bandwidth to 20 MHz:
   a. Push the lower-bezel **Bandwidth** button.
   b. Push the side-bezel button for **20 MHz**.
5. Set the Horizontal **Scale** to **1 ms** per division.
6. *Set the Acquisition mode to Average as follows:*
   a. Push the front-panel **Acquire** button.
   b. Push the **Average** side bezel button.
   c. Make sure that the number of averages is **16**.
7. *Set the trigger source to AC line as follows:*
   a. Push the Trigger **Menu** front-panel button.
   b. Select the **AC Line** trigger source.
8. Set the Vertical **Scale** to **1 mV** per division.
9. *Select the mean measurement (if not already selected) as follows:*
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Push the **Add Measurement** lower bezel button.
   c. Select the **Mean** measurement.
   d. Push the **OK Add Measurement** side-bezel button.
   e. View the **Mean** measurement value in the display.

10. Enter the mean value as the test result in the test record.

11. Repeat steps 8 through 10 for each vertical scale setting in the test record.

12. Push the channel 1 button and then repeat steps 4 thorough 11 for each bandwidth setting.

13. *Repeat the tests at 1 MΩ impedance as follows:*

   a. Push the front-panel channel 1 button.

   b. Set the **Termination** (input impedance) to **1M Ω**.

   c. Repeat steps 4 through 12.

14. *Repeat the procedure for all remaining channels as follows:*

   a. Deselect the channel that you already tested.

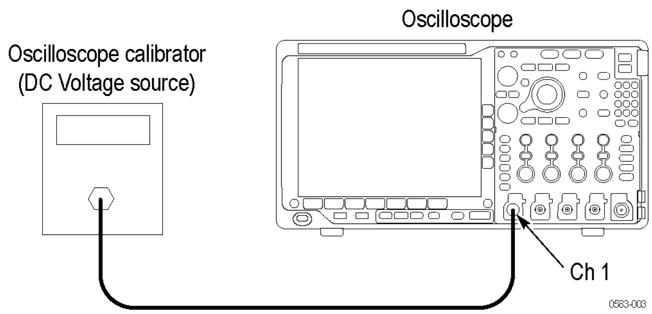
   b. Move the 50 Ω terminator to the next channel input to be tested.

   c. Starting from step 3, repeat the procedure for each channel.

Check DC Gain Accuracy

This test checks the DC gain accuracy.

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



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

2. Push the front-panel **Default Setup** button. The Termination (input impedance) is set to 1 MΩ and channel 1 input is selected.

NOTE. *50 Ω termination testing (steps 4 through 14) is required only for MDO4104-3 and MDO4104-6 models.*

1 MΩ termination testing (step 15) is required for all models.

3. For MDO4104-3 and MDO4104-6 models, perform steps 4 through 15. For other models, go to step 15 now.
4. *Select 50 Ω input impedance as follows:*
   a. Set the calibrator to 50 Ω output impedance.
   b. Push the channel 1 button.
   c. Set the **Termination** (input impedance) to **50 Ω**.
5. *Set the bandwidth to 20 MHz as follows:*
   a. Push the lower-bezel **Bandwidth** button.
   b. Push the **20 MHz** side-bezel button to select the bandwidth.

6. *Set the Acquisition mode to Average as follows:*
   a. Push the front-panel **Acquire** button.
   b. Push the **Mode** lower-bezel button (if it is not already selected), and then push the **Average** side bezel button.
   c. Make sure that the number of averages is **16**.
7. *Select the Mean measurement as follows:*
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Push the **Add Measurement** lower-bezel button (if it is not already selected).
   c. Select the **Mean** measurement.
   d. Push the **OK Add Measurement** side-bezel button.
8. *Set the trigger source to AC line as follows:*
   a. Push the Trigger **Menu** button on the front panel.
   b. Push the **Source** lower-bezel button.
   c. Select the **AC Line** as the trigger source.
9. Set the Vertical **Scale** to **1 mV/division**.
10. *Record the negative-measured and positive-measured mean readings in the worksheet as follows:*
    a. Set the DC Voltage Source to $V_{negative}$.
    b. Push the front-panel Wave Inspector **Measure** button.
    c. Push the **More** lower-bezel button.
    d. Push **Reset Statistics** in the side-bezel menu.
    e. Enter the mean reading in the worksheet as $V_{negative-measured}$. (See Table 16.)
    f. Set the DC Voltage Source to $V_{positive-measured}$
    g. Push **Reset Statistics** in the side-bezel menu again.
    h. Enter the mean reading in the worksheet as $V_{positive-measured}$

Table 16: Gain expected worksheet

Termination	Vertical Scale	$V_{diffExpected}$	$V_{negative}$	$V_{positive}$	$V_{negative-measured}$	$V_{positive-measured}$	V_{diff}	DC Gain Accuracy
50Ω	1 mV	9 mV	-4.5 mV	+4.5 mV				
	2 mV	18 mV	-9 mV	+9 mV				
	5 mV	45 mV	-22.5 mV	+22.5 mV				
	10 mV	90 mV	-45 mV	+45 mV				
	20 mV	180 mV	-90 mV	+90 mV				
	49.8 mV	448.2 mV	-224.1 mV	+224.1 mV				
	50 mV	450 mV	-225 mV	+225 mV				
	100 mV	900 mV	-450 mV	+450 mV				
	200 mV	1800 mV	-900 mV	+900 mV				
	500 mV	4900 mV	-2450 mV	+2450 mV				
	1 V	9000 mV	-4500 mV	+4500 mV				
1MΩ	1 mV	9 mV	-4.5 mV	+4.5 mV				
	2 mV	18 mV	-9 mV	+9 mV				
	5 mV	45 mV	-22.5 mV	+22.5 mV				
	10 mV	90 mV	-45 mV	+45 mV				
	20 mV	180 mV	-90 mV	+90 mV				
	50 mV	450 mV	-225 mV	+225 mV				
	63.5 mV	571.5 mV	-285.75 mV	+285.75 mV				
	100 mV	900 mV	-450 mV	+450 mV				
	200 mV	1800 mV	-900 mV	+900 mV				
	500 mV	4900 mV	-2450 mV	+2450 mV				
	1 V	9000 mV	-4500 mV	+4500 mV				
	5 V	45 V	-22.5 V	+22.5 V				

11. Record Gain Accuracy:

a. Calculate V_{diff} as follows:

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

b. Enter V_{diff} in the worksheet. (See Table 16.)

c. Calculate *Gain Accuracy* as follows:

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

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

12. Repeat steps 9 through 11 for each vertical scale setting in the test record.

13. Repeat steps 9 through 12 for each bandwidth setting in the test record.

14. *Repeat the procedure for all remaining channels as follows:*

    a. Push the front-panel button to deselect the channel that you have already tested.

    b. Move the DC voltage source connection to the next channel input to be tested.

    c. Starting from step 9, repeat the procedure for each channel.

15. Repeat tests at 1 MΩ impedance:

    a. Set the calibrator to 1 MΩ output.

    b. Push the front-panel channel 1 button.

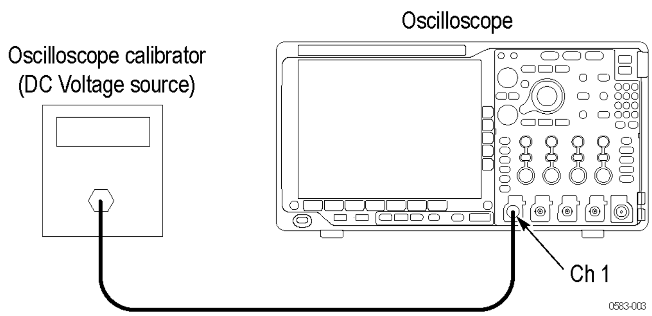
    c. Set the **Termination** to **1 MΩ**.

    d. Repeat steps 9 through 14.

Check Offset Accuracy

This test checks the offset accuracy.

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



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

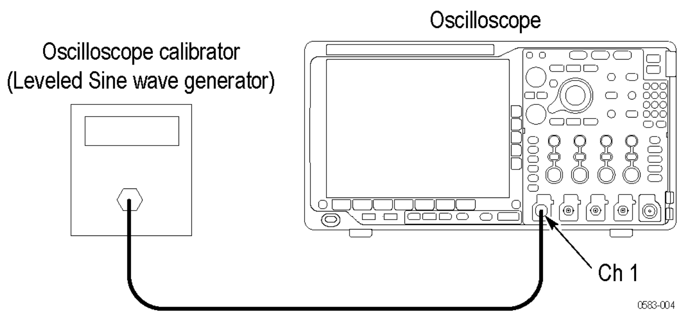
2. Push the front-panel **Default Setup** button.
3. *Set the Acquisition mode to Average as follows:*
   a. Push the front-panel **Acquire** button.
   b. Push the **Mode** lower-bezel button (if not already selected).
   c. Push the **Average** side bezel button.
   d. Make sure that the **number of averages** is set to **16**.
4. Set the trigger source to AC line:
   a. Push the Trigger **Menu** front-panel button.
   b. Push the **Source** lower-bezel button.
   c. Select the **AC Line** as the trigger source.
5. Set the Horizontal **Scale** to **1.00 ms** per division.
6. *Set the Bandwidth to 20 MHz as follows:*
   a. Push the channel 1 button.
   b. Push the lower-bezel **Bandwidth** button.
   c. Push the side-bezel button to set the bandwidth to **20 MHz**.

7. Check that the vertical position is set to 0 divs:
   a. Push the lower-bezel **More** button to select **Position**.
   b. In the side-bezel button, check that the **Vertical Position** is set to **0 divs**.
   c. If it is not 0 divs, turn the Vertical **Position** knob to set the position to 0.
8. *Select 50 Ω impedance as follows:*
   a. Set the calibrator to 50 Ω output impedance (50 Ω source impedance).
   b. Push the channel 1 button.
   c. Set the **Termination** to **50 Ω**.
9. Set the vertical **Scale** to **1 mV** per division.
10. *Set the offset as follows:*
    a. Set the calibrator to 900 mV vertical offset.
    b. Push the lower-bezel **More** button to select **Offset**.
    c. Set the **Vertical Offset** to **900 mV**, as shown in the test record.
11. *Select the Mean measurement (if not already selected) as follows:*
    a. Push the front-panel Wave Inspector **Measure** button.
    b. Push the **Add Measurement** lower-bezel button.
    c. Select the **Mean** measurement.
    d. Push the **OK Add Measurement** side-bezel button.
12. View the mean value in the measurement pane at the bottom of the display and enter it as the test result in the test record.
13. Repeat step 12 for each vertical scale and offset setting combination shown in the test record.
14. *Repeat the tests at 1 MΩ impedance as follows:*
    a. Change the calibrator impedance to 1 MΩ.
    b. Push the front-panel channel 1 button.
    c. Set the **Termination** (input impedance) to **1 MΩ**.
    d. Repeat steps 9 through 13.
15. *Repeat the procedure for all remaining channels as follows:*
    a. Deselect the channel that you have already tested.
    b. Move the DC voltage source connection to the next channel to be tested.
    c. Starting from step 6, repeat the procedure for each channel.

Check Analog Bandwidth

This test checks the bandwidth at 50 Ω and 1 M Ω for each channel.

1. Connect the output of the leveled sine wave generator (for example, Fluke 9500) to the oscilloscope channel 1 input as shown in the following illustration.



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

2. Push the front-panel **Default Setup** button.
3. *Select 50 Ω impedance as follows:*
   a. Set the calibrator to 50 Ω output impedance and to generate a sine wave.
   b. Push the front-panel channel 1 button.
   c. Set the **Termination** (input impedance) to **50 Ω**.
4. *Set the Acquisition mode to Sample as follows:*
   a. Push the front-panel **Acquire** button.
   b. Push the **Mode** lower-bezel button (if not already selected).
   c. Push the **Sample** side bezel button.
5. Set the Vertical **Scale** to **1 mV** per division.
6. For vertical scales less than 500 mV/div, adjust the signal source to at least 8 vertical divisions at the selected vertical scale with a set frequency of 50 kHz. For example, at 5 mV/div, use a ≥40 mV_{p-p} signal, at 2 mV/div, use a ≥16 mV_{p-p} signal, and at 1 mV/div, use a ≥8 mV_{p-p} signal. For vertical scales of 500 mV/div and 1 V/div adjust the signal source to 3 V_{p-p}. Use a sine wave for the signal source.
7. Set the Horizontal **Scale** to **10 µs** per division.

8. Record the peak-to-peak measurement:
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Select the **Peak-to-Peak** measurement.
   c. Push the **OK Add Measurement** side-bezel button.
   d. This will provide a mean V_{p-p} of the signal. Call this value $\mathbf{V}_{in-pp}$.
   e. Enter this value in the test record.
9. Set the Horizontal **Scale** to **4 ns** per division.
10. Adjust the signal source to the maximum bandwidth frequency for the bandwidth and model desired, as shown in the following worksheet.
11. *Record the peak-to-peak measurement as follows:*
    a. View the mean V_{p-p} of the signal. Call this value $\mathbf{V}_{bw-pp}$.
    b. Enter this value in the test record.

NOTE. *For more information on the contents of this worksheet, refer to the bandwidth specifications. (See Table 1 on page 1.)*

Table 17: Maximum bandwidth frequency worksheet

Model: MDO4104-3, MDO4104-6

Impedance	Vertical Scale	Maximum bandwidth
50 Ω	5 mV/div — 1 V/div	1 GHz
	2 mV/div — 4.98 mV/div	350 MHz
	1 mV/div — 1.99 mV/div	175 MHz

Table 17: Maximum bandwidth frequency worksheet (cont.)

Impedance	Vertical Scale	Maximum bandwidth
Model: MDO4104-3, MDO4104-6		
1 MΩ	5 mV/div — 1 V/div	500 MHz [1]
	2 mV/div — 4.98 mV/div	350 MHz
	1 mV/div — 1.99 mV/div	175 MHz
Model: MDO4054-3, MDO4054-6		
50 Ω and 1 MΩ	5 mV/div — 1 V/div	500 MHz
	2 mV/div — 4.98 mV/div	350 MHz
	1 mV/div — 1.99 mV/div	175 MHz
Model: MDO4034-3		
50 Ω and 1 MΩ	2 mV/div — 1 V/div	350 MHz
	1 mV/div — 1.99 mV/div	175 MHz
Model: MDO4014-3		
50 Ω and 1 MΩ	1 mV/div — 1 V/div	100 MHz

[1] For MDO4104-3 and MDO4104-6 performance verification, use 500 MHz, rather than 1 GHz, on the 5 mV/div vertical scale.

12. Use the values of V_{bw-pp} and V_{in-pp} that you entered in the test record to calculate the *Gain* at bandwidth with the following equation:

$$Gain = V_{bw-pp} / V_{in-pp}$$

To pass the performance measurement test, Gain should be ≥ 0.707. Enter *Gain* in the test record.

13. Repeat steps 5 through 12 for all combinations of Vertical Scale and Horizontal Scale settings listed in the test record.

14. *Repeat the tests at 1 MΩ impedance as follows:*

a. Change the calibrator impedance to 1 MΩ.

b. Push the front-panel channel 1 button.

c. Set the **Termination** (input impedance) to **1 MΩ**.

d. Repeat steps 5 through 13.

15. *Repeat the procedure for all remaining channels as follows:*

a. Push the front-panel button to deselect the channel that you have already tested.

b. Move the calibrator connection to the next channel input to be tested.

c. Starting from step 3, repeat the procedure for each input channel.

Check Random Noise, Sample Acquisition Mode

This test checks random noise. You do not need to connect any test equipment to the oscilloscope for this test.

1. Disconnect everything from the oscilloscope inputs.
2. Push the front-panel **Default Setup** button.
3. *Set Gating to Off as follows:*
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Push the bottom-bezel **More** button to select **Gating**.
   c. Push the side-bezel **Off (Full Record)** button.
4. *Select the RMS measurement as follows:*
   a. Push the bottom-bezel **Add Measurement** button.
   b. Select the **RMS** measurement.
   c. Push the side-bezel **OK Add Measurement** button.
5. *Reset statistics as follows:*
   a. Push the bottom-bezel **More** button to select **Statistics**.
   b. Push the side-bezel **Reset Statistics** button.
6. Read and make a note of the RMS Mean value. This is the Sampled Mean Value (SMV).
7. *Set the Acquisition mode to Average as follows:*
   a. Push the front-panel **Acquire** button.
   b. Push the bottom-bezel **Mode** button to display the Acquisition Mode menu (if it is not already selected).
   c. Push the side-bezel **Average** button.
   d. Make sure that the **number of averages** is set to **16**.
8. *Reset statistics as follows:*
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Push the bottom-bezel **More** button to select **Statistics** (if it is not already selected).
   c. Push the side-bezel **Reset Statistics** button.
9. Read and make a note of the RMS Mean value. This is the Averaged Mean Value (AMV).
10. Calculate the RMS noise (RMS noise = SMV – AMV), and enter the calculated RMS noise in the test record.

11. *Set the Acquisition mode to Sample as follows:*

a. Push the front-panel **Acquire** button.

b. Push the **Mode** lower-bezel button (if it is not already selected).

c. Push the **Sample** side bezel button.

12. *Repeat the tests at 50 Ω as follows:*

a. Push the front-panel channel 1 button.

b. Set the **Termination** (input impedance) to **50 Ω**.

c. Push the front-panel Wave Inspector **Measure** button, and repeat steps 5 through 11.

13. *Repeat the tests at 250 MHz bandwidth as follows:*

a. Push the front-panel channel 1 button.

b. Set the **Termination** (input impedance) to **1 MΩ**.

c. Push the bottom-bezel **Bandwidth** button.

d. Push the side-bezel **250 MHz** button.

e. Push the front-panel Waveform Inspector **Measure** button.

f. Repeat steps 5 through 12.

14. *Repeat the tests at 20 MHz bandwidth as follows:*

a. Push the front-panel channel 1 button.

b. Set the **Termination** (input impedance) to **1 MΩ**.

c. Push the bottom-bezel **Bandwidth** button.

d. Push the side-bezel **20 MHz** button.

e. Push the front-panel Waveform Inspector **Measure** button.

f. Repeat steps 5 through 12.

15. *Repeat the procedure for all remaining channels as follows:*

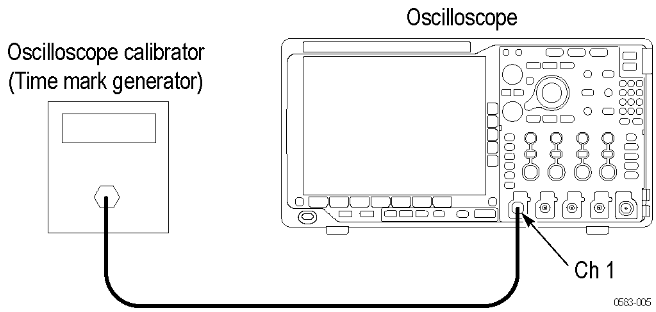
a. Push the front-panel button to deselect the channel that you have already tested.

b. Starting from step 3, repeat the procedure for each input channel.

Check Sample Rate and Delay Time Accuracy

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

1. Connect the output of a time mark generator to the oscilloscope channel 1 input using a 50 Ω cable, as shown in the following illustration.



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

2. Set the time mark generator period to **80 ms**. Use a time mark waveform with a fast rising edge.
3. Push the front-panel **Default Setup** button.
4. *Set the impedance to 50 Ω as follows:*
   a. Push the front-panel channel 1 button.
   b. Set the **Termination** to **50 Ω**.
5. If it is adjustable, set the time mark amplitude to approximately **1** $\mathbf{V_{p-p}}$.
6. Set the Vertical **Scale** to **500 mV** per division.
7. Set the Horizontal **Scale** to **20 ms** per division.
8. Adjust the Vertical **Position** knob to center the time mark signal on the screen.
9. Adjust the Trigger **Level** as necessary for a triggered display.
10. Adjust the Horizontal **Position** to move the trigger location to the center of the screen (50%).
11. *Set the delay to 80 ms as follows:*
    a. Push the front-panel **Acquire** button.
    b. Push the lower-bezel **Delay** button to turn delay on (if it is not already on).
    c. Turn the Horizontal **Position** knob clockwise to set the delay to exactly **80 ms**.

12. Set the Horizontal **Scale** to **400 ns/div**.

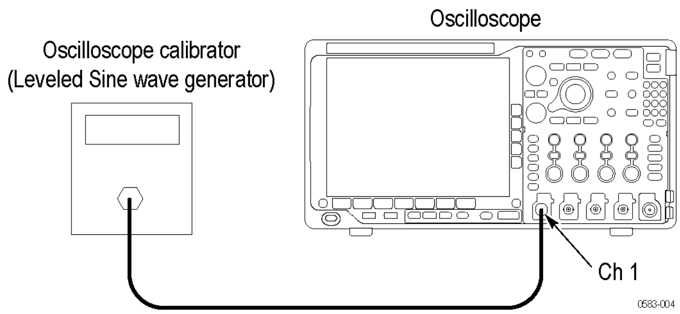
13. Compare the rising edge of the marker with the center horizontal graticule line. The rising edge should be within ±1 divisions of center graticule. Enter the deviation in the test record.

NOTE. *One division of displacement from graticule center corresponds to a 5 ppm time base error.*

Check Delta Time Measurement Accuracy

This test checks the Delta-time measurement accuracy (DTA) for a given instrument setting and input signal.

Connect a 50 Ω coaxial cable from the signal source to the oscilloscope channel 1, as shown in the following illustration.



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

2. Push the oscilloscope front-panel **Default Setup** button.
3. *Select 50 Ω impedance as follows:*
   - **a.** Set the sine wave generator output impedance to 50 Ω.
   - **b.** Push the channel 1 button to display the channel 1 menu.
   - **c.** Set the **Termination** (input impedance) to **50 Ω**.
4. *Set the trigger source to channel 1 as follows:*
   - **a.** Push the Trigger **Menu** button.
   - **b.** Push the **Source** lower-bezel button (if not already selected).
   - **c.** Select channel 1 (if not already selected).
5. *Set the Mean & St Dev Samples to 100 as follows:*
   - **a.** Push the Wave Inspector **Measure** button.
   - **b.** Push the bottom-bezel **Add Measurement** button.
   - **c.** Select the **Burst Width** measurement.
   - **d.** Push the side-bezel **OK Add Measurement** button.
   - **e.** Push the bottom-bezel **More** button to select **Statistics**.
   - **f.** Set the **Mean & Std Dev Samples** to **100**, as shown in the side menu.

6. Set the signal source to 240 MHz and 40 mV as shown in the test record.

NOTE. *To provide consistent results, set the signal source frequency such that the zero crossing does not occur at the beginning or end of the record.*

7. Set the Horizontal **Scale** to **4 ns** per division.
8. Set the Vertical **Scale** to **5 mV** per division.
9. *Record the Std Dev value as follows:*
   a. Push the side-bezel **Reset Statistics** button.
   b. Push the **Menu** button to remove the side-bezel menu.
   c. Wait five or 10 seconds for the oscilloscope to acquire all of the samples.
   d. Verify that the **Std Dev** is less than the upper limit shown in the test record.
   e. Enter the reading in the test record.
10. Repeat steps 6 through 9 for each setting combination shown in the test record.
11. *Repeat the procedure for all remaining channels as follows:*
    a. Push the front-panel button to deselect the channel that you have already tested.
    b. Connect the signal source to the input for the next channel to be tested.
    c. Repeat the procedure from step 3 until all channels have been tested.

Check Digital Threshold Accuracy

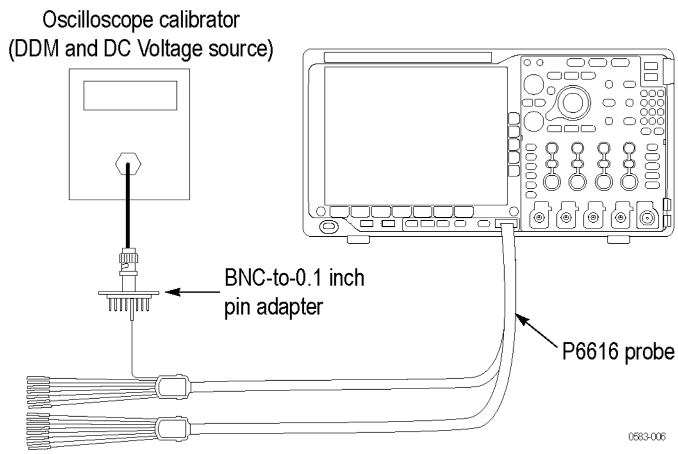
This test checks the threshold accuracy of the digital channels. This procedure applies to digital channels D0 through D15, and to channel threshold values of 0 V and +4 V.

1. Connect the P6616 digital probe to the oscilloscope, as shown in the following illustration:

   a. Connect the DC voltage source to the digital channel D0.

   b. If you are using the Fluke 9500 calibrator as the DC voltage source, connect the calibrator head to the digital channel D0, using the BNC-to-0.1 inch pin adapter listed in the Required Equipment table. (See Table 15 on page 28.)

   c. Connect channel D0 to both the corresponding signal pin and to a ground pin on the adapter.



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

2. *Turn on the digital channels as follows:*

   a. Push the front-panel **D15-D0** button.

   b. Push the **D15-D0 On/Off** lower-bezel button.

   c. Push the **Turn On D7 - D0** and the **Turn On D15 - D8** side-bezel buttons to turn these channels On.

   d. Make sure that the side-bezel **Display** selection is **On**.

   e. The instrument will display the 16 digital channels.

3. *Set the channel threshold to 0 V as follows:*

   a. Push the **Thresholds** lower-bezel button (if not already selected).

   b. Select channel **D0**.

   c. Set the value to **0.00 V** (0 V/div), using the coarse and fine settings of the knob as necessary to set the exact value.

4. Push the **Menu** button and then set the Horizontal **Scale** to **4µs** per division.

5. *Set the Trigger source as follows:*

   a. Push the front-panel Trigger **Menu** button.

   b. Push the **Source** lower-bezel button (if not already selected).

   c. Select channel D0.

6. Set the DC voltage source (Vs) to -400 mV. Wait 3 seconds. Check the logic level of the channel D0 signal display. If it is at a static logic high, change the DC voltage source Vs to -500 mV.

7. Increment Vs by +10 mV. Wait 3 seconds and check the logic level of the channel D0 signal display. If it is a static logic high, record the Vs value as in the 0 V row of the test record.

   If the signal level is a logic low or is alternating between high and low, repeat this step (increment Vs by 10 mV, wait 3 seconds, and check for a static logic high) until a value for $\mathbf{V_{s-}}$ is found.

8. Click the lower-bezel **Slope** button to change the slope to **Falling**.

9. Set the DC voltage source (Vs) to +400 mV. Wait 3 seconds. Check the logic level of the channel D0 signal display.

   If it is at a static logic low, change the DC voltage source Vs to +500 mV.

10. Reduce Vs by -10 mV. Wait 3 seconds and check the logic level of the channel D0 signal display. If it is a static logic low, record the Vs value as $\mathbf{V_{s+}}$ in the 0 V row of the test record.

    If the signal level is a logic high or is alternating between high and low, repeat this step (decrement Vs by 10 mV, wait 3 seconds, and check for a static logic low) until a value for $\mathbf{V_{s+}}$ is found.

11. Find the average using this formula: $V_{sAvg} = (V_{s-} + V_{s+})/2$. 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.

12. *Set the channel threshold to +4 V as follows:*

    a. Push the front-panel **D15-D0** button.

    b. Push the **Thresholds** lower-bezel button.

c. Select channel **D0**.

d. Push the **Fine** front-panel button to turn off the fine adjustment.

e. Set the value near **4.00 V** (4 V/div).

f. Push the **Fine** button to turn the fine adjustment on again.

g. Set the value to exactly **4.00 V** (4 V/div).

13. Set the DC voltage source (Vs) to +4.4 V. Wait 3 seconds. Check the logic level of the channel D0 signal display.

14. Decrement Vs by -10 mV. Wait 3 seconds and check the logic level of the channel D0 signal display. If it is a static logic low, record the Vs value as $\mathbf{V_{s+}}$ in the 4 V row of the test record.

If the signal level is a logic high or is alternating between high and low, repeat this step (decrement Vs by 10 mV, wait 3 seconds, and check for a static logic low) until a value for $\mathbf{V_{s+}}$ is found.

15. Push the front-panel **Trigger Menu** button.

16. Click the lower-bezel **Slope** button to change the slope to **Rising**.

17. Set the DC voltage source (Vs) to +3.6 V. Wait 3 seconds. Check the logic level of the channel D0 signal display.

If the signal level is a static logic high, change the DC voltage source Vs to +3.5 V.

18. Increment Vs by +10 mV. Wait 3 seconds and check the logic level of the channel D0 signal display. If it is a static logic high, record the Vs value as $\mathbf{V_{s-}}$ in the 4 V row of the test record.

If the signal level is a logic low or is alternating between high and low, repeat this step (increment Vs by 10 mV, wait 3 seconds, and check for a static logic high) until a value for $\mathbf{V_{s-}}$ is found.

19. Find the average using this formula: $V_{sAvg} = (V_{s-} + V_{s+})/2$. 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.

20. *Repeat the procedure for all remaining digital channels as follows:*

a. Push the D15–D0 button.

b. Move the DC voltage source connection, including the ground lead, to the next digital channel to be tested.

c. Starting from step 3, repeat the procedure until all 16 digital channels have been tested.

Check Phase Noise

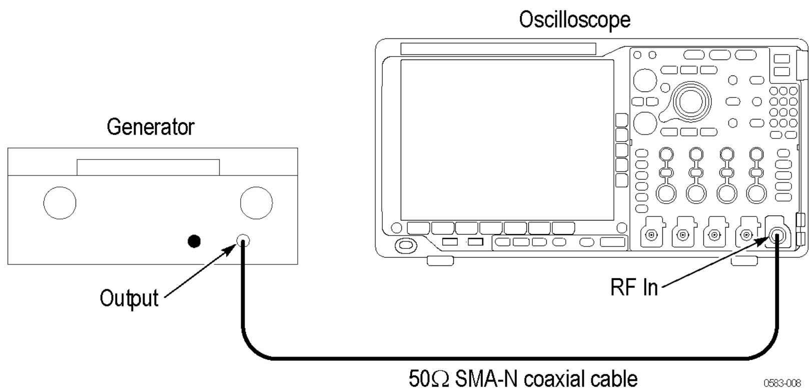
This step checks the phase noise measured offset from a 2 GHz CW signal. It checks at three offset frequencies: 10 kHz, 100 kHz, and 1 MHz.

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

NOTE. *Do not use an N connector with the Anritsu generator. Equipment damage will result if an N connector is used.*

---

1. Connect the output of a signal generator, such as the Anritsu generator, to the oscilloscope RF Input, using a 50 Ω SMA coaxial cable (see the following figure).



2. Set the generator for a 2 GHz, 0 dBm signal.
3. *Initial oscilloscope setup:*
   a. Push the front-panel **Default Setup** button.
   b. Turn Channel 1 off.
   c. Push the front-panel RF button to turn on the RF channel and display the bottom-bezel RF menu.
   d. *Turn on the average trace as follows:* Push the bottom-bezel **Spectrum Traces** button. Push the side-bezel **Average** button to set the **Average Traces** to **On**. Push the side-bezel **Normal** button to set Normal to **Off**.
   e. *Set the center frequency to 2 GHz as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Center Frequency** button. Set the center frequency to **2 GHz**.
   f. *Set the span to 50.0 kHz as follows:* Set the Span to 50.0 kHz.
   g. Center the signal on the display. To do this:

Push the **Markers** front-panel button.

Push the **R To Center** side-bezel button.

h. *Set the resolution bandwidth (RBW) to 250 Hz as follows:* Push the front-panel **BW** button. Push the side-bezel **RBW Mode** button to set the RBW mode to Manual. Set the resolution bandwidth to 250 Hz.

i. *Set the markers to delta as follows:* Push the front-panel **Markers** button. Push the side-bezel **Manual Markers** button to set the manual markers to On. Push the side-bezel **Readout** button to select **Delta**.

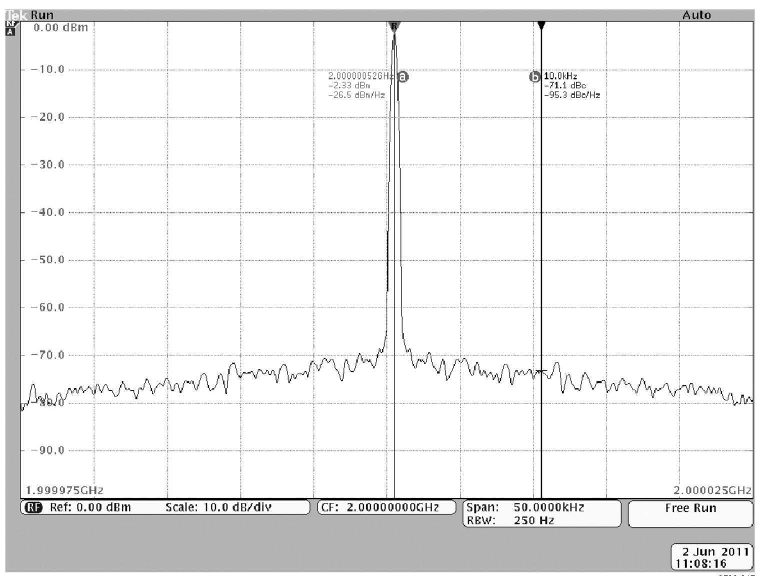
j. *Set the reference level to 0 dbm as follows:* Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the reference level to 0 dBm.

4. *Check at 10 kHz:*

a. Push the front-panel **Markers** button.

b. Set marker a to the signal peak.

c. Set marker b to 10 kHz as shown in the following figure.



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d. Note the bottom value in the marker b readout (in dBc/Hz) and enter it in the test record.

5. *Repeat the check at 100 kHz:*

a. Change the span to 500 kHz.

b. Change the resolution bandwidth (RBW) to 1 kHz.

c. Set marker a to the signal peak.

d. Set marker b to 100 kHz.

e. Note the bottom value in the marker b readout (in dBc/Hz) and enter it in the test record. Make sure that the instrument meets the specification given in the test record.

6. *Repeat the check at 1 MHz:*

a. Change the span to 5 MHz.

b. Change the resolution bandwidth (RBW) to 50 kHz.

c. Set marker a to the signal peak.

d. Set marker b to 1 MHz.

e. Note the bottom value in the marker b readout (in dBc/Hz) and enter it in the test record. Make sure that the instrument meets the specification given in the test record.

Check Displayed Average Noise Level (DANL)

This test does not require an input signal.

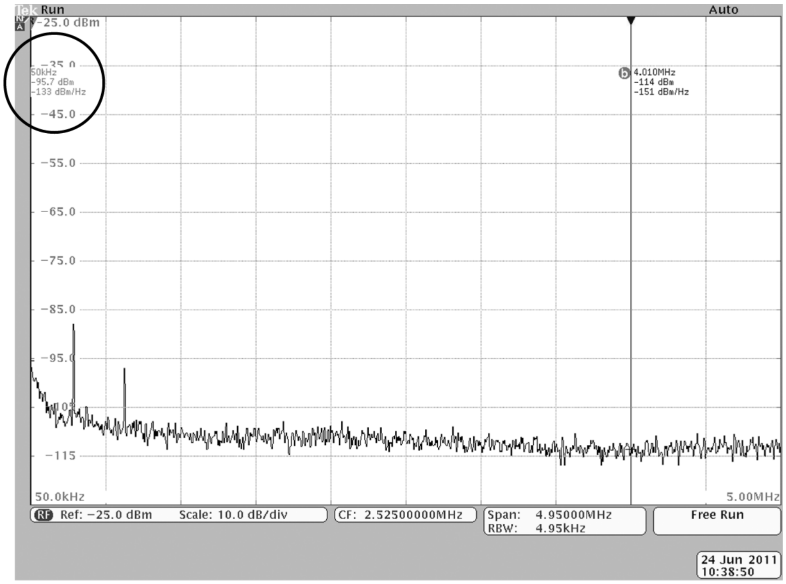
The test measures the average internal noise level of the instrument, ignoring residual spurs.

It checks four ranges:

- 50 kHz to 5 MHz (all models)
- 5 MHz to 3 GHz (all models)
- 3 GHz to 4 GHz (MDO4104-6 and MDO4054-6 only)
- 4 GHz to 6 GHz (MDO4104-6 and MDO4054-6 only)

NOTE. *If the specific measurement frequency results in measuring a residual spur that is visible above the noise level, the DANL specification applies not to the spur but to the noise level on either side of the spur. Please refer to the Spurious Response specifications.* *(See page 19.)*

1. *Initial oscilloscope setup:*
   a. Terminate the RF input in 50 Ω and make sure that no input signal is applied.
   b. Push the front-panel **Default Setup** button.
   c. Turn channel 1 off.
   d. Push the front-panel **RF** button to turn on the RF channel and display the bottom-bezel RF menu.
   e. *Turn on the average trace as follows:* Push the bottom-bezel **Spectrum Traces** button and set Normal to Off. Push the side-bezel **Average** button to set the Average Traces to On.
   f. *Turn on the average detection as follows:* Push the bottom-bezel **Detection Method** button. Push the side-bezel button to set the detection method to **Manual**. Push the side-bezel **Average Trace** button. Set the detection method to Average.
   g. *Set the reference level to –25.0 dBm as follows:* Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to –25.0 dBm.
   h. *Set the start and stop frequency as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Start** button. Set the start frequency to 50 kHz. Push the side-bezel **Stop** button. Set the stop frequency to 5 MHz.
2. *Check from 50 kHz to 5 MHz (all models):*
   a. Set Manual Marker (a) at the frequency with the highest noise level as follows: Push the **Markers** front-panel button. Push the **Manual Markers** side bezel button to turn on the markers. Turn Multipurpose knob **a** to move the marker to the frequency at the noise threshold (highest point of noise), ignoring any spurs. For this span, it should be at 50 kHz on the far left of the screen. See the following figure.



b. Record the noise threshold value (in dBm/Hz) in the test record and compare it to the instrument specification.

3. *Check from 5 MHz to 3 GHz (all models):*

a. Set the stop frequency to 3 GHz.

b. Set the start frequency to 5 MHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

4. *Check from 3 GHz to 4 GHz (MDO4104-6 and MDO4054-6 only):*

a. Set the stop frequency to 4 GHz.

b. Set the start frequency to 3 GHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

5. *Check from 4 GHz to 6 GHz (MDO4104-6 and MDO4054-6 only):*

a. Set the stop frequency to 6 GHz.

b. Set the start frequency to 4 GHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

Check Level Measurement Uncertainty

This test checks the level measurement uncertainty at three reference levels: +10 dBm, 0 dBm, and –15 dBm. This check uses the generator to step frequencies across four spans to verify that the instrument meets the specification.

For this check, you will need the following equipment, which is described in the Required Equipment table. (See Table 15 on page 28.)

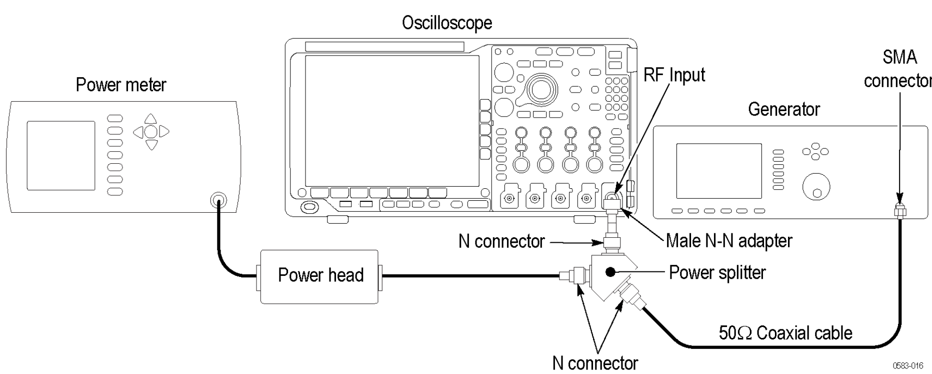
- Generator, such as the Anritsu generator
- Power meter
- Power head
- Power splitter
- Adapters and cables as shown in the following figure.

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

NOTE. *Use an SMA connector with the Anritsu generator. Equipment damage will result if an N connector is used.*

---

1. *Connect the equipment as shown in the following figure.*



2. *Initial oscilloscope setup:*
   a. Push the front-panel **Default Setup** button.
   b. Turn Channel 1 off.
   c. Push the front-panel **RF** button to turn on the RF channel.

3. *Check at +10 dBm:*

a. Set the reference level to 10 dBm as follows: Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to 10 dBm.

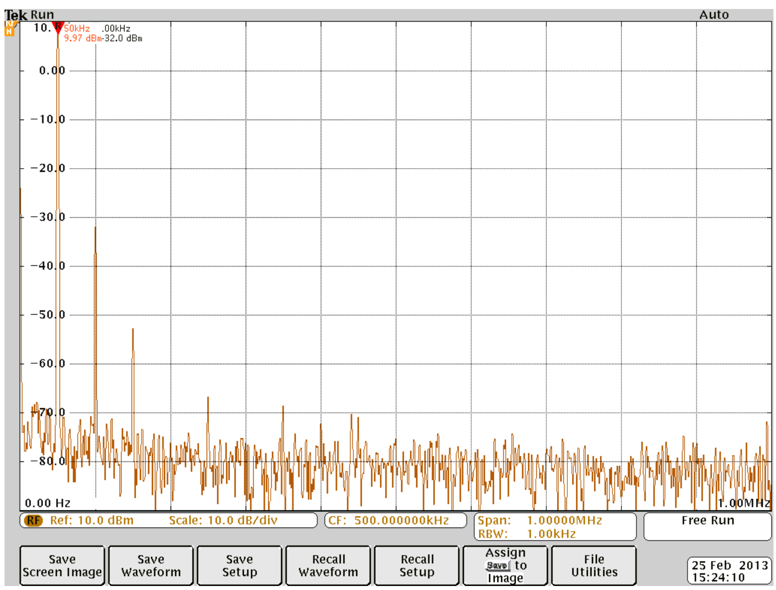
b. *Set the frequency range as follows:*

- Push the front-panel **Freq/Span** button.
- Push the side-bezel **Start** button.
- Set the start frequency to 0 Hz.
- Push the side-bezel **Stop** button.
- Set the stop frequency to 1 MHz.

c. Set the generator to provide a 50 kHz, +10 dBm signal.

d. At 50 kHz, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope. See the following figure.



- Calculate the difference between the two readings. This is the test result.

e. In the test record, enter the greatest result determined at this frequency (50 kHz).

f. Step the generator, in 100 kHz intervals, through frequencies from 100 kHz to 900 kHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

g. In the test record, enter the greatest result determined within this frequency range (100 kHz – 900 kHz).

h. *Change the frequency range as follows:*

- Change the stop frequency to 9.2 MHz.
- Change the start frequency to 980 kHz.

i. Set the generator to provide a 1 MHz, +10 dBm signal.

j. Step the generator, in 1 MHz intervals, through frequencies from 1 MHz to 9 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

k. In the test record, enter the greatest result determined within this frequency range (1 MHz to 9 MHz).

l. *Change the frequency range as follows:*

- Change the stop frequency to 92 MHz.
- Change the start frequency to 9.8 MHz.

m. Set the generator to provide a 10 MHz, +10 dBm signal.

n. Step the generator, in 10 MHz intervals, through frequencies from 10 MHz to 90 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

o. In the test record, enter the greatest result determined within this frequency range (10 MHz to 90 MHz).

For MDO4104-3, MDO4054-3, MDO4034-3, and MDO4014-3 Only (steps p through s)

p. *Change the frequency range as follows:*

- Change the stop frequency to 3.1 GHz.
- Change the start frequency to 99 MHz.

q. Set the generator to provide a 100 MHz, +10 dBm signal.

r. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 2.9 GHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

s. In the test record, enter the greatest result determined within this frequency range (100 MHz to 2.9 GHz).

For MDO4104-6 and MDO4054-6 Only (steps t through w)

t. *Change the frequency range as follows:*

- Change the stop frequency to 6.1 GHz.
- Change the start frequency to 99 MHz.

u. Set the generator to provide a 100 MHz, +10 dBm signal.

v. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 5.7 GHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

w. In the test record, enter the greatest result determined within this frequency range (100 MHz to 5.7 GHz).

4. *Check at 0 dBm:*

a. Set the reference level to 0 dBm as follows: Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to 0 dBm.

b. *Set the frequency range as follows:*

- Push the front-panel **Freq/Span** button.
- Push the side-bezel **Start** button.
- Set the start frequency to 0 Hz.

- Push the side-bezel **Stop** button.
- Set the stop frequency to 1 MHz.

c. Set the generator to provide a 50 kHz, 0 dBm signal.

d. At 50 kHz, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope. See the following figure.
- Calculate the difference between the two readings. This is the test result.

e. In the test record, enter the greatest result determined at this frequency (50 kHz).

f. Step the generator, in 100 kHz intervals, through frequencies from 100 kHz to 900 kHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

g. In the test record, enter the greatest result determined within this frequency range (100 kHz – 900 kHz).

h. *Change the frequency range as follows:*

- Change the stop frequency to 9.2 MHz.
- Change the start frequency to 980 kHz.

i. Set the generator to provide a 1 MHz, 0 dBm signal.

j. Step the generator, in 1 MHz intervals, through frequencies from 1 MHz to 9 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

k. In the test record, enter the greatest result determined within this frequency range (1 MHz to 9 MHz).

l. *Change the frequency range as follows:*

- Change the stop frequency to 92 MHz.
- Change the start frequency to 9.8 MHz.

m. Set the generator to provide a 10 MHz, 0 dBm signal.

n. Step the generator, in 10 MHz intervals, through frequencies from 10 MHz to 90 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

o. In the test record, enter the greatest result determined within this frequency range (10 MHz to 90 MHz).

For MDO4104-3, MDO4054-3, MDO4034-3, and MDO4014-3 Only (steps p through s)

p. *Change the frequency range as follows:*

- Change the stop frequency to 3.1 GHz.
- Change the start frequency to 99 MHz.

q. Set the generator to provide a 100 MHz, 0 dBm signal.

r. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 2.9 GHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

s. In the test record, enter the greatest result determined within this frequency range (100 MHz to 2.9 GHz).

For MDO4104-6 and MDO4054-6 Only (steps t through w).

t. *Change the frequency range as follows:*

- Change the stop frequency to 6.1 GHz.
- Change the start frequency to 99 MHz.

u. Set the generator to provide a 100 MHz, 0 dBm signal.

v. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 5.7 GHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

w. In the test record, enter the greatest result determined within this frequency range (100 MHz to 5.7 GHz).

5. *Check at –15 dBm:*

a. Set the reference level to –15 dBm as follows: Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to –15 dBm.

b. *Set the frequency range as follows:*

- Push the front-panel **Freq/Span** button.
- Push the side-bezel **Start** button.
- Set the start frequency to 0 Hz.
- Push the side-bezel **Stop** button.
- Set the stop frequency to 1 MHz.

c. Set the generator to provide a 50 kHz, –15 dBm signal.

d. At 50 kHz, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

e. In the test record, enter the greatest result determined at this frequency (50 kHz).

f. Step the generator, in 100 kHz intervals, through frequencies from 100 kHz to 900 kHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

g. In the test record, enter the greatest result determined within this frequency range (100 kHz – 900 kHz).

h. *Change the frequency range as follows:*

- Change the stop frequency to 9.2 MHz.
- Change the start frequency to 980 kHz.

i. Set the generator to provide a 1 MHz, –15 dBm signal.

j. Step the generator, in 1 MHz intervals, through frequencies from 1 MHz to 9 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

k. In the test record, enter the greatest result determined within this frequency range (1 MHz to 9 MHz).

l. *Change the frequency range as follows:*

- Change the stop frequency to 92 MHz.
- Change the start frequency to 9.8 MHz.

m. Set the generator to provide a 10 MHz, –15 dBm signal.

n. Step the generator, in 10 MHz intervals, through frequencies from 10 MHz to 90 MHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

o. In the test record, enter the greatest result determined within this frequency range (10 MHz to 90 MHz).

p. **For MDO4104-3, MDO4054-3, MDO4034-3 and MDO4014-3 Only.** *Change the frequency range as follows:*

- Change the stop frequency to 3.1 GHz.
- Change the start frequency to 99 MHz.

q. Set the generator to provide a 100 MHz, –15 dBm signal.

r. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 2.9 GHz. At each interval, determine the test result as follows:

- Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
- Calculate the difference between the two readings. This is the test result.

s. In the test record, enter the greatest result determined within this frequency range (100 MHz to 2.9 GHz).

t. **For MDO4104-6 and MDO4054-6 Only.** *Change the frequency range as follows:*

- Change the stop frequency to 6.1 GHz.
- Change the start frequency to 99 MHz.
- Set the generator to provide a 100 MHz, –15 dBm signal.
- Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 5.7 GHz. At each interval, determine the test result as follows:
  - Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.
  - Calculate the difference between the two readings. This is the test result.
- In the test record, enter the greatest result determined within this frequency range (100 MHz to 5.7 GHz).

Check Third Order Intermodulation Distortion

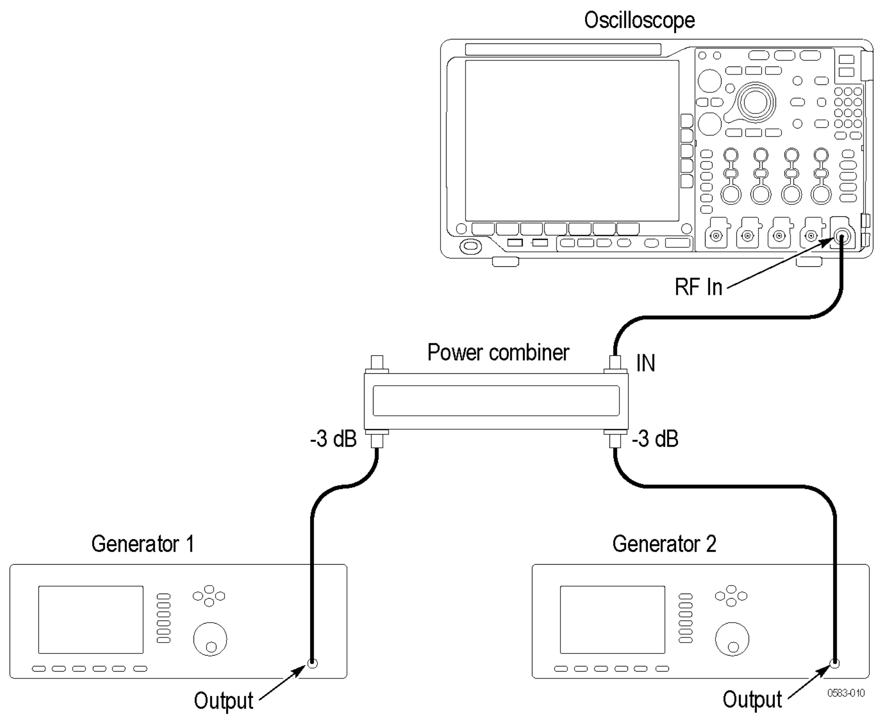
This check verifies that the oscilloscope meets the specification for Third Order Intermodulation Distortion.

⚠ ***WARNING.*** *The generators are capable of providing dangerous voltages. Be sure to set the generators to off or 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure.*

Required equipment. You will need the following equipment for this check. All items are shown in the required equipment list. (See Table 15.)

- Two generators. Each generator must be capable of providing signals up to 6 GHz. You can use two of the same model generator, or two different generators, depending on what you have available. Example generators are the Anritsu and the Rohde & Schwarz SMT06.
- A power combiner (hybrid coupler), such as the Krytar 3005070.
- Three SMA cables. Use cables that will connect to your generators' outputs.

1. *Connect the equipment as follows.* (See the following figure.)
   - Connect an SMA cable from the RF input on the oscilloscope to the power combiner connector labeled "IN."
   - Connect an SMA cable from the RF output of a generator to a -3 dB input on the power combiner.
   - Connect an SMA cable from the RF output of the other generator to the other -3 dB input on the power combiner.



2. Set generator 1 to provide a 2.735 GHz, -5 dBm signal at the RF input of the oscilloscope.
3. Set generator 2 to provide a 2.755 GHz, -5 dBm signal at the RF input of the oscilloscope.
4. *Initial oscilloscope setup:*
   a. Push the front-panel **Default Setup** button.
   b. Turn channel 1 off.
   c. Push the front-panel **RF** button to turn on the RF channel and show the bottom-bezel menu.
   d. *Turn on the average trace as follows:* Push the bottom-bezel **Spectrum Traces** button. Push the side-bezel **Average** button to set the Average Traces to On. Push the side-bezel **Normal** button to set Normal to Off.

e. *Set the center frequency as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Center Frequency** button. Set the center frequency to 2.745 GHz.

f. *Set the span as follows:* Push the side-bezel **Span** button. Set the Span to 100 MHz.

g. *Set the resolution bandwidth (RBW) as follows:* Push the front-panel **BW** button. Push the side-bezel **RBW Mode** button to select Manual. Push the side-bezel **RBW** button. Set the resolution bandwidth to 100 kHz.

h. *Set the vertical scale as follows:* Push the **Amplitude** front-panel button. Push the side-bezel **Vertical** button. Set the scale to 10 dB/division.

i. *Set the Ref Level as follows:* Push the side-bezel **Ref Level** button and set the Ref Level to 0 dBm.

j. Push the front-panel **Markers** button.

k. Push the side-bezel **Manual Markers** button to set the manual markers to On.

l. Push the side-bezel **Readout** button to select **Delta**.

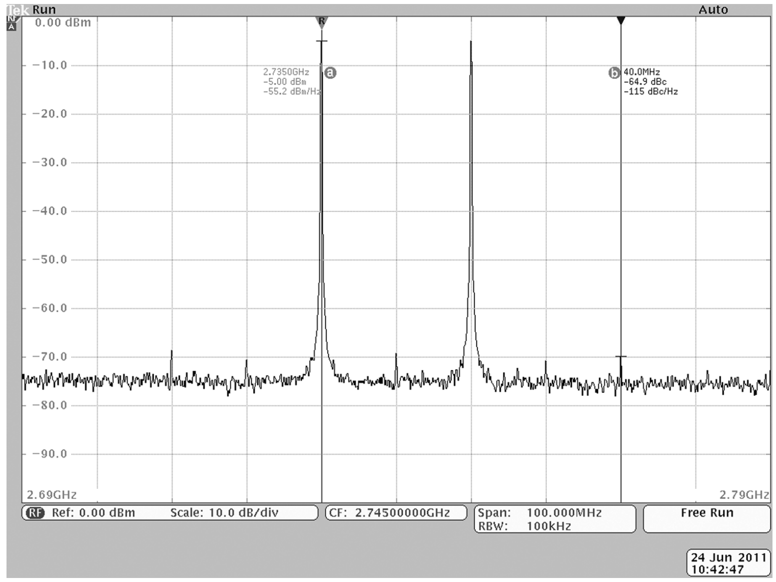
5. *Check at 2.745 GHz as follows (all models):*

a. Set marker a to the peak of the generator 1 signal (2.735 GHz).

b. Check for peaks at two frequencies:

- 20 MHz lower frequency than the generator 1 signal
- 20 MHz higher frequency than the generator 2 signal

c. Set marker b to the highest of these two peaks. See the following figure.



d. Note the difference in amplitude between marker a and marker b. This is the middle value given in the marker b readout, and is displayed in dBc units. Enter this value in the test record and make sure that the instrument meets the specification given in the test record.

6. *Check at 4.5 GHz as follows (MDO4104-6 and MDO4054-6 only):*

a. Set generator 1 to provide a 4.49 GHz, -5 dBm signal at the RF input of the oscilloscope.

b. Set generator 2 to provide a 4.510 GHz, -5 dBm signal at the RF input of the oscilloscope.

a. Set the Center Frequency to 4.5 GHz.

b. Set marker a to the peak of the generator 1 signal (4.49 GHz).

c. Check for peaks at two frequencies:

- 20 MHz lower frequency than the generator 1 signal
- 20 MHz higher frequency than the generator 2 signal

d. Set marker b to the highest of these two peaks. See the figure.

e. Note the difference in amplitude between marker a and marker b. This is the middle value given in the marker b readout, and is displayed in dBc units. Enter this value in the test record and make sure that the instrument meets the specification given in the test record.

Check Residual Spurious Response

This check verifies that the oscilloscope meets the specification for residual spurious response. This check does not require an input signal.

1. Terminate the oscilloscope RF input in 50 Ω and make sure that no input signal is applied.
2. *Set the resolution bandwidth (RBW) as follows:* Push the front-panel **BW** button. Push the side-bezel **RBW Mode** button to select Manual. Push the side-bezel **RBW** button. Set the resolution bandwidth to 50 kHz.
3. *Turn auto level on as follows:*
   a. Push the front-panel **Ampl** button.
   b. Push the side-bezel **Auto Level** button to turn the auto level feature on. The instrument will automatically set the reference level correctly.
4. *Check in the range of 50 kHz to 3 GHz as follows:*
   a. Push the front-panel **Freq/Span** button. Push the side-bezel **Start** button. Set the start frequency to 50 kHz. Push the side-bezel **Stop** button. Set the stop frequency to 3 GHz.
   b. Observe any spurs that are greater than - 80 dBm and note them in the test record.
5. *Check in the range of 2.75 GHz to 4.5 GHz as follows:*
   a. Change the oscilloscope start frequency to 2.75 GHz and the stop frequency to 4.5 GHz.
   b. Observe any spurs that are greater than - 78 dBm and note them in the test record.
6. *Check in the range of 3.5 GHz to 6.0 GHz as follows:*
   a. Change the oscilloscope start frequency to 3.5 GHz and the stop frequency to 6.0 GHz.
   b. Observe any spurs that are greater than - 78 dBm and note them in the test record.

Check Crosstalk to RF Channel from Analog Channels

This check verifies that the oscilloscope meets the specification for crosstalk from an analog channel to the RF channel.

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

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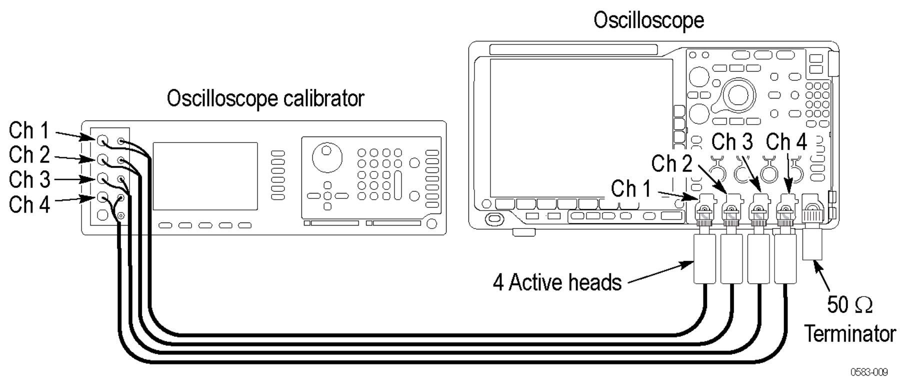
1. Terminate the oscilloscope RF input in 50 Ω.
2. Connect the output of a signal generator to all four analog inputs on the oscilloscope. If you are using the Fluke 9500 oscilloscope calibrator as the signal generator, you can connect the active heads to all four analog inputs at once (Ch 1, Ch 2, Ch 3, and Ch 4). If your generator does not have the capacity to hook up all four channels at once, you can move the connector to each channel in turn.



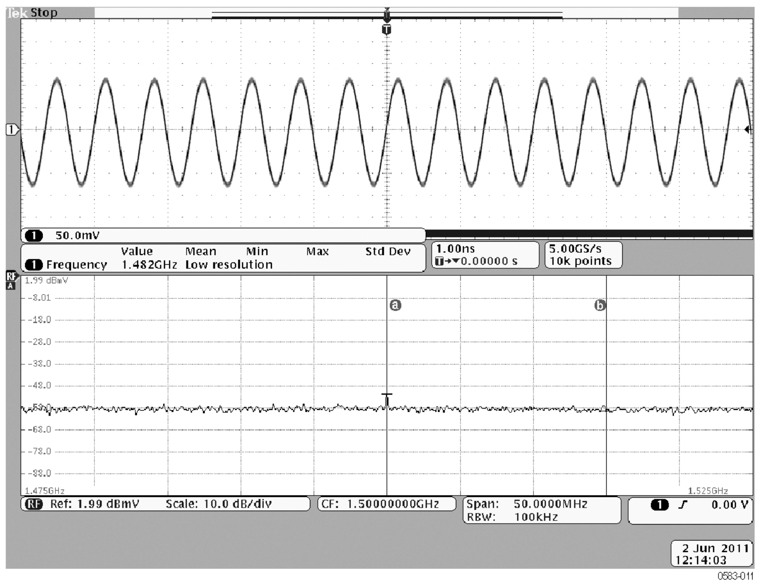
3. Set the generator to provide a 50 kHz, 40 dB, 1 V_{p-p} sine wave signal.
4. *Initial oscilloscope setup:*
   a. Push the front-panel **Default Setup** button.
   b. Select all analog channels (CH1, CH2, CH3, and CH4), and in the vertical menu, push **Termination** to select **50 Ω** impedance.
   c. Turn the analog channels off (so that the RF display will fill the screen for easy viewing).
   d. Push the front-panel **RF** button to turn on the RF channel and display the bottom-bezel menu.
   e. *Turn on the average trace as follows:* Push the bottom-bezel **Spectrum Traces** button. Push the side-bezel **Average** button to set the **Average Traces** to **On**. Push the side-bezel **Normal** button to set **Normal** to **Off**.
   f. *Set the span to 50 MHz as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Span** button. Set the Span to 50 MHz.

5. Set the generator to provide the signal to channel 1

6. *Measure the Channel 1 crosstalk at 100 MHz as follows:*

   a. *Set the center frequency to 100 MHz as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Center Frequency** button. Set the center frequency to 100 MHz.

   b. Use a marker to measure the amplitude of any of the Channel 1 signal that appears in the RF display. See the following figure.



   c. Record the amplitude of the Channel 1 signal in the test record. Make sure that it is within the specified limit.

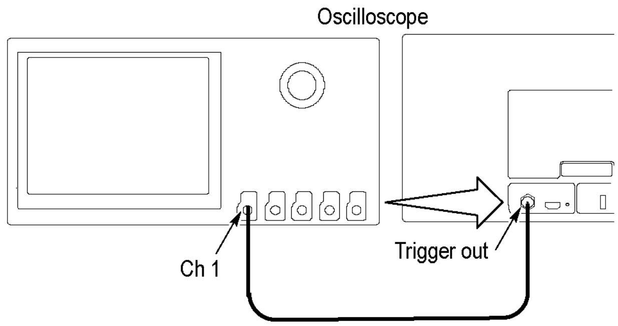
7. Repeat step 6, changing the generator signal frequency and the oscilloscope Center Frequency settings as indicated in the test record. Check all listed frequencies and record the results in the test record.

8. Repeat steps 5 through 7 until you have checked the crosstalk of all four analog channels.

Check Trigger Out

This test checks the Trigger Output.

1. Connect the Trigger Out signal from the rear of the instrument to the channel 1 input using a 50 Ω cable, as shown in the following illustration.



2. Push the front-panel **Default Setup** button.
3. Set the Vertical **Scale** to **1 V** per division.
4. *Record the Low and High measurements at 1 MΩ as follows:*
   a. Push the front-panel Wave Inspector **Measure** button.
   b. Push the **Add Measurement** lower-bezel button.
   c. Select the **Low** measurement.
   d. Push the **OK Add Measurement** side bezel button.
   e. Enter the Low measurement reading in the test record.
   f. Select the **High** measurement.
   g. Push the **OK Add Measurement** side bezel button.
   h. Enter the High measurement reading in the test record.
5. *Record the Low and High measurements at 50 Ω as follows:*
   a. Push the front-panel channel 1 button.
   b. Set the **Termination** (input impedance) to **50 Ω**.
   c. Repeat step 4.

When the MDO4000 Has a TPA-N-PRE Attached to its RF Input

The following instructions apply to situations where the MDO4000 has a TPA-N-PRE preamplifier attached to its RF input

Perform the following functional check to ensure proper operation of the TPA-N-PRE/MDO4000 system.

For this check, you will need the following equipment, which is described in the Required Equipment table. (See Table 15 on page 28.)

- Generator, such as the Anritsu generator
- Power meter
- Power head
- Power splitter
- Adapters and cables as shown in the following figure.

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

NOTE. *Use an SMA connector with the Anritsu generator. Equipment damage will result if an N connector is used.*

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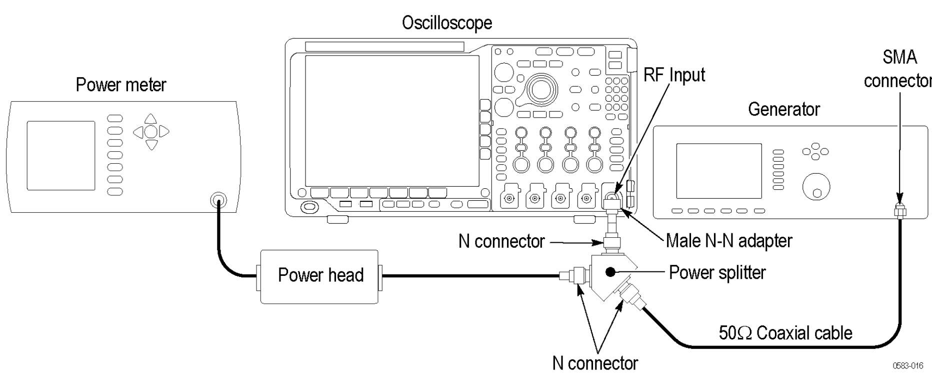
1. *Connect the equipment as shown in the following figure.*



2. *Initial oscilloscope setup:*

a. Push the front-panel **Default Setup** button.

b. Turn Channel 1 off.

c. Push the front-panel **RF** button to turn on the RF channel.

d. Push the Menu button on the TPA-N-PRE preamplifier. On the MDO4000, for the Mode, select **Auto**.

3. Check at 1.7 GHz

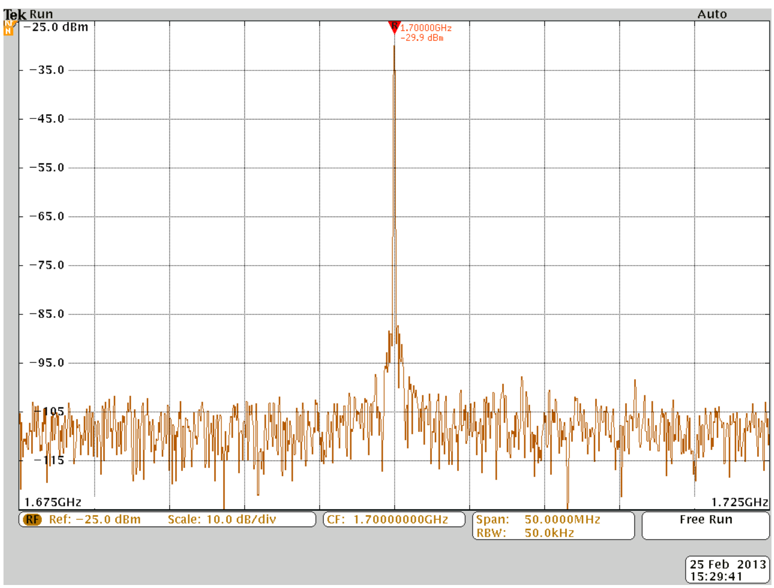
a. Set the reference level to –25 dBm as follows: Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to –25 dBm.

b. *Set the frequency range as follows:*

- Push the front-panel **Freq/Span** button.
- Push the side-bezel **Center Frequency** button.
- Set the center frequency to 1.7 GHz.
- Push the side-bezel **Span** button.
- Set the span to 50 MHz.

c. Set the generator to provide a 1.7 GHz, –30 dBm signal.

d. Note the reading on the power meter and the readout for the Reference marker on the oscilloscope. See the following figure:



e. The absolute difference between the two readings should be small (~ 2dB or less). If the MDO4000 reading is too low, tighten the preamp more firmly to the MDO4000 by hand and check the reading again.

f. Check at the –40 dBm reference level.

- Set the generator to provide a 1.7 GHz, –45 dBm signal..
- Set the reference level to –40 dBm.
- Compare the MDO4000 and the power meter readings as before. The absolute difference between the readings should be ~2dB or less. If

the MDO4000 reading is too low, tighten the preamp more firmly to the MDO4000 by hand and check the reading again.

4. Check at 5.5 GHz

a. Set the reference level to –25 dBm as follows: Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to –25 dBm.

b. *Set the frequency range as follows:*

- Set the center frequency to 5.5 GHz.
- Set the span to 50 MHz.

c. Set the generator to provide a 5.5 GHz, –30 dBm signal.

d. Note the reading on the power meter and the readout for the Reference marker on the oscilloscope.

e. The absolute difference between the two readings should be small (~ 2dB or less). If the MDO4000 reading is too low, tighten the preamp more firmly to the MDO4000 by hand and check the reading again.

f. Check at the –40 dBm reference level.

- Set the generator to provide a 5.5 GHz, –45 dBm signal..
- Set the reference level to –40 dBm.
- Compare the MDO4000 and the power meter readings as before. The absolute difference between the readings should be ~2dB or less. If the MDO4000 reading is too low, tighten the preamp more firmly to the MDO4000 by hand and check the reading again.

With TPA-N-PRE Attached: Check Display Average Noise Level (DANL)

This test does not require an input signal.

The test measures the average internal noise level of the instrument, ignoring residual spurs.

It checks four ranges:

- 50 kHz to 5 MHz (all models)
- 5 MHz to 3 GHz (all models)
- 3 GHz to 4 GHz (MDO4104-6 and MDO4054-6 only)
- 4 GHz to 6 GHz (MDO4104-6 and MDO4054-6 only)

NOTE. *If the specific measurement frequency results in measuring a residual spur that is visible above the noise level, the DANL specification applies not to the spur but to the noise level on either side of the spur. Please refer to the Spurious Response specifications.* *(See page 19.)*

1. *Initial oscilloscope setup:*

   a. Terminate the TPA-N-PRE preamp input in 50 Ω and make sure that no input signal is applied.

   b. Push the front-panel **Default Setup** button.

   c. Turn channel 1 off.

   d. Push the front-panel **RF** button to turn on the RF channel and display the bottom-bezel RF menu.

   e. *Turn on the average trace as follows:* Push the bottom-bezel **Spectrum Traces** button and set Normal to Off. Push the side-bezel **Average** button to set the Average Trace to On.

   f. *Turn on average detection as follows:* Push the bottom-bezel **Detection Method** button. Push the side-bezel button to set the detection method to **Manual**. Push the side-bezel **Average Trace** button. Set the detection method to Average.

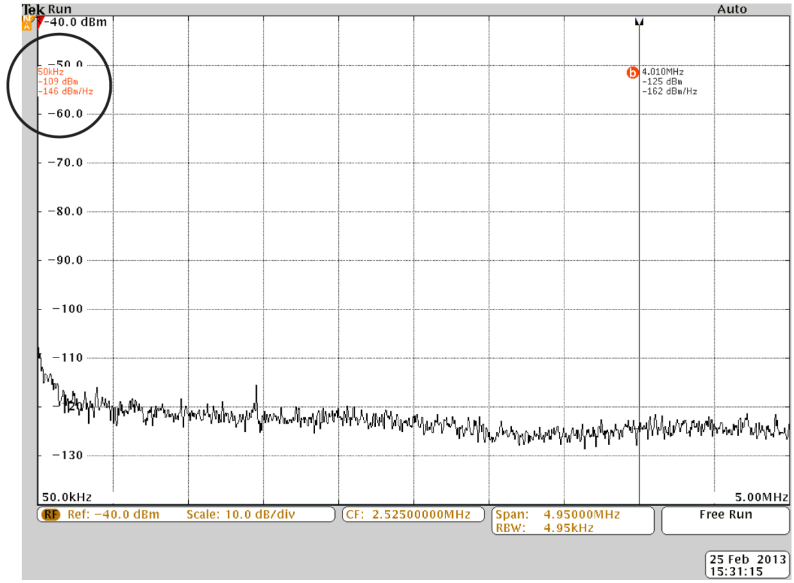
   g. Push the Menu button on the TPA-N-PRE preamplifier. On the MDO4000, for the Mode, select **Auto**.

   h. *Set the reference level to –40.0 dBm as follows:* Push the front-panel **Ampl** button. Push the side-bezel **Ref Level** button. Set the Ref Level to –40.0 dBm.

   i. *Set the start and stop frequency as follows:* Push the front-panel **Freq/Span** button. Push the side-bezel **Start** button. Set the start frequency to 50 kHz. Push the side-bezel **Stop** button. Set the stop frequency to 5 MHz.

2. *Check from 50 kHz to 5 MHz (all models):*

   a. Set Manual Marker (a) at the frequency with the highest noise level as follows: Push the **Markers** front-panel button. Push the **Manual Markers** side bezel button to turn on the markers. Turn Multipurpose knob **a** to move the marker to the frequency at the noise threshold (highest point of noise), ignoring any spurs. For this span, it should be at 50 kHz on the far left of the screen. See the following figure.



b. Record the noise threshold value (in dBm/Hz) in the test record and compare it to the instrument specification.

3. *Check from 5 MHz to 3 GHz (all models):*

a. Set the stop frequency to 3 GHz.

b. Set the start frequency to 5 MHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

4. *Check from 3 GHz to 4 GHz (MDO4104-6 and MDO4054-6 only):*

a. Set the stop frequency to 4 GHz.

b. Set the start frequency to 3 GHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

5. *Check from 4 GHz to 6 GHz (MDO4104-6 and MDO4054-6 only):*

a. Set the stop frequency to 6 GHz.

b. Set the start frequency to 4 GHz.

c. Set Manual Marker (a) at the frequency of the highest noise, ignoring any spurs.

d. *Set the center frequency as follows:* Push the **R To Center** side-bezel button.

e. *Set the span to 10 MHz as follows:* Push the side-bezel **Span** button. Set the Span to 10 MHz.

f. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.

This completes the performance verification procedure.