# Tektronix<sup>•</sup>

MDO3000 Series Mixed Domain Oscilloscopes Specifications and Performance Verification

**Technical Reference** 



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# **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.

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

#### 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 MDO3000 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 performance Verification section.

All specifications apply to all MDO3000 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 operating temperature range specified.
- You must perform the Signal Path Compensation (SPC) operation described in this manual prior to evaluating specifications. (See page 71.) If the operating temperature changes by more than 10 °C (18 °F), you must perform the SPC operation again.

### **Analog Channel Input And Vertical Specifications**

Characteristic	Description	
Number of input channels	MDO3104, MDO3054, MDO3034, MDO3024, 4 analog, digitized simultaneously MDO3014	
	MDO3102, MDO3052, MDO3032, MDO3022, MDO3012	2 analog, digitized simultaneously
Input coupling	DC, AC	
Input termination selection	1 MΩ, 50 Ω, or 75 Ω.	
	The 75 $\Omega$ setting is not available on MDO310X inst	ruments.
Input termination, 1 MΩ, DC coupled	1 MΩ, ±1%	

Table 1: Analog channel input and vertical specifications

Characteristic	Description					
Input termination,	50 Ω, ±1%					
50 Ω, DC coupled (See page 73.)	For instruments with 1 GHz bandwidth (includes MDO310X models as well as MDO305X/303X/302X/301X models with 1 GHz upgrade):	VSWR ≤ 1.5:1 from DC to 1 GHz, typical				
	For instruments with 500 MHz bandwidth (includes MDO305X models as well as MDO303X/302X/301X models with 500 MHz upgrade):	VSWR ≤ 1.5:1 from DC to 500 MHz, typical				
	For instruments with 350 MHz bandwidth (includes MDO303X models as well as MDO302X/301X models with 350 MHz upgrade):	VSWR $\leq$ 1.5:1 from DC to 350 MHz, typical				
	For instruments with 200 MHz bandwidth (includes MDO302X models as well as MDO301X models with 200 MHz upgrade):	VSWR $\leq$ 1.5:1 from DC to 200 MHz, typical				
	For instruments with 100 MHz bandwidth (MDO301X models):	VSWR $\leq$ 1.5:1 from DC to 100 MHz, typical				
Input termination,	75 Ω, ±1%					
75 Ω, DC coupled (See page 73.)	VSWR ≤ 1.3:1 from DC to 30 MHz, typical					
(000 page 70.)	VSWR ≤ 1.5:1 from 30 MHz to 60 MHz, typical					
Maximum input voltage	5 $V_{RMS}$ with peaks $\leq \pm 20$ V, (DF<=6.25%)					
(50 Ω and 75 Ω)	There is an over-voltage trip circuit, intended to protect against overloads that might damage termination resistors. A sufficiently large impulse can cause damage regardless of the over-voltage protection circuitry, due to the finite time required to detect the over-voltage condition and respond to it.					
Maximum input voltage	The maximum input voltage at the BNC, 300 $V_{\mbox{\tiny RMS}}.$					
(1 MΩ)	Installation Category II.					
	De-rate at 20 dB/decade between 4.5 MHz and 45 MHz, De-rate 14 db between 45 MHz and 450 MHz. Above 450 MHz, 5 $V_{\text{RMS}}.$					
Maximum peak input voltage at the BNC, ±424 V						

Table 1: Analog channel input and vertical specifications (cont.)

Characteristic	Description				
DC balance	0.2 div with the input DC-50  coupled and 50 $\Omega$ terminated				
(See page 74.)	0.25 div at 2 mV/div with the input DC-50 $\Omega$ coupled and 50 $\Omega$ terminated				
	0.5 div at 1 m	//div with the input DC-50 $\Omega$ coupled and	d 50 $\Omega$ terminated		
	0.2 div with the	e input DC-75 Ω coupled and 75 Ω termi	inated		
	0.25 div at 2 m	N/div with the input DC-75 $\Omega$ coupled a	nd 75 $\Omega$ terminated		
	0.5 div at 1 m	//div with input DC-75 $\Omega$ coupled and 75	$5\Omega$ terminated		
	0.2 div with the	e input DC-1 M $\Omega$ coupled and 50 $\Omega$ term	ninated		
	0.3 div at 1 m	//div with the input DC-1 M $\Omega$ coupled an	d 50 Ω terminated		
	All the above s	specifications are increased by 0.01 divis	sions per °C above 40 °C.		
Delay between channels, full bandwidth, typical	≤ 100 ps betw ≤ 100 ps betw Note: all settin	$\leq$ 100 ps between any two channels with input termination set to 50 Ω, DC coupling $\leq$ 100 ps between any two channels with input termination set to 75 Ω, DC coupling Note: all settings in the instrument can be manually time aligned using the Probe Deskew function			
Deskew range	-125 ns to +1	-125 ns to +125 ns			
Crosstalk (channel		≤100 MHz	>100 MHz		
isolation), typical	1 MΩ	100:1	30:1		
	50 Ω	100:1	30:1		
	75 Ω	100:1	30:1		
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 CH1-CH4 front panel inputs. Aux In is available on the front of two-channel instrument only and is fully VPI compliant. Four-channel instruments have no Aux In input				
Number of digitized bits	<ul> <li>8 bits</li> <li>Displayed vertically with 25 digitization levels (DL) per division, 10.24 divisions dynamic range</li> <li>"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 LSB (least significant bit).</li> </ul>				
Sensitivity range (coarse)	1 Μ Ω:	1 mV/div to 10 V/div in a 1-2-5 sequen	ice		
	50 Ω and 75 Ω:	1 mV/div to 1 V/div in a 1-2-5 sequence	e		
Sensitivity range (fine)	Allows continuous adjustment from 1 mV/div to 10 V/div, 1 M $\Omega$ Allows continuous adjustment from 1 mV/div to 1 V/div, 75 $\Omega$ Allows continuous adjustment from 1 mV/div to 1 V/div, 50 $\Omega$				
Sensitivity resolution (fine), typical	≤ 1% of curre	≤ 1% of current setting			
Position range	±5 divisions				

Table 1: Analog channel input and vertical specifications (cont.)

Characteristic	Description					
<ul> <li>Analog bandwidth,</li> <li>50 Ω input termination</li> </ul>	The limits stated below are for ambient temperature of $\leq$ 30 °C and the bandwidth selection set to FULL. Reduce the upper bandwidth frequency by 1% for each °C above 30 °C.					
(See page 76.)	Instrument		Vertical Scale Setting			
	Bandwidth	10 mV/div to 1 V/div	5 mV/div to 9.98 mV/div	2 mV/div to 4.98 mV/div	1 mV/div to 1.99 mV/div	
	1.00 GHz	DC to 1.0 GHz	DC to 500 MHz	DC to 350 MHz	DC to 150 MHz	
	500 MHz	DC to 500 MHz		DC to 350 MHz	DC to 150 MHz	
	350 MHz	DC to 350 MHz		DC to 350 MHz	DC to 150 MHz	
	200 MHz	DC to 200 MHz			DC to 150 MHz	
	100 MHz	DC to 100 MHz				
Analog bandwidth, 75 $\Omega$ The limits stated below are for ambient temperature of $\leq$ 30 °C and the bandwidth FULL. Reduce the upper bandwidth frequency by 1% for each °C above 30 °C.					lwidth selection set to °C.	
	Instrument	Vertical Scale Setting				
	Bandwidth	10 mV/div to 1 V/div	5 mV/div to 9.98 mV/div	2 mV/div to 4.98 mV/div	1 mV/div to 1.99 mV/div	
	500 MHz, 350 MHz, and 200 MHz	DC to 200 MHz		DC to 140 MHz	DC to 100 MHz	
	100 MHz	DC to 100 MHz				
Analog bandwidth, 1 M $\Omega$ input termination. The	The limits state FULL. Reduce	ed below are for ar the upper bandwi	nbient temperature of dth frequency by 1% f	$\leq$ 30 °C and the band for each °C above 30	lwidth selection set to °C.	
Analog Bandwidth when the instrument is DC-1MΩ	Instrument	Instrument Vertical Scale Setting				
coupled, typical	Bandwidth	2 mV/div to 10 V/div	1 mV/div to 1.99 mV/div			
	1 GHz, 500 MHz, or 350 MHz	DC to 350 MHz	DC to 150 MHz			
	200 MHz	DC to 200 MHz	DC to 150 MHz	]		
	100 MHz	DC to 100 MHz				

Table 1: Analog channel input and vertical specifications (cont.)

Characteristic	Description					
Analog Bandwidth, 1 M $\Omega$ with Standard Probe,	The limits state FULL. Reduce	The limits stated below are for ambient temperature of $\leq$ 30 °C and the bandwidth selection set to FULL. Reduce the upper bandwidth frequency by 1% for each °C above 30 °C.				
typical	Instrument	Vertical Scale Se	Vertical Scale Setting			
	Bandwidth	100 mV/div to 100 V/div	50 mV/div to 99.8 mV/div	20 mV/div to 49.8 mV/div	10 mV/div to 19.9 mV/div	
	1 GHz	DC to 1.00 GHz	DC to 400 MHz	DC to 250 MHz	DC to 150 MHz	
	500 MHz	DC to 500 MHz	DC to 400 MHz	DC to 250 MHz	DC to 150 MHz	
	350 MHz	DC to 350 MHz		DC to 250 MHz	DC to 150 MHz	
	200 MHz	DC to 200 MHz			DC to 150 MHz	
	100 MHz	DC to 100 MHz				
Calculated rise time, typical	The formula is for the rise tim All values in th and 350 MHz the TPP0250	calculated by mea e contribution of th the above table are models assume th probe.	suring –3 dB bandwid e oscilloscope indepe in pS. 1 GHz BW mod e TPP0500B probe. 2	th of the oscilloscope. endent of the rise time dels assume the TPP1 200 MHz and 100 MHz	The formula accounts of the signal source. 000 probe. 500 MHz z models assume	
	Instrument Bandwidth		Vertical Sca	le Setting (50 $\Omega$ )	_	
		1 mV/div to 1.99 mV/div	2 mV/div to 4.98 mV/div	5 mV/div to 9.98 mV/div	10 mV/div to 1 V/div	
	1 GHz	2,666 ps	1,333 ps	800 ps	400 ps	
	500 MHz	2,666 ps	1,333 ps	800 ps	800 ps	
	350 MHz	2,666 ps	1,333 ps	1,143 ps	1,143 ps	
	200 MHz	2,666 ps	2,000 ps	2,000 ps	2,000 ps	
	100 MHz	4,000 ps	4,000 ps	4,000 ps	4,000 ps	
		1				
	Instrument Bandwidth	Vertical Scale Setting (TPPXXX0 probe)			9)	
	Danuwidth	10 mV to 19.9 mV	20 mV to 49.8 mV	50 mV to 99.8 mV	100 mV to 100 V	
	1 GHz	2,666 ps	1,600 ps	1,000 ps	400 ps	
	500 MHz	2,666 ps	1,600 ps	1,000 ps	800 ps	
	350 MHz	2,666 ps	1,600 ps	1,143 ps	1,143 ps	
	200 MHz	2,666 ps	2,000 ps	2,000 ps	2,000 ps	
	100 MHz	4,000 ps	4,000 ps	4,000 ps	4,000 ps	
Analog bandwidth limit	For instrument	ts with 1 GHz, 500	MHz or 350 MHz ana	log bandwidth: 20 MI	Hz, 250 MHz, and Full	
	For instruments with 200 MHz and 100 MHz analog bandwidth: 20 MHz and Full					

Table 1: Analog channel input and vertical specifications (cont.)

Characteristic	Description	Description				
Lower frequency limit, A	< 10 Hz when AC to 1 M $\Omega$ coupled					
coupled, typical	The AC coupled lower frequency are used.	<i>i</i> limits are reduced by a factor of 10 when 10X passive probes				
Upper frequency limit, 250 MHz bandwidth lim filter, typical	250 MHz, +25%, and –25% (all it	250 MHz, +25%, and -25% (all models, except 100 MHz and 200 MHz)				
Upper frequency limit, 20 MHz bandwidth limit filter, typical	20 MHz, ±25% (all models)	20 MHz, ±25% (all models)				
DC gain accuracy	±2.5% for 1 mV/Div, derated at	0.100%/°C above 30 °C				
(See page 79.)	±2.0% for 2 mV/Div, derated at	0.100%/°C above 30 °C				
	±1.5% for 5 mV/Div and above,	derated at 0.100%/°C above 30 °C				
	±3.0% Variable Gain, derated at	±3.0% Variable Gain, derated at 0.100%/°C above 30 °C				
DC voltage measurement accuracy	Measurement type	DC Accuracy (in volts)				
Sample acquisition mod	Any sample	±[DC gain accuracy X   reading – (offset – position)   + Offset Accuracy +0.15 div + 0.6 mV]				
typical	Delta volts between any two samples acquired with the same oscilloscope setup and ambient conditions	±[DC gain accuracy X   reading   + 0.15 div + 1.2 mV]				
	<b>NOTE.</b> Offset, position, and the the appropriate volts/div term.	<b>NOTE.</b> Offset, position, and the constant offset term must be converted to volts by multiplying b the appropriate volts/div term.				
Average acquisition mode	Average of ≥ 16 waveforms	±[DC gain accuracy X   reading – (offset – position)   + Offset Accuracy + 0.1 div]				
	Delta volts between any two averages of ≥ 16 waveforms acquired with the same oscilloscope setup and ambient conditions	±[DC gain accuracy X   reading   + 0.05 div]				
	<b>NOTE.</b> Offset, position, and the the appropriate volts/div term.	<b>NOTE.</b> Offset, position, and the constant offset term must be converted to volts by multiplying by the appropriate volts/div term.				
	<b>NOTE.</b> The basic accuracy spe measurements: High, Low, Max, accuracy specification applies to	<b>NOTE</b> . 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, Peak-Peak, and Amplitude.					

Table 1: Analog channel input and vertical specifications (cont.)

Chara	cteristic	Description					
Offset	ranges	Volts/div	Offset range				
		setting	1 MΩ input	50 $\Omega$ and 75 $\Omega$	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	±5 V			
	505 mV/div to 995 mV/div	±5 V	±5 V				
	1 V/div to 10 V/div 1	±100 V	±5 V				
		<b>NOTE.</b> The input signal cannot exceed the maximum input voltage for the 50 $\Omega$ and 75 $\Omega$ input paths. Refer to the Maximum input voltage specifications (earlier in this table) for more information.					
¢≞ Of	fset accuracy	±[0.005 X   offset - position   + DC Balance]					
(See page 83.)		<b>NOTE</b> . Both a appropriate vo	the position and c olts/div term.	constant offset term	must be converted to	volts by multiplying by the	
sample	andom noise, e acquisition mode,	50Ω, RMS, unit in mV					
50 Ω t (See p	ermination setting bage 86.)	MDO31xx	MDO305x	MDO303x	MDO302x	MDO301x	
	1 mV, Full BW	0.21	0.2	0.2	0.2	0.19	
	2 mV, Full BW	0.33	0.27	0.25	0.23	0.21	
	5 mV, Full BW	0.5	0.36	0.36	0.3	0.3	
	10 mV, Full BW	0.7	0.5	0.5	0.45	0.45	
	20 mV, Full BW	1	0.9	0.9	0.9	0.9	
	50 mV, Full BW	3	2.75	2.75	2.75	2.25	
	100 mV, Full BW	4.5	4.15	4.15	4.15	4.15	
	200 mV, Full BW	9	8.15	8.15	8.15	8.15	
	500 mV, Full BW	20	20	20	20	20	
	1 V, Full BW	40	40	40	40	40	

Table 1: Analog channel input and vertical specifications (cont.)

Chara	cteristic	Description				
	1 mV, 250 MHz BW	0.21	0.2	0.2	_	_
	2 mV, 250 MHz BW	0.25	0.23	0.23	_	_
	5 mV, 250 MHz BW	0.35	0.3	0.3	_	_
	10 mV, 250 MHz BW	0.5	0.5	0.5	_	_
	20 mV, 250 MHz BW	1	1	1	_	_
	50 mV, 250 MHz BW	2.75	2.75	2.75	_	_
	100 mV, 250 MHz BW	4.15	4.15	4.15	_	_
	200 mV, 250 MHz BW	10	10	10	_	_
	500 mV, 250 MHz BW	20	20	20	_	_
	1 V, 250 MHz BW	40	40	40	—	—
	1 mV, 20 MHz BW	0.12	0.12	0.12	0.12	0.12
	2 mV, 20 MHz BW	0.15	0.15	0.15	0.15	0.15
	5 mV, 20 MHz BW	0.25	0.25	0.25	0.25	0.25
	10 mV, 20 MHz BW	0.45	0.4	0.4	0.4	0.4
	20 mV, 20 MHz BW	0.8	0.75	0.75	0.75	0.75
	50 mV, 20 MHz BW	2.1	2.1	2.1	2.1	2.1
	100 mV, 20 MHz BW	4.1	4.1	4.1	4.1	4.1
	200 mV, 20 MHz BW	8	8	8	8	8
	500 mV, 20 MHz BW	20	20	20	20	20
	1 V, 20 MHz BW	40	40	40	40	40

Table 1: Analog channel input and vertical specifications (cont.)

Chara	cteristic	Description	Description			
Random noise, sample		Random noise, sample Typical, 50Ω, RMS				
acquis termin	sition mode, 50 Ω ation setting, typical	MDO31xx	MDO305x	MDO303x	MDO302x	MDO301x
	1 mV, Full BW	0.179	0.178	0.169	0.178	0.162
	100 mV, Full BW	2.4	2.05	1.98	1.94	1.88
	1 V, Full BW	24.67	20.99	20.03	19.41	18.8

Table 1: Analog channel input and vertical specifications (cont.)

<sup>1</sup> For 50  $\Omega$  and 75 $\Omega$  path, 1 V/div is the maximum vertical setting.

# **Digital Channel Acquisition System Specifications**

Characteristic	Description
Threshold voltage range	-15 V to +25 V
Digital channel timing resolution	Minimum: 2 ns for the main memory
	Minimum: 121.2 ps for MagniVu memory
Threshold accuracy (See page 89.)	$\pm$ [100 mV + 3% of threshold setting after calibration], after valid SPC
Minimum detectable pulse	2.0 ns
	Using MagniVu memory. Specified at the input to the P6316 probe with all eight ground inputs connected to the user's ground. Use of lead sets, grabber clips, ground extenders, or other connection accessories may compromise this specification.
Channel to channel skew (typical)	500 ps
	Digital Channel to Digital Channel only
	This is the propagation path skew, and ignores skew contributions due to bandpass distortion, threshold inaccuracies (see Threshold Accuracy), and sample binning (see Digital Channel Timing Resolution).

Table 2: Digital channel acquisition system specifications

# **Horizontal And Acquisition System Specifications**

Characteristic		Description					
time accuracy (See	nple rate and delay e page 85.)	±10 ppm over any ≥ 1 ms time interval					
Seconds/division r	ange	MDO30XX mod MDO310X mod	lels: 1 ns/div to 1000 se lels: 400 ps/div to 1000 s	c/div sec/div			
Peak detect or		Instrument		Minimum pulse width	1		
envelope mode pu	lse response, typical	Models at 1 GH	Iz BW	> 1.5 ns			
		Models at 500	MHz BW	> 2.0 ns			
		Models at 350	MHz BW	> 3.0 ns			
		Models at 200	MHz BW	> 5.0 ns			
		Models at 100	MHz BW	> 7.0 ns			
Sample-rate range		See Sample Ra	ate Range detail table. (S	See page 13.)			
Record length rang	je	1K, 10K, 100K,	1M, 5M, 10M				
Maximum triggered	d acquisition rate	1 and 2 channe	1 and 2 channels 3 and 4 channels				
	Bandwidth	FastAcq	DPO	FastAcq	DPO		
	1 GHz	> 280,000 wfm/sec	> 80,000 wfm/sec	> 230,000 wfm/sec	> 50,000 wfm/sec		
	< 1 GHz	> 230,000 wfm/sec	> 50,000 wfm/sec	> 230,000 wfm/sec	> 50,000 wfm/sec		
Aperture uncertain (also called "samp	ty, typical le rate jitter")	$\leq$ (5 ps + 1 × 10 <sup>-6</sup> X record duration) <sub>RMS</sub> , for records having duration $\leq$ 1 minute Record duration = (Record Length) / (Sample Rate)					
Number of wavefo acquisition mode	rms for average	2 to 512 waveforms Default of 16 waveforms					
In the second s	asurement accuracy	The formula to calculate delta-time measurement accuracy (DTA) for a given instrument setting and input signal is given below (assumes insignificant signal content above Nyquist).					
		SR <sub>1</sub> = Slew Rate (1 <sup>st</sup> Edge) around the 1 <sup>st</sup> point in the measurement					
		$SR_2$ = Slew Rate (2 <sup>nd</sup> Edge) around the 2 <sup>nd</sup> point in the measurement					
		N = input-referred noise (volts <sub>rms</sub> , refer to the Random Noise, Sample acquisition mode specification)					
		t <sub>sr</sub> = 1 / (Sample Rate)					
		TBA = timebase accuracy specif	TBA = timebase accuracy (refer to the Long-term sample rate and delay time accuracy specification above)				
		t <sub>p</sub> = delta-time r	neasurement duration				
		RD = (Record Length) / (Sample Rate)					

Table 3: Horizontal and acquisition system specifications

Table 3: Horizontal and acquisition system specifications (cont.)

$$ETA_{mn} = 2 \times \sqrt{2 \times \left[\frac{N}{NP_1}\right]^2 + 2 \times \left[\frac{N}{NP_1}\right]^2 + \left[\frac{N}{NP_1}\right]^2 + \left[\frac{N}{NP_1} - 1E^{-N} \times BO\right]^2 + 2 \times t_0 + 704 \times t_0}$$
$$ETA_{mn} = \sqrt{2 \times \left[\frac{N}{NP_1}\right]^2 + 2 \times \left[\frac{N}{NP_1}\right]^2 + \left[\frac{N}{NP_1}\right]^2 + \left[\frac{N}{NP_1} + 1E^{-N} \times BO\right]^2 + \left[\frac{2 \times t_0}{NP_1}\right]} + 704 \times t_0}$$

Assumes that error due to aliasing is insignificant.

The term under the square-root sign is the stability, and is related to the TIE (Time Interval Error). The errors from this term occur throughout a single-shot measurement. The second term is a result of both the absolute center-frequency accuracy and the center-frequency stability of the timebase, 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).

# Sample Rate Range

Table 4:	Sample	rate	range
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Characteristic	Descripti	on					
Sample rate range	Time- /Div	10 M record	5 M record	1 M record	100 K record	10 K record	1 K record
(Analog Channels)	1 ns	2.5 GS/s				•	
onannoioy	2 ns	2.5 GS/s					
	4 ns	2.5 GS/s					
	10 ns	2.5 GS/s					
	20 ns	2.5 GS/s					
	40 ns	2.5 GS/s					
	80 ns						1.25 GS/s
	100 ns	2.5 GS/s					
	200 ns	2.5 GS/s		500 MS/s			
	400 ns	2.5 GS/s					250 MS/s
	800 ns					1.25 GS/s	
	1 µs	2.5 GS/s					100 MS/s
	2 µs	2.5 GS/s				500 MS/s	50 MS/s
	4 µs	2.5 GS/s				250 MS/s	25 MS/s
	8 µs				1.25 GS/s		
	10 µs	2.5 GS/s				100 MS/s	10 MS/s
	20 µs	2.5 GS/s			500 MS/s	50 MS/s	5 MS/s
	40 µs	2.5 GS/s			250 MS/s	25 MS/s	2.5 MS/s
	80 µs			1.25 GS/s			
	100 µs	2.5 GS/s			100 MS/s	10 MS/s	1 MS/s
	200 µs	2.5 GS/s		500 MS/s	50 MS/s	5 MS/s	500 KS/s
	400 µs	2.5 GS/s	1.25 GS/s	250 MS/s	25 MS/s	2.5 MS/s	250 KS/s
	800 µs	1.25 GS/s	625 MS/s				

Table 4: Sample rate range (MDO310X with 3 or 4 channels enabled or all other MDO3000 with 1, 2, 3, or 4 channels enabled) (cont.)

Characteristic	Descripti	Description					
Sample rate range (Analog	Time- /Div	10 M record	5 M record	1 M record	100 K record	10 K record	1 K record
Channels) (Cont.)	1 ms			100 MS/s	10 MS/s	1 MS/s	100 KS/s
(00)	2 ms	500 MS/s	250 MS/s	50 MS/s	5 MS/s	500 KS/s	50 KS/s
	4 ms	250 MS/s	125 MS/s	25 MS/s	2.5 MS/s	250 KS/s	25 KS/s
	10 ms	100 MS/s	50 MS/s	10 MS/s	1 MS/s	100 KS/s	10 KS/s
	20 ms	50 MS/s	25 MS/s	5 MS/s	500 KS/s	50 KS/s	5 KS/s
	40 ms	25 MS/s	12.5 MS/s	2.5 MS/s	250 KS/s	25 KS/s	2.5 KS/s
	100 ms	10 MS/s	5 MS/s	1 MS/s	100 KS/s	10 KS/s	1 KS/s
	200 ms	5 MS/s	2.5 MS/s	500 KS/s	50 KS/s	5 KS/s	500 S/s
	400 ms	2.5 MS/s	1.25 MS/s	250 KS/s	25 KS/s	2.5 KS/s	250 S/s
	1 s	1 MS/s	500 KS/s	100 KS/s	10 KS/s	1 KS/s	100 S/s
	2 s	500 KS/s	250 KS/s	50 KS/s	5 KS/s	500 S/s	50 S/s
	4 s	250 KS/s	125 KS/s	25 KS/s	2.5 KS/s	250 S/s	25 S/s
	10 s	100 KS/s	50 KS/s	10 KS/s	1 KS/s	100 S/s	10 S/s
	20 s	50 KS/s	25 KS/s	5 KS/s	500 S/s	50 S/s	5 S/s
	40 s	25 KS/s	12.5 KS/s	2.5 KS/s	250 S/s	25 S/s	2.5 S/s
	100 s	10 KS/s	5 KS/s	1 KS/s	100 S/s	10 S/s	
	200 s	5 KS/s	2.5 KS/s	500 S/s	50 S/s	5 S/s	
	400 s	2.5 KS/s	1.25 KS/s	250 S/s	25 S/s	2.5 S/s	
	1000 s	1 KS/s	500 S/s	100 S/s	10 S/s		

Characteristic	Descripti	Description						
Sample rate range	Time- /Div	10 M record	5 M record	1 M record	100 K record	10 K record	1 K record	
(Analog Channels)	400 ps	5 GS/s		•				
onannoioj	1 ns	5 GS/s						
	2 ns	5 GS/s						
	4 ns	5 GS/s						
	10 ns	5 GS/s						
	20 ns	5 GS/s						
	40 ns	5 GS/s					2.5 GS/s	
	100 ns	is 5 GS/s						
200 ns 5 GS/s							500 MS/s	
	400 ns	5 GS/s	250 MS/s					
	1 µs	5 GS/s	100 MS/s					
	2 µs	5 GS/s				500 MS/s	50 MS/s	
	4 µs	5 GS/s			2.5 GS/s	250 MS/s	25 MS/s	
	10 µs	5 GS/s			1 GS/s	100 MS/s	10 MS/s	
	20 µs	5 GS/s			500 MS/s	50 MS/s	5 MS/s	
	40 µs	5 GS/s		2.5 GS/s	250 MS/s	25 MS/s	2.5 MS/s	
	100 µs	5 GS/s		1 GS/s	100 MS/s	10 MS/s	1 MS/s	
	200 µs	5 GS/s	2.5 GS/s	500 MS/s	50 MS/s	5 MS/s	500 KS/s	
	400 µs	2.5 GS/s	1.25 GS/s	250 MS/s	25 MS/s	2.5 MS/s	250 KS/s	

Table 5: Sample rate range, (MDO310X models with 1 or 2 channels enabled)

Characteristic	Descripti	Description						
Sample rate range (Analog	Time- /Div	10 M record	5 M record	1 M record	100 K record	10 K record	1 K record	
Channels) (Cont.)	1 ms	1 GS/s	500 MS/s	100 MS/s	10 MS/s	1 MS/s	100 KS/s	
(00)	2 ms	500 MS/s	250 MS/s	50 MS/s	5 MS/s	500 KS/s	50 KS/s	
	4 ms	250 MS/s	125 MS/s	25 MS/s	2.5 MS/s	250 KS/s	25 KS/s	
	10 ms	100 MS/s	50 MS/s	10 MS/s	1 MS/s	100 KS/s	10 KS/s	
	20 ms	50 MS/s	25 MS/s	5 MS/s	500 KS/s	50 KS/s	5 KS/s	
	40 ms	25 MS/s	12.5 MS/s	2.5 MS/s	250 KS/s	25 KS/s	2.5 KS/s	
	100 ms	10 MS/s	5 MS/s	1 MS/s	100 KS/s	10 KS/s	1 KS/s	
	200 ms	5 MS/s	2.5 MS/s	500 KS/s	50 KS/s	5 KS/s	500 S/s	
	400 ms	2.5 MS/s	1.25 MS/s	250 KS/s	25 KS/s	2.5 KS/s	250 S/s	
	1 s	1 MS/s	500 KS/s	100 KS/s	10 KS/s	1 KS/s	100 S/s	
	2 s	500 KS/s	250 KS/s	50 KS/s	5 KS/s	500 S/s	50 S/s	
	4 s	250 KS/s	125 KS/s	25 KS/s	2.5 KS/s	250 S/s	25 S/s	
	10 s	100 KS/s	50 KS/s	10 KS/s	1 KS/s	100 S/s	10 S/s	
	20 s	50 KS/s	25 KS/s	5 KS/s	500 S/s	50 S/s	5 S/s	
	40 s	25 KS/s	12.5 KS/s	2.5 KS/s	250 S/s	25 S/s	2.5 S/s	
	100 s	10 KS/s	5 KS/s	1 KS/s	100 S/s	10 S/s		
	200 s	5 KS/s	2.5 KS/s	500 S/s	50 S/s	5 S/s		
	400 s	2.5 KS/s	1.25 KS/s	250 S/s	25 S/s	2.5 S/s		
	1000 s	1 KS/s	500 S/s	100 S/s	10 S/s			

Table 5: Sample rate range, (MDO310X models with 1 or 2 channels enabled) (cont.)

# **Trigger Specifications**

Table	6:	Trigger	specifications
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Characteristic	Description				
Trigger level ranges	Source		Sensitivity		
	Any input channel		±8 divisions from center of screen, ±8 divisions from 0 V when vertical LF reject trigger coupling is selected		
	Aux In (External)		±8 V		
	Line		Not applicable		
	The line trigger leve	el is fixed at about	50% of the line voltage.		
	This specification a	pplies to logic and	pulse thresholds.		
Trigger level	For signals having	rise and fall times	≥ 10 ns, the limits are as follows:		
accuracy, DC coupled, typical	Source		Range		
	Any channel		±0.20 divisions		
	Aux In (external trig	iger)	±(10% of setting + 25 mV)		
	Line		Not applicable		
Lowest frequency for "Set Level to 50%" function, typical	45 Hz				
Trigger holdoff range	20 ns minimum to 8	3 seconds maximu	m		
Trigger sensitivity	Edge trigger,	Trigger Source	Sensitivity		
	DC coupled, typical	Any analog channel	1 mV/div to 4.98 mV/div: 0.75 div from DC to 50 MHz, increasing to 1.3 div at instrument bandwidth.		
			$\geq$ 5 mV/div: 0.40 divisions from DC to 50 MHz, increasing to 1 div at instrument bandwidth		
		Aux in (External)	200 mV from DC to 50 MHz, increasing to 500 mV at 200 MHz		
		Line	Not applicable		
	Edge trigger, not DC coupled,	Trigger Coupling	Typical Sensitivity		
	typical	AC	1.5 times the DC Coupled limits for frequencies above 10 Hz. Attenuates signals below 10 Hz		
		NOISE REJ	2.5 times the DC-coupled limits		
		HF REJ	1.5 times the DC-coupled limit 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		

Characteristic	Description				
	Logic (pattern) trigg typical:	er, DC coupled,	1.0 division from DC to maximum bandwidth		
	Trigger using a logi DC coupled, typical	c qualifier, l:	1.0 division from DC to maximum band	width	
	Delay-by-events se DC coupled, typical	quence trigger, I:	1.0 division from DC to maximum band	width	
	Runt trigger, typical	:	≥1.0 division from DC to maximum ban	dwidth	
	Pulse-width and glit	ch trigger, typical:	1.0 division, from DC to Max Bandwidth		
	Video trigger,	The limits for both	th delayed and main trigger are as follows	:	
	typical	Source	Typical Sensitivity		
		Any analog input channel	0.6 to 2.5 divisions of video sync tip		
		Aux In (External)	Video not supported through Aux In (External) input		
Aux In (External trigger)	Maximum input volt	age:	At front panel connector, 300 $V_{\text{RMS}}$ , Installation Category II; Derate at 20 dB/decade above 3 MHz to 30 $V_{\text{RMS}}$ at 30 MHz, 10 dB/decade above 30 MHz		
			Based upon sinusoidal or DC input signal. Excursion above 300 V should be less than 100 ms duration and the duty factor is limited to < 44%. RMS signal level must be limited to 300 V. If these values are exceeded, damage to the instrument may result.		
	Bandwidth, typical:		> 250 MHz		
Edge, Pulse, and Logic trigger	For instruments with 1 GHz bandwidth (includes MDO310X models ≥1 GHz as well as MDO305X/303X/302X/301X models with 500 MHz upgrade):				
bandwidth, typical	For instruments with 500 MHz bandwidth (includes MDO305X models ≥500 MHz as well as MDO303X/302X/301X models with 500 MHz upgrade):				
	For instruments with 350 MHz bandwidth (includes MDO303X models ≥500 MHz as well as MDO302X/301X models with 350 MHz upgrade):				
	For instruments with as well as MDO301	h 200 MHz bandwi X models with 200	dth (includes MDO302X models ) MHz upgrade):	≥200 MHz	
	For instruments with	h 100 MHz bandwi	idth (MDO301X models):	≥200 MHz	
Time accuracy	Time range		Accuracy		
tor Pulse-width triagering	1 ns to 500 ns		±(20% of setting + 0.5 ns)		
	520 ns to 8 s		±(0.01% of setting + 100 ns)		

### Table 6: Trigger specifications (cont.)

Characteristic	Description						
Video trigger formats and field rates	Triggers from negative sync composite video, field 1 or field 2 for interlaced systems, any field, specific line, or any line for interlaced or non-interlaced systems. Supported systems include NTSC, PAL, SECAM.						
	Standard Video forr 1080i/50, 1080i/60, bi-level and tri-level	nats are: Trigger o 1080p/24, 1080p/ sync video standa	on 480p/60, 576p/50, 24sF, 1080p/25, 1080 ards.	720p/30, 720p/50, 72 p/30, 1080p/50, 1080	0p/60, 875i/60, p/60, and custom		
Logic trigger,	For all vertical settings, the minimums are:						
minimum logic or re-arm time, typical	Trigger type		Minimum pulse width	Minimum re-arm time	Minimum time between channels 1		
	Logic		Not applicable	2 ns	2 ns		
	Time Qualified Logi	C	4 ns	2 ns	2 ns		
Setup/hold time violation trigger							
Minimum clock	For all vertical settin	ngs, the minimum	clock pulse widths are	:			
pulse widths, typical	Clock Active <sup>2</sup>		Clock Inactive <sup>2</sup>				
	User hold time + 2.5	5 ns <sup>3</sup>	2 ns				
Setup and hold	The limits are as follows;						
time ranges	Feature	Min	Max				
	Setup time <sup>4</sup>	–0.5 ns	1.024 ms				
	Hold time <sup>4</sup>	1 ns		1.024 ms			
	Setup + Hold time 4	0.5 ns		2.048 ms			
	NOTE. Input coupl	ing on clock and d	ata channels must be	the same.			
Minimum pulse width and	Trigger type	Minimum pulse width	Minimum rearm time	9			
rearm time	Glitch	4 ns	2 ns + 5% of glitch v	width setting			
	Pulse-width	4 ns	2 ns + 5% of width u	upper limit setting			
		<b>NOTE.</b> For the pulse being mea	oulse-width trigger cla sured. The rearm time	ss, pulse-width refers e refers to the time be	to the width of the tween pulses.		
	Runt	4 ns	2 ns				
		NOTE. For the measured. The	runt trigger class, pulse rearm time refers to th	e width refers to the w e time between pulse	idth of the pulse being s.		
	Time-qualified runt	4 ns	8.5 ns + 5% of width	n setting			
	Slew rate	4 ns	8.5 ns + 5% of delta	time setting			
		<b>NOTE.</b> For the s measured. The trigger threshold	slew rate trigger class, rearm time refers to th s again.	, pulse width refers to e time it takes the sig	the delta time being nal to cross the two		

Table 6	5:	Trigger	specifications	(cont.)
	· ·	inggei	specifications	(00110)

Characteristic	Description		
Rise/fall time trigger, delta time range	4 ns to 8 seconds		
Glitch, pulse-width, or time-qualified runt trigger, time range	4 ns to 8 seconds		
B trigger	Trigger after events, minimum pulse v	1 / (2 X Rated Instrument Bandwidth)	
(A/B sequence trigger), time range	Trigger after events, maximum event frequency, typical: <sup>5</sup>		[Rated Instrument Bandwidth] or 500 MHz, whichever is lower
	Minimum time between arm and trigg	er	8 ns
	B trigger after time, time range:		8 ns to 8 s
	B trigger after events, event range:		1 to 4,000,000
Standard serial bus interface triggers	Maximum serial trigger bits:	128 bits	
I²C (Requires an	Address Triggering:	7 and 10 bit user specified address, as well as General Call, START byte, HS-mode, EEPROM, and CBUS	
MDO3EMBD	Data Trigger:	1 to 5 bytes of user specified data	
SPI	Trigger On: Maximum Data Rate: Data Trigger:	Start Repeated Start Stop, Missing Ack Address Data Address and Data 10 Mb/s 1 to 16 bytes of use	r specified data
(Requires an MDO3EMBD app. module)	Trigger On: Maximum Data Rate:	SS Active MOSI MISO MOSI and MISO 10 Mb/s	

Table 6: Trigger specifications (cont.)

Ch	aracteristic	Description		
	RS-232/422/	Data Trigger:	Tx Data, Rx Data	
	485/UAR1	Trigger On:	Tx Start Bit	
(Requires a		Rx Start Bit		
	app. module)		Tx End of Packet	
	, ,		Rx End of Packet	
			Tx Data	
			Rx Data	
			Tx Parity Error	
			Rx Parity Error	
		Maximum Data Rate:	10 Mb/s	
	CAN (Requires an MDO3AUTO	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 (>=)	
	app. module)	Trigger On:	Start of Frame	
			Type of Frame	
			Identifier, Data	
			Identifier and Data	
			End of Frame	
			Missing Ack	
			Bit Stuffing Error	
		Frame Type:	Data, Remote, Error, Overload	
		Identifier:	Standard (11 bit) and Extended (29 bit) identifiers	
		Maximum Data Rate:	1 Mb/s	
	LIN (Requires a MDO3AUTO	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 (>=)	
	app. module)	Trigger On :	Sync	
			Identifier	
			Data	
			Identifier & Data	
			Wakeup Frame	
			Sleep Frame	
			Error	
	Maximum Data Rate:	1 Mb/s (by LIN definition, 20 kbit/s)		

Table 6: Trigger specifications (cont.)

Characteristic	Description	
FlexRay (Requires a	Indicator Bits	Normal Frame, Payload Frame, Null Frame, Sync Frame, Startup Frame
MDO3FLEX app. module)	X Identifier Trigger Ie)	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, Outside Range.
	Cycle Count Trigger	6 bits of user-specified data, equal to (<=), greater than or equal to (>=), Inside Range, Outside Range.
	Header Fields Trigger	40 bits of user-specified data comprising Indicator Bits, Identifier, Payload Length, Header CRC, and Cycle Count, equal to (=).
	Data Trigger	1 – 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
MIL-STD-1	553 Trigger on:	Sync
(Requires a	a	Word Type (Command, Status, Data)
MDO3AER app. modul	O le)	Command Word (set the following individually: RT Address (trigger when equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), inside range, outside range), T/R, Sub-Address/Mode, Data Word Count/Mode Code, And Parity)
		Status Word (set the following individually: RT address (trigger when equal to (=), not equal to <>, less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), 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)
		Data Word (user-specified 16-bit data value)
		Error (Sync, Parity, Manchester, Non-Contiguous Data
		Idle Time (minimum time selectable from 4 $\mu$ s to 100 $\mu$ s; maximum time selectable from 12 $\mu$ s to 100 $\mu$ s; trigger on < minimum, > maximum, inside range, outside range)
	Maximum Data Rate:	Up to 1 Mb/s (for automated decoding of bus)

 Table 6: Trigger specifications (cont.)

Characteristic	Description	
I <sup>2</sup> S (Requires a MDO3AUDIO app. module)	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 Mb/s
Left Justified (Requires a MDO3AUDIO app. module)	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 Mb/s
Right Justified (Requires a MDO3AUDIO app. module)	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 Mb/s
TDM (Requires a MDO3AUDIO app. module)	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 Mb/s

 Table 6: Trigger specifications (cont.)

<sup>1</sup> For logic, time between channels refers to the length of time a logic state derived from more than one channel must exist to be recognized. For Time Qualified Logic events, the time is the minimum time between a main and delayed event that will be recognized if more than one channel is used.

An active pulse width is the width of the clock pulse from its active edge (as defined through the Define Inputs button on the lower menu and the Clock Edge button on the side menu) to its inactive edge. An inactive pulse width is the width of the pulse from its inactive edge to its active edge.

<sup>3</sup> The User hold time is the number selected by the user through the Setup and Hold trigger menu.

4 Setup + Hold time is the algebraic sum of the Setup Time and the Hold Time programmed by the user. 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.

<sup>5</sup> Trigger after events is the time between the last A trigger event and the first B trigger event. Trigger after time is the time between the end of the time period and the B trigger event.

# **Display Specifications**

Table 7: Display specifications

Characteristic	Description
Display type	9" WVGA LCD display
	Display Area: 198 mm (H) X 111.696 mm (V).
Display resolution	800 X 480 pixels, each made up of 3 vertical stripe sub-pixels colored red, green, and blue
Minimum Luminance, typical	$300 \text{ cd/m}^2 \text{ at IBL} = 5.0 \text{ mA}_{\text{ms}}/\text{lamp}$

# **Input/Output Port Specifications**

Description		
Standard on all models: 10/100 Mb/s		
Available as an optional accessory that connects to USB Device and USB Host port, with the TEK-USB-488 GPIB to USB Adapter		
Control interface	is incorporated in the instrument user interface	
1 Device and 2 H	lost connectors (all models)	
One USB 2.0 Hig	h Speed port. Also supports Full Speed and Slow Speed Modes	
Two USB 2.0 Hig	h Speed ports. One on front, one on rear	
A 15 pin, VGA RGB-type connector		
Output voltage: Default Mode: 0 to 2.5 V amplitude, ±2% (Source Impedance of 1 KΩ) TPPXXXX Cal Mode: 0 to 2.5 V amplitude, ±5% (Source Impedance of ≤25 Ω) Frequency: 1 kHz ±25%		
Selectable Output: Main Trigger, Event, or AFGMain Trigger: HIGH to LOW transition indicates the trigger occurredEvent Out: The instrument will output a negative edge during a specified triggerevent in a test application.A falling edge occurs when there is a specified event in a test application (i.e. the waveform crosses the violation threshold in the limit / mask test application).A rising edge occurs when the trigger system begins waiting for the next test application event.AFG: The trigger output signal from the AFG.CharacteristicLimitsVout (HI) $\geq 2.25$ V open circuit; $\geq 0.9$ V into a 50 $\Omega$ load to ground		
	DescriptionStandard on all rAvailable as an orwith the TEK-USControl interface1 Device and 2 HOne USB 2.0 HigTwo USB 2.0 HigTwo USB 2.0 HigOutput voltage:Default Mode: 0TPPXXXX Cal MFrequency: 1 kHSelectable OutputMain Trigger: HIGEvent Out: The ievent in a test apA falling edge octapplication eventAFG: The triggerCharacteristicVout (HI)Vout (LO)	

Table 8: Input/Output port specifications

# **Power Source Specifications**

Characteristic	Description
Source voltage	100 V to 240 V ±10%
Source frequency	100 V to 240 V: 50/60 Hz
	115 V: 400 Hz ±10%
Fuse rating	T3.15 A, 250 V
	The fuse is not customer replaceable.

#### Table 9: Power source specifications

# **Data Storage Specifications**

Table 10:	Data	storage	specifications
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Characteristic	Description
Nonvolatile memory retention time, typical	No time limit for front-panel settings, saved waveforms, setups, and calibration constants
Real-time clock	A programmable clock providing time in years, months, days, hours, minutes, and seconds

# **Environmental Specifications**

Table 11: Environmental specificat
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Characteristic	Description	
Temperature	Operating: -10 °C to +55 °C (+14 °F to +131 °F)	
	Nonoperating: -40 °C to +71 °C (-40 °F to +160 °F)	
Humidity	Operating: 5% to 90% relative humidity (% RH) at up to +40 °C, 5% to 60% RH above +40 °C up to +55 °C, non-condensing	
	Nonoperating: 5% to 90% RH (Relative Humidity) at up to +40 °C, 5% to 60% RH above +40 °C up to +55 °C 5% to 40% RH above +55 °C up to +71 °C, non-condensing	
Altitude	Operating: 3,000 m (9,843 feet)	
	Nonoperating: 12,000 m (39,370 feet)	
Acoustic noise emission	Sound power level: 32.0 dBA in accordance with ISO 9296	

### **Mechanical Specifications**

Characteristic	Description			
Dimensions	Height	mm	In.	
	Handle down	203.2	8.0	
	Handle up	254	10.3	
	Width	416.6	16.4	
	Depth	147.4	5.8	
	Weight	kg	Lb.	
	Stand alone, no front cover	4.2	9.2	
	With accessories & carry case	6.8	15.0	
	Packaged for domestic shipment	8.6	19.0	

Table 12: Mechanical specifications

### P6316 Digital Probe Input Characteristics

Table 13: P6316 Digital probe input characteristics

Characteristic	Description
Number of input channels	16 Digital Inputs
Input resistance, typical	101 KΩ to ground
Input capacitance, typical	8 pF <sup>1</sup>
Minimum Input Signal Swing, typical	500 mV <sub>p-p</sub> 1
Maximum Input Signal Swing, typical	+30 V, –20 V
Maximum Input Dynamic Range	50 $V_{p \cdot p}$ , dependent on threshold setting
Channel-to-channel skew	500 ps
	Digital channel to digital channel only.
	This is the propagation path skew. It ignores skew contributions due to bandpass distortion, threshold inaccuracies, and sample binning.

Specified at the input to the P6316 probe with all eight ground inputs connected to the user's ground. Use of leadsets, grabber clips, ground extenders, or other connection accessories may compromise this specification.

# **RF Input Specifications**

The following table shows the RF input specifications for the MDO3000 Series oscilloscopes.

Characteristic	Description			
Center frequency range	9 kHz to 3.0 GHz (with N	9 kHz to 3.0 GHz (with MDO3SA installed)		
	9 kHz to 1.0 GHz (Any model at 1 GHz BW without MDO3SA installed)			
	9 kHz to 500 MHz (Any model at 500 MHz BW without MDO3SA installed)			
	9 kHz to 350 MHz (Any model at 350 MHz BW without MDO3SA installed)			
	9 kHz to 200 MHz (Any model at 200 MHz BW without MDO3SA installed)			
	9 kHz to 100 MHz (Any model at 100 MHz without MDO3SA installed)			
Resolution bandwidth range	RBW Range for Windowing functions as follows: Kaiser (default): 30 Hz – 150 MHz Rectangular: 20 Hz – 150 MHz Hamming: 20 Hz – 150 MHz Hanning: 20 Hz – 150 MHz Blackman-Harris: 30 Hz – 150 MHz Flat-Top: 50 Hz – 150 MHz			
	Adjusted in 1-2-3-5 sequ	ence		
Kaiser RBW shape factor	60 db/3 db Shape factor $\leq$ 4:1			
Reference frequency error (cumulative)	Cumulative Error: ±10 x 10-6			
	Includes allowances for Aging per Year, Reference Frequency Calibration Accuracy, and Temperature Stability.			
	Valid over the recommended 1 year calibration interval, from –10 $^\circ\mathrm{C}$ to +55 $^\circ\mathrm{C}$ .			
	<b>NOTE.</b> The RF and analog channels share the same reference frequency. Reference frequency accuracy is tested by the Long-term Sample Rate and Delay Time Accuracy checks.			
Marker frequency measurement accuracy	±(([Reference Frequency Error] x [Marker Frequency]) + (span / 750 + 2)) Hz			
	Reference Frequency Error = 10 ppm (10 Hz/MHz)			
	Example, assuming the span is set to 10 kHz and the marker is at 1,500 MHz, this would result in a Frequency Measurement Accuracy of $\pm((10 \text{ Hz}/1 \text{ MHz x } 1,500 \text{ MHz}) + (10 \text{ kHz} / 750 + 2)) = \pm 15.015 \text{ kHz}.$			
	Marker Frequency with Span/RBW ≤ 1000:1			
	Reference Frequency Error with Marker level to displayed noise level > 30 dB			
Phase noise	10 kHz: < –81 dBc/Hz (–85 dBc/Hz, typical)			
	100 kHz: < –97 dBc/Hz (–101 dBc/Hz, typical)			
	1 MHz: < –118 dBc/Hz (–122 dBc/Hz, typical)			
	Phase noise measured offset from 1 GHz CW signal			
Displayed average noise level (DANL)	Frequency range	DANL		
	9 kHz – 50 kHz	< –109 dBm/Hz (< –113 dBm/Hz, typical)		
	50 kHz – 5 MHz	< –126 dBm/Hz (< –130 dBm/Hz, typical)		
	5 MHz – 2 GHz	< –136 dBm/Hz (< –140 dBm/Hz, typical)		
	2 GHz – 3 GHz	< –126 dBm/Hz (< –130 dBm/Hz, typical)		

### Table 14: RF input specifications

Table 14: RF input specifications (cont.)

Displayed average noise level (DANL) with TPA-N-PRE Preamp attached	9 kHz - 50 kHz	–117 dBm/Hz		
	50 kHz - 5 MHz	–138 dBm/Hz		
	50 kHz - BW (MDO3SA not installed)	–148 dBm/Hz		
	5 MHz - 2 GHz (MDO3SA installed)	–148 dBm/Hz		
	2 GHz - 3 GHz (MDO3SA installed)	–138 dBm/Hz		
Input vertical range	Vertical Measurement range: +20 dBm to DANL.			
	Vertical setting of 1 dB/div to 20 dB/div in a 1-2-5 sequence.			
Attenuation range	Attenuator Settings from 10 to 30 dB, in 5 dB steps			
Spectrum trace length (points)	751 points			
Spurious response (SFDR)	2nd harmonic distortion >100 MHz: < -55 dBc (< -60 dBc typical)			
	with auto settings on and signals 10 dB below reference level			
	2nd harmonic distortion: 9 kHz to 100 MHz: < -55 dBc (< -60 dBc typical)			
	with auto settings on, signals 10 dB below reference level, and reference level $\leq$ –5 dBm			
	<b>3rd harmonic distortion &gt;100 MHz:</b> < –53 dBc (< –58 dBc typical)			
	with auto settings on and signals 10 dB below reference level			
	<b>3rd harmonic distortion: 9 kHz to 100 MHz:</b> < –55 dBc (< –60 dBc typical)			
	with auto settings on, signals 10 dB below reference level, and reference level $\leq$ –5 dBm			
	2nd order intermodulation distortion: >15 MHz: < -55 dBc (< -60 dBc typical)			
	with auto settings on and signals 10 dB below reference level			
	<b>2nd order intermodulation distortion: 9 kHz to 15 MHz:</b> < –47 dBc (< –52 dBc, typical)			
	with auto settings on, signals 10 dB below reference level, and reference level $\leq$ –5 dBm			
	3rd order intermodulation dis	stortion: > 15 MHz		
	< –55 dBc, (<–60 dBc, typical)	,		
	with auto settings on and signals 10 dB below reference level			
	3rd order intermodulation distortion: 9 kHz to 15 MHz			
	< –55 dBc (<–60 dBc, typical),			
	with auto settings on and signals 10 dB below reference level and reference level $\leq -5$ dBm			
	-45 dBc (-50 dBc typical) for side bands < 25 kHz offset from the carrier.			
	–55 dBc (–60 dBc typical) for side bands ≥ 25 kHz offset from the carrier			
Residual spurious response	<78 dBm			
	< -67 dBm at 2.5 GHz			
	< -76 dBm at 1.25 GHz			
	$\leq$ –15 dBm reference level and RF input terminated with 50 $\Omega$			
Adjacent channel power ratio dynamic range, typical	–58 dBc			
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Frequency measurement resolution	1 Hz			
Span	Span adjustable in 1-2-5	sequence		
	Variable Resolution = 1%	of the next span setting		
Level display range	Log Scale and Units: dB	m, dBmV, dBµV, dBµW, dBr	mA, dBμA	
	Measurement Points: 1,0	000		
	Marker Level Readout R	esolution: Log Scale: 0.1 dE	3	
	Maximum Number of RF	Traces: 4		
	Trace Functions: Maximu Slice (Uses normal trace	ım Hold; Average; Minimum )	Hold; Normal; Spectrogram	
	Detectors: Positive-Peak	, negative-peak, sample, av	erage	
Reference level	Setting Range: -130 dBr	m to +20 dBm, in steps of 5	dBm	
	Default Setting: 0 dBm ref level			
Vertical position	–100 divs to +100 divs (displayed in dB)			
Maximum operating input level	Average Continuous Power: +20 dBm (0.1 W)			
	DC maximum before damage: ±40 V <sub>dc</sub>			
	Max "No damage" 33 dBm (2 W) CW			
	Peak Pulse Power: +45 dBm (32 W)			
	Peak Pulse Power defined as <10 $\mu$ s pulse width, <1% duty cycle, and reference level of $\geq$ +10 dBm.			
Resolution bandwidth (RBW) accuracy	Max RBW % Error = (0.5	5/(25 x WF)) * 100		
	"WF" represents the Window Factor and is set by the window method being used.			
	Method	WF	RBW error	
	Rectangular	0.89	2.25%	
	Hamming	1.30	1.54%	
	Hanning	1.44	1.39%	
	Blackman-Harris	1.90	1.05%	
	Kaiser	2.23	0.90%	
	Flat-Top	3.77	0.53%	
Level measurement uncertainty	< ±1.2 dB, < ±0.6 dB (typical), 18 °C - 28 °C temperature range			
	< ±2.0 dB, –10 °C to 55 °C			
	Specification applies to when the signal-to-noise ratio > 40 dB.			
Occupied bandwidth accuracy, typical	± Span/750			

Table 14: RF input specifications (cont.)

# **Arbitrary Function Generator Features**

## Table 15: AFG Features

Characteristic	Description			
Function types	Arbitrary, Sine, Square, Pulse, Ramp, Triangle, DC Level, Gaussian, Lorentz, Exponential Rise/Fall, Sine(x)/x, Random Noise, Haversine, Cardiac			
Amplitude range	Values are peak-	-to-peak voltages		
	Waveform	50 Ω	1 ΜΩ	
	Arbitrary	10 mV to 2.5 V	20 mV to 5 V	
	Sine	10 mV to 2.5 V	20 mV to 5 V	
	Square	10 mV to 2.5 V	20 mV to 5 V	
	Pulse	10 mV to 2.5 V	20 mV to 5 V	
	Ramp	10 mV to 2.5 V	20 mV to 5 V	
	Triangle	10 mV to 2.5 V	20 mV to 5 V	
	Gaussian	10 mV to 1.25 V	20 mV to 2.5 V	
	Lorentz	10 mV to 1.2 V	20 mV to 2.4 V	
	Exponential rise	10 mV to 1.25 V	20 mV to 2.5 V	
	Exponential fall	10 mV to 1.25 V	20 mV to 2.5 V	
	Sine(x)/x	10 mV to 1.5 V	20 mV to 3.0 V	
	Random noise	10 mV to 2.5 V	20 mV to 5 V	
	Haversine	10 mV to 1.25 V	20 mV to 2.5 V	
	Cardiac	10 mV to 2.5 V	20 mV to 5 V	
Maximum sample rate	250 MS/s			
Arbitrary function record length	128k samples			

# **Arbitrary Function Generator Characteristics**

## Table 16: AFG Characteristics

Characteristic	Description
Sine waveform	Frequency range: 0.1 Hz to 50 MHz
	Frequency setting resolution: 0.1 Hz
	Amplitude flatness (typical): ±0.5 dB at 1 kHz ±1.5 dB for <20 mV <sub>pp</sub> amplitudes
	Total harmonic distortion (typical): 1% at 50 Ω
	Spurious free dynamic range (typical): –40 dB (V <sub>pp</sub> $\ge$ 0.1 V); 30 dB (V <sub>pp</sub> <0.1 V), 50 $\Omega$ load
Square/pulse waveform	Frequency range: 0.1 Hz to 25 MHz
	Frequency setting resolution: 0.1 Hz
	Duty cycle range: 10% - 90% or 10 ns minimum pulse, whichever is larger
	Duty cycle resolution: 0.1%
	Minimum pulse width (typical): 10 ns
	Rise/fall time (typical): 5 ns, 10% to 90%
	Pulse width resolution: 100 ps
	Overshoot (typical): <2% for signal steps greater than 100 mV
	Asymmetry (typical): ±1% ±5 ns, at 50% duty cycle
Ramp/Triangle waveform	Frequency range: 0.1 Hz to 500 kHz
	Frequency setting resolution: 0.1 Hz
	Variable symmetry: 0% to 100%
	Symmetry resolution: 0.1%
	DC level range (typical): $\pm 2.5$ V in to Hi-Z; $\pm 1.25$ V into 50 $\Omega$
	Gaussian Pulse, Lorentz Pulse, Haversine Maximum Frequency (typical): 5 MHz
	Exponential rise/fall maximum frequency (typical): 5 MHz
	Sine(x)/x maximum frequency (typical): 2 MHz
Random noise waveform	Amplitude range: 20 mV $_{pp}$ to 5 V $_{pp}$ in to Hi-Z; 10 mV $_{pp}$ to 2.5 V $_{pp}$ into 50 $\Omega$
sine and ramp frequency accuracy	130 ppm (frequency ≤10 kHz); 50 ppm (frequency > 10 kHz)
Square and pulse frequency accuracy	130 ppm (frequency ≤10 kHz); 50 ppm (frequency > 10 kHz)
Signal amplitude resolution	500 μV (50 Ω) 1 mV (HiZ)
<sup>an</sup> Signal amplitude accuracy	±[ (1.5% of peak-to-peak amplitude setting) + (1.5% of DC offset setting) + 1 mV ] (frequency = 1 kHz)

DC offset range	±2.5 V into Hi-Z
	±1.25 V into 50 Ω
DC offset resolution	500 μV (50 Ω)
	1 mV (HiZ)
DC offset accuracy	±[ (1.5% of offset setting) + 1 mV ]
	Add 3 mV of uncertainty per 10 °C change from 25 °C ambient

#### Table 16: AFG Characteristics (cont.)

# **Digital Voltmeter/Counter**

## Table 17: Digital voltmeter/counter

Characteristic	Description	
Measurement types	AC+DC <sub>rms</sub> , DC <sub>rms</sub> , AC <sub>rms</sub> , frequency count	
Voltage resolution	4 digits	
Voltage accuracy	DC: ±( 2 mV + [ ((( 4 * (Vertical Scale Voltage)) / ( Absolute Input Voltage) ) + 1 )% of Absolute Input Voltage ] + (0.5% of Absolute Offset Voltage))	
	DC example: an input channel set up with +2 V offset and 1 V/div measuring a $-5$ V signal would have $\pm (2 \text{ mV} + [(((4*1)/5) + 1)\% \text{ of } 5 \text{ V}] + [0.5\% \text{ of } 2 \text{ V}]) = \pm (2 \text{ mV} + [1.8\% \text{ of } 5 \text{ V}] + [0.5\% \text{ of } 2 \text{ V}]) = \pm (2 \text{ mV} + 90 \text{ mV} + 10 \text{ mV}) = \pm 102 \text{ mV}.$ This is roughly $\pm 2\%$ of the input voltage.	
	AC: $\pm 2\%$ (40 Hz to 1 kHz)	
	For AC measurements, the input channel vertical settings must allow the $V_{pp}$ input signal to cover between 4 and 8 divisions.	
Frequency resolution	5 digits	
Frequency accuracy	±(10 µHz/Hz + 1 count)	
Frequency counter source	Any analog input channel.	
** Frequency counter maximum input	100 MHz for 100 MHz models	
frequency	150 MHz for all other models	
	Trigger Sensitivity limits must be observed for reliable frequency measurements.	

# **Performance Verification**

This chapter contains performance verification procedures for the specifications marked with the procedures.

Table 18: Required equipment

Description	Minimum requirements	Examples
DC voltage source	3 mV to 100 V, ±0.1% accuracy	Fluke 9500B Oscilloscope Calibrator
Leveled sine wave generator	9 kHz to 3,000 MHz, ±4% amplitude accuracy	with a 9530 Output Module An appropriate BNC-to-0.1 inch pin
Time mark generator	80 ms period, ±1 ppm accuracy, rise time < 50 ns	P6316 probe
$50 \ \Omega$ BNC cable	Male-to-male connectors	Tektronix part number 012-0057-01 (43 inch)
BNC feed-through termination	50 Ω	Tektronix part number 011-0049-02
RF signal generator	9 kHz to 3 GHz, -20 dBm to + 10 dBm	Anritsu MG3690C series with options 2, 3, 4, 15, 22
Power meter	Use with Power sensor	Rhode & Schwarz NRX
Power sensor	–30 dBm to +10 dBm	Rhode & Schwarz NRP-Z98
Frequency counter	0.1 Hz to 50 MHz, 5 ppm accuracy	Tektronix FCA3000
DMM	DC Voltage: 0.1% accuracy AC RMS Voltage: 0.2% accuracy	Tektronix DMM4040

You may need additional cables and adapters, depending on the actual test equipment you use.

These procedures cover all MDO3000 models. Please disregard any 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 adjustment procedures in the service manual are successfully completed.

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 perform the factory adjustment procedures as described in the *MDO3000 Series Service Manual*.

# **Upgrade the Firmware**

For the best functionality, you can upgrade the oscilloscope firmware. To upgrade the firmware, follow these steps:

- 1. Open a Web browser and go to www.tektronix.com/software/downloads to locate the most recent firmware upgrade.
- 2. Download the latest firmware for your oscilloscope onto your PC.
- 3. Unzip the files and copy the "firmware.img" file into the root folder of a USB flash drive.
- 4. Power off your oscilloscope.
- 5. Insert the USB flash drive into a USB Host port on the front or back of the oscilloscope.
- 6. Power on the oscilloscope. The oscilloscope automatically recognizes the replacement firmware and installs it.

If the instrument does not install the firmware, rerun the procedure. If the problem continues, contact qualified service personnel.

NOTE. Do not power off the oscilloscope or remove the USB flash drive until the oscilloscope finishes installing the firmware.

- 7. Power off the oscilloscope and remove the USB flash drive.
- 8. Power on the oscilloscope.
- 9. Push the Utility button on the front-panel.
- 10. Push Utility Page on the lower menu.
- 11. Turn Multipurpose knob "a" and select Config.
- 12. Push About on the lower menu. The oscilloscope displays the firmware version number.
- 13. Confirm that the version number matches that of the new firmware.

The oscilloscope displays a message when the installation is complete.

# **Test Record**

Print this section for use during the Performance Verification.

Model number	Serial number	Procedure performed by	Date

Test	Passed	Failed
Self Test		

# Input Termination Tests

Input Impedance				
Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 1				
Channel 1 Input	10 mV/div	990 kΩ		1.01 MΩ
Impedance, 1 MΩ	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 1 Input	10 mV/div	49.5 Ω		50.5 Ω
Impedance, 50 Ω	100 mV/div	49.5 Ω		50.5 Ω
Channel 1 Input	10 mV/div	74.25 Ω		75.75 Ω
Impedance, 75Ω	100 mV/div	74.25 Ω		75.75 Ω
NOTE. This setting is not available on MDO310X models.				
Channel 2				
Channel 2 Input	10 mV/div	990 kΩ		1.01 MΩ
Impedance, 1 MΩ	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 2 Input	10 mV/div	49.5 Ω		50.5 Ω
Impedance, 50 Ω	100 mV/div	49.5 Ω		50.5 Ω
Channel 2 Input	10 mV/div	74.25 Ω		75.75 Ω
Impedance, 75 Ω	100 mV/div	74.25 Ω		75.75 Ω
NOTE. This setting is not available on MDO310X models.				
Channel 3 <sup>1</sup>				
Channel 3 Input	10 mV/div	990 kΩ		1.01 MΩ
Impedance, 1 MΩ	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ
Channel 3 Input	10 mV/div	49.5 Ω		50.5 Ω
Impedance, 50 Ω	100 mV/div	49.5 Ω		50.5 Ω
Channel 3 Input	10 mV/div	74.25 Ω		75.75 Ω
Impedance, 75 Ω	100 mV/div	74.25 Ω		75.75 Ω
<b>NOTE.</b> This setting is not available on MDO310X models.				
Channel 4 <sup>1</sup>				
Channel 4 Input	10 mV/div	990 kΩ		1.01 MΩ
Impedance, 1 MΩ	100 mV/div	990 kΩ		1.01 MΩ
	1 V/div	990 kΩ		1.01 MΩ

Input Impedance				
Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 4, 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, 75 Ω	10 mV/div	74.25 Ω		75.75 Ω
	100 mV/div	74.25 Ω		75.75 Ω
NOTE. This setting is not available on MDO310X models.				

<sup>1</sup> Channels 3 and 4 are only on four-channel oscilloscopes.

# **DC Balance Tests**

#### Table 19: DC Balance

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)
Channel 1				
Channel 1 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, 20 MHz BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, 250 MHz BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)
Channel 1 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.5 mV		0.5 mV
75 Ω, Full BW	2 mV/div	-0.500		0.500
	10 mV/div	-0.250		250
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 1 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, Full BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2				
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, 20 MHz BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance	1 mV/div	-0.300		0.300
1 MΩ, 250 MHz BW	2 mV/div	-0.2000		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	0.200		0.200
Channel 2 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, Full BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)			
Channel 3 <sup>1</sup>							
Channel 3 DC Balance,	1 mV/div	-0.500		0.500			
50 Ω, 20 MHz BW	2 mV/div	-0.250		0.250			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0.200		0.200			
Channel 3 DC Balance,	1 mV/div	-0.500		0.500			
75 Ω, 20 MHz BW	2 mV/div	-0.250		0.250			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0200		0.200			
Channel 3 DC Balance,	1 mV/div	-0.300		0.300			
1 MΩ, 20 MHz BW	2 mV/div	-0.200		0.200			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0.200		0.200			
Channel 3 DC Balance,	1 mV/div	-0.500		0.500			
50 Ω, 250 MHz BW	2 mV/div	-0.250		0.250			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0.200		0.200			
Channel 3 DC Balance,	1 mV/div	-0.500		0.500			
75 Ω, 250 MHz BW	2 mV/div	-0.250		0.250			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0.200		0.200			
Channel 3 DC Balance,	1 mV/div	-0.300		0.300			
1 MΩ, 250 MHz BW	2 mV/div	-0.200		0.200			
	10 mV/div	-0.200		0.200			
	100 mV/div	-0.200		0.200			
	1 V/div	-0.200		0.200			

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)
Channel 3 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 3 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 3 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, Full BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 <sup>1</sup>				
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 20 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, 20 MHz BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200

Performance checks	Vertical scale	Low limit (div)	Test result	High limit (div)
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, 250 MHz BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, 250 MHz BW	2 mV/div	-0.2000		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
50 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.500		0.500
75 Ω, Full BW	2 mV/div	-0.250		0.250
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200
Channel 4 DC Balance,	1 mV/div	-0.300		0.300
1 MΩ, Full BW	2 mV/div	-0.200		0.200
	10 mV/div	-0.200		0.200
	100 mV/div	-0.200		0.200
	1 V/div	-0.200		0.200

Table 19: DC Balance (cont.)

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# Analog Bandwidth Tests, 50 $\boldsymbol{\Omega}$

Table 20: Bandwidth

Bandwidth at Channel	Termination	Vertical scale	V <sub>in-pp</sub>	V <sub>bw-pp</sub>	Limit	Test result Gain = V <sub>bw-pp</sub> /V <sub>in-pp</sub>
1	50 Ω	10 mV/div			≥ 0.707	
	50 Ω	5 mV/div			≥ 0.707	
	50 Ω	2 mV/div			≥ 0.707	
	50 Ω	1 mV/div			≥ 0.707	
2	50 Ω	10 mV/div			≥ 0.707	
	50 Ω	5 mV/div			≥ 0.707	
	50 Ω	2 mV/div			≥ 0.707	
	50 Ω	1 mV/div			≥ 0.707	
31	50 Ω	10 mV/div			≥ 0.707	
	50 Ω	5 mV/div			≥ 0.707	
	50 Ω	2 mV/div			≥ 0.707	
	50 Ω	1 mV/div			≥ 0.707	
4 1	50 Ω	10 mV/div			≥ 0.707	
	50 Ω	5 mV/div			≥ 0.707	
	50 Ω	2 mV/div			≥ 0.707	
	50 Ω	1 mV/div			≥ 0.707	

1 Channels 3 and 4 are only on four-channel oscilloscopes

# DC Gain Accuracy Tests

Table 2	21:	DC	Gain	Accuracy
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Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 1	1 mV/div	-2.5%		2.5%
0 V offset, 0 V vertical position	2 mV/div	-2.0%		2.0%
$20 \text{ MHz BW}, 1 \text{ M}\Omega$	4.98 mV/div	-3.0%		3.0%
	5 mV/div	-1.5%		1.5%
	10 mV/div	-1.5%		1.5%
	20 mV/div	-1.5%		1.5%
	49.8 mV	-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%
Channel 2	1 mV/div	-2.5%		2.5%
0 V offset, 0 V vertical position	2 mV/div	-2.0%		2.0%
20 MHz BW, 1 M $\Omega$	4.98 mV/div	-3.0%		3.0%
	5 mV/div	-1.5%		1.5%
	10 mV/div	-1.5%		1.5%
	20 mV/div	-1.5%		1.5%
	49.8 mV	-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%

Performance checks	Vertical scale	Low limit	Test result	High limit
Channel 3 <sup>1</sup>	1 mV/div	-2.5%		2.5%
0 V offset, 0 V vertical position	2 mV/div	-2.0%		2.0%
20 MHz BW, 1 MΩ	4.98 mV/div	-3.0%		3.0%
	5 mV/div	-1.5%		1.5%
	10 mV/div	-1.5%		1.5%
	20 mV/div	-1.5%		1.5%
	49.8 mV	-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%
Channel 4 <sup>1</sup>	1 mV/div	-2.5%		2.5%
0 V offset, 0 V vertical position	2 mV/div	-2.0%		2.0%
20 MHz BW, 1 MΩ	4.98 mV/div	-3.0%		3.0%
	5 mV/div	-1.5%		1.5%
	10 mV/div	-1.5%		1.5%
	20 mV/div	-1.5%		1.5%
	49.8 mV	-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%

Table 21: DC Gain Accuracy (cont.)

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# **DC Offset Accuracy Tests**

Table	22:	DC	Offset	Accuracy
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Performance checks	Vertical scale	Vertical offset <sup>1</sup>	Low limit	Test result	High limit
All models					
Channel 1	1 mV/div	700 mV	696.2 mV		703.8 mV
20 MHz BW, 1 MΩ	1 mV/div	–700 mV	–703.8 mV		–696.2 mV
	2 mV/div	700 m	696.1 mV		703.9 mV
	2 mV/div	–700 mV	–703.9 mV		–696.1 mV
	10 mV/div	1 V	993 mV		1007 mV
	10 mV/div	–1 V	–1007 mV		–993 mV
	100 mV/div	10.0 V	9.930 V		10.07 V
	100 mV/div	–10.0 V	–10.07 V		–9.930 V
	1 V/div	100 V	99.30 V		100.7 V
	1 V/div	–100 V	–100.7 V		–99.30 V
	1.01 V/div	100 V	99.30 V		100.7 V
_	1.01 V/div	–100 V	–100.7 V		–99.30 V
Channel 2	1 mV/div	700 mV	696.2 mV		703.8 mV
20 MHz BW, 1 MΩ	1 mV/div	–700 mV	–703.8 mV		–696.2 mV
	2 mV/div	700 mV	696.1 mV		703.9 mV
	2 mV/div	–700 mV	–703.9 mV		–696.1 mV
	10 mV/div	1 V	993 mV		1007 mV
	10 mV/div	–1 V	–1007 mV		–993 mV
	100 mV/div	10.0 V	9.930 V		10.07 V
	100 mV/div	–10.0 V	–10.07 V		–9.930 V
	1 V/div	100 V	99.30 V		100.7 V
	1 V/div	-100 V	-100.7 V		-99.30 V
	1.01 V/div	100 V	99.30 V		100.7 V
	1.01 V/div	-100 V	–100.7 V		-99.30 V

Performance checks	Vertical scale	Vertical offset <sup>1</sup>	Low limit	Test result	High limit
Channel 3 <sup>2</sup>	1 mV/div	700 mV	696.2 mV		703.8 mV
20 MHz BW, 1 MΩ	1 mV/div	–700 mV	-703.8 mV		–696.2 mV
	2 mV/div	700 mV	696.1 mV		703.9 mV
	2 mV/div	–700 mV	–703.9 mV		–696.1 mV
	10 mV/div	1 V	993 mV		1007 mV
	10 mV/div	–1 V	–1007 mV		–993 mV
	100 mV/div	10.0 V	9.930 V		10.07 V
	100 mV/div	–10.0 V	–10.07 V		–9.930 V
	1 V/div	100 V	99.30 V		100.7 V
	1 V/div	–100 V	–100.7 V		–99.30 V
	1.01 V/div	100 V	99.30 V		100.7 V
	1.01 V/div	–100 V	–100.7 V		–99.30 V
Channel 4 <sup>2</sup>	1 mV/div	700 mV	696.2 mV		703.8 mV
20 MHz BW, 1 MΩ	1 mV/div	–700 mV	–703.8 mV		–696.2 mV
	2 mV/div	700 mV	696.1 mV		703.9 mV
	2 mV/div	–700 mV	–703.9 mV		–696.1 mV
	10 mV/div	1 V	993 mV		1007 mV
	10 mV/div	–1 V	–1007 mV		–993 mV
	100 mV/div	10.0 V	9.930 V		10.07 V
	100 mV/div	–10.0 V	–10.07 V		–9.930 V
	1 V/div	100 V	99.30 V		100.7 V
	1 V/div	-100 V	–100.7 V		-99.30 V
	1.01 V/div	100 V	99.30 V		100.7 V
	1.01 V/div	–100 V	–100.7 V		–99.30 V

Table 22: DC Offset Accuracy (cont.)

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

<sup>2</sup> Channels 3 and 4 are only on four-channel oscilloscopes.

# Sample Rate and Delay Time Accuracy

#### Table 23: Sample Rate and Delay Time Accuracy

Performance checks	Low limit	Test result	High limit
Sample Rate and Delay Time Accuracy	–2 division		+2 division

# Random Noise, Sample Acquisition Mode Tests

Random Noise, Sample Acquisition Mode		Bandwidth Selection	Test result	High limit
For instruments with	Channel 1	Full		4.50 mV
1 GHz bandwidth		250 MHz		4.15 mV
models as well as		20 MHz		4.10 mV
MDO305X/303X/302 X/301X models with	Channel 2	Full		4.50 mV
1 GHz upgrade)		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 3 <sup>1</sup>	Full		4.50 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 4 <sup>1</sup>	Full		4.50 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV
For instruments with	Channel 1	Full		4.15 mV
500 MHz bandwidth (includes MDO305X		250 MHz		4.15 mV
models as well as		20 MHz		4.10 mV
MDO303X/302X/301X models with 500 MHz	Channel 2	Full		4.15 mV
upgrade)		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 3 <sup>1</sup>	Full		4.15 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 4 <sup>1</sup>	Full		4.15 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV

Random Noise, Sampl	e Acquisition Mode	Bandwidth Selection	Test result	High limit
For instruments with 350 MHz bandwidth (includes MDO303X	Channel 1	Full		4.15 mV
		250 MHz		4.15 mV
models as well as		20 MHz		4.10 mV
MDO302X/301X models with 350 MHz	Channel 2	Full		4.15 mV
upgrade)		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 3 <sup>1</sup>	Full		4.15 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV
	Channel 4 <sup>1</sup>	Full		4.15 mV
		250 MHz		4.15 mV
		20 MHz		4.10 mV
For instruments with	Channel 1	Full		4.15 mV
200 MHz bandwidth (MDO302X models		20 MHz		4.10 mV
as well as MDO301X	Channel 2	Full		4.15 mV
models with 200 MHz upgrade)		20 MHz		4.10 mV
apg)	Channel 3	Full		4.15 mV
		20 MHz		4.10 mV
	Channel 4	Full		4.15 mV
		20 MHz		4.10 mV
For instruments with	Channel 1	Full		4.15 mV
100 MHz bandwidth (MDO301X models)		20 MHz		4.10 mV
()	Channel 2	Full		4.15 mV
		20 MHz		4.10 mV
	Channel 3 <sup>1</sup>	Full		4.15 mV
		20 MHz		4.10 mV
	Channel 4 <sup>1</sup>	Full		4.15 mV
		20 MHz		4.10 mV

Table 24: Random Noise, Sample Acquisition Mode (cont.)

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# Delta Time Measurement Accuracy Tests (MDO30XX models)

Table	25:	Delta	Time	Measurement	Accuracy
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MDO V/Div	Source $V_{pp}$	Test Result	High Limit
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/Div,	Source frequency = 24	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		435 ps
100 mV	800 mV		359 ps
500 mV	4 V		356 ps
1 V	4 V		583 ps
MDO = 400 ns/Div	v, Source frequency = 2.	4 MHz	·
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.69 ns
100 mV	800 mV		2.75 ns
500 mV	4 V		2.71 ns
1 V	4 V		5.36 ns
MDO = 4 µs/Div, S	Source frequency = 240	kHz	·
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		36.8 ns
100 mV	800 mV		27.4 ns
500 mV	4 V		27.0 ns
1 V	4 V		53.5 ns
MDO = 40 µs/Div,	Source frequency = 24	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		368 ns
100 mV	800 mV		274 ns
500 mV	4 V		270 ns
1 V	4 V		535 ns
MDO = 400 µs/Div	v, Source frequency = 2.	4 kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
E	40 m)/		2.60 μο

Table 25: Delta Time Measurement Accuracy (cont.)

100 mV	800 mV		2.74 µs
500 mV	4 V		2.70 µs
1 V	4 V		5.35 µs
	·	·	·
MDO = 4 ns/Div, S	Source frequency = 240 M	/Hz (does not apply to 1	00 and 200 MHz models)
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/Div,	Source frequency = 24 I	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		435 ps
100 mV	800 mV		359 ps
500 mV	4 V		356 ps
1 V	4 V		583 ps
MDO = 400 ns/Div	v, Source frequency = 2.4	1 MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.69 ns
100 mV	800 mV		2.75 ns
500 mV	4 V		2.71 ns
1 V	4 V		5.36 ns
MDO = 4 µs/Div, S	Source frequency = 240 I	٢Hz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		36.8 ns
100 mV	800 mV		27.4 ns
500 mV	4 V		27.0 ns
1 V	4 V		53.5 ns
MDO = 40 µs/Div,	Source frequency = 24 I	(Hz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		368 ns
100 mV	800 mV		274 ns
500 mV	4 V		270 ns
4.1/	4.14		<b>F</b> 2 <b>F</b> = -

Channel 3<sup>1</sup>

### Table 25: Delta Time Measurement Accuracy (cont.)

MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.68 µs
100 mV	800 mV		2.74 µs
500 mV	4 V		2.70 µs
1 V	4 V		5.35 µs
	·	·	·
MDO = 4 ns/Div, S	Source frequency = 240 I	MHz (does not apply to 1	00 and 200 MHz models)
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
100 mV	800 mV		233 ps
500 mV	4 V		233 ps
1 V	4 V		237 ps
MDO = 40 ns/Div,	Source frequency = 24	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		435 ps
100 mV	800 mV		359 ps
500 mV	4 V		356 ps
1 V	4 V		583 ps
MDO = 400 ns/Div	v, Source frequency = 2.	4 MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.69 ns
100 mV	800 mV		2.75 ns
500 mV	4 V		2.71 ns
1 V	4 V		5.36 ns
MDO = 4 µs/Div, S	Source frequency = 240	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		36.8 ns
100 mV	800 mV		27.4 ns
500 mV	4 V		27.0 ns
1 V	4 V		53.5 ns
MDO = 40 µs/Div,	Source frequency = 24	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		368 ns
100 mV	800 mV		274 ns
500 mV	4 V		270 ns

Table 25:	Delta	Time	Measurement	Accuracy	(cont.)
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1 V	4 V		535 ns				
MDO = 400 µs/Div, Sou	MDO = 400 µs/Div, Source frequency = 2.4 kHz						
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit				
5 mV	40 mV		3.68 µs				
100 mV	800 mV		2.74 µs				
500 mV	4 V		2.70 µs				
1 V	4 V		5.35 µs				

## Channel 4<sup>1</sup>

MDO = 4 ns/Div, Source frequency = 240 MHz (does not apply to 100 and 200 MHz models)					
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
100 mV	800 mV		233 ps		
500 mV	4 V		233 ps		
1 V	4 V		237 ps		
MDO = 40 ns/Div, Sour	ce frequency = 24 MHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		435 ps		
100 mV	800 mV		359 ps		
500 mV	4 V		356 ps		
1 V	4 V		583 ps		
MDO = 400 ns/Div, Sou	rce frequency = 2.4 MHz	:			
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		3.69 ns		
100 mV	800 mV		2.75 ns		
500 mV	4 V		2.71 ns		
1 V	4 V		5.36 ns		
MDO = 4 µs/Div, Sourc	e frequency = 240 kHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		36.8 ns		
100 mV	800 mV		27.4 ns		
500 mV	4 V		27.0 ns		
1 V	4 V		53.5 ns		
MDO = 40 µs/Div, Sour	ce frequency = 24 kHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		368 ns		

## Table 25: Delta Time Measurement Accuracy (cont.)

100 mV	800 mV		274 ns		
500 mV	4 V		270 ns		
1 V	4 V		535 ns		
MDO = 400 µs/Div, Source frequency = 2.4 kHz					
	Seuree V	Teet Desult	Lliada Linait		
	Source V <sub>pp</sub>	lest Result	Fign Limit		
5 mV	40 mV		3.68 µs		
5 mV 100 mV	40 mV 800 mV		3.68 μs 2.74 μs		
5 mV 100 mV 500 mV	40 mV 800 mV 4 V		3.68 μs   2.74 μs   2.70 μs		

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# Delta Time Measurement Accuracy Tests (MDO310X models)

#### Table 26: Delta Time Measurement Accuracy

MDO = 4 ns/Div, S	Source frequency = 240	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
100 mV	800 mV		119 ps
500 mV	4 V		119 ps
1 V	4 V		128 ps
MDO = 40 ns/Div,	Source frequency = 24	MHz	·
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		386 ps
100 mV	800 mV		298 ps
500 mV	4 V		294 ps
1 V	4 V		584 ps
MDO = 400 ns/Div	v, Source frequency = 2.	4 MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.69 ns
100 mV	800 mV		2.75 ns
500 mV	4 V		2.71 ns
1 V	4 V		5.36 ns
MDO = 4 µs/Div, S	Source frequency = 240	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		36.8 ns
100 mV	800 mV		27.4 ns
500 mV	4 V		27.0 ns
1 V	4 V		53.5 ns
MDO = 40 µs/Div,	Source frequency = 24	kHz	·
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		368 ns
100 mV	800 mV		274 ns
500 mV	4 V		270 ns
1 V	4 V		535 ns
MDO = 400 µs/Div	v, Source frequency = 2.	4 kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.68 µs
<b>MDO = 400 μs/Div</b> <b>MDO V/Div</b> 5 mV	v, Source frequency = 2. Source V <sub>pp</sub> 40 mV	4 kHz Test Result	High Limit 3.68 µs

Table 26:	Delta	Time	Measurement	Accuracy	(cont.)
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100 mV	800 mV		2.74 µs
500 mV	4 V		2.70 µs
1 V	4 V		5.35 µs
MDO = 4 ns/Div,	Source frequency = 240	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
100 mV	800 mV		119 ps
500 mV	4 V		119 ps
1 V	4 V		128 ps
MDO = 40 ns/Div,	Source frequency = 24	MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		386 ps
100 mV	800 mV		298 ps
500 mV	4 V		294 ps
1 V	4 V		584 ps
MDO = 400 ns/Div	v, Source frequency = 2.4	4 MHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		3.69 ns
100 mV	800 mV		2.75 ns
500 mV	4 V		2.71 ns
1 V	4 V		5.36 ns
MDO = 4 µs/Div, 3	Source frequency = 240	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		36.8 ns
100 mV	800 mV		27.4 ns
500 mV	4 V		27.0 ns
1 V	4 V		53.5 ns
MDO = 40 µs/Div,	Source frequency = 24	kHz	
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit
5 mV	40 mV		368 ns
100 mV	800 mV		274 ns
500 mV	4 V		270 ns

	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	5 mV	40 mV		3.68 µs	
	100 mV	800 mV		2.74 µs	
	500 mV	4 V		2.70 µs	
	1 V	4 V		5.35 µs	
<b>3</b> 1					
	MDO = 4 ns/Div, §	Source frequency = 240	MHz		
	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	100 mV	800 mV		119 ps	
	500 mV	4 V		119 ps	
	1 V	4 V		128 ps	
	MDO = 40 ns/Div,	Source frequency = 24	MHz		
	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	5 mV	40 mV		386 ps	
	100 mV	800 mV		298 ps	
	500 mV	4 V		294 ps	
	1 V	4 V		584 ps	
	MDO = 400 ns/Div	<i>v</i> , Source frequency = 2.	4 MHz		
	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	5 mV	40 mV		3.69 ns	
	100 mV	800 mV		2.75 ns	
	500 mV	4 V		2.71 ns	
	1 V	4 V		5.36 ns	
	MDO = 4 µs/Div, S	Source frequency = 240	kHz		
	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	5 mV	40 mV		36.8 ns	
	100 mV	800 mV		27.4 ns	
	500 mV	4 V		27.0 ns	
	1 V	4 V		53.5 ns	
	MDO = 40 $\mu$ s/Div,	Source frequency = 24	kHz		
	MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
	5 mV	40 mV		368 ns	
	100 mV	800 mV		274 ns	
	500 mV	4 V		270 ns	

Table 26: Delta Time Measurement Accuracy (cont.)

## Table 26: Delta Time Measurement Accuracy (cont.)

1 V	4 V		535 ns		
MDO = 400 µs/Div, Source frequency = 2.4 kHz					
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		3.68 µs		
100 mV	800 mV		2.74 µs		
500 mV	4 V		2.70 µs		
1 V	4 V		5.35 µs		

#### Channel 4<sup>1</sup>

MDO = 4 ns/Div, Source frequency = 240 MHz					
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
100 mV	800 mV		119 ps		
500 mV	4 V		119 ps		
1 V	4 V		128 ps		
MDO = 40 ns/Div, Sour	rce frequency = 24 MHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		386 ps		
100 mV	800 mV		298 ps		
500 mV	4 V		294 ps		
1 V	4 V		584 ps		
MDO = 400 ns/Div, Sou	urce frequency = 2.4 MHz	Z			
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		3.69 ns		
100 mV	800 mV		2.75 ns		
500 mV	4 V		2.71 ns		
1 V	4 V		5.36 ns		
MDO = 4 µs/Div, Sourc	e frequency = 240 kHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		36.8 ns		
100 mV	800 mV		27.4 ns		
500 mV	4 V		27.0 ns		
1 V	4 V		53.5 ns		
MDO = 40 µs/Div, Sour	rce frequency = 24 kHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit		
5 mV	40 mV		368 ns		

## Table 26: Delta Time Measurement Accuracy (cont.)

100 mV	800 mV		274 ns	
500 mV	4 V		270 ns	
1 V	4 V		535 ns	
MDO = 400 μs/Div, Source frequency = 2.4 kHz				
MDO V/Div	Source V <sub>pp</sub>	Test Result	High Limit	
5 mV	40 mV		3.68 µs	
100 mV	800 mV		2.74 µs	
500 mV	4 V		2.70 µs	

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# Digital Threshold Accuracy Tests (with MDO3MSO option)

Digital Thresho	Id Accuracy (wit	h MDO3MSO opt	ion)			
Digital channel	Threshold	V <sub>s</sub> .	V <sub>s+</sub>	Low limit	Test result V <sub>sAvg</sub> = (V <sub>s-</sub> + V <sub>s+</sub> )/2	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

Table 27: Digital Threshold Accuracy (with MDO3MSO option)

Digital Thresho	old Accuracy (with	MDO3MSO optic	on)			
Digital channel	Threshold	V <sub>s</sub> .	V <sub>s+</sub>	Low limit	Test result V <sub>sAvg</sub> = (V <sub>s</sub> + V <sub>s+</sub> )/2	High limit
D15	0 V			-0.1 V		0.1 V
	4 V			3.78 V		4.22 V

Table 27: Digital Threshold Accuracy (with MDO3MSO option) (cont.)

# Displayed Average Noise Level Tests (DANL)

# Table 28: Displayed Average Noise Level

Displayed Average N	loise Level (DANL)				
Performance checks		Low limit	Test result	High limit	
All models	9 kHz – 50 kHz	N/A		–109 dBm/Hz	
	50 kHz – 5 MHz	N/A		–126 dBm/Hz	
	5 MHz – BW (MDO3SA not installed)	N/A		–136 dBm/Hz	
	5 MHz – 2 GHz (MDO3SA installed)	N/A		–136 dBm/Hz	
	2 GHz – 3 GHz (MDO3SA installed)	N/A		–126 dBm/Hz	

## **Residual Spurious Response Tests**

#### Table 29: Residual Spurious Response

<b>Residual Spurious Resp</b>	Residual Spurious Response						
Performance checks		Low limit Test result	High limit				
All models	9 kHz to 50 kHz	N/A	–78 dBm				
	50 kHz to 5 MHz	N/A	–78 dBm				
	5 MHz to 2 GHz (not 1.25 GHz)	N/A	–78 dBm				
	1.25 GHz (MDO3SA installed)	N/A	–76 dBm				
	2 GHz to 3 GHz (not 2.5 GHz) (MDO3SA installed)	N/A	–78 dBm				
	2.5 GHz (MDO3SA installed)	N/A	–69 dBm				

## Level Measurement Uncertainty Tests

#### Table 30: Level Measurement Uncertainty

Level Measurement Uncertainty						
Performance c	hecks		Low limit	Test result	High limit	
+10 dBm All r	All models	9 kHz	–1.2 dB		+1.2 dB	
		50 kHz	–1.2 dB		+1.2 dB	
		100 kHz – 900 kHz	–1.2 dB		+1.2 dB	
		1 MHz – 9 MHz	–1.2 dB		+1.2 dB	
		10 MHz - 90 MHz	–1.2 dB		+1.2 dB	
		100 MHz – BW	–1.2 dB		+1.2 dB	
0 dBm	All models	9 kHz	–1.2 dB		+1.2 dB	
		50 kHz	–1.2 dB		+1.2 dB	
		100 kHz – 900 kHz	–1.2 dB		+1.2 dB	
		1 MHz – 9 MHz	–1.2 dB		+1.2 dB	
		10 MHz - 90 MHz	–1.2 dB		+1.2 dB	
		100 MHz – BW	–1.2 dB		+1.2 dB	
–15 dBm	All models	9 kHz	–1.2 dB		+1.2 dB	
		50 kHz	–1.2 dB		+1.2 dB	
		100 kHz – 900 kHz	–1.2 dB		+1.2 dB	
		1 MHz – 9 MHz	–1.2 dB		+1.2 dB	
		10 MHz – 90 MHz	–1.2 dB		+1.2 dB	
		100 MHz – BW	–1.2 dB		+1.2 dB	

## Functional check with a TPA-N-PRE Preamp Attached

Table 31: Functional check with a TPA-N-PRE Preamp attached

Functional check with a TPA-N-PRE Preamp attached				
Performance che	cks	Limit	Test result	
All models	1.7 GHz	≤ 1.5 dB		
	2.9 GHz	≤ 1.5 dB		
# Displayed Average Noise Level (DANL) with a TPA-N-PRE Preamp Attached

Displayed Average No	oise Level (DANL) with a	a TPA-N-PRE Pream	p Attached	
Performance checks		Low limit	Test result	High limit
All models	9 kHz - 50 kHz	N/A		–117 dBm/Hz
	50 kHz - 5 MHz	N/A		–138 dBm/Hz
	50 kHz - BW (MDO3SA not installed)	N/A		–148 dBm/Hz
	5 MHz - 2 GHz (MDO3SA installed)	N/A		–148 dBm/Hz
	2 GHz - 3 GHz (MDO3SA installed)	N/A		–138 dBm/Hz

### Table 32: Displayed Average Noise Level (DANL) with a TPA-N-PRE Preamp Attached

# Auxiliary (Trigger) Output Tests

#### Table 33: Auxiliary (Trigger) Output Tests

Auxiliary (Trigger) O	utput Tests				
Performance checks		Low limit	Test result	High limit	
Trigger Output	High 1 MΩ	≥ 2.25 V		—	
	Low 1 MΩ	—		≤ 0.7 V	
	High 50 Ω	≥ 0.9 V		—	
	Low 50 Ω	—		≤ 0.25 V	

# AFG Sine and Ramp Frequency Accuracy Tests

Table 34: AFG Sine and Ramp Frequency Accuracy Tests

equency Accuracy			
	Low limit	Test result	High limit
Sine Wave at 10 kHz, 2.5 V, 50 Ω	9.9987 kHz		10.0013 kHz
Sine Wave at 50 MHz, 2.5 V, 50 $\Omega$	49.9975 MHz		50.0025 MHz
	Sine Wave at 10 kHz, 2.5 V, 50 Ω Sine Wave at 50 MHz, 2.5 V, 50 Ω	Low limit           Sine Wave at 10 kHz, 2.5 V, 50 Ω         9.9987 kHz           Sine Wave at 50 MHz, 2.5 V, 50 Ω         49.9975 MHz	Low limit         Test result           Sine Wave at 10 kHz, 2.5 V, 50 Ω         9.9987 kHz           Sine Wave at 50 MHz, 2.5 V, 50 Ω         49.9975 MHz

# AFG Sine and Ramp Frequency Accuracy

# AFG Square and Pulse Frequency Accuracy Tests

AFG Square and Pulse I	Frequency Accuracy			
Performance checks		Low limit	Test result	High limit
All models	Square Wave at 25 kHz, 2.5 V, 50 Ω	24.99875 kHz		25.00125 kHz
	Square Wave at 25 MHz, 2.5 V, 50 Ω	24.99875 MHz		25.00125 MHz

#### Table 35: AFG Square and Pulse Frequency Accuracy Tests

# AFG Signal Amplitude Accuracy Tests

#### Table 36: AFG Signal Amplitude Accuracy Tests

AFG Signal Amplitude A	Accuracy				
Performance checks		Low limit	Test result	High limit	
All models	Square Wave 20 mV <sub>pp</sub> @ 1 kHz, 50 Ω, 0 V Offset	9.35 mV		10.65 mV	
	Square Wave 1 V <sub>pp</sub> @ 1 kHz, 50 Ω, 0.2 V Offset	490.5 mV		509.5 mV	

# **AFG DC Offset Accuracy Tests**

Table 37: AFG DC Offset Accuracy Tests

AFG DC Offset Accurac	у				
Performance checks		Low limit	Test result	High limit	
All models	20 mV DC offset @ 50 $\Omega$	18.7 mV		21.3 mV	
	1 V DC offset @ 50 Ω	984 mV		1.016 V	

# **DVM Voltage Accuracy Tests (DC)**

Channel 1					
Vertical Scale	Input Voltage	Offset Voltage	Low Limit	Test Result	High Limit
1	-5	-5	-5.117		-4.883
0.5	-2	-2	-2.052		-1.948
0.5	-1	-0.5	-1.0345		-0.9655
0.2	-0.5	-0.5	-0.5175		-0.4825
0.01	0.002	0	0.00042		0.00442
0.2	0.5	0.5	0.4825		0.5175
0.5	1	0.5	0.9655		1.0345
0.5	2	2	1.948		2.052
1	5	5	4.883		5.117
Channel 2					
Vertical Scale	Input Voltage	Offset Voltage	Low Limit	Test Result	High Limit
1	-5	-5	-5.117		-4.883
0.5	-2	-2	-2.052		-1.948
0.5	-1	-0.5	-1.0345		-0.9655
0.2	-0.5	-0.5	-0.5175		-0.4825
0.01	0.002	0	0.00042		0.00442
0.2	0.5	0.5	0.4825		0.5175
0.5	1	0.5	0.9655		1.0345
0.5	2	2	1.948		2.052
1	5	5	4.883		5.117
Channel 3 <sup>1</sup>					
Vertical Scale	Input Voltage	Offset Voltage	Low Limit	Test Result	High Limit
1	-5	-5	-5.117		-4.883
0.5	-2	-2	-2.052		-1.948
0.5	-1	-0.5	-1.0345		-0.9655
0.2	-0.5	-0.5	-0.5175		-0.4825
0.01	0.002	0	0.00042		0.00442
0.2	0.5	0.5	0.4825		0.5175
0.5	1	0.5	0.9655		1.0345
0.5	2	2	1.948		2.052
1	5	5	4.883		5.117

# Table 38: DVM Voltage Accuracy (DC)

Channel 4 <sup>1</sup>					
Vertical Scale	Input Voltage	Offset Voltage	Low Limit	Test Result	High Limit
1	-5	-5	-5.117		-4.883
0.5	-2	-2	-2.052		-1.948
0.5	-1	-0.5	-1.0345		-0.9655
0.2	-0.5	-0.5	-0.5175		-0.4825
0.01	0.002	0	0.00042		0.00442
0.2	0.5	0.5	0.4825		0.5175
0.5	1	0.5	0.9655		1.0345
0.5	2	2	1.948		2.052
1	5	5	4.883		5.117

Table 38: DVM Voltage Accuracy (DC) (cont.)

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# **DVM Voltage Accuracy Tests (AC)**

Channel 1				
Vertical Scale	Input Signal	Low Limit	Test Result	High Limit
5 mV	20 mV $_{\rm pp}$ at 1 kHz	9.800 mV		10.200 mV
10 mV	50 mV $_{\rm pp}$ at 1 kHz	24.5 mV		25.500 mV
100 mV	$0.5 V_{pp}$ at 1 kHz	245.000 mV		255.000 mV
200 mV	$1 V_{pp}$ at 1 kHz	490.000 mV		510.000 mV
1 V	5 $V_{pp}$ at 1 kHz	2.450 mV		2.550 mV
Channel 2				
Vertical Scale	Input Signal	Low Limit	Test Result	High Limit
5 mV	20 mV <sub>pp</sub> at 1 kHz	9.800 mV		10.200 mV
10 mV	50 mV $_{\rm pp}$ at 1 kHz	24.5 mV		25.500 mV
100 mV	$0.5 V_{pp}$ at 1 kHz	245.000 mV		255.000 mV
200 mV	1 V <sub>pp</sub> at 1 kHz	490.000 mV		510.000 mV
1 V	5 V <sub>pp</sub> at 1 kHz	2.450 mV		2.550 mV
Channel 3 <sup>1</sup>		_		
Vertical Scale	Input Signal	Low Limit	Test Result	High Limit
5 mV	20 mV $_{\rm pp}$ at 1 kHz	9.800 mV		10.200 mV
10 mV	50 mV $_{\rm pp}$ at 1 kHz	24.5 mV		25.500 mV
100 mV	$0.5 \ V_{\mbox{\tiny pp}}$ at 1 kHz	245.000 mV		255.000 mV
200 mV	$1 V_{pp}$ at 1 kHz	490.000 mV		510.000 mV
1 V	5 $V_{pp}$ at 1 kHz	2.450 mV		2.550 mV
Channel 4 <sup>1</sup>				
Vertical Scale	Input Signal	Low Limit	Test Result	High Limit
5 mV	20 mV $_{\rm pp}$ at 1 kHz	9.800 mV		10.200 mV
10 mV	50 mV <sub>pp</sub> at 1 kHz	24.5 mV		25.500 mV
100 mV	$0.5 \ V_{\mbox{\tiny pp}}$ at 1 kHz	245.000 mV		255.000 mV
200 mV	1 V <sub>pp</sub> at 1 kHz	490.000 mV		510.000 mV
1 V	5 V <sub>pp</sub> at 1 kHz	2.450 mV		2.550 mV

1 Channels 3 and 4 are only on four-channel oscilloscopes.

# **DVM Frequency Accuracy Tests and Maximum Input Frequency**

# Table 40: DVM Frequency Accuracy

Channel 1				
	Nominal	Low Limit	Test Result	High Limit
	9.0000 Hz	8.9998 Hz		9.0002 Hz
	99.000 Hz	98.998 Hz		99.002 Hz
	999.00 Hz	998.98 Hz		999.02 Hz
	99.000 kHz	98.998 kHz		99.002 kHz
	999.00 kHz	998.98 kHz		999.02 kHz
	150 MHz <sup>2</sup>	149.99 MHz		150.01 MHz
Channel 2	_			
	9.0000 Hz	8.9998 Hz		9.0002 Hz
	99.000 Hz	98.998 Hz		99.002 Hz
	999.00 Hz	998.98 Hz		999.02 Hz
	99.000 kHz	98.998 kHz		99.002 kHz
	999.00 kHz	998.98 kHz		999.02 kHz
	150 MHz <sup>2</sup>	149.99 MHz		150.01 MHz
Channel 3 <sup>1</sup>				
	9.0000 Hz	8.9998 Hz		9.0002 Hz
	99.000 Hz	98.998 Hz		99.002 Hz
	999.00 Hz	998.98 Hz		999.02 Hz
	99.000 kHz	98.998 kHz		99.002 kHz
	999.00 kHz	998.98 kHz		999.02 kHz
	150 MHz <sup>2</sup>	149.99 MHz		150.01 MHz
Channel 4 <sup>1</sup>				
	9.0000 Hz	8.9998 Hz		9.0002 Hz
	99.000 Hz	98.998 Hz		99.002 Hz
	999.00 Hz	998.98 Hz		999.02 Hz
	99.000 kHz	98.998 kHz		99.002 kHz
	999.00 kHz	998.98 kHz		999.02 kHz
	150 MHz 2	149.99 MHz		150.01 MHz

1 Channels 3 and 4 are only on four-channel oscilloscopes.

2 Verifies the maximum frequency.

# **Performance Verification Procedures**

The following three conditions must be met prior to 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.
- You must perform a signal path compensation (SPC). (See Self Tests System Diagnostics and Signal Path Compensation section below.) If the operating temperature changes by more than 10 °C (18 °F), you must perform the signal path compensation again.
- 3. You must connect the oscilloscope and the test equipment to the same AC power circuit. Connect the oscilloscope and test instruments into a common power strip if you are unsure of the AC power circuit distribution. Connecting the oscilloscope and test instruments into separate AC power circuits can result in offset voltages between the equipment, which can invalidate the performance verification procedure.

The time required to complete all the procedures is approximately one hour.



**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 Tests — System Diagnostics and Signal Path Compensation

These procedures use internal routines to verify that the oscilloscope functions and passes its internal self tests. No test equipment or hookups are required. Start the self test with these steps:

Run the System Diagnostics (may take several minutes):

- 1. Disconnect all probes and cables from the oscilloscope inputs.
- 2. Push Default Setup on the front-panel to set the instrument to the factory default settings.
- 3. Push Utility .
- 4. Push Utility Page on the lower menu, and turn Multipurpose knob "a" to select Self Test.
- 5. Push Self Test on the lower menu. The Loop X Times side menu button will be set to Loop 1 Times.
- 6. Push OK Run Self Test on the side menu.
- 7. Wait while the self test runs. When the self test completes, a dialog box displays the results of the self test.
- 8. Cycle the oscilloscope power off and back on before proceeding.

NOTE. Remember to cycle the oscilloscope power off and back on before proceeding.

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

- 1. Push Default Setup on the front panel.
- 2. Push Utility .
- 3. Push Utility Page on the lower menu.
- 4. Turn Multipurpose knob "a" to select Calibration.
- 5. Push Signal Path on the lower menu.

- 6. Push OK-Compensate Signal Paths on the side menu.
- 7. When the signal path compensation is complete, push Menu Off twice to clear the dialog box and Self Test menu.
- 8. Check the **Signal Path** button on the lower menu to verify that the status is **Pass**. If it does not pass, run the test again. If it still does not pass, recalibrate the instrument or have the instrument serviced by qualified service personnel.

#### Check Input Termination, DC Coupled (Resistance)

This test checks the Input Termination for 1 MΩ, 75  $\Omega$  or 50  $\Omega$  settings.

#### **NOTE.** The 75 $\Omega$ setting is not available on MDO310X instruments.

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



- 2. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 3. Push the channel button on the front panel for the oscilloscope channel that you are testing, as shown in the test record (for example, 1, 2, 3, or 4).
- 4. Confirm that the oscilloscope termination and calibrator impedance are both set to 1 M $\Omega$ . The default **Termination** setting is 1 M $\Omega$ .
- 5. Turn the Vertical Scale knob to set the vertical scale, as shown in the test record (for example, 10 mV/div, 100 mV/div, 1 V/div). (See page 36, *Input Termination Tests*.)
- 6. Measure the input resistance of the oscilloscope with the calibrator. Record this value in the test record.
- 7. Repeat steps 5 and 6 for each volt/division setting in the test record.
- 8. Change the oscilloscope termination to 75  $\Omega$  and calibrator impedance to 50  $\Omega$  and repeat steps 5 through 7.
- **9.** Change the oscilloscope termination to 50  $\Omega$  and repeat steps 5 through 7.
- Repeat steps 4 through 9 for each channel listed in the test record and relevant to the model of oscilloscope that you are testing, as shown in the test record (for example, 2, 3, or 4).

# **Check DC Balance**

This test checks the DC balance.

You do not need to connect the oscilloscope to any equipment to run this test. The only piece of equipment needed is a BNC feed-through 50  $\Omega$  terminator.

1. For 50  $\Omega$  coupling, attach a 50  $\Omega$  terminator to the channel input of the oscilloscope being tested.



- 2. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 3. Push the channel button on the front panel for the oscilloscope channel that you are testing, as shown in the test record (for example, 1, 2, 3, or 4).
- 4. Set the oscilloscope termination to 50  $\Omega$ . Push Termination on the lower menu to select 50  $\Omega$ .
- 5. Push Bandwidth on the lower menu, and push the appropriate bandwidth button on the side menu for 20MHz, 150MHz, or Full, as given in the test record.
- 6. Turn the Horizontal Scale knob to 1 ms/division.

**NOTE.** Step 6 only needs to be done once, at the beginning of the test.

- 7. Turn the Vertical Scale knob to set the vertical scale, as shown in the test record (for example, 1 mV/div, 2 mV/div, 10 mV/div, 100 mV/div, 1 V/div).
- 8. Push Acquire on the front panel.

NOTE. Steps 8, 9, and 10 only need to be performed once, at the beginning of this test.

- 9. Push Mode on the lower menu, and then, if needed, push Average on the side menu.
- 10. If needed, adjust the number of averages to 16 using Multipurpose knob "a" .
- 11. Push the Trigger Menu button on the front panel.

NOTE. Steps 11, 12, and 13 only need to be performed once, at the beginning of this test.

- 12. Push Source on the lower menu.
- 13. Select the AC Line trigger source on the side menu using Multipurpose knob "a". You do not need to connect an external signal to the oscilloscope for this DC Balance test.
- 14. On the front panel, push the **Measure** button on the Wave Inspector.

NOTE. Steps 14 though 17 must be performed once for each input channel under test.

- 15. Push Add Measurement on the lower menu.
- Use Multipurpose knob "b" to select the Mean measurement. If needed, use Multipurpose knob "b" to select the channel input being tested.
- 17. Push OK Add Measurement on the side menu, and then Menu Off on the front panel.
- View the mean measurement value in the display and enter that mean value as the test result in the test record. (See page 38, DC Balance Tests.)

**NOTE.** Translate the mean value into divisions for use in the test record. To do this, divide the voltage value by the vertical scale value. (e.g.0.2 V / (1 V / division) = 0.2 divisions)

- **19.** Repeat step 7 and step 18 for each volts/division value listed in the results table.
- 20. Push the channel button on the front panel, then change the oscilloscope bandwidth (for example, 20 MHz, 150 MHz, or Full), and repeat step 7, step 18, and step 19.
- **21.** For 1 M $\Omega$  coupling, change the oscilloscope termination to 1 M $\Omega$  and repeat steps 5 through 20.
- Repeat steps 3 through 20 for each channel combination listed in the test record and relevant to your model of oscilloscope (for example, 1, 2, 3, or 4).

**NOTE.** The BNC 50  $\Omega$  terminator needs to be moved to next input channel.

**23.** For 75  $\Omega$  coupling, change the oscilloscope termination to 75  $\Omega$  and repeat steps 5 through 20.

**NOTE.** The BNC 50  $\Omega$  terminator needs to be moved to next input channel.

24. Repeat steps 3 through 20 for each channel combination listed in the test record and relevant to your model of oscilloscope (for example, 1, 2, 3, or 4).

**NOTE.** The BNC 50  $\Omega$  terminator needs to be moved to next input channel.

## Check Analog Bandwidth, 50 Ω

This test checks the bandwidth at 50  $\Omega$  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 below.



- 2. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 3. Push channel button 1, 2,3, or 4 for the channel that you want to check.
- 4. Set the calibrator to 50  $\Omega$  output impedance (50  $\Omega$  source impedance) and to generate a sine wave.
- 5. Set the oscilloscope termination to 50  $\Omega$ . Push Termination on the lower menu to select 50  $\Omega$ .
- Turn the Vertical Scale knob to set the vertical scale, as shown in the test record (for example, 1 mV/div, 2 mV/div, 5 mV/div).
- 7. Push Acquire on the front panel.
- 8. Confirm that the mode is set to **Sample**. If not, push **Mode** on the lower menu, if needed, and then push the **Sample** side bezel button.
- 9. Adjust the signal source to at least 6 vertical divisions at the selected vertical scale with a set frequency of 50 kHz. For example, at 5 mV/div, use a ≥ 30 mV<sub>p-p</sub> signal; at 2 mV/div, use a ≥ 12 mV<sub>p-p</sub> signal; at 1 mV/div, use a <sup>3</sup> 6 mV<sub>p-p</sub> signal. Use a sine wave for the signal source.
- 10. Turn the Horizontal Scale knob to 40 µs/division.
- 11. On the front panel, push the **Measure** button on the Wave Inspector, and then push **Add Measurement** on the lower menu.

NOTE. Steps 11 though 14 must be performed once for each input channel under test.

- 12. Use Multipurpose knob "b" to select the Peak-to-peak measurement. Use Multipurpose knob "a" to select the input channel being tested, and then push OK Add Measurement on the side menu.
- 13. Push More on the lower menu to select Gating, and then push Off (Full Record) on the side menu.
- **14.** Push **Menu Off** on the front panel. This will allow you to see the display. Note the mean  $V_{p,p}$  of the signal. Call this reading  $V_{in,pp}$ .

Record the mean value of  $V_{in-pp}$  (for example, 816 mV) in the test record. (See page 44, Analog Bandwidth Tests, 50  $\Omega$ .)

15. Turn the Horizontal Scale knob to 10 ns/division.

16. Adjust the signal source to the maximum bandwidth frequency for the bandwidth and model desired, as shown in the following worksheet. Measure V<sub>p-p</sub> of the signal on the oscilloscope using statistics, as in the previous step, to get the mean V<sub>p-p</sub>. Call this reading V<sub>bw-pp</sub>.

Record the value of  $V_{bw-pp}$  in the test record.

**NOTE.** For more information on the contents of this worksheet, refer to the Analog Channel Input and Vertical Specifications table. (See page 1, Analog Channel Input And Vertical Specifications.)

#### Table 41: Maximum Bandwidth Frequency worksheet

Termination	Vertical Scale	Maximum Bandwidth Frequency
For instruments with 1 GHz bandwidth (includes MDO310X models as well as	MDO305X/303X/302X/301X models with 1	GHz upgrade):
50 Ω	10 mV/div	1 GHz
50 Ω	5 mV/div	500 MHz
50 Ω	2 mV/div	350 MHz
50 Ω	1 mV/div	150 MHz
For instruments with 500 MHz bandwid (includes MDO305X models as well as	th MDO303X/302X/301X models with 500 M	Hz upgrade):
50 Ω	5 mV/div	500 MHz
50 Ω	2 mV/div	350 MHz
50 Ω	1 mV/div	150 MHz
For instruments with 350 MHz bandwid (includes MDO303X models as well as	th MDO302X/301X models with 350 MHz up	grade):
50Ω	5 mV/div	350 MHz
50Ω	2 mV/div	350 MHz
50Ω	1 mV/div	150 MHz
For instruments with 200 MHz bandwid (includes MDO302X models as well as	th MDO301X models with 200 MHz upgrade	:):
50 Ω	2 mV/div	200 MHz
50 Ω	1 mV/div	150 MHz
For instruments with 100 MHz bandwid (MDO301X models):	th	
50 Ω	1 mV/div	100 MHz

**17.** Use the values of *V*<sub>bw-pp</sub> and *V*<sub>in-pp</sub> obtained above and stored in the test record to calculate the *Gain* at bandwidth with the following equation:

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

**18.** To pass the performance measurement test, Gain should be  $\geq 0.707$ . Enter *Gain* in the test record.

- 19. Repeat steps 9 through 17 for the other oscilloscope volts/div settings listed in the test record.
- 20. Repeat steps 3 through 18 for each channel combination listed in the test record and relevant to your model of oscilloscope (for example, 1, 2, 3, or 4).

#### **Check DC Gain Accuracy**

This test checks the DC gain accuracy.

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



- 2. Push **Default Setup** on the front panel to set the instrument to the factory default settings.
- 3. Push channel button 1, 2,3, or 4 to select the channel that you want to check.
- 4. Confirm that the oscilloscope termination and calibrator impedance are both set to 1 M $\Omega$ . On the oscilloscope, push **Termination** on the lower menu to select 1 M  $\Omega$ .
- Push 20 MHz on the side menu to select the bandwidth (push Bandwidth on the lower menu, if necessary, to activate the Bandwidth menu).
- 6. Push Acquire on the front panel.
- 7. Push Mode on the lower menu, and then push Average on the side menu. Use the default number of averages (16).
- 8. On the front panel, push the Measure button on the Wave Inspector, and then Add Measurement on the lower menu.
- 9. Use Multipurpose knob "b" to select the Mean measurement. Use Multipurpose knob "a" to select the input channel to be tested.
- 10. Push OK Add Measurement on the side menu.
- 11. Push the Trigger Menu button on the front panel.
- 12. Push Source on the lower menu.
- 13. Turn Multipurpose knob "a" to select AC Line as the trigger source. Push Menu Off on the front panel.
- 14. Turn the vertical Scale knob to the next setting to measure, as shown in the Gain Expected worksheet below.
- Set the DC Voltage Source to V<sub>negative</sub>. Push Measure on the front panel, then push More on the lower menu to select Statistics. Push Reset Statistics on the side menu, and then push Menu Off on the front panel.
- 16. Enter the mean reading into Gain Expected worksheet below as V<sub>negative-measured</sub>.
- 17. Set the DC Voltage Source to V<sub>positive</sub>. Push More on the lower menu to select Statistics, push the Reset Statistics on the side menu, and then push Menu Off on the front panel. Enter the mean reading into the Gain Expected worksheet as V<sub>positive-measured</sub>.

Oscillo- scope Vertical Scale Set- ting	VdiffExpected	V <sub>negative</sub>	V <sub>positive</sub>	V <sub>negative-</sub> measured	V <sub>positive-</sub> measured	V <sub>diff</sub>	Test Result (Gain Accuracy)
1 mV/div	7 mV	–3.5 mV	+3.5 mV				
2 mV/div	14 mV	–7 mV	+7 mV				
4.98 mV	34.86 mV	–17.43 mV	+17.43 mV				
5 mV	35 mV	–17.5 mV	+17.5 mV				
10 mV	70 mV	–35 mV	+35 mV				
20 mV	140 mV	–70 mV	+70 mV				
49.8 mV	348.6 mV	–174.3 mV	+174.3 mV				
50 mV	350 mV	–175 mV	+175 mV				
100 mV	700 mV	–350 mV	+350 mV				
200 mV	1400 mV	–700 mV	+700 mV				
500 mV	3500 mV	–1750 mV	+1750 mV				
1.0 V	7000 mV	–3500 mV	+3500 mV				

Table 42: Gain Expected worksheet - channel 1

Table 43: Gain Expected worksheet - channel 2

Oscillo- scope Vertical Scale Set- ting	VdiffExpected	V <sub>negative</sub>	V <sub>positive</sub>	V <sub>negative-</sub> measured	V <sub>positive-</sub> measured	V <sub>diff</sub>	Test Result (Gain Accuracy)
1 mV/div	7 mV	–3.5 mV	+3.5 mV				
2 mV/div	14 mV	–7 mV	+7 mV				
4.98 mV	34.86 mV	–17.43 mV	+17.43 mV				
5 mV	35 mV	–17.5 mV	+17.5 mV				
10 mV	70 mV	–35 mV	+35 mV				
20 mV	140 mV	–70 mV	+70 mV				
49.8 mV	348.6 mV	–174.3 mV	+174.3 mV				
50 mV	350 mV	–175 mV	+175 mV				
100 mV	700 mV	–350 mV	+350 mV				
200 mV	1400 mV	–700 mV	+700 mV				
500 mV	3500 mV	–1750 mV	+1750 mV				
1.0 V	7000 mV	–3500 mV	+3500 mV				

Oscillo- scope Vertical Scale Set- ting	VdiffExpected	V <sub>negative</sub>	V <sub>positive</sub>	V <sub>negative-</sub> measured	V <sub>positive-</sub> measured	V <sub>diff</sub>	Test Result (Gain Accuracy)
1 mV/div	7 mV	–3.5 mV	+3.5 mV				
2 mV/div	14 mV	–7 mV	+7 mV				
4.98 mV	34.86 mV	–17.43 mV	+17.43 mV				
5 mV	35 mV	–17.5 mV	+17.5 mV				
10 mV	70 mV	–35 mV	+35 mV				
20 mV	140 mV	–70 mV	+70 mV				
49.8 mV	348.6 mV	–174.3 mV	+174.3 mV				
50 mV	350 mV	–175 mV	+175 mV				
100 mV	700 mV	–350 mV	+350 mV				
200 mV	1400 mV	–700 mV	+700 mV				
500 mV	3500 mV	–1750 mV	+1750 mV				
1.0 V	7000 mV	-3500 mV	+3500 mV				

Table 44: Gain Expected worksheet - channel 3

Table 45: Gain Expected worksheet - channel 4

Oscillo- scope Vertical Scale Set- ting	VdiffExpected	V <sub>negative</sub>	V <sub>positive</sub>	V <sub>negative-</sub> measured	V <sub>positive-</sub> measured	V <sub>diff</sub>	Test Result (Gain Accuracy)
1 mV/div	7 mV	–3.5 mV	+3.5 mV				
2 mV/div	14 mV	–7 mV	+7 mV				
4.98 mV	34.86 mV	–17.43 mV	+17.43 mV				
5 mV	35 mV	–17.5 mV	+17.5 mV				
10 mV	70 mV	–35 mV	+35 mV				
20 mV	140 mV	–70 mV	+70 mV				
49.8 mV	348.6 mV	–174.3 mV	+174.3 mV				
50 mV	350 mV	–175 mV	+175 mV				
100 mV	700 mV	–350 mV	+350 mV				
200 mV	1400 mV	–700 mV	+700 mV				
500 mV	3500 mV	–1750 mV	+1750 mV				
1.0 V	7000 mV	-3500 mV	+3500 mV				

**18.** Calculate  $V_{diff}$  as follows:

V<sub>diff</sub> = |V<sub>negative-measured</sub> - V<sub>positive-measured</sub> |

Enter V<sub>diff</sub> in the Gain Expected worksheet.

19. Calculate GainAccuracy as follows:

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

Write down *GainAccuracy* in the Gain Expected worksheet and in the test record. (See page 45, *DC Gain Accuracy Tests*.)

- 20. Repeat steps 14 through 18 for each volts/division value in the test record.
- 21. Repeat steps 3 through 19 for each channel of the oscilloscope that you want to check.

#### **Check Offset Accuracy**

This test checks the offset accuracy.

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



- 2. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 3. Push channel button 1,2,3, or 4 to select the channel you want to check.
- Confirm that the oscilloscope termination and calibrator impedance are both set to 1 MΩ. Push Termination on the lower menu to select 1 MΩ.
- 5. Set the calibrator to the vertical offset value shown in the test record (for example, 700 mV for a 1 mV/div setting). Set the calibrator impedance to match the termination setting for the oscilloscope.
- 6. On the oscilloscope, push More on the lower menu repeatedly, to select Offset.
- 7. Set the oscilloscope to the vertical offset value shown in the test record (for example, 700 mV for a 1 mV/div setting).
- 8. Turn the vertical Scale knob to match the value in the test record (for example, 1 mV/division).
- 9. Turn the Horizontal Scale knob to 1 ms/div.
- **10.** Push **Bandwidth** on the lower menu.
- 11. Push 20 MHz on the side menu.
- 12. Check that the vertical position is set to 0 divs. If not, turn the appropriate Vertical Position knob to set the position to 0 divs.

Or, push More on the lower menu repeatedly to select Position, and then push Set to 0 divs on the side menu.

- **13.** Push **Acquire** on the front panel.
- 14. Push Mode on the lower menu, and then push Average on the side menu. Use the default number of averages (16).
- 15. Push the Trigger Menu button on the front panel.
- 16. Push Source on the lower menu.
- 17. Turn Multipurpose knob "a" to select AC Line as the trigger source.
- **18.** On the front panel, push the **Measure** button on the Wave Inspector.
- 19. Push Add Measurement on the lower menu.
- 20. Use Multipurpose knob "b" to select the Mean measurement. Use Multipurpose knob "a" to select the input channel to be tested.

- 21. Push OK Add Measurement on the side menu, and then Menu Off on the front panel. The mean value should appear in a measurement pane at the bottom of the display.
- 22. Enter the measured value in the test record. (See page 47, DC Offset Accuracy Tests.)
- 23. Repeat the procedure (steps 6, 7, 8 and 22) for each volts/division setting shown in the test record.
- 24. Repeat all steps, starting with step 1, for each oscilloscope channel you want to check.

#### Check Long-term Sample Rate and Delay Time Accuracy

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

- 1. Push Default Setup on the oscilloscope front panel to set the instrument to the factory default settings.
- 2. Connect the output of the time mark generator to the oscilloscope channel 1 input using a 50  $\Omega$  cable. Use the time mark generator with a 50  $\Omega$  source with the oscilloscope set for internal 50  $\Omega$  termination.



- 3. Set the time mark generator to 80 ms. Use a time mark waveform with a fast rising edge.
- 4. Set the mark amplitude to 1 V<sub>pp</sub>.
- 5. Set the oscilloscope vertical Scale to 500 mV/div.
- 6. Set the Horizontal Scale to 20 ms/div.
- 7. Adjust the Trigger Level for a triggered display.
- 8. Adjust the vertical Position knob to center the time mark on center screen.
- 9. Adjust the Horizontal Position knob counterclockwise to set the delay to exactly 80 ms.
- 10. Set the Horizontal Scale to 400 ns/div.
- **11.** Compare the rising edge of the marker to the center horizontal graticule. The rising edge should be within ±2 divisions of the center graticule. Enter the deviation in the test record. (See page 49, *Sample Rate and Delay Time Accuracy*.)

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

## **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 connected to the oscilloscope inputs.
- Push Default Setup on the front panel to set the instrument to the factory default settings. This sets the oscilloscope to Channel 1, Full Bandwidth, 1 MΩ input termination, 100 mV/div, and 4.00 µs/div.
- 3. Set Horizontal to 10 ms/div.
- 4. Set CH1 Vertical Channel Setting to 50  $\Omega$  termination and the desired bandwidth.
- 5. Set up the measurements to do RMS and Mean measurement of selected channel and record the measurement.
- 6. Calculate RMS noise voltage = Square root of (RMS<sup>2</sup> Mean<sup>2</sup>), and record the result.
- 7. The calculated RMS noise voltage from step 6 should be less than the high limit in the test record (the calculated maximum RMS noise).
- 8. Repeat the above test for all other input channels. Channels 3 and 4 are only available on three or four channel oscilloscopes.

#### **Check Delta Time Measurement Accuracy**

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

- 1. Set the sine wave generator output impedance to 50  $\Omega$ .
- 2. Push the oscilloscope front-panel Default Setup button, and then push Menu Off.
- 3. Connect a 50  $\Omega$  coaxial cable from the signal source to the oscilloscope channel being tested.



- 4. Push the channel 1 button to display the channel 1 menu.
- 5. Push Termination on the lower menu to set the channel to 50  $\Omega$ .
- 6. Push the Trigger Menu button on the front panel, and then, if necessary, set the trigger source to the channel being tested:
  - a. Push Source on the lower menu.
  - b. Use the Multipurpose a knob to select the channel being tested.
- 7. On the front panel, push the **Measure** button on the Wave Inspector, and then push **Add Measurement** on the lower menu.
- 8. Use Multipurpose Knob "b" to select the Burst Width measurement, and then push OK Add Measurement on the side menu. Use Multipurpose Knob "a" to select the input channel to be tested.
- Push More on the lower menu to select Statistics and, if necessary, use Multipurpose Knob "a" to set the Mean & Std Dev Samples to 100, as shown in the side menu.
- 10. Push Menu Off on the front panel to remove the Statistics menu.
- **11.** Refer to the Test Record *Delta Time Measurement Accuracy* table. (See page 57, *Delta Time Measurement Accuracy Tests (MDO310X models)*.) Set the oscilloscope and the signal source as directed there.
- Push More on the lower menu to select Statistics, and then push Reset Statistics. Wait five or 10 seconds for the
  oscilloscope to acquire all the samples before taking the reading.
- 13. Verify that the Std Dev is less than the upper limit shown for each setting, and note the reading in the Test Record.
- 14. Repeat steps 11 through 13 for each setting combination shown in the Test Record for the channel being tested.
- 15. Push the channel button on the front panel for the current channel to shut off the channel. Push the channel button for the next channel to be tested, and move the coaxial cable to the appropriate input on the oscilloscope. Only the channel being tested should be enabled
- 16. Repeat steps 5 through 15 until all channels have been tested.

**NOTE.** For this test, enable only one channel at a time. If three or more channels are enabled at the same time, the maximum sample rate is reduced and the limits in the Test Record are no longer valid.

#### Check Digital Threshold Accuracy (with MDO3MSO option)

For models with the MDO3MSO option only, 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 P6316 digital probe to the MDO3000 series instrument.
- Connect the P6316 Group 1 pod to the DC voltage source to run this test. You will need a BNC-to-0.1 inch pin adapter to complete the connection.

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



- 3. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 4. Push D15-D0 on the front panel.
- 5. Push D15-D0 On/Off on the lower menu.
- 6. Push Turn On D7 D0 and Turn On D15 D8 on the side menu. The instrument will display the 16 digital channels.
- 7. Push Thresholds on the lower menu.
- 8. Before you change the threshold value, push **Fine** on the front panel to turn off the fine adjustment and make adjusting the value quicker.

Turn Multipurpose knob "a" (for channels D7 - D0) or Multipurpose knob "b" (for channels D15 - D8) to set the threshold value to 0.00 V (0 V/div).

The thresholds are set for the 0 V threshold check. You need to record the test values in the test record row for 0 V for each digital channel. (See page 62, *Digital Threshold Accuracy Tests (with MDO3MSO option)*.)

- 9. Push the Trigger Menu button on the front panel.
- 10. Push Source on the lower menu, and then turn Multipurpose knob "a" to select the appropriate channel, such as D0.

By default, the Type is set to Edge, Coupling is set to DC, Slope is set to Rising, Mode is set to Auto, and Level is set to match the threshold of the channel being tested.

 Set the DC voltage source (Vs) to -400 mV. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display. If the channel is a static logic level high (green), change the DC voltage source Vs to -500 mV.

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

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

NOTE. In this procedure, the channel might not change state until after you pass the set threshold level.

- 13. Push Slope on the lower menu to change the slope to Falling.
- Set the DC voltage source (Vs) to +400 mV. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

If the channel is a static logic level low (blue), change the DC voltage source Vs to +500 mV.

15. Decrement Vs by -20 mV. Wait 3 seconds and check the logic level of the corresponding digital channel in the display. If the channel is at a static logic level low, record the Vs value as Vs+ in the 0 V row of the test record.

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

16. Find the average, V<sub>sAvg</sub> = (Vs- + Vs+)/2. Record the average as the test result in the test record.

Compare the test result to the limits. If the result is between the limits, continue with the procedure to test the channel at the +4 V threshold value.

- 17. The remaining part of this procedure is for the +4 V threshold test. Push D15-D0 on the front panel. The Thresholds menu should display.
- With the Fine button on the front panel turned off, turn Multipurpose knob "a" (for channels D7 D0) or Multipurpose knob "b" (for channels D15 D8) to set the threshold value to 4.00 V (+4.0 V/div). To remove the menu from the display, push Menu Off on the front panel.
- Set the DC voltage source (Vs) to +4.4 V. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

If the channel is a static logic level low (blue), change the DC voltage source Vs to +4.5 V.

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

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

- 21. Push the Trigger Menu button on the front panel.
- 22. Push the Slope lower-bezel button to change the slope to Rising.
- 23. Set the DC voltage source (Vs) to +3.6 V. Wait 3 seconds. Check the logic level of the corresponding digital channel in the display.

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

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

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

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

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

- 26. Push D15-D0 on the front panel. The Thresholds menu should display.
- **27.** Repeat the procedure starting with step 8 for each remaining digital channel in the pod.
- 28. Disconnect the P6316 Group 1 pod from the BNC-to-0.1 inch pin adapter and connect the Group 2 pod in its place.
- 29. Repeat the procedure starting with step 8 for each digital channel in the Group 2 pod.

# 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 these ranges:

- 9 kHz to 50 kHz (all models)
- 50 kHz to 5 MHz (all models)
- 5 MHz to BW (MDO3SA not installed)
- 5 MHz to 2 GHz (MDO3SA installed)
- 2 GHz to 3 GHz (MDO3SA installed)

**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.

- 1. Initial oscilloscope setup:
  - a. Terminate the RF input in 50  $\Omega$  with no input signal applied.
  - b. Push the Default Setup button on the front panel.
  - 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 and set Normal to Off. Push the side-bezel **Average** button to set the Average Traces to On.
  - e. *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.
  - f. 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 -15.0 dBm.
  - **g.** 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 9 kHz. Push the side-bezel **Stop** button. Set the stop frequency to 50 kHz.
- 2. Check from 9 kHz to 50 kHz (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 near 9 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. In the test record, enter the result at this frequency (9 kHz).
- 4. Check from 50 kHz to 5 MHz (all models):
  - a. Set the stop frequency to 5 MHz.
  - **b.** Set the start frequency to 50 kHz.
  - 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. In the test record, enter the result at this frequency (50 kHz).

- 6. Check from 5 MHz to BW (MDO3SA not installed):
  - a. Set the stop frequency to the maximum bandwidth.
  - 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.
- 7. Check from 5 MHz to 2 GHz (MDO3SA installed).
  - a. Set the stop frequency to 2 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.
- 8. Check from 2 GHz to 3 GHz (MDO3SA installed).
  - a. Set the stop frequency to 3 GHz.
  - b. Set the start frequency to 2 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 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.** Initial Setup:
  - **a.** Terminate the oscilloscope RF input in 50  $\Omega$  with no input signal applied.
  - b. Push Default Setup.
  - c. Turn on RF.
  - d. Turn on Average Trace. Push the bottom-bezel Spectrum Traces button and set Normal to Off. Push the side-bezel Average button to set Average Traces to On.
  - e. Set Ref Level to -15 dBm. Push the front-panel Ampl button. Push the side-bezel Ref Level button. Set the Ref Level to -15 dB.
- 2. Check in the range of 9 kHz to 50 kHz (all models).
  - a. Set Start Frequency to 9 kHz. Push the front-panel Freq/Span button. Push the side-bezel Start button. Set the start frequency to 9 kHz.
  - b. Set Stop Frequency to 50 kHz. Push the side-bezel Stop button. Set the stop frequency to 50 kHz.
  - c. Observe any spurs above -78 dBm and note them in the test record.
- 3. Check in the range of 50 kHz to 5 MHz (all models).
  - a. Set Stop Frequency to 5 MHz.
  - **b.** Set Start Frequency to 50 kHz.
  - c. Observe any spurs above -78 dBm and note them in the test record.
- **4.** Check in the range of 5 MHz to Maximum Bandwidth (MDO3SA not installed):
  - a. Set Stop Frequency to the maximum bandwidth.
  - b. Set Start Frequency to 5 MHz.
  - c. Set RBW to 100 kHz. Push the BW front-panel button. Turn the Multipurpose a knob counter-clockwise to change the RBW to 100 kHz.
  - d. Observe any spurs above –78 dBm and note them in the test record.
- 5. Check in the range of 5 MHz to 2 GHz (MDO3SA installed):
  - a. Set Stop Frequency to 2 GHz.
  - b. Set Start Frequency to 5 MHz.
  - c. Set RBW to 100 kHz. Push the BW front-panel button. Turn the Multipurpose a knob counter-clockwise to change the RBW to 100 kHz.
  - d. Check the spur level at 1.25 GHz, if present. Push the Markers front-panel button and then push the Manual Markers side-bezel button to turn on manual markers. Turn the Multipurpose a knob to line up Marker a on the

1.25 GHz spur, if it is present. Adjust the marker until the horizontal dash on the marker sits on top of the spur. Note the spur level in the test record.

- e. Observe any spurs above -78 dBm in the rest of the span, and note them in the test record.
- 6. Check in the range of 2 GHz to 3 GHz (MDO3SA installed):
  - a. Set Stop Frequency to the 3 GHz.
  - b. Set Start Frequency to 2 GHz.
  - c. Set RBW to 100 kHz.
  - d. Check the spur level at 2.5 GHz, if present. Push the Markers front-panel button and then push the Manual Markers side-bezel button to turn on manual markers. Turn the Multipurpose a knob to line up Marker a on the 2.5 GHz spur, if it is present. Adjust the marker until the horizontal dash on the marker sits on top of the spur. Note the spur level in the test record.
  - e. Observe any spurs above -78 dBm in the rest of the span, and note them in the test record.

#### **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 18 on page 33.)

- RF Signal Generator
- Power meter
- Power sensor
- 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 Default Setup button on the front panel.
  - b. 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 9 kHz, +10 dBm signal.
  - d. At 9 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 result at this frequency (9 kHz).
- f. Set the generator to provide a 50 kHz, +10 dBm signal.
- g. 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.

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- Calculate the difference between the two readings. This is the test result.
- **h.** In the test record, enter the result at this frequency (50 kHz).
- i. 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.
- j. In the test record, enter the greatest result determined within this frequency range (100 kHz 900 kHz).
- **k.** 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.
- m. 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.
- n. In the test record, enter the greatest result determined within this frequency range (1 MHz to 9 MHz).
- o. Change the frequency range as follows:
  - Change the stop frequency to 92 MHz.
  - Change the start frequency to 9.8 MHz.
- p. Set the generator to provide a 10 MHz, +10 dBm signal.
- q. 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.
- r. In the test record, enter the greatest result determined within this frequency range (10 MHz to 90 MHz).

#### For all models without the MSO3MDO 3 GHz option (steps p through u)

- p. Change the frequency range as follows:
  - Change the stop frequency to the maximum bandwidth.
  - Change the start frequency to 99 MHz.
- s. Set the generator to provide a 100 MHz, +10 dBm signal.
- t. Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to the maximum bandwidth. 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.
- u. In the test record, enter the greatest result determined within this frequency range (100 MHz to 3 GHz).

For models with the MSO3MDO 3 GHz option (steps v through y).

- v. Change the frequency range as follows:
  - Change the stop frequency to 3 GHz.
  - Change the start frequency to 99 MHz.
- w. Set the generator to provide a 100 MHz, +10 dBm signal.
- **x.** Step the generator, in 100 MHz intervals, through frequencies from 100 MHz to 3 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.
- y. In the test record, enter the greatest result determined within this frequency range (100 MHz to 3 GHz).
- 4. Repeat the previous step with these changes:
  - a. Set the reference level to 0 dBm.
  - b. Set the generator level to 0 dBm.
- 5. Repeat the previous step with these changes:
  - **a.** Set the reference level to -15 dBm.
  - b. Set the generator level to -15 dBm.
#### Functional Check of the MDO3000 with a TPA-N-PRE Attached to its RF Input

The following instructions apply to situations where the MDO3000 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/MDO3000 system.

For this check, you will need the following equipment, which is described in the Required Equipment table. (See Table 18 on page 33.)

- RF Signal Generator
- Power meter
- Power sensor
- 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. Push the front-panel RF button to turn on the RF channel.
  - c. Push the Menu button on the TPA-N-PRE preamplifier. On the MDO3000, verify that the side-menu Mode button is set to Auto.

- 3. Check at 1.7 GHz
  - 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 **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, –20 dBm signal.
  - **d.** Note the reading on the power meter and the readout for the Reference marker on the oscilloscope. See the following figure:

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- e. The absolute difference between the two readings should be small (~ 1.5 dB or less). If the MDO3000 reading is too low, tighten the preamp more firmly to the MDO3000 by hand and check the reading again.
- f. Check at the -30 dBm reference level.
  - = Set the generator to provide a 1.7 GHz, -35 dBm signal.
  - Set the MDO3000's reference level to -30 dBm.
  - Compare the MDO3000 and the power meter readings as before. The absolute difference between the readings should be ~1.5 dB or less. If the MDO3000 reading is too low, tighten the preamp more firmly to the MDO3000 by hand and check the reading again.
- 4. Check at 2.9 GHz
  - 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:
    - Set the center frequency to 2.9 GHz.
    - Set the span to 50 MHz.
  - c. Set the generator to provide a 2.9 GHz, -20 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 (~ 1.5 dB or less). If the MDO3000 reading is too low, tighten the preamp more firmly to the MDO3000 by hand and check the reading again.
  - f. Check at the -30 dBm reference level.
    - = Set the generator to provide a 2.9 GHz, -35 dBm signal.
    - Set the MDO3000's reference level to -30 dBm.
    - Compare the MDO3000 and the power meter readings as before. The absolute difference between the readings should be ~1.5 dB or less. If the MDO3000 reading is too low, tighten the preamp more firmly to the MDO3000 by hand and check the reading again.

# Check Displayed Average Noise Level (DANL) with a TPA-N-PRE Attached:

This test does not require an input signal.

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

It checks these ranges:

- 9 kHz to 50 kHz (all models)
- 50 kHz to 5 MHz (all models)
- 5 MHz to BW (MDO3SA not installed)
- 5 MHz to 2 GHz (MDO3SA installed)
- 2 GHz to 3 GHz (MDO3SA installed)

**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.

- 1. Initial oscilloscope setup:
  - a. Terminate the TPA-N-PRE preamp input in 50  $\Omega$  and make sure that no input signal is applied.
  - b. Push the front-panel Default Setup button.
  - 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 average trace to On.
    - = Set the side-bezel Normal to Off.
  - d. 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**.
  - e. Push the Menu button on the TPA-N-PRE preamplifier. On the MDO3000, verify that the side-bezel Mode button is set to Auto.
  - f. Set the reference level to -30.0 dBm as follows:
    - = Push the front-panel Ampl button.
    - = Push the side-bezel **Ref Level** button.
    - Set the Ref Level to -30.0 dBm.
- 2. Check from 9 kHz to 50 kHz (all models):
  - a. Set the stop and start frequencies as follows:

- = Push the front-panel **Freq/Span** button.
- Push the side-bezel Stop button.
- Set the stop frequency to 50 kHz.
- Push the side-bezel Start button.
- Set the start frequency to 9 kHz.
- Wait 60 seconds. Due to the low RBW for this span, it takes a little while for the instrument to compute a valid average.
- b. 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. See the following figure.



- c. Record the highest noise value (in dBm/Hz) in the test record and compare it to the instrument specification.
- 3. Check from 50 kHz to 5 MHz (all models):
  - a. Set the start and stop frequency as follows:
    - Push the front-panel Freq/Span button.
    - = Push the side-bezel **Stop** button.
    - Set the stop frequency to 5 MHz.
    - Push the side-bezel Start button.
    - Set the start frequency to 50 kHz.
  - b. 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. See the following figure.



- c. Record the noise threshold value (in dBm/Hz) in the test record and compare it to the instrument specification.
- 4. Check from 5 MHz to BW (MDO3SA not installed)
  - a. Set the stop frequency to the maximum BW.
  - 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.
    - 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 5 MHz to 2 GHz (MDO3SA installed)
  - a. Set the stop frequency to 2 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.
    - 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.
- 6. Check from 2 GHz to 3 GHz (MDO3SA installed):
  - a. Set the stop frequency to 3 GHz.
  - b. Set the start frequency to 2 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 Auxiliary Output**

This test checks the Auxiliary Output.

1. Connect the Aux Out signal from the rear of the instrument to the channel 1 input using a 50  $\Omega$  cable.



- 2. Push the Default Setup button on the front panel to set the instrument to the factory default settings.
- 3. Push the channel 1 button.
- 4. Set the oscilloscope termination to 1 M $\Omega$ . The default Termination setting is 1M  $\Omega$ .
- 5. Set the horizontal to 4 uS/div and the vertical to 1 V/div.
- 6. On the front panel, push the Measure button on the Wave Inspector.
- 7. Push Add Measurement on the lower menu.
- Use Multipurpose Knob "b" to select Low in the Measurements menu, and then push OK Add Measurement on the side menu.
- 9. Use Multipurpose Knob "b" to select High in the Measurements menu, and then push OK Add Measurement on the side menu.
- 10. Push Menu Off on the front panel.
- **11.** Record the high and low measurements in the test record (for example, low = 200 mV and high = 3.52 V). (See page 65, *Auxiliary (Trigger) Output Tests.*)
- 12. Repeat the procedure, using 50  $\Omega$  instead of 1 M $\Omega$  in step 4.

### **Check AFG Sine and Ramp Frequency**

This test checks the AFG Sine and Ramp Frequency.

1. Connect AFG output to the frequency counter.



- 2. Push the Default Setup button on the oscilloscope front panel.
- 3. Push the AFG button on the front panel.
- 4. Under Waveform Settings, set amplitude and frequency to those shown in the test record.
- 5. Set Waveform to Sine wave (or Ramp).
- 6. Push Output Settings on the bottom menu. Push Load Impedance on the side menu to select 50  $\Omega$ .
- 7. Measure frequency in the frequency counter. Compare results to the limits in the test record.
- 8. Repeat steps 3 7 above for all rows in the test record.

# **Check AFG Square and Pulse Frequency Accuracy**

This test checks the AFG Square and Pulse Frequency Accuracy.



- 1. Connect the AFG output to the frequency counter.
- 2. Push the Default Setup button on the oscilloscope front panel.
- 3. Push the AFG button on the front panel.
- 4. Under Waveform Settings, set Amplitude and frequency to that shown in the test record.
- 5. Set output to Square wave (or Pulse).
- 6. Push Output Settings on the bottom menu. Push Load Impedance on the side menu to select 50  $\Omega$ .
- 7. Measure frequency in the frequency counter. Compare results to the limits in the test record.
- 8. Repeat steps 3 7 for all rows in the test record.

#### **Check AFG Signal Amplitude Accuracy**

This test checks the AFG Signal Amplitude Accuracy.

1. Connect the AFG output to the DMM through a 50  $\Omega$  termination.



- 2. Push the Default Setup button on the oscilloscope front panel.
- 3. Push the AFG button on the front panel.
- 4. Under Waveform Settings, set amplitude and frequency to the value shown in the test record.
- 5. Under Waveform set the signal to Square.
- 6. Push Output Settings on the bottom menu. Push Load Impedance on the side menu to select 50  $\Omega$ .
- 7. Set the DMM to measure ACRMS Voltage.
- 8. Measure voltage on the DMM. Compare the result to the limits in the test record.
- 9. Repeat steps 3 8 above for all rows in the test record.

## Check AFG DC Offset Accuracy

This test checks the AFG DC Offset Accuracy.

1. Connect the AFG output to the DMM through a 50  $\Omega$  termination.



- 2. Push the **Default Setup** button on the oscilloscope front panel.
- 3. Push the AFG button on the front panel.
- 4. Under Waveform set the signal to DC.
- 5. Under Waveform Settings, set Amplitude to the value shown in the test record.
- 6. Push Output Settings on the bottom menu. Push Load Impedance on the side menu to select 50  $\Omega$ .
- 7. Measure voltage on the DMM. Compare the value to the limits in the test record.
- 8. Repeat steps 3 7 above for each line in the test record.

## **Check DVM Voltage Accuracy (DC)**

This test checks the DVM voltage accuracy (DC).

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



- 2. Push the Default Setup button on the front panel to set the instrument to the factory default settings.
- 3. Push channel button 1, 2, 3, or 4 to select the channel you want to check.
- 4. Confirm that the oscilloscope termination and calibrator impedance are both set to 1 M $\Omega$ . Push **Termination** on the lower menu to select 1 M $\Omega$ .
- 5. Set the calibrator to the input voltage shown in the test record (for example, -5 V for a 1 V/div setting). Set the calibrator impedance to match the termination setting for the oscilloscope.
- 6. On the oscilloscope, push More on the lower menu repeatedly, to select Offset.
- 7. Set the oscilloscope to the vertical offset value shown in the test record (for example, -5 V for -5 V input and 1 V/div setting).
- 8. Turn the vertical Scale knob to match the value in the test record (for example, 1 V/division).
- 9. Turn the Horizontal Scale knob to 1 ms/div.
- 10. Push Bandwidth on the lower menu.
- 11. Push 20 MHz on the side menu.
- **12.** Check that the vertical position is set to 0 divs. If not, turn the appropriate **Vertical Position** knob to set the position to 0 divs.

Or, push More on the lower menu repeatedly to select Position, and then push Set to 0 divs on the side menu.

- 13. Push Acquire on the front panel.
- 14. Push Mode on the lower menu, and then push Average on the side menu. Use the default number of averages (16).
- **15.** Push the Trigger **Menu** button on the front panel.
- 16. Push Source on the lower menu.
- 17. Turn Multipurpose knob "a" to select AC Line as the trigger source.
- **18.** On the front panel, push the **Measure** button.
- 19. Push the DVM lower-bezel button to turn on the DVM function.
- 20. Turn the Multipurpose a knob to select DC mode

- 21. Turn the Multipurpose b knob to select the input channel to be tested.
- 22. Push Menu Off on the front panel. The measured value should appear in a measurement pane at the top of the display.
- 23. Enter the measured value in the test record. (See page 67, DVM Voltage Accuracy Tests (DC).)
- 24. Repeat the procedure (steps 6, 7, 8 and 22) for each volts/division setting shown in the test record.
- 25. Repeat all steps, starting with step 1, for each oscilloscope channel you want to check.

# Check DVM Voltage Accuracy (AC)

This test checks the DVM voltage accuracy (AC).

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



- 2. Push Default Setup on the front panel to set the instrument to the factory default settings.
- 3. Push channel button 1, 2, 3, or 4 for the channel that you want to check.
- 4. Set the generator to 50  $\Omega$  output impedance (50  $\Omega$  source impedance).
- 5. Set the oscilloscope termination to 50  $\Omega$ . Push Termination on the lower menu to select 50  $\Omega$ .
- 6. Set the generator to produce a square wave of the amplitude and frequency listed in the test record (for example,  $20 \text{ mV}_{pp}$  and 1 kHz).
- 7. Turn the vertical scale knob so that the signal covers between 4 and 8 vertical divisions on screen.
- 8. Push the Measure button, then the DVM lower-bezel button to turn on the DVM function.
- 9. Use the multipurpose knob a to select AC RMS mode
- 10. Use the multipurpose knob b to select the input channel being tested.
- 11. Enter the measured value in the test record.
- 12. Repeat procedure for each voltage and frequency combination shown in the record.
- **13.** Repeat all steps for each oscilloscope channel.

#### **Check DVM Frequency Accuracy and Maximum Input Frequency**

This test checks DVM Frequency Accuracy.

- 1. Push Default Setup on the oscilloscope front panel to set the instrument to the factory default settings.
- 2. Connect the output of the time mark generator to the oscilloscope channel 1 input using a 50  $\Omega$  cable. Use the time mark generator with a 50  $\Omega$  source with the oscilloscope set for internal 50  $\Omega$  termination.



- 3. Set the time mark generator to the value shown in the test record. For example, use 9 Hz. Use a time mark waveform with a fast rising edge (square wave), except at 150 MHz use a sine wave.
- 4. Set the mark amplitude to 1  $V_{pp}$ .
- 5. Set the oscilloscope vertical Scale to 200 mV/div.
- 6. Set the Horizontal Scale to 20 ms/div.
- 7. Adjust the Trigger Level for a triggered display.
- 8. Adjust the vertical **Position** knob to center the time mark on center screen.
- 9. Push the Measure button on the front panel, and then the DVM lower-bezel button to turn on the DVM feature.
- 10. Turn multipurpose knob a to select Frequency mode.
- **11.** Turn multipurpose knob **b** to select the input channel being tested.
- 12. Enter the measured value in the test record.
- **13.** Repeat this procedure for each frequency setting shown in the record. (Keep the same vertical and horizontal scales as set in steps 5 and 6.)
- 14. Repeat all these steps for each oscilloscope channel.

This completes the procedure.

#### This completes the Performance Verification procedures