

# Keysight Technologies

M8195A 65 GSa/s Arbitrary Waveform Generator

and

M8197A Multi-Channel Synchronization Module

Data Sheet  
Version 3.0



## M8195A at a Glance

Go where you have never been able to test before: with real-time mode, sequencing and deep memory – explore your possibilities.

- Sample rate up to 65 GSa/s (on up to 4 channels)
- Analog bandwidth: 25 GHz
- 8 bits vertical resolution
- Up to 16 GSa of waveform memory per AXIe module
- 1, 2 or 4 differential channels per 1-slot high AXIe module (number of channels is software upgradeable)
- Multi-module synchronization
  - Up to 16 channels per 5-slot AXIe chassis<sup>1</sup>
- Advanced 3-level sequencing with external dynamic control<sup>1</sup>
- Load new waveforms on-the-fly without interrupting the playback of the previous one<sup>1</sup> (“memory ping-pong”)
- Amplitude up to  $1 V_{pp(se)}$ ,  $2 V_{pp(diff)}$ , voltage window -1.0 ... +3.3V
- $t_{rise/fall}$  20%/80% 18 ps (typ). With pre-distortion applied 12 ps (typ)
- Ultra low intrinsic jitter ( $RJ_{rms} < 200$  fs)
- Built-in frequency and phase response calibration for clean output signals
- Up to 64-tap FIR filter in hardware for frequency response compensation
- Up to 2 markers with 1 sample resolution (markers don't reduce vertical resolution)
- Embedded DSP enables real-time waveform and impairment generation

Speed your test by up to 100 times with unique real-time mode.

## Key Applications

As devices and interfaces become faster and more complex, the M8195A AWG gives you the versatility to create the signals you need for digital applications, optical and electrical communication, advanced research, wideband radar and satcom.

- *Coherent optical* – a single M8195A module can generate two independent I/Q baseband signals (dual polarization = 4 channels) at up to 32 GBaud (and beyond).
- *Multi-level / Multi-channel digital signals* – generate NRZ, PAM4, PAM8, DMT, etc. signals of up to 32 GBaud. Embed/de-embed channels, add jitter, ISI, noise and other distortions.
- *Physics, chemistry and electronics research* – generate any mathematically defined arbitrary waveforms, ultra-short yet precise pulses and extremely wideband chirps.
- *Wideband RF/ $\mu$ W* – generate extreme wideband RF signals with an instantaneous bandwidth of DC to 25 GHz for aerospace/defense/communication applications

## Coherent optical applications

The M8195A supports leading edge research for 100 Gb/s, 400 Gb/s and 1 Tb/s optical transmission systems that require a very wideband electrical stimulus with a variety of complex modulation formats from QPSK to  $n$ QAM to OFDM at symbol rates up to 32 GBaud and beyond.

In order to drive dual-polarization systems, the M8195A has 4 independent, yet precisely synchronized analog output channels in a single module. Since all 4 channels are generated by the same instrument without any external circuitry, precise synchronization down to the femto-second-range can be achieved and maintained.

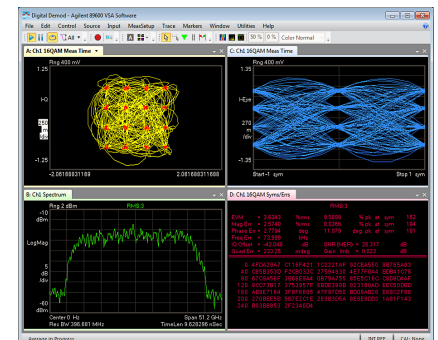


Figure 1. 16QAM @ 32 GBaud.

1. Available with M8195A plus M8197A.



## Physics, chemistry and electronics research

You can generate any arbitrary waveform that you can mathematically describe (e.g. in MATLAB) and download it directly to the M8195A. This includes ultra-short yet precise pulses down to ~100 ps pulse width or extremely short, yet wideband RF pulses and chirps.

In conjunction with the M8197A synchronization module, these signals can be triggered from external sources with very low jitter.

## Wideband RF/ $\mu$ W signals

The M8195A can address wideband wireless, EW and comms/satcom applications where extremely wide instantaneous bandwidth (DC to 25 GHz) and fast frequency hopping are critical parameters.

With built-in frequency and phase calibration, it is straight forward to generate wideband multi-tone signals with a flat frequency response up to 25 GHz.

Wideband wireless signals with any modulation scheme (e.g. nPSK, nQAM, APSK, OFDM, etc.) can be generated directly at carrier frequencies of up to 25 GHz. In many cases, this saves an additional up-conversion stage (e.g. in case of IEEE 802.11ad) or enables waveform generation directly at the carrier frequency.

Note that the available frequency range depends on the number of channels that are used simultaneously as well as the amount of memory per channel (see sample memory modes in this document).



Figure 5. 100 ps pulse with 17 ps risetime.

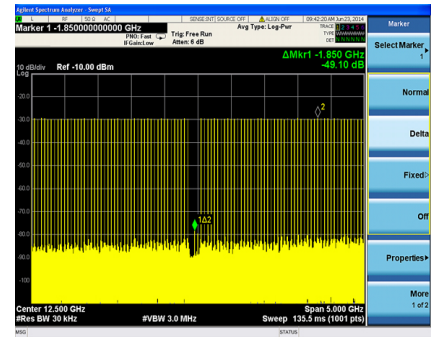


Figure 6. Multi-tone signal from 10 GHz to 15 GHz.

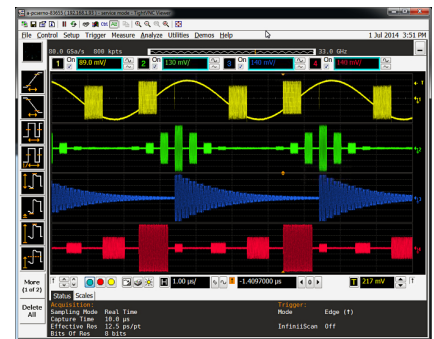


Figure 7. Four different pulsed signals up to 25 GHz.

## M8197A

The M8197A is a synchronization module for up to four M8195A modules. Using the M8197A, a fully synchronous system with up to 16 channels per AXIe 5-slot chassis can be realized. The M8197A also provides a dynamic control input/general purpose output that can be used with one or more M8195A modules. Trigger-to-output delay accuracy is improved when using the M8197A trigger input (see timing characteristics paragraph).

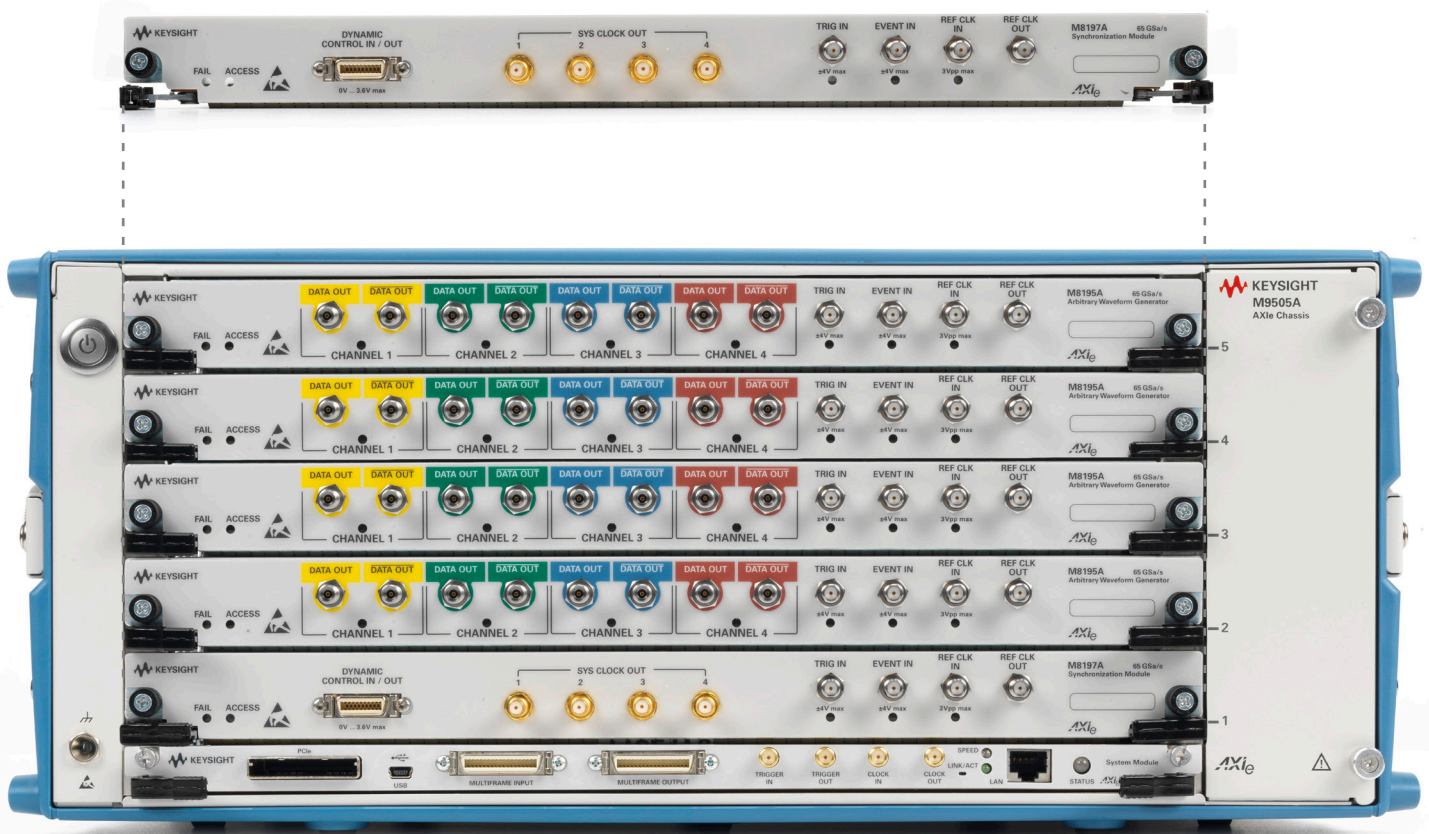


Figure 8. M8197A, front panel view and system with 16 synchronized channels (4x M8195A modules and 1x M8197A module)

## Software

The basic functionality of the M8195A is controlled from a soft front panel application running on the AXIe embedded controller or external PC or laptop. In addition to basic settings such as sample clock rate, output amplitudes, etc., the soft front panel offers functionality to:

- Load waveforms from files
- Generate standard waveforms (sine, square, etc.)
- Generate multi-tone waveforms
- Generate complex modulated waveforms (nPSK, nQAM, etc.)
- Generate binary and multi-level digital waveforms
- Generate serial data waveforms
- Control FIR filters

In addition to the soft front panel, the M8195A can be controlled via *SCPI* and *IVI-COM* remote programming interfaces.

External software applications that can be used to generate and download waveforms directly to the M8195A via SCPI or IVI-COM include MATLAB, LabView, C++, C# or any other .NET language.

The M8195A is integrated into the following Keysight software applications:

- M8070A - system software for M8000 Series of BER test solutions
- M8085A - MIPI® receiver test solutions
- 81195A - optical modulation generator software
- M9099A - waveform creator application software
- W146xA - SystemVue electronic system-level design software

For additional information see the respective data sheets.

## Configuration

The following products/options are available.

Product number	Description	Comment
M8195A-001	1 channel, 65 GSa/s, 2 GSa per module	Including local start-up assistance and one 50 $\Omega$ termination for each channel
M8195A-002	2 channel, 65 GSa/s, 2 GSa per module	
M8195A-004	4 channel, 65 GSa/s, 2 GSa per module	
M8195A-16G	Upgrade to 16 GSa per module	Software license
M8195A-SEQ	Sequencer functionality per module	Software license
M8195A-FSW	Fast switching per module	Software license
M8195A-1A7	ISO 17025 report	
M8195A-Z54	Z54 calibration report	
M8195A-BU1	Pre-configured system consisting of one M9505A 5-slot AXIe Chassis with USB Option and one M9536A AXIe Embedded PC Controller	
M8195A-BU2	Pre-configured system consisting of one M9502A 2-slot AXIe Chassis with USB Option	
M8195A-BU3	Pre-configured system consisting of one M9502A 2-slot AXIe Chassis with USB Option and one M9536A AXIe Embedded PC Controller	
M8197A	Synchronization module for up to four M8195A modules	Including four synchronization cables
M8195S	Pre-configured Arbitrary Waveform Generator System including one M8197A	In addition to the required modules, a local start-up assistance, one 50 $\Omega$ termination for each channel and an AXIe chassis with an embedded controller or external PC connectivity will automatically be added.

## Upgrade options for M8195A

Product number	Description	Comment
M8195AU-U02	Upgrade from 1 ch. to 2 ch.	Software license
M8195AU-U04	Upgrade from 2 ch. to 4 ch. <sup>1</sup>	Software license
M8195AU-16G	Upgrade to 16 Gsa per module	Software license
M8195AU-SEQ	Sequencer functionality per module	Software license
M8195AU-FSW	Fast switching per module	Software license

1. For an upgrade from 1 to 4 channels, both M8195AU-U02 and M8195AU-U04 are required.

## Accessories

In order to be operational, an AXI chassis plus either an embedded controller or external PC or laptop are required in addition to one or more M8195A/M8197A modules. (See <http://www.keysight.com/find/AXIe> for more details.)

Product number	Description	Comment
M9502A-U20	2 slot AXIe chassis with USB option	
M9505A-U20	5 slot AXIe chassis with USB option	
M9536A	AXIe embedded controller	
8121-1243	Cable-Assembly USB Type A-MINI B 28-AWG 5-Conductor 2-M-LG PVC	
M9048A	PCIe® desktop card adapter Gen 2 x 8	
Y1202A	PCIe cable for M9048A desktop adapter	
M8195A-810	Matched cable pair for M8195A AWG, 2.92 mm	
M8195A-820	Termination 50 Ω, 26.5GHz	

## Software

Product number	Description	Comment
81195A	Optical Modulation Generator Software	Free to download
81195A-RSP	Real-Time Signal Processing	requires 81195A
81195A-OSP	Optical Signal Properties	
M8070A-OTP	System Software for M8000 Series of BER Test Solutions, Transportable, Perpetual License	
M8070A-ONP	System Software for M8000 Series of BER Test Solutions, Network/Floating, Perpetual License	
M8070A-1TP	DUT Control Interface, Transportable, Perpetual License	
M8085A-CT1	MIPI C-PHY <sup>sm</sup> Editor for M819xA AWG, transportable, perpetual License	
M8085A-CN1	MIPI C-PHY Editor for M819xA AWG, network/floating, perpetual License	
M8085A-CTA	MIPI C-PHY Calibration, Conformance and Characterization Procedures for M819xA AWG, Transportable, Perpetual License	
M8085A-CNA	MIPI C-PHY Calibration, Conformance and Characterization Procedures for M819xA AWG, Network/Floating, Perpetual License	requires M8070A license
M8085A-DT1	MIPI D-PHY <sup>sm</sup> Editor for M819xA AWG, transportable, perpetual License	
M8085A-DN1	MIPI D-PHY Editor for M819xA AWG, network/floating, perpetual License	
M8085A-DTA	MIPI D-PHY Calibration, Conformance and Characterization Procedures for M819xA AWG, transportable, perpetual License	
M8085A-DNA	MIPI D-PHY Calibration, Conformance and Characterization Procedures for M819xA AWG, Network/Floating, Perpetual License	
N6171A-M02	MATLAB license (standard)	
N6171A-M03	MATLAB license (extended)	



## Specifications

### General characteristics

M8195A	
Sample rate	53.76 GSa/s to 65.00 GSa/s or 26.88 GSa/s to 32.50 GSa/s (sample rate divider = 2) or 13.44 GSa/s to 16.25 GSa/s (sample rate divider = 4)
DAC resolution	8 bits
Number of channels per M8195A module	1, 2 or 4 (corresponds to Opt. 001, 002, 004) Number of channels is software upgradable via license key

### Sample memory

M8195A	
Internal sample memory	1 MSa per module (for modes of operation see Sample memory modes table below)
Extended sample memory	2 GSa per M8195A module (standard)16 GSa per M8195A module (with Option 16G) (for modes of operation see Sample memory modes table below)
Waveform granularity <sup>1</sup>	
Int. memory	128 samples
Ext. memory, sample rate divider = 1	256 samples
Ext. memory, sample rate divider = 2	128 samples
Ext. memory, sample rate divider = 4	64 samples
Minimum waveform length	
Int. memory	128 samples
Ext. memory, sample rate divider = 1	1280 samples
Ext. memory, sample rate divider = 2	640 samples
Ext. memory, sample rate divider = 4	320 samples

### Useable number of Channels with extended memory

Option	Mode	Sample rate divider				
		1	2	4		
		53.76 GSa/s to 65.00 GSa/s max. 16G memory	26.88 GSa/s to 32.50 GSa/s max. 8G memory	13.44 GSa/s to 16.25 GSa/s max. 4G memory		
001	002	004	single channel <sup>2</sup>	1	1	1
			single channel with marker	1	1	1
			dual channel <sup>2</sup>	1	2	2
			dual channel with marker <sup>2</sup>	1	2	2
			dual channel duplicate	N/A	2	2
			four channel <sup>2</sup>	1	2	4

1. The length of waveform segments must be a multiple of the granularity.
2. Unused channels can be used at full sample rate with internal memory.

## Sample memory modes

Mode	Available with option	Sample memory (standard)	Sample memory (with Opt. 16G)	Max. sample rate	Interpolation <sup>1</sup>	Max. output frequency <sup>2</sup>	Analog BW (typ) (3 dB)
1 ch, ext.mem.	001, 002, 004	2 GSa	16 GSa	65 GSa/s	None	> 25 GHz	25 GHz
1 ch, int. mem.	001, 002, 004	1 MSa	1 MSa	65 GSa/s	None	> 25 GHz	25 GHz
2 ch, ext.mem.	002, 004	1 GSa per ch.	8 GSa per ch.	32.5 GSa/s	2 x	12.8 GHz	25 GHz
2 ch, int.mem.	002, 004	512 KSa per ch.	512 KSa per ch.	65 GSa/s	None	> 25 GHz	25 GHz
4 ch, ext.mem.	004	0.5 GSa per ch.	4 GSa per ch.	16.25 GSa/s	4 x	6.4 GHz	25 GHz
4 ch, int.mem.	004	256 KSa per ch.	256 KSa per ch.	65 GSa/s	None	> 25 GHz	25 GHz

## Frequency switching characteristics

M8195A	
Effective frequency switching time <sup>3</sup>	
with Option FSW	38 ps
without Option FSW	> 505 $\mu$ s

## Out 1, 2, 3, 4

M8195A	
Output type	Single ended <sup>4</sup> or differential
Bandwidth (3 dB, excl. sin(x)/x roll-off)	25 GHz (typ)
Rise/fall time <sup>5</sup> (20% / 80%)	18 ps (typ)
Impedance	50 $\Omega$ (nom)
Amplitude	75 mV <sub>pp</sub> to 1.0 V <sub>pp</sub> , single-ended into 50 $\Omega$ 150 mV <sub>pp</sub> to 2.0 V <sub>pp</sub> , differential
Amplitude resolution	200 $\mu$ V (nom)
DC amplitude accuracy <sup>6</sup>	$\pm$ (2.5% +10 mV) (typ)
Voltage window	-1.0 V to +3.7 V single-ended into 50 $\Omega$
Offset resolution	200 $\mu$ V (nom)
DC offset accuracy <sup>7</sup>	$\pm$ 20 mV (typ)
Differential offset	In system adjustable to 0 mV
Termination voltage window	-1.0 V to +3.7 V $V_{OL} \leq 1.5$ V: (low level - 500 mV) to (high level +1000 mV) $V_{OL} > 1.5$ V: low level to (high level +1000 mV)
Total jitter, with pre-distortion	6 ps (pp) at 32 Gb/s PRBS (nom)
Random jitter, RMS <sup>8</sup>	200 fs (typ)

- Interpolation is performed by FIR filters in hardware. For 2x (4x) interpolation, samples are read from memory at a rate up to 32.5 GSa/s (16.25 GSa/s) and interpolated to a DAC sample rate of up to 65 GSa/s. For interpolation = none, the sample rate from memory is the same as the DAC sample rate.
- With default FIR configuration the maximum sample rate is calculated as 80% of Nyquist. With custom FIR configurations higher output frequencies can be achieved.
- Effective switching frequency is determined as  $1/f_{max}$ , with  $f_{max} = f_{sa}(max) / 2.5$
- Unused output must be terminated with 50  $\Omega$  to GND. In case the termination voltage is not GND, the unused output must be terminated to  $V_{Term}$ .
- Sample rate 64 GSa/s, output amplitude 500 mV<sub>pp(se)</sub>.
- Termination voltage = 0 V; adjusted at 23 °C ambient temperature, amplitude increases by 0.2%/°C (typ) for ambient temperature below 23 °C.
- Termination voltage = 0 V.
- 10 GHz clock; 1 V ampl.; 60 GSa/s.

## Out 1, 2, 3, 4 (continue)

<b>M8195A</b>	
Harmonic distortions <sup>1,2</sup>	
2nd harmonic	-45 dBc (typ), $f_{out} < 3$ GHz -35 dBc (typ), $f_{out} = 3$ GHz... 6 GHz -30 dBc (typ), $f_{out} > 6$ GHz
3rd harmonic	-45 dBc (typ), $f_{out} < 1$ GHz -40 dBc (typ), $f_{out} = 1$ GHz... 3 GHz -35 dBc (typ), $f_{out} = 3$ GHz... 6 GHz -30 dBc (typ), $f_{out} > 6$ GHz
Two-tone IMD <sup>1</sup>	-45 dBc (typ), $f_{out1} = 990$ MHz, $f_{out2} = 1010$ MHz
SFDR <sup>1</sup> (excluding harmonic distortions)	
In-band	-80 dBc (typ), $f_{out} = 100$ MHz, measured DC to 1 GHz -70 dBc (typ), $f_{out} = DC...400$ MHz, measured DC to 400 MHz -48 dBc (typ), $f_{out} = DC...4$ GHz, measured DC to 4 GHz -53 dBc (typ), $f_{out} = 4$ GHz...6 GHz, measured 4 GHz to 6 GHz -53 dBc (typ), $f_{out} = 6$ GHz...8 GHz, measured 6 GHz to 8 GHz -50 dBc (typ), $f_{out} = 8$ GHz...10 GHz, measured 8 GHz to 10 GHz -46 dBc (typ), $f_{out} = 10$ GHz...12 GHz, measured 10 GHz to 12 GHz -50 dBc (typ), $f_{out} = 12$ GHz...14 GHz, measured 12 GHz to 14 GHz -42 dBc (typ), $f_{out} = 14$ GHz...16 GHz, measured 14 GHz to 16 GHz -42 dBc (typ), $f_{out} = 16$ GHz...18 GHz, measured 16 GHz to 18 GHz -42 dBc (typ), $f_{out} = 18$ GHz...20 GHz, measured 18 GHz to 20 GHz -48 dBc (typ), $f_{out} = 20$ GHz...21 GHz, measured 20 GHz to 21 GHz -42 dBc (typ), $f_{out} = 21$ GHz...22 GHz, measured 21 GHz to 22 GHz -40 dBc (typ), $f_{out} = 22$ GHz...24 GHz, measured 22 GHz to 24 GHz -40 dBc (typ), $f_{out} = 24$ GHz...26 GHz, measured 24 GHz to 26 GHz
Adjacent band	-48 dBc (typ), $f_{out} = DC...4$ GHz, measured DC to 8 GHz -48 dBc (typ), $f_{out} = 4$ GHz...6 GHz, measured 3 GHz to 8 GHz -34 dBc (typ), $f_{out} = 6$ GHz...8 GHz, measured 4 GHz to 10 GHz -34 dBc (typ), $f_{out} = 8$ GHz...10 GHz, measured 6 GHz to 12 GHz -46 dBc (typ), $f_{out} = 10$ GHz...12 GHz, measured 8 GHz to 14 GHz -42 dBc (typ), $f_{out} = 12$ GHz...14 GHz, measured 10 GHz to 16 GHz -32 dBc (typ), $f_{out} = 14$ GHz...16 GHz, measured 12 GHz to 18 GHz -30 dBc (typ), $f_{out} = 16$ GHz...18 GHz, measured 14 GHz to 20 GHz -40 dBc (typ), $f_{out} = 18$ GHz...20 GHz, measured 16 GHz to 22 GHz -35 dBc (typ), $f_{out} = 20$ GHz...22 GHz, measured 18 GHz to 24 GHz -30 dBc (typ), $f_{out} = 22$ GHz...24 GHz, measured 20 GHz to 26 GHz -28 dBc (typ), $f_{out} = 24$ GHz...25 GHz, measured 22 GHz to 27 GHz -28 dBc (typ), $f_{out} = 25$ GHz...26 GHz, measured 23 GHz to 27 GHz
Amplitude flatness (at SMA connector, <sup>3</sup> compensated for $\sin(x)/x$ )	$\pm 2$ dB (typ), $f_{out} = DC...10$ GHz $+2$ dB, $-3$ dB (typ), $f_{out} = 10...25$ GHz (typ)
Connector type	2.92 mm "K-style" (female)

1. Sample rate 64 GSa/s, output amplitude 500 mV<sub>pp(se)</sub>.
2. Measured with a balun (e.g. HL 9405).
3. Measured at Data Out.

### Phase noise

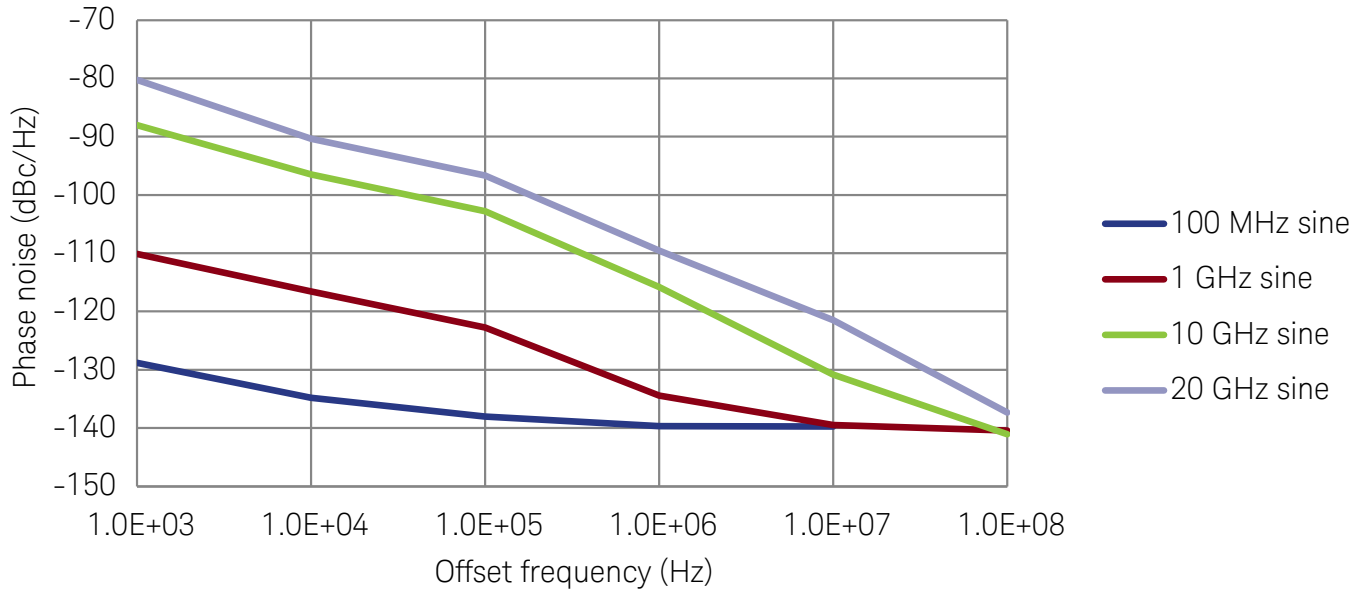


Figure 9. Nominal phase noise measured with a sample rate of 64 GSa/s, at Out 1, single ended, 500 mV amplitude

### Frequency response

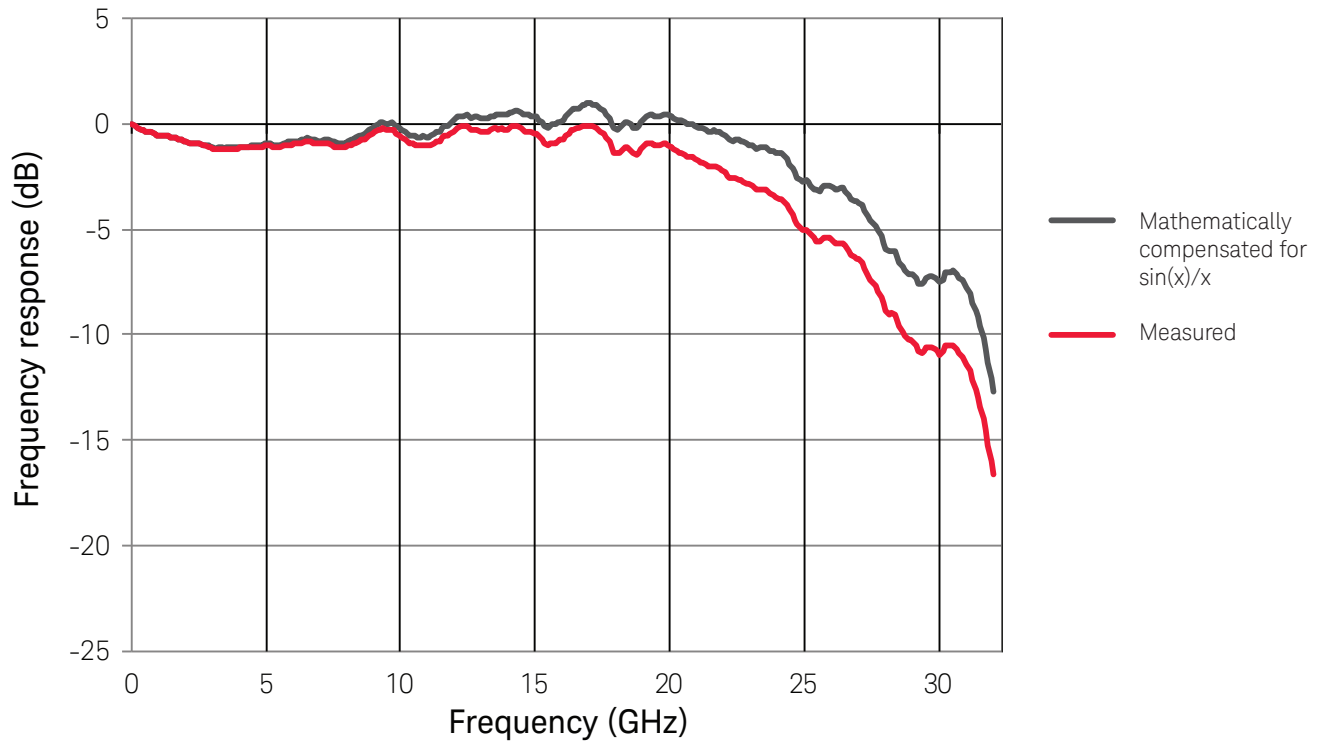


Figure 10. Nominal frequency response measured with a sample rate of 64 GSa/s and a multi-tone signal containing frequencies from DC to 32 GHz with equal amplitudes

## ENOB

ENOB measured at 64 GSa/s using the sine fit method according to IEEE Std 1658-2011 with a sampling scope. Bandwidth is limited to maximum tone frequency, except for the ones labeled with Nyquist.

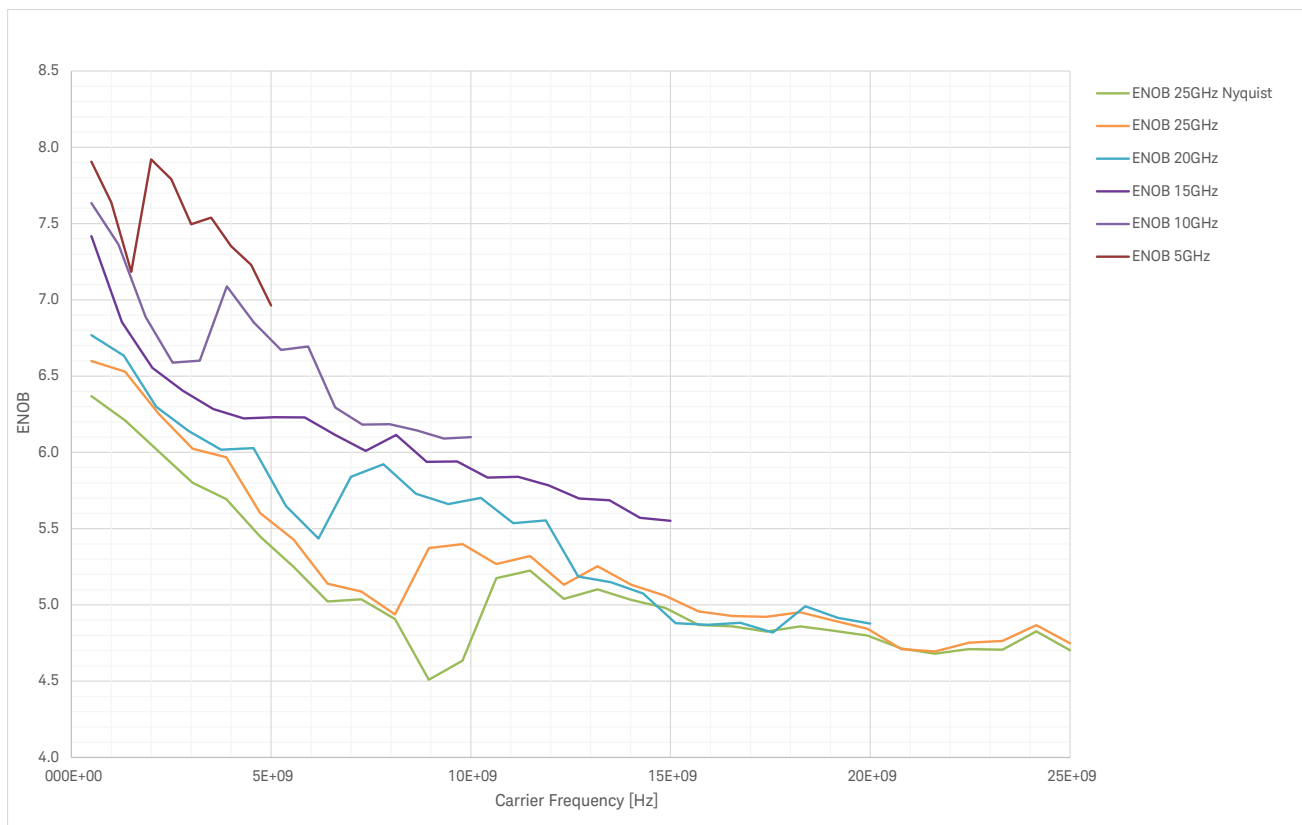


Figure 11. Nominal ENOB measured on a differential signal combined by a 50 GHz Balun Hyperlabs HL9405 with a sample rate of 64 GSa/s, internal clock and 500 mV amplitude at different bandwidths.

## Markers

Two independent digital markers and their complements are available in single channel with markers and dual channel with markers mode. The markers are available only for channels on extended memory. They are provided on channel 3 and 4 on normal and complement.

In all other modes, no markers are available.

Markers do not reduce vertical resolution.

The granularity of markers is one sample, a maximum of one rising and one falling edge of a marker are possible within 128 samples.

## Dual channel duplicate mode

In “Dual channel duplicate mode” the signal on channel 1 is duplicated on channel 2 and the signal on channel 4 is duplicated on channel 3.

This mode allows differential signals to be generated with adjustable skew between normal and complement.

## Run modes

<b>M8195A and M8197A</b>	
Continuous	
Int. Memory	A waveform segment is continuously repeated
Ext. Memory	A waveform segment/sequence/scenario is continuously repeated
Triggered	
Int. Memory	A waveform segment is looped continuously after a trigger event is received
Ext. Memory	A waveform segment/sequence/scenario is generated once after a trigger event is received
Gated	
Int. Memory	A waveform segment is looped continuously after a rising edge of the trigger/gate input
Ext. Memory	A waveform segment/sequence/scenario is generated as long as the trigger/gate input is high

## Sequencer modes

The sample memory can be split into a maximum of 16 M waveform segments. Waveform segments can have different sizes, but the segment size must be the same across channels. The sequence table can contain up to 16 M entries (sequence IDs).

<b>M8195A</b>	
Arbitrary	
Int. Memory	One waveform segment of arbitrary length is continuously looped
Ext. Memory	
Sequence (requires Opt. SEQ)	
Int. Memory	Not available
Ext. Memory	One or more waveform segments are arranged in a linear sequence. Each segment can be repeated a programmable number of times or until an external event is signaled.
Scenario (requires Opt. SEQ)	
Int. Memory	Not available
Ext. Memory	One or more sequences are arranged in a linear sequence. Each sequence can be repeated a programmable number of times or until an external event is signaled

## Trigger/gate input

A trigger/gate input is provided on the front panel of the M8195A and the M8197A. The trigger input is used to start/gate waveform playback.

- The trigger/gate input of the M8195A affects the channels of that M8195A.
- The trigger/gate input of the M8197A affects all channels of all M8195A that are combined in a multi-module system. To achieve best delay accuracy between trigger/gate input and the OUT signals, use the trigger/gate input of the M8197A. See timing characteristics below.

M8195A and M8197A	
Input range	-4 V to +4 V
Threshold	
Range	-4 V to +4 V
Resolution	10 mV (nom)
Sensitivity	100 mV (typ)
Polarity	Selectable, positive or negative
Input impedance	50 $\Omega$ (nom), DC coupled
Max. toggle rate <sup>1</sup>	
Sample rate divider = 1	Sample rate/3584
Sample rate divider = 2	Sample rate/1792
Sample rate divider = 4	Sample rate/896
Connector type	SMA (female)

## Event input

An event input is provided on the front panel of the M8195A and the M8197A. It is used in conjunction with the sequencer to advance to the next waveform segment or sequence.

- The event input of the M8195A affects the channels of that M8195A.
- The event input of the M8197A affects all channels of all M8195A that are combined in a multi-module system.

M8195A and M8197A	
Input range	-4 V to +4 V
Threshold	
Range	-4 V to +4 V
Resolution	10 mV (nom)
Sensitivity	100 mV (typ)
Polarity	Selectable, positive or negative
Input impedance	50 $\Omega$ (nom), DC coupled
Connector type	SMA (female)

1. Without option -FSW the trigger interval is limited as described under the 'Frequency switching characteristics'

## Trigger output (M8195A only)

The “Trigger output” and “Event input” functions share the same connector on the front panel.

The “Trigger output” functionality is only used in conjunction with the 81195A Optical Modulation Generator Software.

For details of using the “Trigger output” functionality, refer to the 81195A data sheet and user guide.

M8195A	
Output impedance	50 $\Omega$ (nom)
Level	
Voltage window	-0.5 V to 2.0 V
Amplitude	200 mVpp to 2.5 Vpp
Resolution	10 mV
Accuracy	$\pm$ (10% + 25 mV) (typ)
Rise/fall time (20% to 80%)	150 ps (nom)
Width	20ns (1280 sample clock cycles @ 64GS/s)

## Dynamic control input/general purpose output (M8197A only)

A bidirectional parallel input and output port is provided on the front panel of the M8197A synchronization module. When the port is configured as input, it can be used as ‘dynamic control input’ for all channels of a synchronous system to control the sequencing by external hardware. The dynamic control input affects all channels of a synchronous system. When the port is configured as a parallel output, the 14 digital lines can be individually controlled by software to represent logical states zero or one.

A detailed description of the dynamic control input, including timing diagram and pin assignment, is shown in the *M8195A User’s Guide*.

M8197A	
Configuration as input	
Input signals	Data[0..12]_In, Data_Select, Load
Number of addressable segments	$2^{24} = 16\,777\,216$
Data rate	DC to 1 MHz
Setup time	3.0 ns (‘Data[0..12]_In’, ‘Data_Select’ to rising edge of ‘Load’)
Hold time	0.0 ns (rising edge of ‘Load’ to ‘Data[0..12]_In’, ‘Data_Select’)
Input range	
Low level	0 V to +0.7 V
High level	+1.6 V to 3.6 V
Input impedance	Internal 10 k $\Omega$ (nom) to GND
Configuration as output	
Output signals	Data[0..13]_Out
Output range	
Low level (-12 mA to 0 mA)	0 V to +0.4 V
High level (0 mA to 12 mA)	+2.4 V to 3.3 V
Connector type	20 pin mini D ribbon (MDR) connector <sup>1</sup>

1. Manufacturer: 3M. Manufacturer Part Number: N10220-52B2PC.



## Timing characteristics

The sequencing of a single M8195A can be controlled with the 'Trigger/Gate Input' as well as the 'Event Input' of the M8195A. In a synchronous system that consists of one M8197A and up to four M8195A, the sequencing of the entire synchronous system can be controlled with the 'Trigger/Gate Input' as well as the 'Event Input' of the M8197A. A single M8195A or a synchronous system can operate asynchronously or synchronously. In case of synchronous operation, a timing requirement between the Reference Clock Output and 'Trigger/Gate Input' or 'Event Input' must be met.

	<b>M8195A</b>	<b>M8197A</b>
Delay		
Trigger/Gate Input to Data Out	40192 sample clock cycles + 0 ns (nom)	45317 sample clock cycles + 8 ns (nom)
Event Input to Data Out	40192 sample clock cycles + 0.15 ns (nom)	45317 sample clock cycles + 8 ns (nom)
Delay accuracy, asynchronous operation		
Trigger/Gate Input to Data Out	± 100 ps (typ)	± 20 ps (typ)
Event Input to Data Out	± 100 ps (typ)	± 100 ps (typ)
Delay accuracy, synchronous operation		
Trigger/Gate Input to Data Out	± 1 ps (typ)	± 1 ps (typ)
Event Input to Data Out	± 1 ps (typ)	± 1 ps (typ)
Synchronous operation		
Set-up time	-2.5 ns (typ) ('TRIG IN', 'EVENT IN' to rising edge of 'REF CLK OUT')	-1.9 ns (typ) ('TRIG IN', 'EVENT IN' to rising edge of 'REF CLK OUT')
Hold time	5.1 ns (typ) (Rising edge of 'REF CLK OUT' to 'TRIG IN', 'EVENT IN')	4.5 ns (typ) (Rising edge of 'REF CLK OUT' to 'TRIG IN', 'EVENT IN')
Skew between normal and complement	0 ps ± 1 ps (nom)	
Skew between any pair of outputs		
within one M8195A module	0 ps ± 5 ps (typ) <sup>1</sup>	
across multiple M8195A modules	0 ps ± 100 ps (typ) <sup>2</sup>	

1. can be adjusted to 0 ps using variable channel delay

2. can be adjusted to 0 ps using variable module delay and variable channel delay.

## Variable channel delay

In order to compensate for external cable length differences as well as the initial skew, channels 1, 2, 3 and 4 can be individually delayed with a very high timing resolution. There are two possibilities to adjust the variable channel delay:

- The sample clock delay can be changed in discrete steps. The step size is  $1 / \text{DAC Sample Frequency}$ . E.g. the step size is 15.625 ps for a DAC Sample Frequency of 64 GHz.
- The FIR delay can be used for sub sample delay adjust. Note: This delay functionality uses a digitally implemented FIR filter with limited length and accuracy. As a result the output signal may show some degradation when using the FIR delay adjust.

<b>M8195A</b>	
Sample clock delay range	0 ... 95 sample clocks
FIR delay range	
Sample Rate Divider = 1	-50 ps...+50 ps
Sample Rate Divider = 2	-100 ps...+100 ps
Sample Rate Divider = 4	-200 ps...+200 ps
FIR delay resolution	10 fs

## Variable module delay

In order to compensate for external cable length differences as well as the initial skew, channels 1, 2, 3 and 4 can be jointly delayed with a very high timing resolution. In case the M8197A synchronization module is used to configure a synchronous system, the variable delay can be used to align the channels of multiple M8195A modules.

Modifying the variable delay always affects the delay of all four channels.

E.g. setting the variable delay to 10 ps has the following effect. Out 1, 2, 3 and 4 are delayed by 10 ps with respect to trigger/gate input and event input.

<b>M8195A</b>	
Delay range	0 ns to 10 ns
Delay resolution	50 fs
Delay accuracy	$\pm 10$ ps (typ)

## FIR filter

Each channel in the M8195A has an FIR filter with programmable coefficients in front of its respective DAC. The FIR filters are used to realize variable channel delay and waveform interpolation with sample rate divider 2 and 4. The following presets are available for the FIR filter coefficients: Nyquist, Low Pass, Linear Interpolation, Zero Order Hold and User Defined. The number of taps of each filter is 16 when internal memory is used and depends on the sample rate divider when extended memory is used as shown in the following table:

Sample Rate Divider	Taps	Memory Sample Rate	DAC Sample Rate
1	16	53.76 GSa/s ... 65.00 GSa/s	53.76 GSa/s ... 65.00 GSa/s
2	32	26.88 GSa/s ... 32.50 GSa/s	53.76 GSa/s ... 65.00 GSa/s
3	64	13.44 GSa/s ... 16.25 GSa/s	53.76 GSa/s ... 65.00 GSa/s

## Reference clock input

The clock reference input is provided on the front panel of each module. The clock reference input of the M8195A is used as the clock reference for all four channels of that M8195A. The clock reference input of the M8197A synchronization module is used as the clock reference for all channels of all M8195A that are combined in a synchronous system.

M8195A and M8197A	
Input frequency ranges	10 MHz to 300 MHz 210 MHz to 17 GHz
Lock range	± 1 % (typ)
Jitter	< 2 ps <sub>pp</sub>
Input level	250 mV <sub>pp</sub> to 2 V <sub>pp</sub>
Impedance	50 Ω (nom), AC coupled
Connector	SMA
Sample clock frequency resolution	1 ppm; e.g. sample clock frequency = 64 GHz => frequency resolution = 64 kHz

## Reference clock output

The clock reference output is provided on the front panel of each module.

M8195A and M8197A	
AXIe backplane clock source	
Output frequency	$f_{Out}^1 = f_{Sa} / (32 * n)$ with $n = 1...1024$ or $f_{Out}^2 = f_{Sa} / 256$
Frequency accuracy	± 20 ppm
Internal clock source	
Output frequency	$f_{Out}^1 = f_{Sa} / (32 * n)$ with $n = 1...1024$ or $f_{Out}^2 = f_{Sa} / 256$ or $f_{Out}^2 = 100$ MHz
Frequency accuracy	See internal synthesizer clock characteristic
External reference clock input frequency $f_{In} = 10$ MHz to 300 MHz	
Output frequency	$f_{Out}^2 = f_{In} / (n * m)$ with $n, m = 1...8$ or $f_{Out}^2 = f_{Sa} / 256$
Frequency accuracy	Depends on external reference clock
External reference clock input frequency $f_{In} = 210$ MHz to 17 GHz	
Output frequency	$f_{Out}^1 = f_{Sa} / (32 * n)$ with $n = 1...1024$ or $f_{Out}^2 = f_{Sa} / 256$
Frequency accuracy	Depends on external reference clock
Output amplitude	900 mV <sub>pp</sub> (nom) into 50 Ω
Source impedance	50 Ω (nom), AC coupled
Connector	SMA

1. Reference clock output phase shifts when the variable delay is changed.
2. For M8195A: Reference clock output remains unchanged when the variable delay is changed.
3. Warm-up time 2 minutes min.
4.  $f_{Sa} = 64$  GHz; reference clock source: internal.

## Internal synthesizer clock characteristics

M8195A	
Frequency	53.76 GHz to 65.00 GHz
Accuracy <sup>1</sup>	0.7 ppm (spec) initial accuracy ± 0.3 ppm aging / year
Frequency resolution	7 digits, e.g. 100 Hz at 1 GHz
Phase noise <sup>2</sup>	< -115 dBc/Hz (typ) at 10 kHz offset, $f_{OUT} = 1$ GHz < -95 dBc/Hz (typ) at 10 kHz offset, $f_{OUT} = 10$ GHz

## Download speed

Download speed is measured by transferring the samples from the controlling PC's memory into the M8195A.

	USB using SCPI or IVI	PCIe using SCPI <sup>3</sup>	PCIe using IVI <sup>3,4</sup>
Download Speed	~8 MSa/s (meas)	~40 MSa/s (meas)	~400 MSa/s (meas)

## Instrument software

The M8195A and M8197A are controlled by a combined soft-front panel and firmware application that runs on an embedded AXIe controller or external PC or laptop.

M8195A and M8197A	
Supported Operating Systems	Windows 7 (32 or 64 bit), Windows 8 / 8.1 (32 or 64 bit), Windows 10 (32 or 64 bit)
Required hard disk space	1 Gb
Interface to hardware	PCI Express® or USB
Application programming interfaces	SCPI, IVI-COM, LabView

## General

	M8195A	M8197A
Power consumption	180 W (nom) @ 65 GSa/s	60 W (nom)
Operating temperature	0 °C to 40 °C	
Operating humidity	5% to 80% relative humidity, non-condensing	
Operating altitude	Up to 2000 m	
Storage temperature	-40 °C to +70 °	
Stored states	User configurations and factory default	
Interface to controlling PC	PCIe (see AXIe chassis specification) or USB	
Form factor	1-slot AXIe	
Dimensions (W x H x D)	322.25 mm x 30 mm x 281.5 mm	
Weight	3.75 kg	2.7 kg
Safety designed to	IEC61010-1, UL61010, CSA22.2 61010.1 tested	
EMC tested to	IEC61326-1	
Warm-up time	30 min	
Calibration interval	2 years recommended	
Warranty	3 years standard	
Cooling requirements	When operating the system choose a location that provides at least 80 mm of clearance at rear, and at least 30 mm of clearance at each side	

1. Warm-up time 2 minutes min.
2.  $f_{Sa} = 64$  GHz; reference clock source: internal.
3. Using M9048A PCIe adapter.
4. Download of waveform samples without marker information.

## Definitions

### Specification (spec)

The warranted performance of a calibrated instrument that has been stored for a minimum of 2 hours within the operating temperature range of 0°C to 40°C and after a 45-minute warm up period. All specifications include measurement uncertainty and were created in compliance with ISO-17025 methods. Data published in this document are specifications (spec) only where specifically indicated.

### Typical (typ)

The characteristic performance, which 80% or more of manufactured instruments will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 23°C).

### Nominal (nom)

The mean or average characteristic performance, or the value of an attribute that is determined by design such as a connector type, physical dimension, or operating speed. This data is not warranted and is measured at room temperature (approximately 23°C).

### Measured (meas)

An attribute measured during development for purposes of communicating the expected performance. This data is not warranted and is measured at room temperature (approximately 23°C).

### Accuracy

Represents the traceable accuracy of a specified parameter. Includes measurement error and timebase error, and calibration source uncertainty.

## Connectivity



[www.axistandard.org](http://www.axistandard.org)

AdvancedTCA<sup>®</sup> Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. The business that became Keysight was a founding member of the AXIe consortium. ATCA<sup>®</sup>, AdvancedTCA<sup>®</sup>, and the ATCA logo are registered US trademarks of the PCI Industrial Computer Manufacturers Group.



[www.lxistandard.org](http://www.lxistandard.org)

LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. The business that became Keysight was a founding member of the LXI consortium.

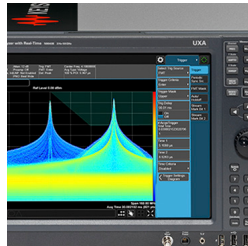
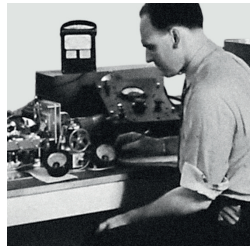


[www.pxisa.org](http://www.pxisa.org)

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

## From Hewlett-Packard through Agilent to Keysight

For more than 75 years, we've been helping you unlock measurement insights. Our unique combination of hardware, software and people can help you reach your next breakthrough. **Unlocking measurement insights since 1939.**



1939

THE FUTURE

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: [www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)

### Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

### Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

### Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:  
[www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)  
 (BP-02-10-16)



### [www.keysight.com/go/quality](http://www.keysight.com/go/quality)

Keysight Technologies, Inc.  
 DEKRA Certified ISO 9001:2015  
 Quality Management System

This information is subject to change without notice.  
 © Keysight Technologies, 2014 - 2016  
 Published in USA, June 3, 2016  
 5992-0014EN  
[www.keysight.com](http://www.keysight.com)

### myKeysight

[www.keysight.com/find/mykeysight](http://www.keysight.com/find/mykeysight)  
 A personalized view into the information most relevant to you.

### Three-Year Warranty

[www.keysight.com/find/ThreeYearWarranty](http://www.keysight.com/find/ThreeYearWarranty)  
 Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.

### Keysight Assurance Plans

[www.keysight.com/find/AssurancePlans](http://www.keysight.com/find/AssurancePlans)  
 Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

### Keysight Infoline

[www.keysight.com/find/services](http://www.keysight.com/find/services)  
 Keysight's insight to best in class information management. Free access to your Keysight equipment company reports and e-library.

### Keysight Channel Partners

[www.keysight.com/find/channelpartners](http://www.keysight.com/find/channelpartners)  
 Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

MIPI® service marks and logo marks are owned by MIPI Alliance, Inc. and any use of such marks by Keysight Technologies is under license. Other service marks and trade names are those of their respective owners.

PCI-SIG®, PCIe® and the PCI Express® are US registered trademarks and/or service marks of PCI-SIG.

[www.keysight.com/find/m8195a](http://www.keysight.com/find/m8195a)

### myKeysight



### Keysight Infoline