M8194A 120 GSa/s Arbitrary Waveform Generator
Version 1.0

M8194A in a 2-slot AXIe chassis

M8194A at a glance

The Keysight Technologies, Inc. M8194A arbitrary waveform generator (AWG) has the highest sample rate and the widest bandwidth in its class with up to four synchronized channels operating simultaneously in one module

- Sample rate up to 120 GSa/s (on all 4 channels simultaneously)
- Analog bandwidth: 45 GHz (typical), generate signals with frequency components up to 50 GHz [1]
- 8 bits vertical resolution
- 512 kSa of waveform memory per channel
- 1, 2, or 4 differential channels per 1-slot AXIe module (number of channels is software upgradeable)
- Amplitude up to 0.8 V_{pp}(se) / 1.6 V_{pp}(diff.), voltage window -1.0 to +2.5 V
- Transition time (20%/80%): 11 ps without corrections / 6 ps with corrections applied (typical)
- Built-in frequency and phase response calibration for clean output signals
- Up to 4 modules (= 16 channels) can be synchronized

Coherent Optical Applications

400 G and 1 Terabit applications demand a new class of generators that provide high speed, precision and flexibility at the same time. The M8194A is the ideal solution to test different optical systems from discrete components like optical power amplifiers to more complex dual polarization systems like optical modulators or optical receivers.

With up to 4 channels per 1-slot AXIe module, each running at up to 120 GSa/s with 45 GHz of analog bandwidth, it allows dual polarization testing in a small form factor and the generation of complex signals with multiple modulation schemes (PAM-4, PAM-8, QPSK, nQAM) up to 100 GBaud.

Compensation for distortions generated e. g. by cables and amplifiers can be realized by embedding/de-embedding the S-parameters of the respective circuits or by performing an in-situ calibration using the Keysight Technologies vector signal analysis software.

Combined with the 81195A optical modulation generator software, the M8194A makes it easy to generate optical impairments (e.g. PMD) for stressing the optical receiver over multiple test scenarios.
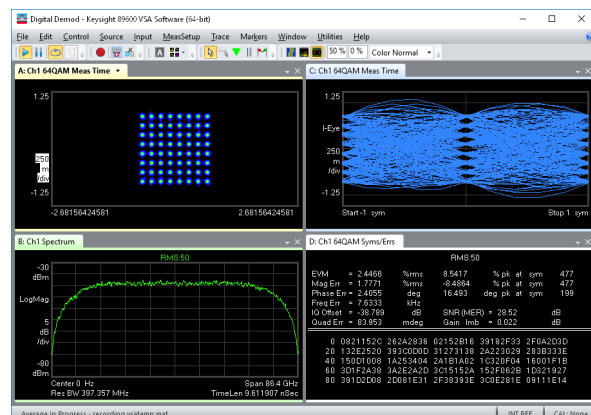

Figure 1. 64-QAM at 64 GBaud (electrical)

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[1] At 50 GHz, attenuation is approx. 7.5 dB (refer to figure 3) – can be compensated by digital pre-distortion

Multi-Level/Multi-Channel Digital Signals

The M8194A is also ideally suited to address multi-level/multi-channel interfaces using any standard or custom data format, for example high-speed backplane connections using PAM-4 or PAM-8 format, as well as technologies in the mobile application space.

The flexibility of the waveform generation at its highest speeds, combined with excellent intrinsic jitter performance makes the M8194A a truly future-proof instrument.

At data rates of multiple Gb/s, the effect of cables, board traces, and connectors etc. must be considered in order to generate the desired signal at the test point of the device under test. The M8194A incorporates digital pre-distortion techniques for frequency- and phase-response compensation of the AWG output and any external circuit to generate the desired signal at the device under test. Channels can be embedded/de-embedded if the S-parameters of the respective circuits are provided.

In conjunction with the 81195A optical modulation generator software various kinds of distortions can be added to the signal.

With its high channel density, the M8194A is well-suited to affordably and precisely stimulate multi-lane high-speed interfaces.
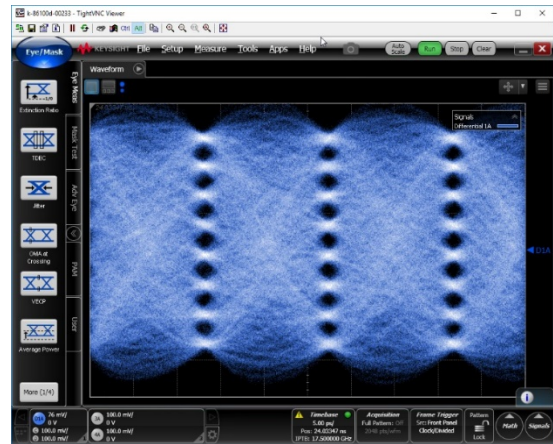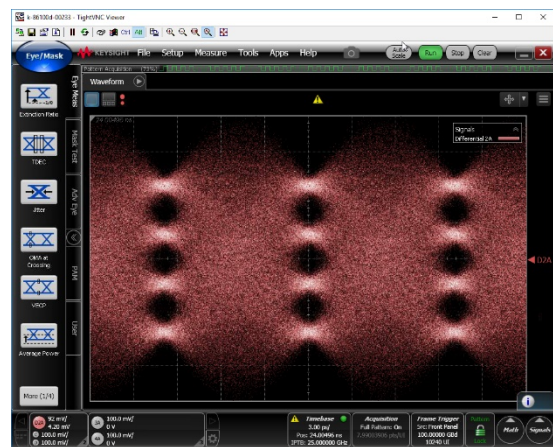

Figure 2. 70 GBaud PAM8 (= 210 Gpbs)

Figure 3. 100 GBaud PAM4 (= 200 Gpbs)

Physics, Chemistry and Electronics Research

With the M8194A AWG it is possible to generate any arbitrary waveform you can mathematically describe and download it directly to the M8194A. This includes ultra-short yet precise pulses down to 16 ps pulse width or extremely short, yet wideband RF pulses and chirps which are needed to investigate in live time chemical reactions and elementary particle excitation.

Multi-Module Operation

Up to four M8194A can be synchronized. For two modules, an M8194A-830 sync cable kit is required. For three (four) modules, two (three) M8194A-830 sync cable kits plus an M8197A sync module is required. Instead of the M8197A, an external clock source can be used that meets the specifications for the Sync B In connector

Configuration

Product number	Description	Comment
M8194A-001	Arbitrary waveform generator module, 1 channel, 120 GSa/s, 512 kSa per channel	Includes local start-up assistance
M8194A-002	Arbitrary waveform generator module, 2 channels, 120 GSa/s, 512 kSa per channel	
M8194A-004	Arbitrary waveform generator module, 4 channels, 120 GSa/s, 512 kSa per channel	
M8194A-BU2	Pre-configured system consisting of one M9502A 2-slot AXIe Chassis with USB Option	
M8194A-BU3	Pre-configured system consisting of one M9502A 2-slot AXIe Chassis with USB Option and one M9537A AXIe Embedded PC Controller	

Upgrade options

Product number	Description	Comment
M8194AU-U02	Upgrade from 1 channel to 2 channels	Software license
M8194AU-U04	Upgrade from 2 channels to 4 channels	Software license

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 M8194A modules: (See http://www.keysight.com/find/AXIe for more details)

Product number	Description
M9502A-U20	2-slot AXIe chassis with USB Option
M9505A-U20	5-slot AXIe chassis with USB Option
M9537A	AXIe embedded controller
8121-1243	Cable assembly USB Type A-MINI B
M9048A	PCIe® desktop card adapter Gen 2 x8
Y1202A	PCIe cable for M9048A desktop adapter
M8194A-810	Matched cable pair for M8194A AWG, 1.85 mm
M8194A-820	Termination 50-Ohm, 1.85 mm
M8194A-830	Synchronization cable kit

Software

The M8194A comes with a Soft Front Panel application to control its functionality, download waveforms from files and generate basic waveforms, including multi-tone signals, digitally modulated signals and multi-level serial data signals.

In addition, a free MATLAB utility (IQtools) is included with the instrument software to generate various types of waveforms. IQtools also supports "in-system calibration" to measure and compensate the frequency and phase response of the AWG and any external circuitry and compensates skew between channels

Product number	Description	Comment
81195A	Optical Modulation Generator Software	Free to download

81195A-OSP	Optical Signal Properties	requires 81195A
N6171A-M02	MATLAB license (standard)	
N6171A-M03	MATLAB license (extended)	

Specifications

General characteristics

Sample rate	115.2 to 120.2 GSa/s 107.2 to 112.2 GSa/s 95.6 to 100.2 GSa/s
DAC resolution	8 bits
Number of channels per M8194A module	1, 2, or 4 (corresponds to Opt. 001, 002, and 004) Additional number of channels can be enabled via user-installable software license
Frequency accuracy (at 1 GHz, at output)	±30 ppm

Sample memory

Sample memory	512 kSa per channel. The waveforms in each channel can have different length
Waveform granularity	128 samples. The length of waveform segments must be a multiple of the granularity
Minimum waveform length	128 samples

Out 1, 2, 3, 4

Output type	Single-ended[2] or differential
Analog bandwidth (3 dB, excl. sin(x)/x roll-off)	45 GHz (typ)
Rise/fall time (20%/80%)[3,4]	6 ps (typ) corrected[3] 11 ps (typ) uncorrected
Impedance	50 Ω (nom)
Amplitude	75 mV$_{pp}$(se) to 0.8 V$_{pp}$ (se) into 50 Ω 150 mV$_{pp}$ (diff.) to 1.6 V$_{pp}$ (diff.) into 50 Ω
Amplitude resolution	400 µV (nom)
DC amplitude accuracy[4]	±(5% +10 mV) (typ)
Voltage window	−1.0 to +2.5 V single-ended into 50 Ω
Offset resolution	400 µV (nom)
DC offset accuracy[5]	±20 mV (typ)
Differential offset	Adjustable
Termination voltage window	−1.5 to +3.5 V (low level -400 mV) to (high level +400 mV)
Termination voltage resolution	300 µV (nom)
Skew between any pair of outputs	
Within channel pairs 1/2 and 3/4	0 ps ±1 ps (typ)

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[2] Unused output must be terminated with 50 Ω to GND
[3] Frequency response corrected up to 50 GHz
[4] Termination voltage = 0 V; adjusted at 23 °C ambient temperature, amplitude increases by 0.4%/°C (typical) for ambient temperature below 23 °C
[5] Termination voltage = 0 V

Between channels 1/2 and 3/4	0 ps ±2 ps (typ)
Between any pair of channels of different, synchronized modules	Skew does not change across start/stop and pattern reload, provided that the sample rate is not changed. This allows the user to calibrate all channels of a synchronized system to zero skew relative to each other using in-system calibration.
Skew between normal and complement	0 ps ±3 ps (nom)
Random Jitter	
Within channel pairs 1/2 and 3/4	125 fs_{RMS} (typ)
Between channels 1/2 and 3/4	400 fs_{RMS} (typ)
Harmonic distortions	
2nd harmonic	-35 dBc (typ), f_{out} <= 20 GHz -30 dBc (typ), f_{out} > 20 GHz
3rd harmonic	-30 dBc (typ), f_{out} <= 10 GHz -25 dBc (typ), f_{out} > 10 GHz
SFDR (excluding harmonic distortions)	-35 dBc (typ), f_{out} = DC…10 GHz -30 dBc (typ), f_{out} = 10 GHz…40 GHz -25 dBc (typ), f_{out} = 40 GHz…45 GHz
Amplitude flatness (at RF output connector, compensated for sin(x)/x)	+/- 1 dB (typ), f_{out} = DC ... 5 GHz +/- 2 dB (typ), f_{out} = 5 GHz ... 40 GHz +/- 3 dB (typ), f_{out} = 40 GHz ... 45 GHz
Total Harmonic Distortion	1.3 % (typ), f_{out} = 1 GHz 1.5 % (typ), f_{out} = 2 GHz 1.8 % (typ), f_{out} = 5 GHz 2.3 % (typ), f_{out} = 10 GHz
Connector type	1.85 mm (female)

Sync A In/Out

The Sync A In/Out connectors are used for multi-module operation. The User Guide contains detailed information on how they need to be connected

Sync B In (Ref Clk In)

Input coupling	AC
Input impedance	50 Ohm
Input levels	500 mV_{pp} to 900 mV_{pp}
Input signal shape	Square wave preferred; sine wave acceptable
Frequency range	200 MHz … 300 MHz
Lock range	+/- 1%
Connector type	3.5 mm

Sync B Out (Ref Clk Out)

Impedance	50 Ohm
Output amplitude	800 mV_{pp} (nominal)
Frequency accuracy	+/- 60 ppm
Connector type	3.5 mm

Frequency response

Frequency response measured with a sample rate of 120 GSa/s, differential output, 500 mV amplitude. No sin(x)/x correction has been applied to the graph.
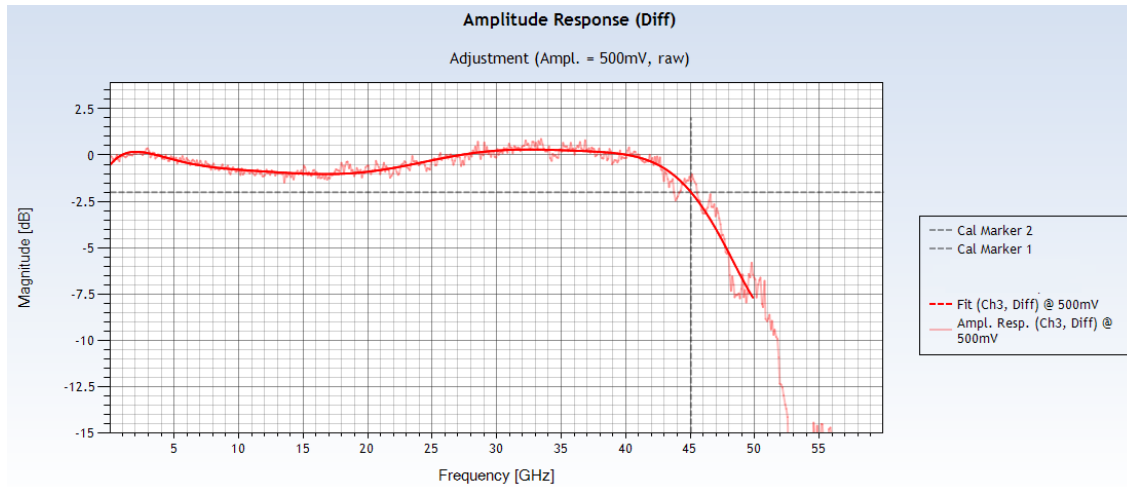

Figure 3.

ENOB

ENOB measured with a sample rate of 120 GSa/s, differential output, 500 mV amplitude, according to IEEE 1658-2000, with noise and distortions up to the Nyquist frequency (60 GHz) considered.
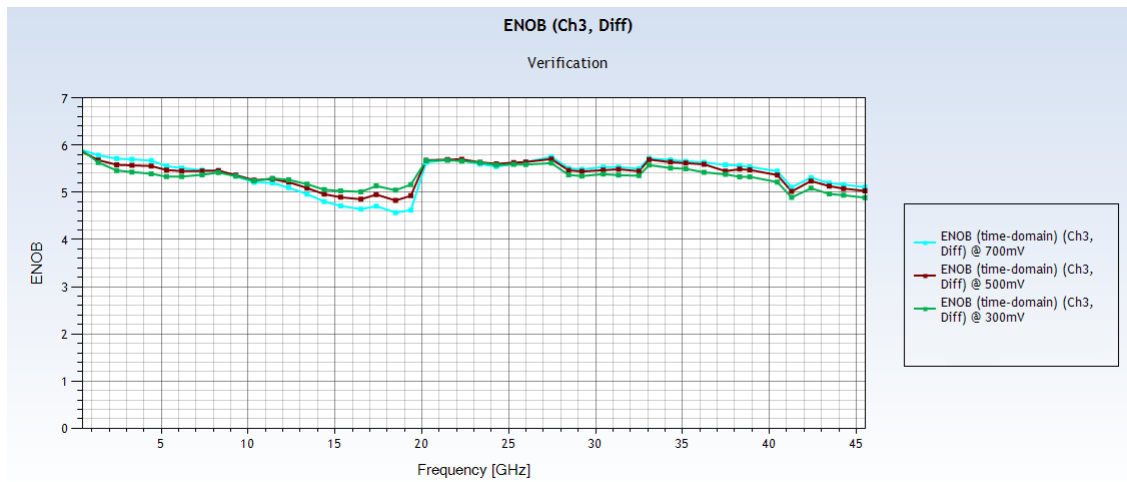

Figure 4.

Instrument software

The M8194A is controlled by a combined soft-front panel and firmware application that runs on an embedded AXIe controller or external PC or laptop.

Supported operating systems	Windows 7, 8.1, 10, all 64 bit
Required hard disk space	1 GB
Interface to M8194A hardware	PCI Express® (see AXIe chassis specification)
	USB (see AXIe chassis specification)
Application programming interfaces	SCPI, MATLAB

General

Power consumption	50 W (nom) at 120 GSa/s
Operating temperature	0 to 40°C
Operating humidity	15% to 80% relative humidity, non-condensing
Operating altitude	Up to 2000 m
Storage temperature	–40 to +70°C
Stored states	User configurations and factory default
Form factor	1-slot AXIe
Dimensions (W x H x D)	322.25 mm x 30 mm x 281.5 mm
Weight	3.15 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
Cooling requirements	When operating the M8194A choose a location that provides at least 80 mm of clearance at rear, and at least 30 mm of clearance at each side

Learn more at: www.keysight.com

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

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