Pulse, Pattern, Function, and Arbitrary Waveform Generators

For Digital and Analog Testing

Choosing the correct type of signal generation instrument to match your application requirements

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Sources for Analog and Digital Signals

Choose the performance you need from Keysight's comprehensive portfolio of reliable pulse, data, function, and arbitrary waveform generator instruments. This family of signal stimulus instruments include:

- Pulse generators
- Pattern generators
- Data generators
- PRBS generators
- Jitter generators
- Noise generators
- Controllable jitter injection
- Timing generators
- Function arbitrary generators
- Arbitrary waveform generators

The Perfect Signal Generation Instrument for Your Application

Keysight's pulse, pattern, function, and arbitrary waveform generators deliver the reliable and accurate results you require whether you:

- Need to test your baseband devices with complex, digitally modulated waveforms, or
- Need to characterize a high-speed serial bus device at the physical layer, or
- Need to get a detailed insight into your system's signal integrity.
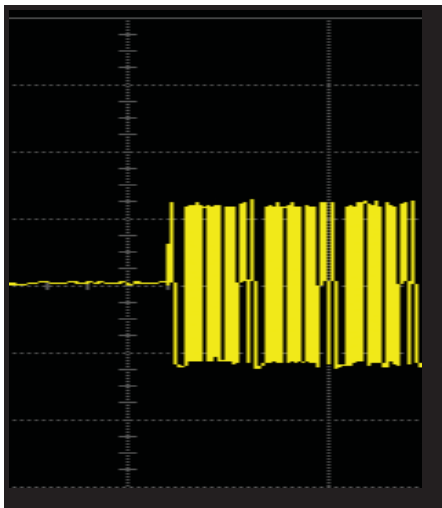
Typical application requirements:

- Demanding high-speed digital pulses and high-speed clock signals
- Serial or parallel bit patterns and data streams
- Sine waves, square waves, and arbitrary waveforms.
- Modulated signals
- Jitter and noise generation
- High-resolution radar, satellite, and wireless communication signals

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TECHNOLOGIES

Pulse Generation
Pulse generation and signal parameters

A pulse generator provides full control over all pulse parameters like timing, levels and edges as shown in the Figure 1 below. It is used to set up continuous or triggered pulse streams and offers flexibility to address the most challenging applications.

All parameters can be adjusted to meet the needs of the specific application. Pulse generation capability is provided by all models. The pulse function arbitrary noise generator provides all flexibility to generate ideal and worst-case signals. The Keysight instruments cover a frequency range from 1 µHz to 3 GHz and an output amplitude range from 50 mV up to 10 V.

Figure 1: Pulse Parameters

Glitch-free timing changes
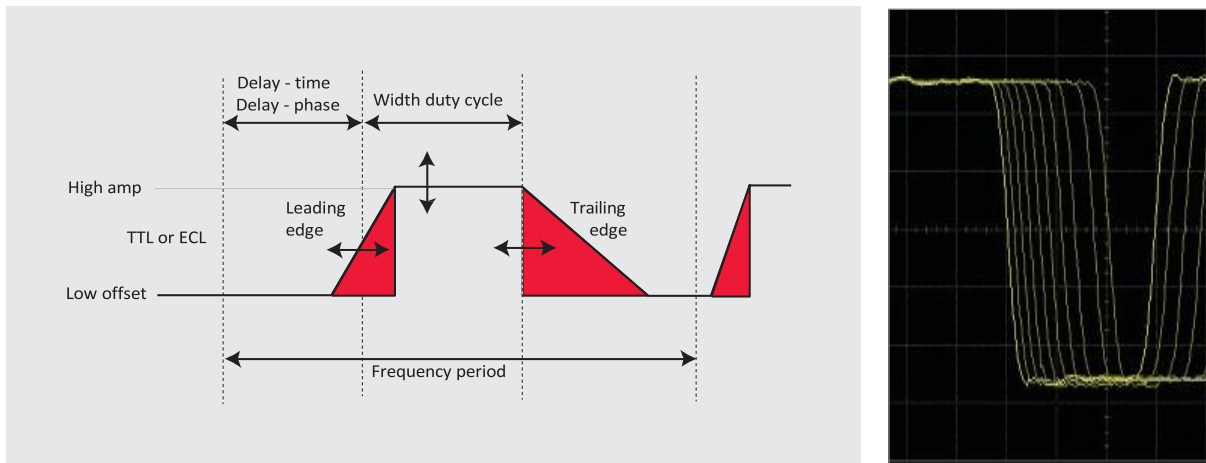
The Keysight 81150A, 81160A, 81133A, and 81134A uniquely allow timing parameter changes, such as changing the frequency, without dropouts or glitches. This industry-leading feature enables continuous operation without rebooting or resetting the device under test, when measuring a PLL pull-in and hold range for instance, or to characterize a device over a sweeping clock frequency.

From Pulse to Pattern, Data and PRBS

Pulse-pattern generators not only generate single impulses, bursts or continuous pulse streams as mentioned before. Their pattern capability also allows the generation of data signals. This versatility is key to digital device test applications, for example for compliance tests.

In pattern mode, the same full control over the signal output is available as in the traditional pulse generation mode. This allows the generation of uncounted forms of data signals, including standard non-return-to-zero (NRZ) signals, or data bursts with programmable pulse width with additional delay to the clock signal. Apart from user defined data signals, standardized pseudo-random binary sequences (PRBS) can also be generated.
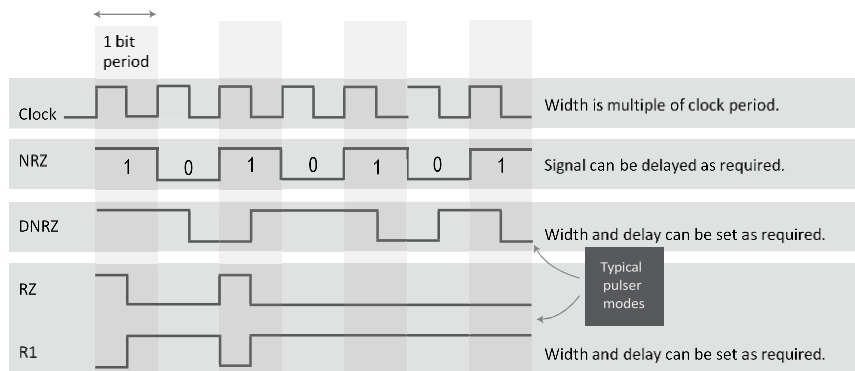
The ability to create user-defined bit patterns, standard compliant data and PRBS make the Keysight pulse-pattern generators the ideal source for:

- Stimulated eye diagram measurements
- Cross-talk measurements
- Compliance tests
- Jitter tests
- Signal integrity measurements
- Stress tests for receivers

The 81130A's data-looping capabilities or the 12-MBit deep memory and the PC based pattern management tool of the 81133A and 81134A enable you to generate 'real-life' data sequences for today's latest technology, like serial high-speed busses.

Pulse-pattern generators provide all the tools to generate the data packets needed for digital bus device tests: integrated pattern editors, PC-based graphically enhanced data and pattern management software, segment looping features as well as hardware-generated PRBS. This enables engineers to quickly gain detailed insight into their digital bus device - including devices for:

- USB 2.0
- Serial ATA
- PCI Express®
- Firewire and more

These tools allow the easy carrying out of all measurements from physical layer characterization, signal integrity, and jitter measurements, to complete standard compliance test.

From Digital to Analog

The Keysight family of function-arbitrary and arbitrary waveform generators with a wide range of possibilities to generate the signals you need. Whether you require a clean, low distortion sine wave, a variable-edge-time pulse or a complex, digitally-modulated waveform Keysight provides the right choice.

Until recently, DDS has been the waveform generation technology of choice in function generators and economical arbitrary waveform generators. DDS enables waveform generators with great frequency resolution, convenient custom waveforms, and a low price.

However, DDS has limitations including increased jitter and harmonic distortion. Keysight Technologies' Trueform technology offers an alternative that blends the best of DDS and point-per-clock architectures, giving you the benefits of both without the limitations of either. Trueform technology can be found in the 33500, 33600, M9336A, and P9336A.

As devices and interfaces become faster and more complex, high-performance AWGs with increased bandwidth at higher frequencies are required to create the signals you need for signal emulation, advanced research, design verification, and product test. The M8190A, M8195A, and M8196A AWGs provide multiple channels, greater fidelity, high resolution and wide bandwidth – simultaneously.

Mixed signal devices require analog and digital signals in addition to modulation capabilities

The 81150A and 81160A are examples of signal sources that combine different instruments such as a pulse generator, function arbitrary generator, and noise generator allowing you to generate the signal you need, whether it is an ideal pulse or a real-world signal.

Signal imperfections such as rise time, ringing, glitches, noise and random timing varia- tions can be easily simulated in a controlled manner. Physics, chemistry, biomedicine, electronics, mechanics, and other fields can benefit from the versatility of an arbitrary waveform generator. Wherever things vibrate, pump, pulse, bubble, burst, or change with time, there are applications available – limited only by your ability to specify the waveform data.

The noise generators are needed to distort the signal in a controlled and repeatable manner. Your device under test might require an arbitrary or a Gaussian distribution. A long repetition rate of 20 days (or even 26 days for the 81150A) guarantees an almost random signal with exact signal repetition. The selectable crest factor guarantees to test even serial bus standards.

Transition/Time Converters

Reducing the signal transition times also increases the overall pulse-performance for overshoot/reflection sensitive applications. Keysight 1543xA/B transition/time converters can be used to accomplish this by converting fast, fixed transition times, to slower, fixed transition/times. The design of these converters ensures very low signal reflection (far beyond the 3 dB point) and all transition times are measured between 10% and 90% of amplitude.

Key features

- Each converter as two SMA connectors, one male and one female
- Output transition times ranging from 150 ps to 2 ns
- 3 dB point varies from 2.1 GHz to 190 MHz depending on corresponding output transition
- Input voltage < 10 Vpp
- Insertion loss < 0.2 dB
- Overshoot and ringing < 3 %
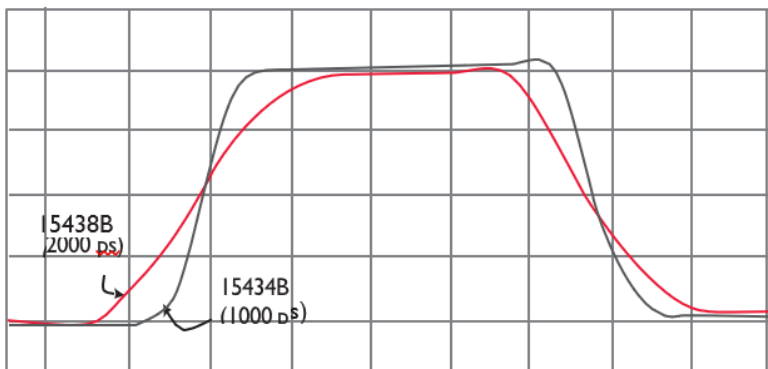
www.keysight.com/find/time_converter

Keysight Pulse and Arbitrary Signal Sources

The following sections summarize the key attributes and applications for Keysight pulse, function, and arbitrary signal sources.

	Pulse Pattern Generators & BERT test solutions	Function/Arbitrary Generators	Arbitrary Waveform Generators
128 Gb/s	M8040A		
32 GHz 32 Gb/s	M8020A and M8062A		M8196A
25 GHz			M8195A
16 Gb/s	M8020A		
5 GHz			M8190A
3 GHz	81133A 81134A		
540 MHz		P9336A-B50	M9336A-B50
500 MHz		N8241A-125 N8242A-125	M9330A M9331A
400 MHz		M3202A	
330 MHz	81160A		
200 - 250 MHz	M9195B	M3201A	N8241A-062 N8242A-062
120 - 125 MHz	81150A	33621A 33622A	P9336A-B12 M9336A-B12
80 MHz		33611A 33612A	
30 MHz		33521B 33522B	

Product Characteristics at a Glance

Product number	Pulse or ARB Frequency range	Maximum sample rate	Number of channels	Amplitude range	ARB voltage resolution (bits)	Differential outputs	LVDS levels	Triggerable	Gate Mode	Built-in function generator	Pulse generation	Pattern & data generation
33521B 33522B	1 µHz - 30 MHz	250 MSa/s	1/2	1 mVpp - 10 Vpp [1]	16			√		√	√	
33611A 33612A	1 µHz - 80 MHz	660 MSa/s	1/2	10 mVpp - 10 Vpp [1]	14			√		√	√	
33621A 33622A	1 µHz - 120 MHz	660 MSa/s	1/2	10 mVpp - 10 Vpp [1]	14			√		√	√	
81133A 81134A	15 MHz - 3.35 GHz	NA	1/2	50 mVpp - 2.0 Vpp [3]	NA	√	√				√	√
81150A	1 µHz - 120 MHz	2 GSa/s	1/2	100 mVpp - 10 Vpp [1]	14	√	√	√	√	√	√	√
81160A	1 µHz - 330 MHz	2.5 GSa/s	1/2	50 mVpp - 5 Vpp [1]	14	√	√	√	√	√	√	√
M3201A	DC- 200 MHz	500 MSa/s	2/4	0 Vpp - 3 Vpp [1,3]	16	√		√		√	√	
M3202A	DC- 400 MHz	1 GSa/s	2/4	0 Vpp - 3 Vpp [1,3]	14	√		√		√	√	
M8020A	256 M - 16 Gb/s [4]	NA	1-4	100 mVpp - 2.4 Vpp [2]	NA	√	√					√
M8020A + M8062A	256 M - 32 Gb/s [4]	NA	1-4	100 mVpp - 2.4 Vpp [2]	NA	√	√					√
M8040A	2 - 128 Gb/s [4]	NA	1/2	50 mVpp - 1.2 Vpp [2]	NA	√	√					√
M8190A	1Hz - 5 GHz	12 GSa/s 8 GSa/s	1/2	200 mVpp - 2.0 Vpp [3]	14 12	√	√	√	√		√	√
M8195A	DC - 25 GHz	65 GSa/s	1, 2 or 4	75 mVpp - 1.0 Vpp [3]	8	√		√	√		√	√
M8196A	DC - 32 GHz	92 GSa/s	1, 2 or 4	150 mVpp - 2.0 Vpp [2]	8	√		√	√		√	√
M9195B	5 mHz - 250 MHz	250 Mb/s	16	-1.5 V - +6.5 V [1]	NA			√			√	√
M9330A M9331A	1 Hz - 500 MHz	1.25 GSa/s	2	0.5 Vpp - 1.0 Vpp [1,2]	15 16	√		√			√	
M9336A-B12 P9336A-B12	DC - 125 MHz	1.28 GSa/s	3	0 Vpp - 3.6 Vpp [1,2]	16	√		√			√	
M9336A-B50 P9336A-B50	DC - 540 MHz	1.28 GSa/s	3	0 Vpp - 3.6 Vpp [1,2]	16	√		√			√	
N8241A-062 N8242A-062	1 Hz - 500 MHz	625 MSa/s	2	0.5 Vpp - 1.0 Vpp [1,2]	15 16	√		√			√	
N8241A-125 N8242A-125	1 Hz - 500 MHz	1.25 GSa/s	2	0.5 Vpp - 1.0 Vpp [1,2]	15 16	√		√			√	

[1] 50 Ω into 50 Ω
[2] 1 kΩ into 50 Ω
[3] single ended
[4] For BERT pattern generators only bit rates can be specified

Product Characteristics at a Glance (2)

Product number	Memory per channel or Total memory per instrument	PRBS variations (2n-1)	Bursts	Data bursts	Segment looping	Controlled jitter injection	Variable width	Variable delay	Glitch-free timing changes	Multi-level signals	Built-in modulation (M) or Play modulated waveform files (F)	Noise with adjustable crest factor	Independent or Un-coupled channels	Synchronized or Coupled channels
33521B 33522B	1 MSa - 16 MSa	n = 7,9,11,15, 20,23	√		√		√	√		√	M/F		√	√
33611A 33612A	4 MSa - 64 MSa	n = 3,4 … 32	√		√		√	√	√	√	M/F		√	√
33621A 33622A	4 MSa - 64 MSa	n = 3,4 … 32	√		√		√	√	√	√	M/F		√	√
81133A 81134A	12 kbit	n = 5,6 … 32	√	√		√	√	√	√					√
81150A	512 kSa	n = 7,9,11,15, 23,31	√	√	√	√	√	√	√	√	M/F	√	√	√
81160A	256 kSa	n = 7,9,11,15, 23,31	√	√	√	√	√	√	√	√	M/F	√	√	√
M3201A	8 MSa - 1 GSa Total	NA	√		√		√	√		√	M/F		√	√
M3202A	8 MSa - 1 GSa Total	NA	√		√		√	√		√	M/F		√	√
M8020A	2 Gbit	n = 7,9,11,15, 23,31,33,35,39, 41,45,49,51	√	√	√	√		√	√	√				√
M8040A	2 Gbit	n = 7,9,11,15, 23,31,33,35,39, 41,45,49,51,58	√	√	√	√		√	√	√				√
M8190A	2 GSa	NA			√		√	√		√	F		√	√
M8195A	16 GSa Total	NA			√		√	√		√	F			√
M8196A	512 kSa	NA			√		√	√		√	F			√
M9195B	16 Mbit - 125 Mbit	NA	√		√		√	√	√					√
M9330A M9331A	8 MSa - 16 MSa	NA	√		√		√	√		√	F		√	√
M9336A-B12 P9336A-B12	Up to 500 MSa Total	NA	√		√		√	√		√	F		√	√
M9336A-B50 P9336A-B50	Up to 500 MSa Total	NA	√		√		√	√		√	F		√	√
N8241A-062 N8242A-062	8 MSa - 16 MSa	NA	√		√		√	√		√	F		√	√
N8241A-125 N8242A-125	8 MSa - 16 MSa	NA	√		√		√	√		√	F		√	√

Key Applications at a Glance

Product number	Clock generation	System trigger source	Wireless comms waveforms	Radar test	Mixed signal devices	PRBS generation	Serial bus test < 1 Gbit/s	High speed serial bus test > 1 Gbit/s	Signal integrity	Jitter (stress) test	Noise immunity test
33521B 33522B	√	√			√	√			√	√	√
33611A 33612A	√	√	√		√	√	√		√	√	√
33621A 33622A	√	√	√		√	√	√		√	√	√
81133A 81134A	√	√				√			√	√	√
81150A	√	√		√	√	√			√	√	√
81160A	√	√		√	√				√	√	√
M3201A			√	√	√				√		
M3202A			√	√	√				√		
M8020A	√	√				√		√	√	√	√
M8040A	√	√				√		√	√	√	√
M8190A			√	√	√			√	√	√	√
M8195A			√	√	√			√	√	√	√
M8196A			√	√	√			√	√	√	√
M9195B	√	√			√		√				
M9330A M9331A			√	√	√				√	√	√
M9336A-B12 P9336A-B12			√	√	√				√	√	√
M9336A-B50 P9336A-B50			√	√	√				√	√	√
N8241A-062 N8242A-062			√	√	√				√	√	√
N8241A-125 N8242A-125			√	√	√				√	√	√

Signal Source Product Overviews
33500B Series Waveform Generators

The Keysight 33500B function/ arbitrary waveform generators are economical instruments used to create signals up to 30 MHz. With their ability to produce functions (sine, square, pulse, etc.) as well as user-defined arbitrary waveforms, these instruments are versatile additions to any electronics bench or test system.
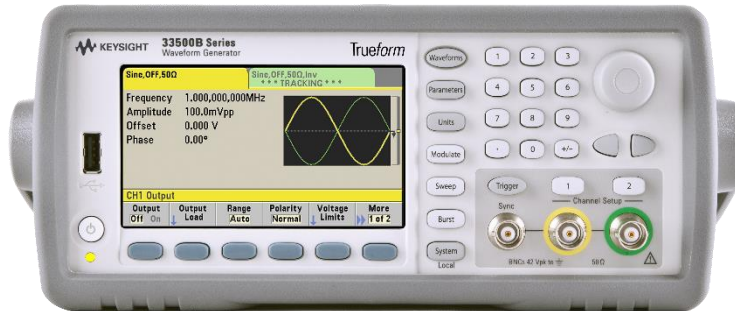
Function

Pulse

Arbitrary

Key features

- Keysight Trueform technology for the highest signal fidelity in its class
- 30 MHz, 16-bit, 250 MSa/s waveform generation
- 16-bit resolution with 1 mVpp to 10 Vpp amplitude for greater amplitude accuracy
- Large display with built-in waveform editor in a 2U x ½ rack package
- USB, LAN (LXI-C), GPIB standard for quick and easy connectivity to PC or network
- Includes Waveform Builder Basic software plus optional Waveform Builder Pro software

Target applications:

- General signal generation for R&D and manufacturing including function, pulse and arbitrary
- PRBS signal generation
- Modulated waveforms for communications test

Complementary products
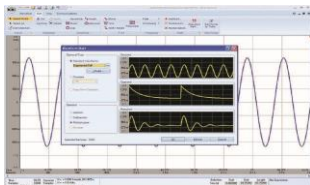
33503A Benchlink Waveform Builder Pro

Infiniivision 1000 and 2000 X-series oscilloscopes

34400A series Truevolt DMMs

www.keysight.com/find/33522B

33600A Series Waveform Generators

33600A Series waveform generators with exclusive Trueform signal generation technology offer more capability, fidelity an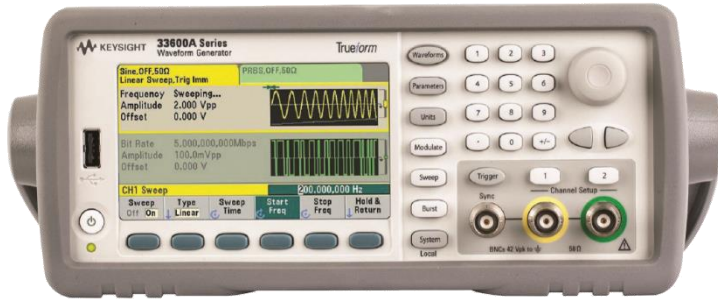d flexibility than previous generation Direct Digital Synthesis (DDS) generators. Use them to accelerate your development process from start to finish.

Function

Pulse

Arbitrary

Key features

- Keysight Trueform generation with 5x lower harmonic distortion than DDS
- Generate a full range of signals including sine, square, triangle, pulse, PRBS pattern, modulation, sweep, and burst
- Arbitrary waveform generation with 1 GSa/s sampling rate, sequencing, <1 ps jitter and up to 64 MSa memory
- Up to 120 MHz bandwidth (100 MHz for pulse)
- 14-bit resolution with 1 mVpp to 10 Vpp amplitude for greater amplitude accuracy
- USB, LAN (LXI-C), GPIB standard for quick and easy connectivity to PC or network
- Includes Waveform Builder Basic software plus optional Waveform Builder Pro software

Target applications:

- General signal generation for R&D and manufacturing including function, pulse and arbitrary
- PRBS signal generation
- Modulated waveforms for communications test

Complementary products
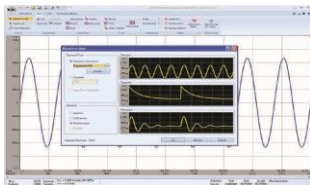
33503A Benchlink Waveform Builder Pro

Infiniivision 1000 and 2000 X-series oscilloscopes

34400A series Truevolt DMMs

www.keysight.com/find/33622A

81133A and 81134A Pulse Pattern Generator

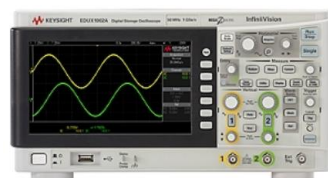 The Keysight 81133A and 81134A 3.35 GHz pulse pattern generators provide the ultimate timing accuracy and signal performance. With their unrivaled performance, they are the perfect clock, pulse, data, pattern and PRBS sources for all applications up to 3.35 GHz.

Precision timing
Data and PRBS
Pattern
Pulse
Jitter

Key features

- 1 or 2 channels with differential outputs
- 50 mVpp up to 2 Vpp amplitude (50 Ω into 50 Ω)
- 15 MHz to 3.35 GHz repetition rate and 0 to 200 MHz modulation frequency
- Programmable termination voltage
- Adjustable transition times between 60 ps and 120 ps
- Total jitter typically less than 2 ps
- 12 Mbit pattern memory per channel
- NRZ/RZ/R1 signal formats over the full frequency range

Target applications:

Sample applications comprise crossover point adjustments and jitter insertion using the delay control input. With the 12 Mbit pattern memory per channel, the 81133A and 81134A enable you to generate the long data patterns required to test today's high-speed interfaces, such as PCI Express or Serial ATA. Other applications include physical layer characterization, signal integrity and jitter tests.

Complementary products
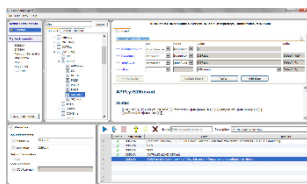
Command Expert

Infiniivision 6000 X-series oscilloscopes

33600A series Waveform Generators

www.keysight.com/find/81134A

81150A Pulse Function Arbitrary Noise Generator

The Keysight 81150A pulse function arbitrary noise generator enables reliable and repeatable measurements. It is the instrument of choice for pulse and clock generation. It combines the benefits of a pulse generator, a n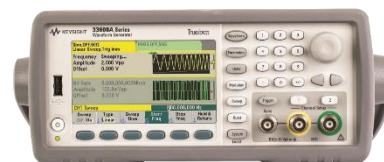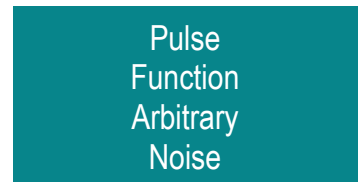oise generator and a function arbitrary generator. The pattern generator is optional and allows sending ideal and real-world pattern. The arbitrary bit shaping lets you emulate overshoot, asymmetric delay and duty cycle distortion up to 120 Mbit/s.

Pulse
Function
Arbitrary
Noise

Key features

- 1 or 2 channels with differential outputs and up to three level signals
- Generate pulse, sine, square, ramp, noise, and arbitrary waveforms
- 1 µHz – 120 MHz pulse with variable rise/fall time and 1 µHz – 240 MHz sine wave
- Precise digital noise with selectable crest factor (peak/RMS) and a repetition period of 26 days
- Full control of all pulse parameters (rise/fall/width, etc.)
- FM, AM, PM, FSK, PWM modulation capability
- Ideal and arbitrary bit shaped pattern up to 120 Mbit/s plus serial PRBS 2^{31} patterns
- Enhanced trigger capabilities

Target application

Test your DUT with high quality pulses without any effects generated by the source. Achieve complete control over timing parameters including trigger ability with fixed latency and glitch-free change of timing. The different modulation capabilities up to 10 MHz, combined with the precision digital noise functionality, allow you to build real-world signals, simply and quickly for worst case scenarios e.g., reproducible noise.

Complementary products

33503A Benchlink
Waveform Builder Pro

Infiniivision 3000 and 4000
X-series oscilloscopes

N5183B MXG Analog signal
generator

www.keysight.com/find/81150A

81160A Pulse Function Arbitrary Noise Generator

The Keysight 81160A pulse function arbitrary noise generator tackles a new speed class up to 500 MHz, offering at the same time the well-proven flexibility and quality in signal generation of the 81150A pulse function arbitrary noise generator. Functionality like glitch-free change of timing parameters allows frequency changes without drop-outs or glitches so that tests can be performed without interruptions or time-consuming repetitions.

Pulse
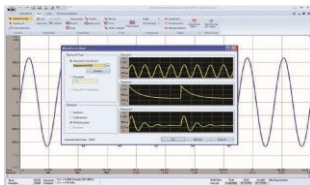Function
Arbitrary
Noise

Key features

- 1 or 2 channels with differential outputs and up to three level signals
- Generate pulse, sine, square, ramp, noise, and arbitrary waveforms
- 1 µHz – 330 MHz pulse with variable rise/fall time and 1 µHz – 500 MHz sine wave
- Precise digital noise with selectable crest factor (peak/RMS) and a repetition period of 20 days
- Full control of all pulse parameters (rise/fall/width, etc.)
- FM, AM, PM, FSK, PWM modulation capability
- Ideal and arbitrary bit shaped pattern up to 600 Mbit/s plus serial PRBS 2^{31} patterns
- Enhanced trigger capabilities

Target application

Like the 81150A, the 81160A allows high-precision pulse, clock and trigger generation and addresses the same vast spectrum of applications: digital and mixed signal device test, capture and reproduce live signals, radar distance test, sensor simulation and disc drive tests. he optional pattern generator is available with a data rate up to 330 Mbit/ s (Option 330) and up to 660 Mbit/s (Option 660).

Complementary products
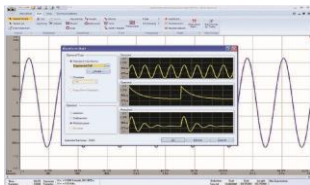
33503A Benchlink
Waveform Builder Pro

Infiniivision 3000 and 4000
X-series oscilloscopes

N5183B MXG Analog signal
generator

www.keysight.com/find/81160A

M3201A and M3202A Arbitrary Waveform Generators

The M3201A and M3202A arbitrary waveform generators combine an advanced waveform generation system with embedded function generators and modulators (frequency/phase/amplitude) for broadband and IF signal generation. They are multi-channel AWGs with similar feature sets but differ in bandwidth, sample rate, and resolution.

Key features

- 1 slot PXIe 2/4 channel AWG
- 500 MSa/s to 1 GSa/s, 14 – 16 bit, 200 - 400 MHz bandwidth
- High-quality output signal with low phase noise
- Includes function generation (sinusoidal, triangular, square, DC) and phase, frequency and amplitude modulation capability
- Flowchart style programming enabled by Hardware Virtual Instrument Design Environment provides real-time sequencing, inter-module synchronization and real-time decision making.
- PathWave FPGA graphical provides an FPGA design environment enabling easy customization by a non-FPGA programmer.

Target applications:

The M3201A and M3202A PXIe arbitrary waveform generators are ideal for general purpose AWG automated test requirements. They offer high channel density with high-quality output with low phase noise. The optional real-time sequencing, intermodulation synchronization, and graphical FPGA programming software tools expand its capability to enable a number of solutions including Quantum Computing research, 5G, wireless device manufacturing, envelope tracking (ET), MIMO, beamforming and other multi-channel coherent signal generation applications.

Complementary products

M3601A/KF9000A HVI and PathWave FPGA design tools

M9243A PXIe Infiniivision Oscilloscope

M9391A PXIe 6GHz vector signal analyzer

www.keysight.com/find/M3201A
www.keysight.com/find/M3202A

M8020A High-performance J-BERT Pattern Generator

The J-BERT M8020A offers pattern generator options for data rates up to 8.5 Gb/s, 16 Gb/s and 32 Gb/s. It's a high-performance pattern generator with integrated jitter, de-emphasis, and level interference for characterizing single and multiple lanes of high-speed digital devices, sub-systems and boards in the computer, consumer and communication industry.



Jitter
De-emphasis
Pattern
Coding

Key features

- Data rates up to 8.5/ 16 Gb/s for pattern generator. Expandable to 32 Gb/s with M8062A BERT Front-End
- One to four 16 Gb/s channels or one 32 Gb/s channel in a 5-slot AXI chassis
- Fast transition times of 12 ps and low intrinsic jitter 8 ps pp (typical performance)
- Differential outputs on data and clock with variable amplitude between 50 mV and 1.2 Vpp single ended.
- Patterns in NRZ format, 2 Gbit/ch user definable, PRBS, coding, pattern blocks and loops
- Integrated and calibrated jitter injections: RJ, high-frequency PJ1, PJ2, low-frequency PJ, BUJ, Clk/2, SSC, sinusoidal interference, and ISI
- 8- tap de-emphasis (positive and negative) up to 20 dB

Target applications:

R&D and test engineers who characterize, verify compliance of chips, devices, boards and systems with serial I/O ports up to 16 Gb/s and 32 Gb/s. The M8020A can be used to test popular serial bus standards, such as: PCI Express, USB, MIPI™ M-PHY®, SATA/ SAS, DisplayPort, SD UHS-II, Fibre Channel, front-side and memory buses, backplanes, repeaters, active optical cables, Thunderbolt, 10 GbE, 100GbE (optical and electrical), SFP+, CFP2/4 transceivers, CEI.

Complementary products
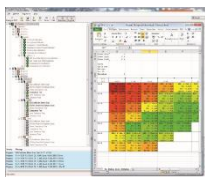
N5990A Test Automation Software
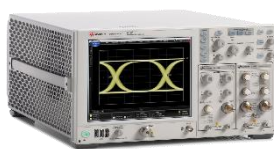
86100D Infiniium DCA-X Wide-Bandwidth Oscilloscope

M8048A ISI Channels

www.keysight.com/find/m8020a

M8040A 64 Gbaud High-performance BERT

The M8040A is a highly integrated BERT for physical layer characterization and compliance testing. With support for pulse amplitude modulation 4-level (PAM4) and non-return-to-zero (NRZ) signals, and symbol rates up to 64 Gbaud (corresponds to 128 Gbit/s) it covers all flavors of the emerging 400/200 GbE and CEI-56G standards.

Jitter
De-emphasis
Pattern
Coding

Key features

- Data rates from 2 to 32 Gbaud and 64 Gbaud PAM4 signal
- Built-in de-emphasis and built-in analyzer equalization
- Integrated and calibrated jitter injection: RJ, PJ1, PJ2, SJ, BUJ, and clk/2 jitter
- Two pattern generator channels per module to emulate aggressor lane
- Short connections to the DUT with remote heads for the pattern generator
- True PAM4 error detection in real-time for low BER levels
- Algorithmic PRBS, QPRBS and memory based patterns, pattern sequencer. For PAM4: Gray coding, FEC encoding and precoder

Target applications:

The M8040A is designed for R&D and test engineers who characterize chips, devices, transceiver modules and sub-components, boards and systems with serial I/O ports operating with symbol rates up to 32 Gbaud and 64 Gbaud in the data center and communications industries. The M8040A can be used for receiver (input) testing for many emerging interconnect standards, such as: IEEE 802.3bs 400 and 200 Gigabit Ethernet (200GAUI, 200GBASE, 400GAUI, 400GBASE), IEEE 802.3bj 100 Gigabit Ethernet, IEEE 802.3cd 50, 100 and 200 Gigabit Ethernet, OIF CEI - 56G (NRZ and PAM4 versions), 64G/112G Fibre Channel, and Infiniband-HDR.

Complementary products

M8091BSPA IEEE 802.3bs Pre-Compliance Application
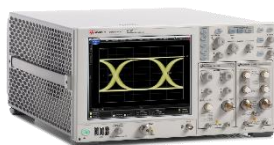
86100D Infiniium DCA-X Wide-Bandwidth Oscilloscope

M8057A Remote Head

www.keysight.com/find/m8040a

M8190A 12 GSa/s Arbitrary Waveform Generator

The M8190A arbitrary waveform generator (AWG) is the source of greater fidelity, delivering high resolution and wide bandwidth simultaneously. This unique combination lets you create signal scenarios that push your designs to the limits and bring new insights to your analysis.
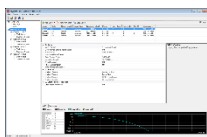

Arbitrary

I/Q Signals

Key features

- Variable sample rate from 125 MSa/s to 8 or 12 GSa/s
- Two DAC settings: 14-bit up to 8 GSa/s and 12-bit up to 12 GSa/s
- 5 GHz analog bandwidth with a spurious-free-dynamic range (SFDR) up to 90 dBc (typical)
- Harmonic distortion (HD) up to –72 dBc (typical)
- Up to 12.25 effective number of bits (ENOB)
- Up to 2 GSa of waveform memory per channel with advanced sequencing
- Choice of three amplifiers for different application requirements with up to 2 Vpp output
- I/Q signal generation with 2 differential channels per 2-slot AXIe module
- Optional real-time digital signal processing in Keysight Technologies proprietary ASIC

Target applications:

the Keysight M8190A contains three amplifiers that are optimized for I/Q signals, IF/RF output, or clean time-domain signals. You can switch between them as needed through software commands as signal scenarios change. It is ideal for testing radar and electronic warfare designs because waveforms need to be stored only once and amplitude, frequency and phase are stored independently. Complex operations such as frequency sweep are possible and streaming functionality is available for infinite playtime. The AWG is also well-suited for emulating digitally -modulated transmissions including interference, fading, and more. For applications requiring multi-channel support, the M8192A can ensure the alignment up to 12-channels.

Complementary products

Keysight Signal Studio Software

E8267D PSG Vector Signal Generator

M8192A Multi-Channel Synchronization Module

www.keysight.com/find/m8190A

M8195A 65 GSa/s Arbitrary Waveform Generator

The Keysight M8195A arbitrary waveform generator (AWG) provides up to 65 GSa/s, 25 GHz bandwidth, 8 bits vertical resolution, and up to 4 channels in a 1-slot AXIe module - simultaneously. Advanced 3-level sequencing allows longer signal scenarios.
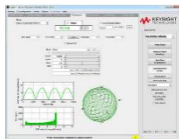

Arbitrary

Key features

- Sample rate up to 65 GSa/s and 8-bit vertical resolution
- Analog bandwidth up to 20 GHz
- Up to 16 GSa of waveform memory per AXI module
- 1, 2 or 4 channels in one slot AXIe module (number of channels is SW upgradeable)
- Advanced 3-level sequencing with external dynamic control1
- Amplitude up to 1 Vpp(se) or 2 Vpp(diff) with a voltage window -1.0 to +3.3. V
- trise/fall 20%/80% < 18ps (typical)
- Ultra-low intrinsic jitter
- Multi-module synchronization up to 16 channels per 5-slot AXIe chassis

Target applications:

Due to its versatility, the M8195A AWG is ideal for creating the signals required for digital applications, optical and electrical communication, advanced research, wideband radar and satcom. It has four independent, precisely synchronized output channels for driving dual-polarization systems in optical applications. The M8195A supports multi-level signaling techniques required in mobile applications such as MIPI C-PHY, and is perfect for physics, chemistry and electronics researchers working on advanced technologies. The M8195A can also address communications/satcom requirements, such as extremely wide instantaneous bandwidth from DC to the Ku-Band.

Complementary products

81195A Optical Modulation Generator Software

Infiniivision DSAV254A V-series oscilloscope

M8197A Multi-Channel Synchronization Module

www.keysight.com/find/m8195A

M8196A 92 GSa/s Arbitrary Waveform Generator

The M8196A arbitrary waveform generator (AWG) is based on AXIe standard and has the highest sample rate plus the widest bandwidth in its class. A single module can be configured with up to four synchronized channels operating simultaneously.


Arbitrary

Key features

- Sample rate up to 92 GSa/s (on up to 4 channels simultaneously) with 32 GHz Analog bandwidth
- 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 1 Vpp(se) or 2 Vpp(diff.) with a voltage window –1.0 to +2.5 V
- trise/fall (20%/80%) < 9 ps (typical)
- Ultra-low intrinsic jitter
- Built-in frequency and phase response calibration for clean output signals

Target applications:

The AWG is ideally suited for 200G, 400G and 1 Terabit coherent optical applications including LR4, CFP2-ACO, and Coherent. With up to 4 channels per 1-slot AXIe module, each running at up to 92 GSa/s with 32 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 an outstanding speed of 64 GBaud and beyond. The M8196A AWG can generate any arbitrary waveform you can mathematically describe. This includes ultrashort yet precise pulses down to 20 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.

Complementary products
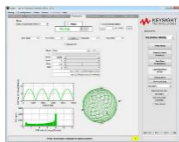
81195A Optical Modulation
Generator Software

Infiniivision DSAV334A
V-series oscilloscope

M8040A High Performance
BERT

www.keysight.com/find/m8196A

M9195B Digital Stimulus/Response

The Keysight M9195B PXIe digital stimulus/response module is ideal for IC design validation and production test environments. It can be configured for synchronized cyclized digital data, for parametric measurements, or for static digital IO.
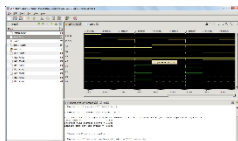

Data

Pattern

Key features

- 16 bidirectional channels with per-pin programmable logic levels
- Up to 250 MHz pattern rate, 125 Mvectors/channel memory
- 1 ns, per-vector, edge placement resolution
- Highly flexible, per-bit timing control for fast and accurate waveform development
- Per-channel programmable delay to compensate for cable and fixture propagation delays
- Real-time compare on response channels
- Multi-module synchronization for up to 12 modules (192 channels)
- Hardware triggers and markers for test system synchronization
- Per-channel Parametric Measurement Unit (PPMU)

Target applications:

- RFFE bus emulation used in PA/FEM semiconductor device verification or production test
- Wireless communication devices using parallel or serial digital control
- Automated test in product validation or manufacturing test
- Backplane emulation for device, board, or module testing
- Digital serial and parallel applications

Complementary products

M9192/3A Pattern Editor and data converters software

Infiniivision 6000 X-series oscilloscopes

Y1245A – Y1255A DSR Accessories

www.keysight.com/find/m9195b

M9330A/31A and N824xA Arbitrary Waveform Generators

The Keysight M9330A and M9331A with their high resolution and high sampling rate deliver unprecedented performance in arbitrary waveform creation. The equivalent to these PXI-modules are the benchtop instruments N8241A and N8242A.

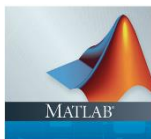Arbitrary

I/Q signals

Function

Key features

- Up to a 1.25 GSa/s sample rate with 500 MHz modulation bandwidth per channel (1 GHz IQ bandwidth)
- 10- or 15-bit vertical resolution depending on model
- 8 to 16 MSa/channel memory
- Two differential channels with up to a 1 Vpp output
- Triggerable with gate mode
- Advanced waveform sequencing
- Dynamic sequencing, direct digital synthesis, and function generator options
- Available in either PXI or LXI format
- Synchronize up to 8 AWGs for multi-emitter simulations and multi-path scenarios

Target applications:

The M9330A and the N8241A provide the most realistic waveforms for radar, satellite and frequency agile communication systems, thanks to their 15-bit vertical resolution and 1.25 GSa/ s sampling rate. At the same speed, with 10-bit vertical resolution, the M9331A is ideal for compliance testing of digital radios targeted for use with communication standards such as MB-OFDM ultra-wide-band, 802.11n, MIMO and proprietary wideband formats.

Complementary products

N6171A MATLAB
development software

Infiniivision 3000 and 4000 X-series oscilloscopes

M9243A or P9243A
Infiniivision oscilloscopes

www.keysight.com/find/m9330a
www.keysight.com/find/n8241a

M9336A and P9336A Arbitrary Waveform Generators

The Keysight Technologies M9336A and P9336A PXIe Arbitrary Waveform Generators provide multiple independent or synchronized signal outputs with exceptional performance in either a single-slot PXIe module or a compact USB3 format.

Arbitrary

I/Q Signals

Key features

- Three differential or single-ended signal channels with SMB connectors
- 16-bit amplitude resolution with up to 3.6 Vpp
- Keysight exclusive Trueform waveform generation utilizing a 1.28 GSa/s sample rate
- Up to 540 MHz bandwidth per channel (1080 MHz I/Q modulation bandwidth)
- Per-channel control of channel skew, gain, and offset
- Highly flexible waveform definition and sequencing with up to 4 GB of waveform sample and waveform sequencing memory
- Front panel and PXIe backplane triggers and markers (up to 8 markers/channel)
- Simple to use soft front panel

Target applications:

This AWG is ideal for creating digitally modulated waveforms for wideband communication systems and high-resolution waveforms for radar and satellite test. Industry standard waveforms for the AWG can be easily generated using Keysight software applications tools such as Signal Studio or Waveform Creator. In addition to these tools, users can generate their own waveforms using MATLAB or custom tools. The AWG provides standard IVI compliant drivers for integration with multiple application development environments.

Complementary products

Keysight Signal Studio Software

Infiniivision 3000 and 4000 X-series oscilloscopes

E8267D PSG Vector Signal Generator

www.keysight.com/find/m9336Aa
www.keysight.com/find/p9336a

Related Literature

Publication title	Pub number
33500B Series Waveform Generators Data Sheet	5991-0692EN
33600A Series Trueform Waveform Generators Data Sheet	5991-3272EN
81133A and 81134A 3.35 GHz Pulse Pattern Generators Data Sheet	5988-5549EN
81150A and 81160A Pulse Function Arbitrary Noise Generator Data Sheet	5989-6433EN
81150A and 81160A Pulse Function Arbitrary Noise Generators Applications	5989-7860EN
M3201A PXIe AWG Data Sheet	5992-1797EN
M3202A PXIe AWG Data Sheet	5992-1798EN
M8020A High-performance BERT Data Sheet	5991-3647EN
M8020A High-Performance BERT - Configuration Guide	5991-4032EN
M8062A 32 Gb/s Front-End for the M8020A	5992-0987EN
M8040A High-performance BERT Data Sheet	5992-1525EN
M8190A 12GSa/s Arbitrary Waveform Generator Data Sheet	5990-7516EN
M8190A Arbitrary Waveform Generator - Configuration Guide	5991-1401EN
M8195A 65GSa/s Arbitrary Waveform Generator Data Sheet	5992-0014EN
M8196A 92 GSa/s Arbitrary Waveform Generator Data Sheet	5992-0971EN
M9195B PXIe Digital Stimulus/Response Data Sheet	5992-1396EN
M9330A Arbitrary Waveform Generator 15-bit, 1.25 GS/s Data Sheet	5990-6426EN
M9331A Arbitrary Waveform Generator 10-bit, 1.25 GS/s Data Sheet	5990-6421EN
M9336A PXIe I/Q Arbitrary Waveform Generator	5992-2140EN
P9336A USB I/Q Arbitrary Waveform Generator	5992-2769EN
N8241A Arbitrary Waveform Generator Synthetic Instrument Module	5989-2595EN
N8242A Arbitrary Waveform Generator Synthetic Instrument Module	5989-5010EN
10 Hints for Getting More from Your Function Generator	5989-1456EN
Trueform Waveform Generation Technology - Technical Overview	5991-0852EN
How to Easily Create an Arbitrary Waveform Without Programming	5992-2673EN
Fundamentals of Arbitrary Waveform Generation, AWG Primer	M8190-91050

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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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