DATA SHEET

33500B and 33600A Series True*form* Waveform Generators 20, 30, 80, 120 MHz

- Built-in modulation and 17 popular waveforms
- Full bandwidth sine and square waves
- Lowest total harmonic distortion (THD) in its class
- One or two independent channels that can be coupled
- True*form* arbitrary waveform generation up to 1 GSa/s and 64 MSa

KEYSIGHT TECHNOLOGIES

33500B and 33600A Series True*form* Function / Arbitrary Waveform Generators

- Easily generate the full range of signals you need for the most demanding measurements
- Test your devices with confidence that the waveform generator is outputting the signals you expect
- Select just the capabilities you need now, then upgrade easily when your needs change

Features

The 33500B and 33600A Series True*form* Function / Arbitrary waveform generators offer a variety of capabilities you can't find anywhere else—capabilities designed to help you accelerate your testing and get your project completed faster.

EASE OF USE	Large, color, graphical display offers simultaneous parameter setup, signal viewing, and editing along with a help system. Most standard waveforms and modulation are built-in including signal summing.
SIGNAL INTEGRITY	True*form* offers precise, low noise signals with the lowest jitter and harmonic distortion in its class. Create full bandwidth sine and square waves with True*form* generators.
TRUE*FORM* ARBS	True*form* arbs ensure every waveform point is accurately represented, with up to 64 MSamples per channel. Segment waveforms to simplify waveform creation and save memory, connect up to 512 segments.
PULSE GENERATOR	Create a single pulse, a burst of pulses, or a steady pulse train with high bandwidth, up to 100 MHz. Set leading and trailing edge times independently down to 2.9 ns.
2-CHANNEL COUPLING	Quickly synchronize the independent outputs to share the same frequency, amplitude or both. The phase between the channels is also adjustable.
CONNECTIVITY	Use LAN, GPIB, USB, and USB thumb drive to automate testing or download waveforms. BenchVue Function Generator Control & Automation app simplifies the creation of waveforms and control of multiple instruments.
UPGRADEABILITY	Protect your investment. Configure your instrument, for now, and easily upgrade later.

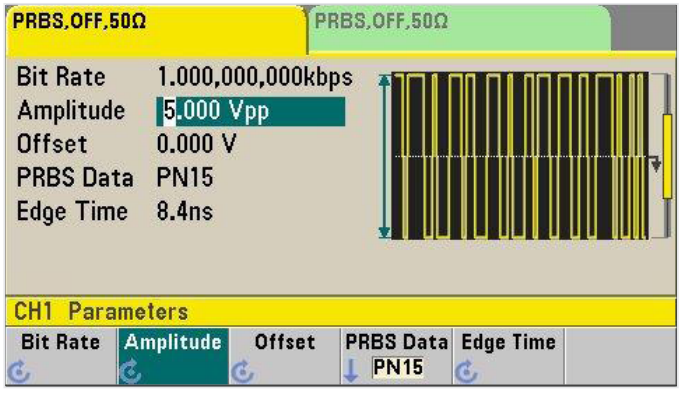
Ease of Use: All the Features You Expect

The 33500B and 33600A Series function / arbitrary waveform generators offer the standard signals and features you expect, such as modulation, sweep, and burst. However, it also provides features that give you the capabilities and flexibility you need to get your job done quickly, no matter how complex. An intuitive front-panel user interface, for example, can be quickly and easily relearned when your attention has been focused elsewhere. And that is just the beginning.

- Large, color, graphical display offers simultaneous parameter setup, signal viewing and editing for easy operation
- Two independent channels which can be coupled in amplitude and frequency
- Front-panel USB thumb drive port for file management
- Built-in help system
- LAN (LXI Core), USB and optional GPIB connectivity for quick and easy connectivity to a PC or network
- External triggering

Modulation and built-in waveforms

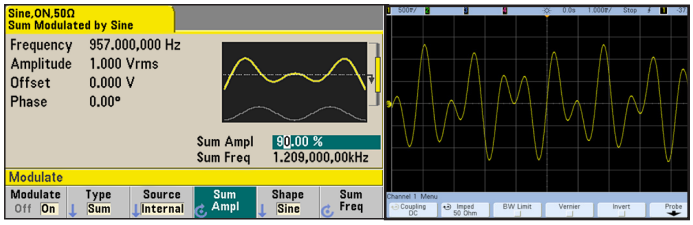
17 arbitrary waveforms built-in, including standard waveforms such as sine, square, ramp, PRBS and Gaussian Noise. As well as specialty waveforms: Cardiac, Haversine, and Lorentz. Built-in modulations include AM, FM, PM FSK and PWM.



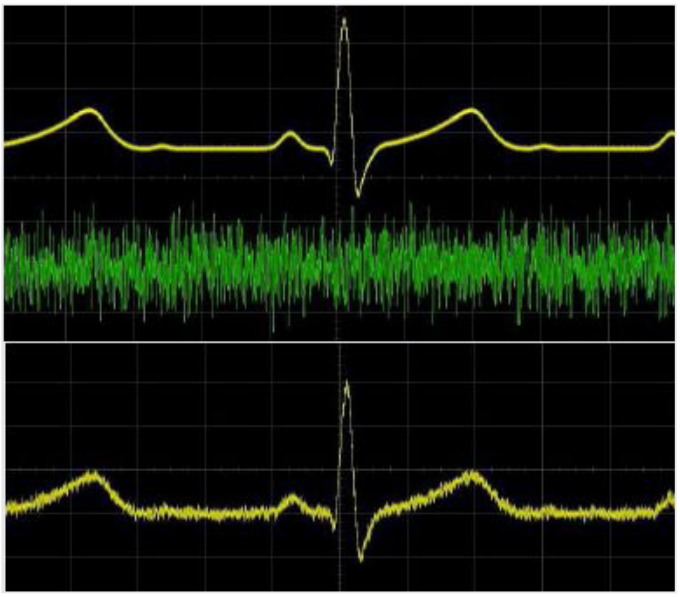
Test your digital serial buses by streaming standard PRBS patterns—PN3 through PN32.

Waveform summing and combining capability

Add noise to your signal for margin and distortion testing using only a single channel. You can create dual-tone multi-frequency signals without a dual-channel generator, which means you can preserve your budget for other test needs. On a two-channel model, you can sum and combine up to four signals.



Dual-tone signal created by summing waveforms using the modulation type “Sum”.



Add variable BW noise to any signal.

Smartphone and tablet access to full documentation

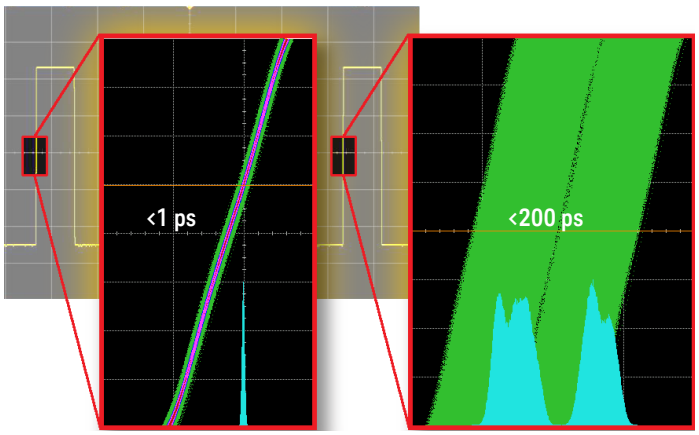
Need a quick answer? Get instant access to instrument documentation in seven different languages in smartphone-friendly WebHelp format. You can access all user documentation in the palm of your hand—no PC or hardcopy manuals required. Another feature you will not find in comparable function/arb generators.

Signal Integrity: Outputting the Signals You Expect

If your generator is introducing spurious signals or harmonics, you'll have a hard time producing reliable designs. To be successful, you need to test with clean, precise, low-noise signals. Keysight True*form* function / arbitrary waveform generators offer the highest signal fidelity so you can generate the exact waveforms you need for your most challenging measurements. You can be confident you are seeing your design's characteristics, and not that of your waveform generator, in your measurements.

Lowest jitter

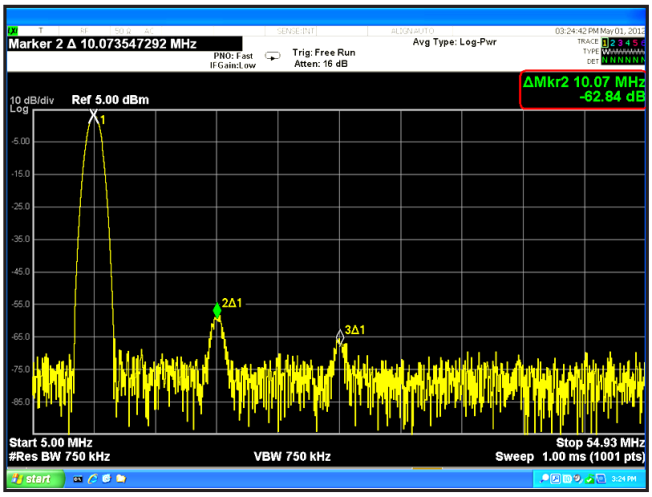
With jitter as low as 1 ps, True*form* function / arbitrary waveform generators offer exceptional edge stability. You can even use them as a system clock for timing and triggering your other instruments. With better jitter performance, you can place edges more accurately, helping you reduce timing errors in your circuit design.



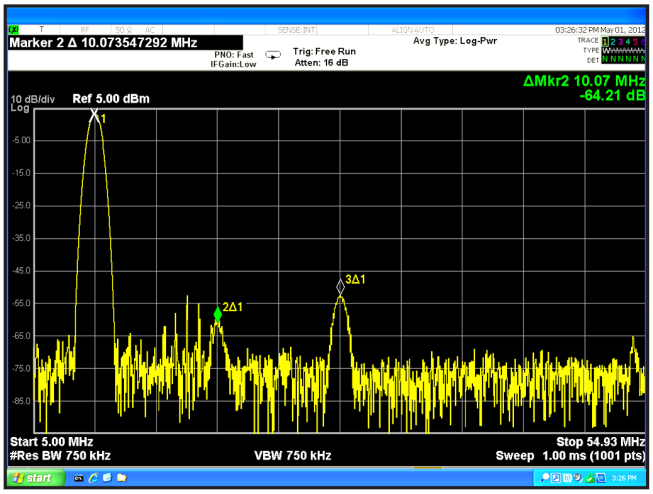
True*form* technology shown on the left significantly improves jitter performance compared to a traditional function generator shown on the right.

Lowest harmonic distortion

With total harmonic distortion of just 0.03%, True*form* waveform generators offer up to 5x better fidelity than other generators. Clean, spurious-free signals don't introduce noise or artifacts. See your design's characteristics, not the waveform generator's, in your measurements.



True*form* function / arbitrary waveform generators offer the lowest total harmonic distortion (THD) in its class.



Typical direct digital synthesizer (DDS) generator has a higher noise floor and greater harmonics.

Reproduce lower-voltage output signals

Today's ultra-low-power products such as pacemakers, hearing aids and remote sensors use very low voltages. With True*form* function / arbitrary waveform generators, you can create signals as low as 1 mVpp. That is a 10x lower voltage range than typical waveform generators.

Use the optional high-stability time base for even better accuracy

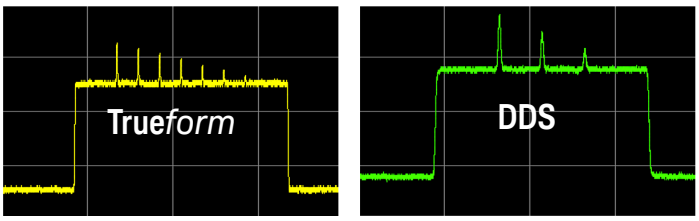
Get improved time-based stability and frequency accuracy using the optional high-stability time base. The optional timebase offers 0.1 ppm stability, which is 20x more stable than the standard time base over one year.

Trueform Arbs: Generating a Full Range of Signals for the Most Demanding Requirements

Trueform function / arbitrary waveform generators use a technology that plays every point in your signal exactly as you designed it. That means to test the robustness of your design, you can create a specific signal with noise, overshoots, spikes and dropouts just where you need them.

Non aliasing

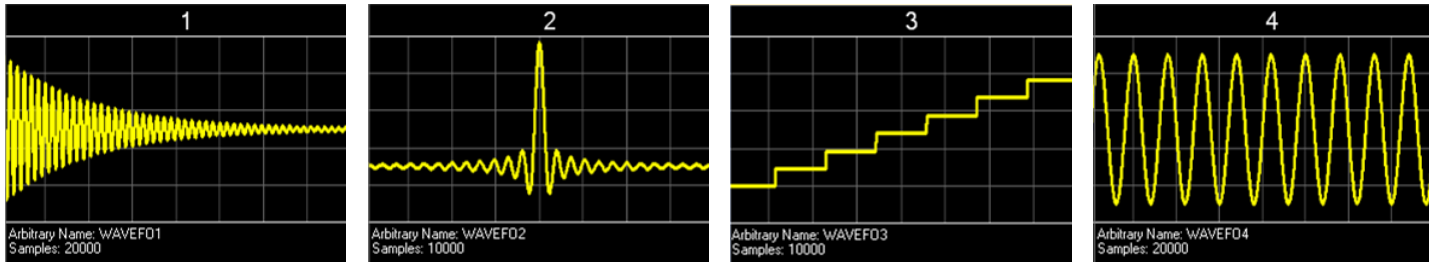
Define any waveform shape and any waveform length using the Trueform arbitrary waveform capability. Play your signals as defined, at your exact sample rate, without the chance of missing short-duration anomalies that are critical for testing device reliability.



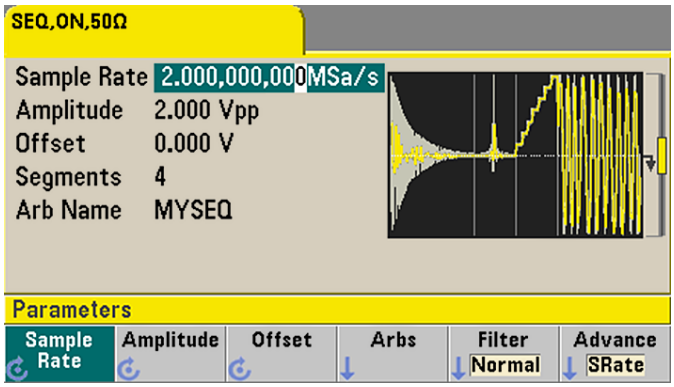
While DDS technology may skip points at higher frequencies, Trueform never skips points and is always anti-aliased.

Waveform sequencing

Waveform sequencing lets you create multiple configured waveforms with several common segments and lets you build long, complex waveforms using minimal instrument memory.



Sequence of desired signals.



Waveform generator display of the desired sequence.

Standard deep memory

If you want to test your design with long, complex waveforms with a variety of anomalies, you need to make sure your waveform generator has sufficient memory. The 33500B and 33600A Series come standard with 1 M Samples and 4 M Samples deep memory respectively. Typical DDS generators offer only a fraction of that capacity. In addition to this, higher memory options up to 64 MSamples are available to handle your most complex waveforms.

How does Keysight get such revolutionary advances over previous generation DDS signal generation?

As with any technology, DDS has its limitations. Engineers with exacting requirements have had to either work around the compromised performance or spend up to 5 times more for a high-end, point-per-clock waveform generator.

Keysight's True*form* 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. True*form* technology uses an exclusive digital sampling technique that delivers unmatched performance at the same low price you are accustomed to with DDS.

You can find a detailed comparison of DDS and True*form* technology in the Technical Overview- True*form* Waveform Generation Technology

Signal integrity improvements of True*form* technology over DDS					
	DDS: Traditional 25 MHz waveform generator	**True*form*: Keysight 20 MHz and 30 MHz waveform generators**	**DDS: Traditional 100 MHz waveform generator**	**True*form*: Keysight 80 MHz and 120 MHz waveform generators**	**Improvements**
Edge jitter	< 500 ps	< 40 ps	< 200 ps	< 1 ps	12x to 200x better
Custom waveform replication	Skips waveform points	100% point coverage	Skips waveform points	100% point coverage	Exact waveform replication
Total harmonic distortion	0.2%	0.04%	0.2%	0.03%	Up to 5x better
Anti-alias filtering	Must provide externally	Always anti-aliased	Must provide externally	Always anti-aliased	No anti-aliasing artifacts
Sequenced arb	Not possible	Standard	Not possible	Standard	Easy creation of complex waveform sequences

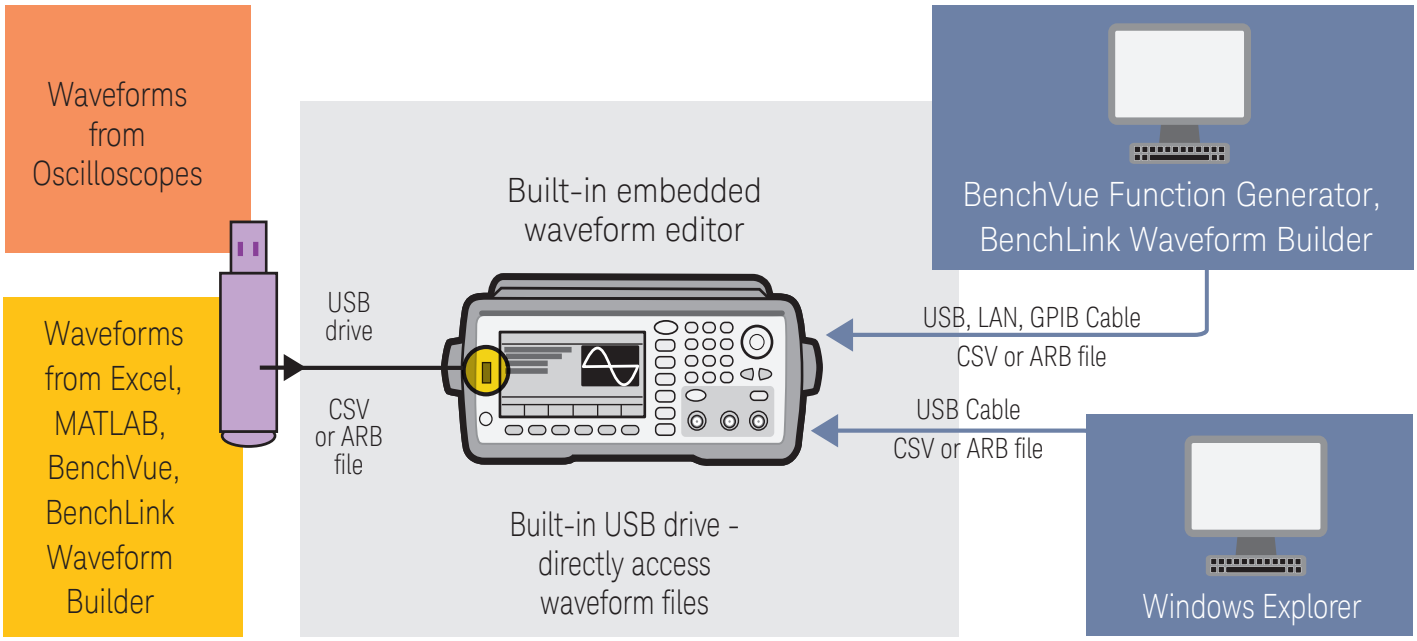
Pulse Generator with Fast Edge Times

Create pulses up to 100 MHz with the True*form* function / arbitrary waveform generators. Most DDS-based generators offer reduced bandwidth when generating pulses. True*form* waveform generators produce higher harmonic content, allowing for rapid transitions. Like a dedicated pulse generator, edge times can be set independently down to 2.9 ns, which is twice as fast as a typical function generator.

Channel Coupling with Baseband Generation Capability

Channel coupling simplifies the operation of a two-channel function generator. Both channels can be controlled with a single parameter for phase, amplitude, or frequency, making it simple to create differential or tracking signals. In addition, IQ signal generation has now been made easier with the IQ Baseband Signal Player for Trueform function / arbitrary waveform generators. The IQ Baseband Signal Player configures and controls both channels as if they were a single channel. It also keeps the phase of each channel in nominal IQ range. Quickly, go from simulation to signal generation to test your RF component or system design.

Connectivity: Flexibility in Creating and Playing Waveforms



Multiple interfaces provide flexibility for creating and downloading waveforms.

Keysight BenchVue Software (Now Included)

Keysight BenchVue software for the PC makes it simple to connect, control instruments, and automate test sequences so you can quickly move past the test development phase and access results faster with just a few clicks.

The Function Generator Control & Automation App within BenchVue is now included with your instrument purchase.

- Point and click to control your function generators
- Advanced waveform creation and editing capability with embedded Keysight BenchLink Waveform Builder Pro
- Load custom arbitrary waveforms from files
- Drag-and-drop measured traces easily from the BenchVue Oscilloscope App
- Rapidly build custom test sequences with Test Flow
- Remotely monitor and control your function generators from anywhere via the BenchVue Mobile app
- Access deeper instrument controls with Command Expert integration
- Intuitively control, automate and simplify testing with your function generators, and hundreds of other Keysight instruments

Keysight BenchLink Waveform Builder Pro Software

Easily create custom waveforms with advanced waveform creation and editing software. The application is now included within the Function Generator App.

- Library of signals
- Freeform draw and edit
- Equation editor, waveform math
- Apply filters and windowing functions
- Create waveform sequences

Download BenchVue software at no cost today
visit www.keysight.com/find/benchvue

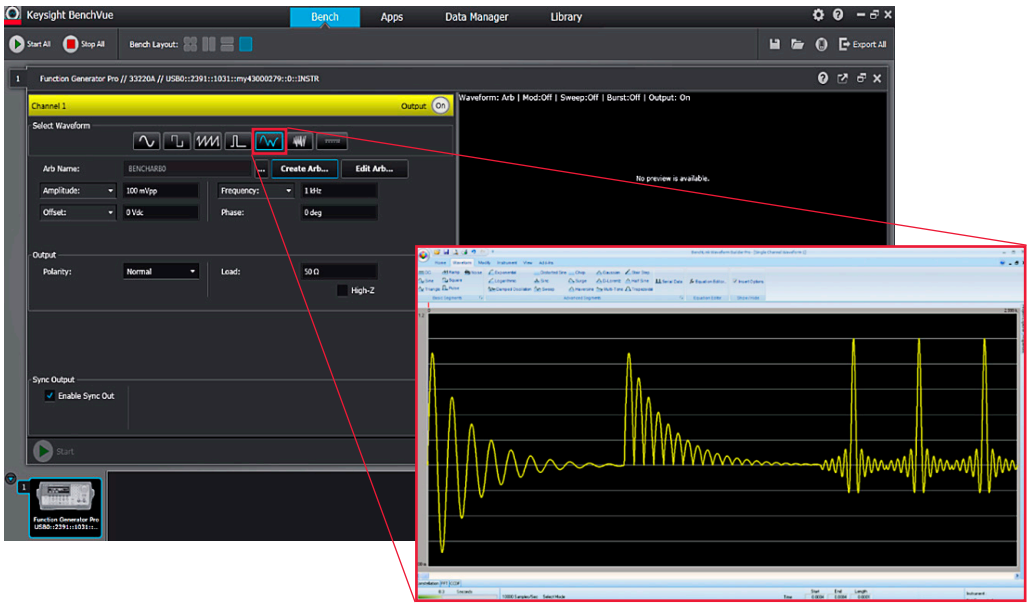


Figure 1. Design and build arbitrary waveform with Benchlink Waveform Builder Pro within BenchVue Function Generator App.

Select the Capabilities You Need Now, Then Upgrade Easily When Your Needs Change

With most waveform generators, you get what you pay for when you buy your instrument. However, with the 33500B and 33600A Series function / arbitrary waveform generators, there are four different models to choose from so you can purchase the capability you need now and simply upgrade later when your project needs change. Your investment in test equipment is protected. If you need deeper memory for generating more complex signals, you can easily add the capability later with software upgrades. And there's no price penalty for adding the capability later.

Configuration Guide

Step 1. Choose your bandwidth and channel count

Bandwidth	**20 MHz**	**20 MHz**	**30 MHz**	**30 MHz**	**80 MHz**	**80MHz**	**120 MHz**	**120 MHz**
Number of channels	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Waveform generator	33509B	33510B	33519B	33520B	-	-	-	-
Waveform generator with arbitrary capability	33511B	33512B	33521B	33522B	33611A	33612A	33621A	33622A

Step 2. Tailor your waveform generator for more demanding applications

Application	**Order option**
Additional memory for long waveforms	MEM (only available on models with arbitrary)
Security features with NISPOM	SEC
OCXO-high stability timebase	OCX

Step 3. Upgrade your waveform generator in the future

Upgrade desired	Order upgrade option (for 33500B series)	Order upgrade option (for 33600A series)
Increase bandwidth	335BW1U on 1-channel models (up to 30 MHz) 335BW2U on 2-channel models (up to 30 MHz)	336BW1U on 1-channel models (up to 120 MHz) 336BW2U on 2-channel models (up to 120 MHz)
Add arbitrary waveform capability	335ARB1U on 1-channel models 335ARB2U on 2-channel models	
Increase arbitrary memory	335MEM1U on 1-channel arb models (inc to 16M) 335MEM2U on 2-channel arb models (inc to 16M)	336MEM1U on 1-channel models (inc to 64M) 336MEM2U on 2-channel models (inc to 64M)
Add NISPOM and file security	335SECU	336SECU
Add high stability timebase	33500U-OCX (must return to Keysight)	33600U-OCX (must return to Keysight)
Add GPIB	-	3446GPBU (customer installable)

NOTE: A 1-channel generator cannot be "upgraded" to a 2-channel generator.

Specifications

Unless otherwise stated, all specifications apply with a 50-Ω resistive load and automatic amplitude range selection enabled.

Instrument characteristics

Models & options								
Model number	33509B 33511B	33510B 33512B	33519B 33521B	33520B 33522B	33611A	33612A	33621A	33622A
Maximum frequency	20 MHz	20 MHz	30 MHz	30 MHz	80 MHz	80 MHz	120 MHz	120 MHz
Number of channels	1	2	1	2	1	2	1	2
Option MEM	Increase arb waveform memory to 16 MSa/Channel [15]				Increase arb waveform memory from 4 MSa/Channel to 64 MSa/Channel			
Option SEC	Enables NISPOM and file security							
Option OCX	Oven-controlled frequency reference for improved stability, jitter, and phase noise							
Waveforms								
Standard	Sine, Square, Ramp, Pulse, Triangle, Gaussian Noise, PRBS (Pseudorandom Binary Sequence), DC							
Built-in arbitrary [15]	Cardiac, Exponential Fall, Exponential Rise, Gaussian Pulse, Haversine, Lorentz, D-Lorentz, Negative Ramp, Sinc							
User-defined arbitrary [15]	Up to 1 MSa (16 MSa with Option MEM) with multi segment sequencing				Up to 4 MSa (64 MSa with Option MEM) with multi segment sequencing			
Operating modes & modulation types								
Operating modes	Continuous, Modulate, Frequency Sweep, Counted Burst, Gated Burst							
Modulation types	AM, FM, PM, FSK, BPSK, PWM, Sum (carrier + modulation)							

Footnotes referenced on page 18

Waveform characteristics

Sine

Trueform Series	**33500B models**	**33600A models**	
Frequency range	**V_{OUT} ≤ 10 V_{pp}:** 1 µHz to 20 MHz or 30 MHz, 1-µHz resolution	**V_{OUT} ≤ 10 V_{pp}:** 1 µHz to 60 MHz, 1-µHz resolution **V_{OUT} ≤ 8 V_{pp}:** 1 µHz to 80 MHz, 1-µHz resolution **V_{OUT} ≤ 4 V_{pp}:** 1 µHz to 120 MHz, 1-µHz resolution[1]	
Amplitude flatness (spec) [2,3,17] (relative to 1 kHz)	**V_{OUT} ≤ 10 V_{pp}** f_{OUT} < 100 kHz: ± 0.10 dB f_{OUT} 100 kHz to 5 MHz: ± 0.15 dB f_{OUT} 5 MHz to 20 MHz: ± 0.30 dB f_{OUT} 20 MHz to 30 MHz[16]: ± 0.40 dB	**V_{OUT} = 1 V_{pp}** f_{OUT} < 10 MHz: ± 0.10 dB f_{OUT} 10 MHz to 60 MHz: ± 0.20 dB f_{OUT} 60 MHz to 80 MHz: ± 0.30 dB f_{OUT} 80 MHz to 120 MHz[1]: ± 0.40 dB **V_{OUT} > 1 V_{pp}** f_{OUT} < 10 MHz: ± 0.10 dB f_{OUT} 10 MHz to 60 MHz: ± 0.25 dB f_{OUT} 60 MHz to 80 MHz: ± 0.40 dB f_{OUT} 80 MHz to 120 MHz[1]: ± 0.50 dB	
Harmonic distortion (typ) [2,17]	**V_{OUT} ≤ 10 V_{pp}** f_{OUT} < 20 kHz: < -70 dBc f_{OUT} 20 kHz to 100 kHz: < -65 dBc f_{OUT} 100 kHz to 1 MHz: < -50 dBc f_{OUT} 1 MHz to 20 MHz: < -40 dBc f_{OUT} 20 MHz to 30 MHz[16]: < -35 dBc	**V_{OUT} = 1 V_{pp}** f_{OUT} < 1 MHz: -70 dBc f_{OUT} = 1 MHz to 10 MHz: -61 dBc f_{OUT} > 10 MHz: -43 dBc **V_{OUT} = 4 V_{pp}** f_{OUT} < 1 MHz: -69 dBc f_{OUT} = 1 MHz to 10 MHz: -58 dBc f_{OUT} > 10 MHz: -36 dBc **V_{OUT} = 8 V_{pp}** f_{OUT} < 1 MHz: -68 dBc f_{OUT} = 1 MHz to 10 MHz: -54 dBc f_{OUT} > 10 MHz: -40 dBc **V_{OUT} = 10 V_{pp}** f_{OUT} < 1 MHz: -67 dBc f_{OUT} = 1 MHz to 10 MHz: -51 dBc f_{OUT} > 10 MHz: -39 dBc	
THD (typ) [2]	**V_{OUT} ≤ 10 V_{pp}** f_{OUT} = 20 Hz to 20 kHz: <0.04%	**V_{OUT} = 1 V_{pp}** f_{OUT} = 20 Hz to 20 kHz: 0.03% **V_{OUT} > 1 V_{pp}** f_{OUT} = 20 Hz to 20 kHz: 0.04%	
Non-harmonic suprious (typ) [2,4,17]	Standard < -75 dBc, increasing 20 dB/decade above 2 MHz Option OCX: < -75 dBc increasing 20 dB/decade above 10 MHz (or < -100 dBm, whichever is greater, below 500 MHz)	f_{OUT} < 10 MHz: -80 dBc f_{OUT} = 10 MHz to 60 MHz: -75 dBc f_{OUT} > 60 MHz: -70 dBc	
Phase noise (SSB) (typ) [5]	**Standard** 1-kHz offset: -105 dBc/Hz 10-kHz offset: -115 dBc/Hz 100-kHz offset: -125 dBc/Hz	**Standard (80 MHz)** 100-Hz offset: -105 dBc/Hz 1-kHz offset: -116 dBc/Hz 10-kHz offset: -122 dBc/Hz 100-kHz offset: -129 dBc/Hz	**Standard (120 MHz) [1]** 100-Hz offset: -101 dBc/Hz 1-kHz offset: -112 dBc/Hz 10-kHz offset: -118 dBc/Hz 100-kHz offset: -125 dBc/Hz
	Opt OCX 1-kHz offset: -110 dBc/Hz 10-kHz offset: -125 dBc/Hz 100-kHz offset: -135 dBc/Hz	**Opt OCX (80 MHz)** 100-Hz offset: -114 dBc/Hz 1-kHz offset: -122 dBc/Hz 10-kHz offset: -125 dBc/Hz 100-kHz offset: -131 dBc/Hz	**Opt OCX (120 MHz) [1]** 100-Hz offset: -110 dBc/Hz 1-kHz offset: -118 dBc/Hz 10-kHz offset: -121 dBc/Hz 100-kHz offset: -127 dBc/Hz

Footnotes referenced on page 18

Waveform characteristics (continued)

Square & Pulse		
Trueform Series	**33500B models**	**33600A models**
Frequency ranges	**V_{OUT} ≤ 10 V_{pp}**	**V_{OUT} ≤ 10 V_{pp}**
	1 µHz to 20 MHz or 30 MHz, 1-µHz resolution	1 µHz to 50 MHz, 1-µHz resolution
		V_{OUT} ≤ 4 V_{pp}
		1 µHz to 100 MHz, 1-µHz resolution[1]
Rise and fall times (nom)	**V_{OUT} ≤ 10 V_{pp}**	**V_{OUT} ≤ 4 V_{pp}**
	Square: 8.4 ns, fixed Pulse: 8.4 ns to 1 µs, independently variable, 100-ps resolution	Square: 2.9 ns Pulse: 2.9 ns to 10 µs, independently variable, 100-ps resolution
		V_{OUT} > 4 V_{pp}
		Square: 4.0 ns Pulse: 3.3 ns to 10 µs, independently variable, 100-ps resolution
Overshoot (typ)	**V_{OUT} ≤ 10 V_{pp}**	**V_{OUT} ≤ 4 V_{pp}**
	< 2%	Square: < 4% Pulse, min edge: < 4% Pulse, 4-ns edge: < 2% Pulse, ≥ 6-ns edge: < 2%
		V_{OUT} > 4 V_{pp}
		Square: < 4% Pulse, min edge: < 7% Pulse, 4-ns edge: < 4% Pulse, ≥ 6-ns edge: < 2%
Duty cycle [6]	0.01% to 99.99%, 0.01% resolution	
Pulse width	**V_{OUT} ≤ 10 V_{pp}**	**V_{OUT} ≤ 4 V_{pp}**
	16 ns minimum, 100-ps resolution	5 ns minimum (high or low), 1-ps resolution
		V_{OUT} > 4 V_{pp}
		8 ns minimum (high or low), 1-ps resolution
Jitter (rms)(meas) [7]	1 Hz to 20MHz or 30 MHz band Standard: < 40 ps	10 Hz to 40 MHz band Standard: < 1 ps Opt OCX: < 0.5 ps

Ramp & Triangle		
Trueform Series	**33500B models**	**33600A models**
Frequency range	1 µHz to 200 kHz, 1-µHz resolution	1 µHz to 800 kHz, 1-µHz resolution
Ramp symmetry	0% to 100%, 0.1% resolution, (0% is negative ramp, 100% is positive ramp, 50% is triangle)	
Non-linearity (typ)	< 0.05% from 5% to 95% of the signal amplitude	

Gaussian Noise		
Trueform Series	**33500B models**	**33600A models**
Variable bandwidth (typ)	**V_{OUT} ≤ 10 V_{pp}**	**V_{OUT} ≤ 10 V_{pp}**
	1 mHz to 20 MHz or 30 MHz	1 mHz to 60 MHz
		V_{OUT} ≤ 8 V_{pp}
		1 mHz to 80 MHz
		V_{OUT} ≤ 4 V_{pp}
		1 mHz to 120 MHz[1]
Crest factor (nom)	4.6	4.6
Repetition period	> 50 years	> 100 years

Footnotes referenced on page 18

Waveform characteristics (continued)

Pseudorandom Binary Sequence (PRBS)						
Trueform Series	**33500B models**			**33600A models**		
Bit rate	**$V_{OUT} \leq 10\ V_{pp}$**			**$V_{OUT} \leq 10\ V_{pp}$**		
	1 mbps to 50 Mbps, 1-mbps resolution			1 mbps to 100 Mbps, 1-mbps resolution		
				$V_{OUT} \leq 4\ V_{pp}$		
				1 mbps to 200 Mbps, 1-mbps resolution[1]		
Sequence length	2^m - 1, m = 7, 9, 11, 15, 20, 23			2^m - 1, m = 3 to 32		
Rise & fall times (nom)	**$V_{OUT} \leq 10\ V_{pp}$**			**$V_{OUT} \leq 4\ V_{pp}$**		
				2.9 ns to 1 ms, independently variable, 100-ps resolution		
	8.4 ns to 1 µs, variable, 100-ps or 3-digit resolution			**$V_{OUT} > 4\ V_{pp}$**		
				3.3 ns to 1 ms, independently variable, 100-ps resolution		
Arbitrary waveforms						
Waveform length	8 Sa to 1 MSa per channel (16 MSa with opt MEM), in increments of 1 Sa			32 Sa to 4 MSa per channel (64 MSa with opt MEM), in increments of 1 Sa		
Sample rate	20 MHz models: 1 µSa/s to 160 MSa/s, 1-µSa/s resolution 30 MHz models: 1 µSa/s to 250 MSa/s, 1-µSa/s resolution			80 MHz models: 1 µSa/s to 660 MSa/s, 1-µSa/s resolution[8] 120 MHz models: 1 µSa/s to 1 GSa/s, 1-µSa/s resolution[8]		
Voltage resolution	16 bits			14 bits		
Waveform filters	"Normal" (highest bandwidth, ~5% preshoot and overshoot), "Step" (lower bandwidth, ~0% preshoot and overshoot), or "Off" (transitions from point to point occur as quickly as possible)					
Frequency and time characteristics	**Filter="Normal"**	**Filter="Step"**	**Filter="Off"**	**Filter="Normal"**	**Filter="Step"**	**Filter="Off"**
Bandwidth (-3dB)(nom)	0.27 x (Sa rate)	0.13 x (Sa rate)	40 MHz	0.27 x (Sa rate)	0.13 x (Sa rate)	100 MHz
Rise & fall time (nom)	0.35/bandwidth (10 ns min)	0.35/bandwidth (10 ns min)	10 ns	0.35/bandwidth (3.5 ns min)	0.35/bandwidth (3.5 ns min)	3.5 ns
Jitter(rms)(meas) [8]	< 5 ps	< 5 ps	< 40 ps	< 2 ps	< 1 ps	< 10 ps
Arb waveform sequencing [20]						
Operation	Individual arbitrary waveforms (segments) can be combined into user defined lists (sequences) to form longer, more complex waveforms. Each sequence step specifies whether to repeat the associated segment a certain number of times, to repeat indefinitely, to repeat until a Trigger event occurs, or to stop and wait for a Trigger event. Additionally, the behavior of the Sync output (Marker) can be specified in each step. To improve throughput, multiple sequences and segments can be pre-loaded into volatile memory.					
Segment length	8 Sa to 1 MSa per channel (16 MSa with Option MEM), in increments of 1 Sa			32 Sa to 4 MSa per channel (64 MSa with Option MEM), in increments of 1 Sa		
Sequence length	1 to 512 steps					
Segment repeat count	1 to $1x10^{10}$, or infinite			1 to $1x10^6$, or infinite		

Footnotes referenced on page 18

Waveform output characteristics (continued)

General	
Connector	Front-panel BNC, shell and pin isolated from chassis (±42 V maximum)
Function	On, Off, or Inverted
Output impedance (nom)	50 Ω
Isolation	Connector shells for channel output(s), Sync, and Mod In are connected together but isolated from the instrument's chassis. Maximum allowable voltage on isolated connector shell or pin is ±42 V relative to chassis.
Overload protection	Output turns off automatically when an overload is applied. Instrument will tolerate a short circuit to ground indefinitely.
Amplitude	
Range[9]	1 mVpp to 10 Vpp into 50 Ω, 4-digit resolution 2 mVpp to 20 Vpp into open circuit, 4-digit resolution
Units	Vpp, Vrms, or dBm
Accuracy (at 1 kHz) (spec) [3,17]	± (1% of setting in Vpp) ± (1 mVpp)
Voltage limit function	User-definable maximum and minimum voltage limits
DC offset	
Range[18]	± (5 VDC - Peak AC) into 50 Ω, 4-digit resolution ± (10 VDC - peak AC) into open circuit, 4-digit resolution
Units	VDC
Accuracy (spec) [3,17]	± (1% of Offset setting) ± (0.25% of amplitude in Vpp) ± (2 mV)
Frequency accuracy (spec)	
Standard frequency reference	± (1 ppm of setting + 15 pHz), 1 year, 23 °C ± 5 °C ± (2 ppm of setting + 15 pHz), 1 year, 0 °C to 55 °C
High stability frequency reference (Option OCX)	± (0.1 ppm of setting + 15 pHz), 1 year, 0 °C to 55 °C

Modulation, burst, and sweep capability

Carrier	AM	FM	PM	FSK	BPSK	PWM	Sum	Burst	Sweep
Sine & square	■	■	■	■	■		■	■	■
Pulse	■	■	■	■	■	■	■	■	■
Ramp & triangle	■	■	■	■	■		■	■	■
Gaussian noise	■						■	■ [10]	
PRBS	■	■	■				■	■	
Single arbitrary [20]	■	□	■		■		■	■	□
Sequenced arbitrary [20]	■						■		

Modulating signals

Carrier	Sine	Square	Ramp	Triangle	Noise	PRBS	Arbitrary[20]	External
Sine	■	■	■	■	■	■	■	■
Square & pulse	■	■	■	■	■	■	■	■
Ramp & triangle	■	■	■	■	■	■	■	■
Gaussian noise	■	■	■	■		■	■	■
PRBS	■	■	■	■	■		■	■
Arbitrary [20]	■	■	■	■	■	■		■

Footnotes referenced on page 18

Legend

■ All models

□ Only 33600A Series models

Modulation, burst, and sweep characteristics

Amplitude modulation (AM)	
Source	Internal or external (all models), or other channel (all 2-channel models)
Type	Full-Carrier or Double-Sideband Suppressed-Carrier (DSSC)
Depth [3,11]	0% to 120%, 0.01% resolution
Frequency modulation (FM) [12]	
Source	Internal or external (all models), or other channel (all 2-channel models)
Deviation	1 µHz to 15 MHz, 1-µHz resolution (all 33500 Series models) 1 µHz to 40 MHz, 1-µHz resolution (33611A/33612A) 1 µHz to 60 MHz, 1-µHz resolution (33621A/33622A)
Phase modulation (PM)	
Source	Internal or external (all models), or other channel (all 2-channel models)
Deviation	0° to 360°, 0.1° resolution
Frequency-shift key modulation (FSK)[12]	
Source	Internal timer or rear-panel connector
Mark & space	Any frequency within the carrier signal's range
Rate	≤ 1 MHz
Binary phase-shift key modulation (BPSK)	
Source	Internal timer or rear-panel connector
Phase shift	0° to 360°, 0.1° resolution
Rate	≤ 1 MHz
Pulse width modulation (PWM)	
Source	Internal or external (all models), or other channel (all 2-channel models)
Deviation[6]	0% to 100% of pulse width, 0.01% resolution
Additive modulation (Sum)	
Source	Internal or external (all models), or other channel (all 2-channel models)
Ratio[11]	0% to 100% of carrier amplitude, 0.01% resolution
Burst characteristics[10]	
Type	Counted or gated
Counted burst operation	Each trigger event causes the instrument to produce from 1 to 10^8 or an "infinite" number of waveform cycles
Gated burst operation	Instrument produces waveforms while the trigger is in the "on" state. For Gaussian Noise, waveform generation stops immediately when the trigger is in the "off" state. All other waveforms stop at the completion of a cycle; more than one cycle might elapse before generation stops.
Start/stop phase[19]	-360° to +360°, 0.1° resolution
Trigger source	Internal timer or rear-panel connector
Marker	Indicated by the trailing edge of the Sync pulse; adjustable to any cycle of the burst
Sweep characteristics[12]	
Type	Linear, Logarithmic, or List (up to 128 user-defined frequencies)
Operation	Linear and Logarithmic sweeps are characterized by a Sweep time (during which the frequency changes smoothly from Start to Stop), a Hold time (during which the frequency stays at the Stop frequency), and a Return time (during which the frequency changes smoothly from Stop to Start). Returns are always linear in the 33600A Series.
Direction	Up (start freq < stop freq) or Down (start freq > stop freq)

Footnotes referenced on page 18

Modulation, burst, and sweep characteristics (continued)

Sweep time	
Linear	1 millisecond to 3,600 seconds, 1-ms resolution 3,601 seconds to 250,000 seconds, 1-second resolution
Logarithmic	1 millisecond to 500 seconds, 1-ms resolution
Hold time	0 to 3,600 seconds, 1-ms resolution
Return time	0 to 3,600 seconds, 1-ms resolution
Trigger source[13,14]	Immediate (continuous), external (rear-panel connector), manual (front-panel button), bus or internal timer
Marker	Indicated by the trailing edge of the Sync pulse; adjustable to any frequency between Start and Stop for Linear and Logarithmic types or any frequency in the list for List type.
Internal timer for FSK, BPSK, burst, and sweep	
Range	1 µs to 8,000 seconds, 6-digit or 8-ns resolution (33500B Series models) 1 µs to 4,000 seconds, 4-ns resolution (33600A Series models)

Two-channel characteristics (all 2-channel models)

Standard		
True*form* Models	**33500B Series, 2-channel models**	**33600A Series, 2-channel models**
Standard		
Operating modes	Independent, Coupled parameter(s), Combined (Ch 1 + Ch 2), Equal (Ch 1 = Ch 2), or Differential (Ch 1 = –Ch 2)	
Parameter coupling	None, Frequency (ratio or difference) and/or Amplitude and DC offset	
Relative Phase	0° to 360°, 0.1° resolution	
Channel-to-channel skew (typ) (Both channels configured identically)	< 200 ps	< 100 ps
Crosstalk (typ)	< –85 dB	

IQ player characteristics (33512B, 33522B, 33612A, 33622A)

IQ player characteristics		
True*form* Series	**33512B/33522B**	**33612A/33622A**
Balance Adjust		
Operation	This enables a two-channel model with arbitrary waveform capability to function as a baseband IQ (quadrature modulation) source. Programmable impairments include amplitude imbalance, DC offset difference, and channel-to-channel time skew.	
Channel-to-channel amplitude balance[11]	-30% to +30%, 0.001% resolution	
Channel-to-channel DC offset difference	± (5 VDC - peak AC), 0.1-mV resolution into 50 Ω ± (10 VDC - peak AC), 0.2-mV resolution into open circuit	
Channel-to-channel time skew	-4 ns to +4 ns, 10-ps resolution	-1 ns to +1 ns, 10-ps resolution
Display views	Voltage versus Time or Constellation diagram (Channel 1 versus Channel 2)	

Note: IQ player is now a standard option on 33512B/22B and 33612A/22A models.

Sync/Marker output

True*form* Series	**33500B Series**	**33600A Series**
Sync/marker output		
Connector	Front-panel BNC, shell and pin isolated from chassis (± 42 V maximum)	
Functions	Sync, Sweep Marker, Burst Marker, Arbitrary Waveform Marker, or Off	
Assignment	Channel 1 or Channel 2	
Polarity	Normal or Inverted	
Output level (nom)	0 to +1.5 V into 50 Ω ; 0 to +3.0 V into high impedance	
Output impedance (nom)	50 Ω	
Minimum pulse width (nom)	16 ns	5 ns

Footnotes referenced on page 18

Modulation input

Trueform Series	33500B Series	33600A Series
Modulating input		
Connector	Rear-panel BNC, shell and pin isolated from chassis (±42 V maximum)	
Assignment	Channel 1, Channel 2, or both	
Voltage level (nom)	±5 V full-scale	±1 V or ±5 V full scale, selectable
Input Impedance (nom)	5 kΩ	
Bandwidth (–3 dB) (typ)	0 Hz to 100 kHz	

External trigger/gate input/output

Trueform Series	33500B Series	33600A Series
General characteristics		
Connector	Rear-panel BNC, chassis-referenced (functions as Input or Output)	
Assignment	Input: Channel 1, Channel 2, or both Output: Channel 1 or Channel 2	
Polarity	Positive or Negative Slope	
Maximum rate	1 MHz	
Input characteristics		
Threshold voltage (nom)	(Output level setting)/2	
Impedance (nom)	10 kΩ, DC-coupled	
Minimum pulse width	16 ns	100 ns
Variable Trigger Delay	0 to 1,000 s, 4-ns resolution	0 to 1,000 s, 1-ns resolution
Latency (typ)	< 135 ns with trigger delay set to zero	< 140 ns with trigger delay set to zero
Jitter (typ)	< 2.5 ns, rms	< 320 ps, rms
Output characteristics		
Output voltage (nom)		
Low level	0 V	
High level	3 Vpp (nom) into open circuit, 1.5 Vpp (nom) into 50 Ω	0.9 V to 3.8 V into open circuit, 0.1 V resolution
Impedance (nom)	50 Ω	
Duty cycle (nom)	50%	
Fan-out	Up to four Keysight Trueform waveform generators	

External frequency reference input/output

Trueform Series	33500B Series	33600A Series
Input characteristics		
Connector	Rear-panel BNC, shell and pin isolated from chassis and all other connectors (±42 V max.)	
Frequency range	Standard: 10 MHz ± 20 Hz Option OCX: 10 MHz ± 1 Hz	
Voltage	200 mVpp to 5 Vpp	
Impedence	1 kΩ || 20 pF, AC-coupled	
Lock time (typ)	< 2 s	
Output characteristics		
Connector	Rear-panel BNC, chassis-referenced	
Frequency (nom)	10 MHz	
Level (nom)	0 dBm (632 mVpp) into 50 Ω	
Impedance (nom)	50 Ω	

Footnotes referenced on page 18

Programming times

Trueform Series	33500B Series				33600A Series			
Configuration changes (meas)	**LAN (socket)**	**LAN (VXI-11)**	**USB 2.0**	**GPIB**	**LAN (socket)**	**LAN (VXI-11)**	**USB 2.0**	**GPIB**
Change function (meas)	5 ms	6 ms	5 ms	5 ms	29.2 ms	29.7 ms	29.4 ms	29.2 ms
Change frequency (meas)	2 ms	3 ms	2 ms	3 ms	2.7 ms	3.3 ms	2.8 ms	2.7 ms
Change amplitude (meas)	20 ms	20 ms	19 ms	22 ms	8.3 ms	9.0 ms	8.3 ms	8.3 ms
Select arbitrary waveform (16 k samples)(meas)	9 ms	11 ms	9 ms	9 ms	12.7 ms	13.9 ms	13.1 ms	12.6 ms
Arbitrary waveform download speed to volatile	**LAN (socket)**	**LAN (VXI-11)**	**USB 2.0**	**GPIB**	**LAN (socket)**	**LAN (VXI-11)**	**USB 2.0**	**GPIB**
4k samples (binary transfer)(meas)	6 ms	18 ms	8 ms	39 ms	6.4 ms	13.2 ms	6.6 ms	52.3 ms
1M samples (binary transfer)(meas)	1.3 s	2.6 s	13 s	9.1 s	1.26 s	2.40 s	1.25 s	12.3 s

Memory

Trueform Series	33500B Series	33600A Series
Arbitrary waveform		
Volatile	1 MSa/channel (16 MSa/channel with Option MEM). 512 sequence steps per channel	4 MSa/channel (64 MSa/channel with Option MEM). 512 sequence steps per channel
Non-volatile	64 MB in file system (~32 MSa of arbitrary waveform records)	970 MB in file system (~485 MSa of arbitrary waveform records)
Instrument state		
Store/recall	User defined instrument states (with user-defined names in file system)	
Power-On state	Default settings or state at power-off, selectable	
USB file system		
Front-panel port	USB 2.0 high-speed mass storage class (MSC) device	
Capability	Read or write instrument configuration settings, instrument states, arbitrary-waveform, and sequence files	
Speed (nom)	10 MB/s	

General characteristics

Trueform Series	33500B Series	33600A Series
Computer interfaces		
LXI-C (rev1.3)	10/100Base-T (Sockets & VXI-11 protocols) USB 2.0 (USB-TMC488 protocol) GPIB/IEEE-488.1, IEEE-488.2	
Web user interface	Remote operation and monitoring	
Programming language	SCPI-1999, IEEE-488.2 Keysight 33210A, 33220A and 33250A Series compatible	
Graphical display	4.3 inch color TFT, WQVGA (480x272) with LED backlight	
Real-time clock/calendar battery	CR-2032 coin type, replaceable, > 5-year life (typ)	
Mechanical		
Size (nom)	261.1 mm W x 103.8 mm H x 303.2 mm D (with bumpers installed) 212.8 mm W x 88.3 mm H x 272.3 mm D (with bumpers removed) 2U x 1/2 rack width	
Weight (nom)	3.3 kg (7.2 lbs.)	3.5 kg (7.7 lbs.)
Environmental		
Storage temperature	-40 °C to 70 °C	
Warm-up time	1 hour	
Operating environment	EN61010, pollution degree 2, indoor locations	
Operating temperature	0 °C to 55 °C	
Operating humidity	5% to 80% RH, non-condensing	
Operating altitude	Up to 3,000 meters	

Footnotes referenced on page 18

General characteristics (continued)

Trueform Series	33500B Series	33600A Series
Regulatory		
	Refer to the Declaration of Conformity Acoustic noise: Sound pressure level (1-m free-field)(nom) 35 dB(A) at $T_{AMBIENT} \leq 28$ °C	
Line power		
Line voltage	100 to 240 V, 50/60 Hz 100 to 120 V, 400 Hz	
Power consumption	< 45 W, < 130 VA	< 75 W, < 150 VA

Footnotes

1 Applies to 120 MHz models (33621A/22A) only.
2 DC Offset set to zero.
3 Add 1/10 of the specification per °C for operation at temperatures below 18 °C or above 28 °C.
4 At low amplitude, non-harmonic spurious level is -100 dBm (typ).
5 Measured with a Keysight E5052B signal source analyzer. Phase noise improves by 20 dB/decade as output frequency is decreased.
6 Subject to pulse width limits.
7 Measured with a Keysight E5052B signal source analyzer.
8 Maximum sample rate with Filter "Off" in 160 MSa/s for 80 MHz models and 250 MSa/s for 120 MHz models.
9 Maximum amplitude is less at high frequency for certain waveforms.
10 Counted burst is not available for Gaussian Noise.
11 Subject to amplitude limits.
12 All frequency changes are phase-continuous.
13 External trigger only for sweep time > 8,000 seconds.
14 Measured with a Square or Pulse waveform, edge time set to minimum, and trigger delay set to zero. Trigger latency is generally greater for other instrument settings. For some waveforms, trigger latency is a function of output frequency.
15 Only available on 33511B/12B/21B/22B models.
16 Only available on 33519B/20B/21B/22B models.
17 Auto range ON.
18 Output noise is typically 20 dB lower when (DC + Peak AC) < 320 mV (into 50 Ω) or 640 mV (into open circuit).
19 Limited to arbitrary waveforms that are < 1 million points, phase resolution limited by number of points in arbitrary waveforms < 3,600 points.
20 Only applies to 33511B/12B/21B/22B and 33611A/12A/21A/22A models.

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 to 55 °C and after a 1-hour warm up period. All specifications account for the effects of measurement and calibration-source uncertainties, 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 that 80% or more of manufactured instruments will meet. This data is not warranted, does not include measurement or calibration-source 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 product development for the purpose of communicating expected performance. This data is not warranted and is measured at room temperature (approximately 23 °C).

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