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DATA SHEET

# 33500B and 33600A Series Trueform 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.

| Features | Descriptions |
|---|---|
| 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 | Trueform offers precise, low noise signals with the lowest jitter and harmonic distortion in its class. Create full bandwidth sine and square waves with Trueform generators. |
| Trueform Arbs | Trueform 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 and 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

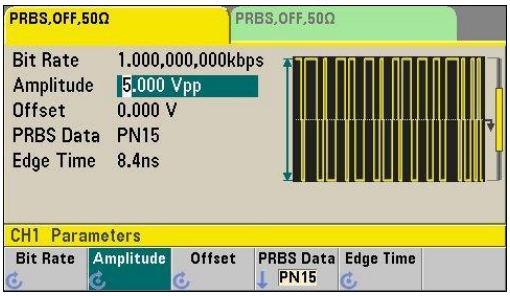
The 33500B and 33600A Series function/arbitrary waveform generators offer the standard signals and features you expect, such as modulation, sweep, and burst. However, it also provides features that give you the capabilities and flexibility you need to get your job done quickly, no matter how complex. 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

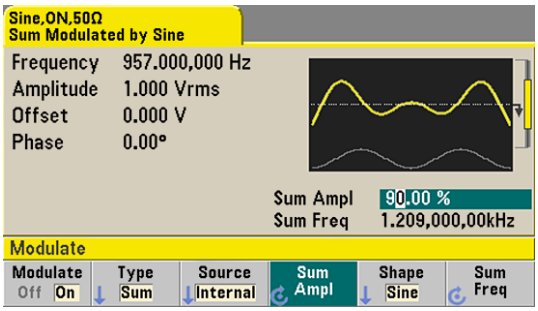
17 arbitrary waveforms built-in, including standard waveforms such as sine, square, ramp, PRBS and Gaussian Noise. As well as specialty waveforms: Cardiac, Haversine, and Lorentz. Built-in modulations include AM, FM, PM FSK and PWM.

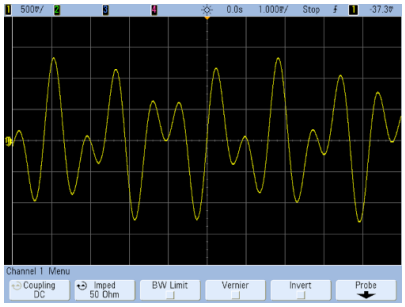



Test your digital serial buses by streaming standard PRBS patterns—PN3 through PN32.

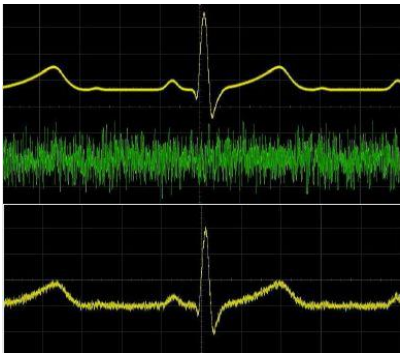
## Waveform summing and combining capability

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

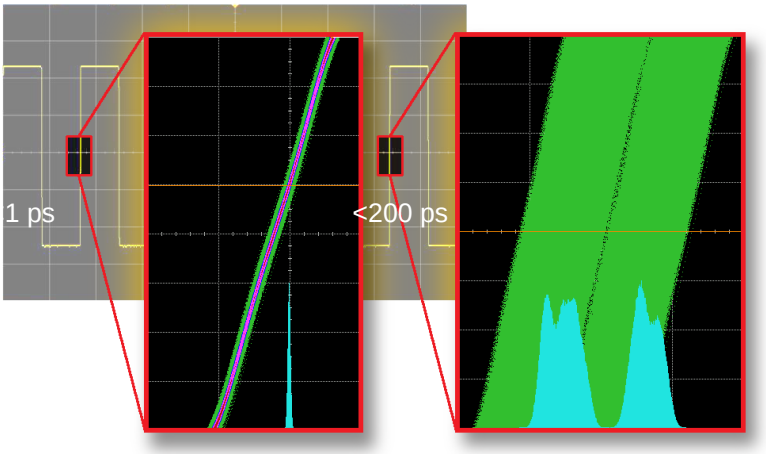
Need a quick answer? Get instant access to instrument documentation in seven different languages in smartphone-friendly WebHelp format. You can access all user documentation in the palm of your hand-no PC or hardcopy manuals required. Another feature you will not find in comparable function/arb generators.

## 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

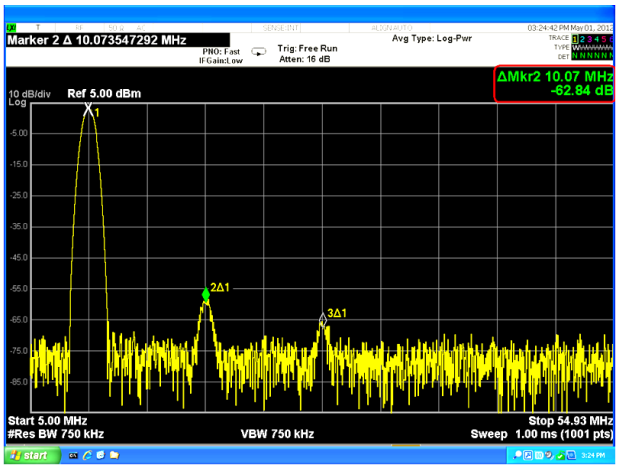
With jitter as low as 1 ps, True*form* function / arbitrary waveform generators offer exceptional edge stability. You can even use them as a system clock for timing and triggering your other instruments. With better jitter performance, you can place edges more accurately, helping you reduce timing errors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



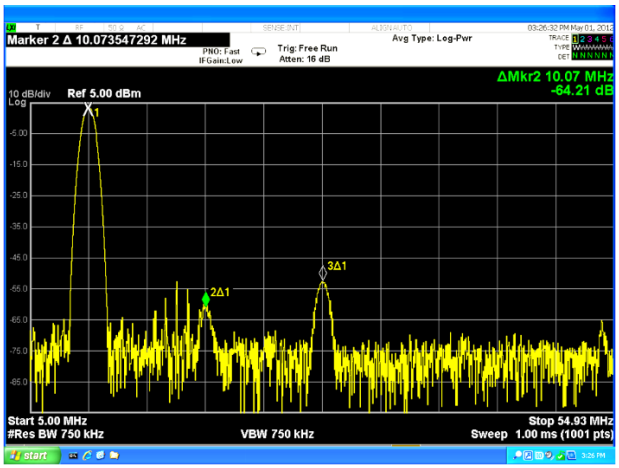

True*form* technology shown on the left significantly improves jitter performance compared to a traditional function generator shown on the right.

## 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

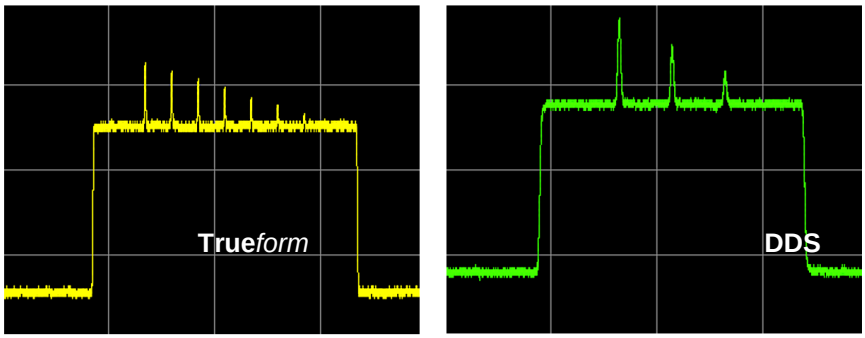
Get improved time-based stability and frequency accuracy using the optional high-stability time base. The optional timebase offers 0.1 ppm stability, which is 20x more stable than the standard time base over one year.

# True*form* Arbs: Generating a Full Range of Signals for the Most Demanding Requirements

True*form* 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

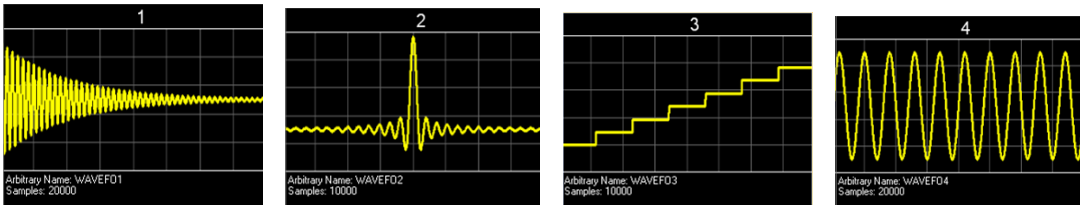
Define any waveform shape and any waveform length using the True*form* arbitrary waveform capability. Play your signals as defined, at your exact sample rate, without the chance of missing short-duration anomalies that are critical for testing device reliability.



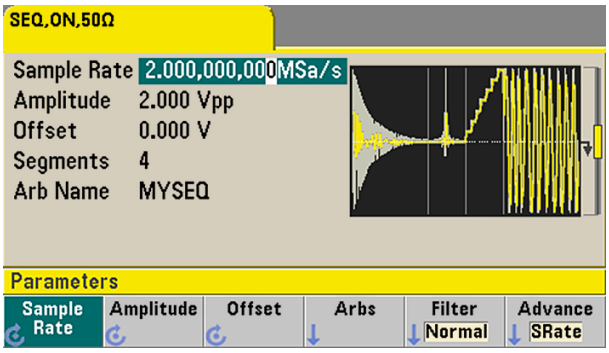

While DDS technology may skip points at higher frequencies, True*form* never skips points and is always anti-aliased.

## 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

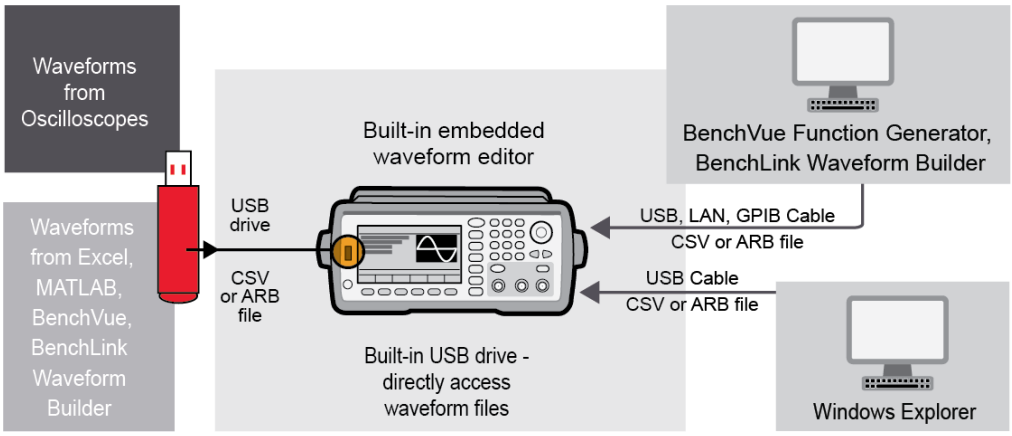
Create pulses up to 100 MHz with the True*form* function / arbitrary waveform generators. Most DDS-based generators offer reduced bandwidth when generating pulses. True*form* waveform generators produce higher harmonic content, allowing for rapid transitions. Like a dedicated pulse generator, edge times 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 True*form* 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 and 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

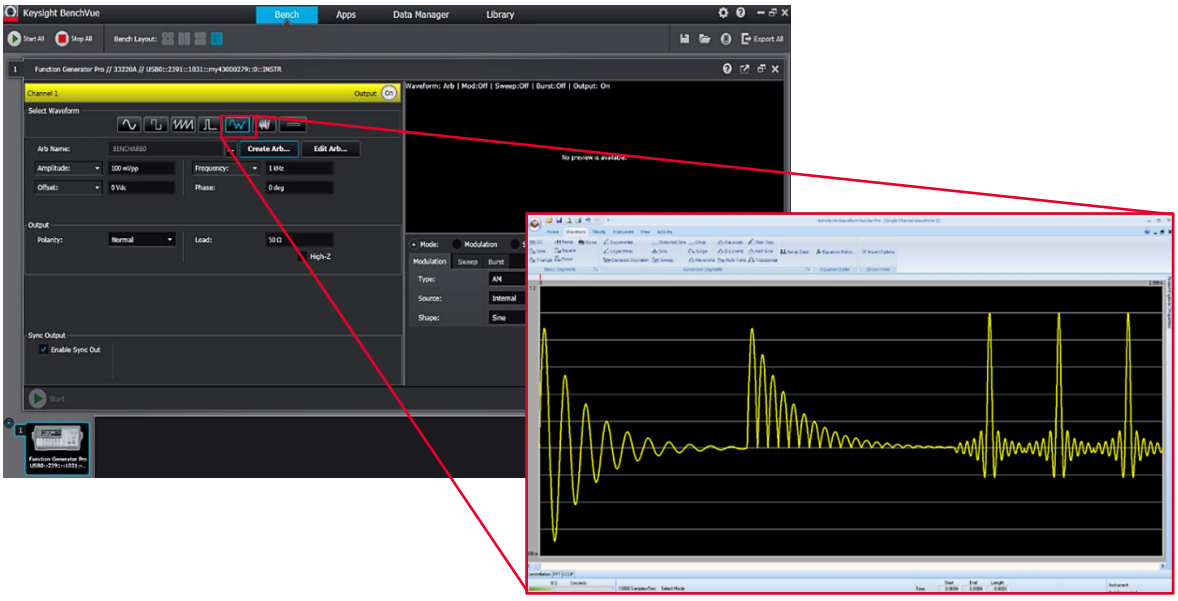



Figure 1. Design and build arbitrary waveform with Benchlink Waveform Builder Pro within BenchVue Function Generator App.

## 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 |
| OCX0-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) | 336BW1U on 1-channel models (up to 120 MHz) |
| | 335BW2U on 2-channel models (up to 30 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) | 336MEM1U on 1-channel models (inc to 64M) |
| | 335MEM2U on 2-channel arb models (inc to 16M) | 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) [3] | 33600U-OCX (must return to Keysight) [3] |
| Add GPIB | — | 3446GPBU (customer installable) |

## Step 4. Add on optional accessories

| Optional accessories | Description |
|---|---|
| 34162A | Accessory pouch |
| 1CM124A | Rackmount kit with filler panel |
| 1CM107A | 2U dual flange kit (mounting two instruments side-by-side) |
| 34194A | Dual Lock link kit (to connect the two units together) |

Note:
1. A 1-channel generator cannot be “upgraded” to a 2-channel generator.
2. GPIB option is included as standard for 33500B Series.
3. This option upgrade must be returned to Keysight for installation and calibration.
4. Option IQP is included as standard in 33512B/22B and 33612A/22A models.

# Specifications

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

## Instrument characteristics

| Models and options | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model number | 33509B | 33510B | 33519B | 33520B | 33611A | 33612A | 33621A | 33622A |
| | 33511B | 33512B | 33521B | 33522B | | | | |
| 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 [20] | Cardiac, Exponential Fall, Exponential Rise, Gaussian Pulse, Haversine, Lorentz, D-Lorentz, Negative Ramp, Sinc | | | | | | | |
| User-defined arbitrary [20] | 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 and 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 30.

## 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<br>**$V_{OUT}$ ≤ 8 $V_{pp}$:** 1 µHz to 80 MHz, 1-µHz resolution<br>**$V_{OUT}$ ≤ 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 $V_{pp}$** | **$V_{OUT}$ = 1 $V_{pp}$** |
| | $f_{OUT}$ < 100 kHz: ± 0.10 dB<br>$f_{OUT}$ 100 kHz to 5 MHz: ± 0.15 dB<br>$f_{OUT}$ 5 MHz to 20 MHz: ± 0.30 dB<br>$f_{OUT}$ 20 MHz to 30 MHz[16]: ± 0.40 dB | $f_{OUT}$ < 10 MHz: ± 0.10 dB<br>$f_{OUT}$ 10 MHz to 60 MHz: ± 0.20 dB<br>$f_{OUT}$ 60 MHz to 80 MHz: ± 0.30 dB<br>$f_{OUT}$ 80 MHz to 120 MHz[1]: ± 0.40 dB |
| | | **$V_{OUT}$ > 1 $V_{pp}$** |
| | | $f_{OUT}$ < 10 MHz: ± 0.10 dB<br>$f_{OUT}$ 10 MHz to 60 MHz: ± 0.25 dB<br>$f_{OUT}$ 60 MHz to 80 MHz: ± 0.40 dB<br>$f_{OUT}$ 80 MHz to 120 MHz[1]: ± 0.50 dB |
| Harmonic distortion (typ) [2, 17] | **$V_{OUT}$ ≤ 10 $V_{pp}$** | **$V_{OUT}$ = 1 $V_{pp}$** |
| | $f_{OUT}$ < 20 kHz: < -70 dBc<br>$f_{OUT}$ 20 kHz to 100 kHz: < -65 dBc<br>$f_{OUT}$ 100 kHz to 1 MHz: < -50 dBc<br>$f_{OUT}$ 1 MHz to 20 MHz: < -40 dBc<br>$f_{OUT}$ 20 MHz to 30 MHz[16]: < -35 dBc | $f_{OUT}$ < 1 MHz: -70 dBc<br>$f_{OUT}$ = 1 MHz to 10 MHz: -61 dBc<br>$f_{OUT}$ > 10 MHz: -43 dBc |
| | | **$V_{OUT}$ = 4 $V_{pp}$** |
| | | $f_{OUT}$ < 1 MHz: -69 dBc<br>$f_{OUT}$ = 1 MHz to 10 MHz: -58 dBc<br>$f_{OUT}$ > 10 MHz: -36 dBc |
| | | **$V_{OUT}$ = 8 $V_{pp}$** |
| | | $f_{OUT}$ < 1 MHz: -68 dBc<br>$f_{OUT}$ = 1 MHz to 10 MHz: -54 dBc<br>$f_{OUT}$ > 10 MHz: -40 dBc |
| | | **$V_{OUT}$ = 10 $V_{pp}$** |
| | | $f_{OUT}$ < 1 MHz: -67 dBc<br>$f_{OUT}$ = 1 MHz to 10 MHz: -51 dBc<br>$f_{OUT}$ > 10 MHz: -39 dBc |

Footnotes referenced on page 30.

| | | | |
|---|---|---|---|
| THD (typ) [2] | **$V_{OUT}$ ≤ 10 $V_{pp}$** | **$V_{OUT}$ = 1 $V_{pp}$** | |
| | $f_{OUT}$ = 20 Hz to 20 kHz: <0.04% | $f_{OUT}$ = 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<br>Option OCX: < -75 dBc increasing 20 dB/decade above 10 MHz<br>(or < -100 dBm, whichever is greater, below 500 MHz) | $f_{OUT}$ < 10 MHz: -80 dBc<br>$f_{OUT}$ = 10 MHz to 60 MHz: -75 dBc<br>$f_{OUT}$ > 60 MHz: -70 dBc | |
| Phase noise (SSB) (typ) [5] | **Standard** | **Standard (80 MHz)** | **Standard (120 MHz) 1** |
| | 1-kHz offset: -105 dBc/Hz<br>10-kHz offset: -115 dBc/Hz<br>100-kHz offset: -125 dBc/Hz | 100-Hz offset: -105 dBc/Hz<br>1-kHz offset: -116 dBc/Hz<br>10-kHz offset: -122 dBc/Hz<br>100-kHz offset: -129 dBc/Hz | 100-Hz offset: -101 dBc/Hz<br>1-kHz offset: -112 dBc/Hz<br>10-kHz offset: -118 dBc/Hz<br>100-kHz offset: -125 dBc/Hz |
| | **Opt OCX** | **Opt OCX (80 MHz)** | **Opt OCX (120 MHz) 1** |
| | 1-kHz offset: -110 dBc/Hz<br>10-kHz offset: -125 dBc/Hz<br>100-kHz offset: -135 dBc/Hz | 100-Hz offset: -114 dBc/Hz<br>1-kHz offset: -122 dBc/Hz<br>10-kHz offset: -125 dBc/Hz<br>100-kHz offset: -131 dBc/Hz | 100-Hz offset: -110 dBc/Hz<br>1-kHz offset: -118 dBc/Hz<br>10-kHz offset: -121 dBc/Hz<br>100-kHz offset: -127 dBc/Hz |

Footnotes referenced on page 30.

| Square and Pulse | | |
|---|---|---|
| Frequency ranges | **$V_{OUT}$ ≤ 10 Vpp**<br>1 µHz to 20 MHz or 30 MHz, 1-µHz resolution | **$V_{OUT}$ ≤ 10 Vpp**<br>1 µHz to 50 MHz, 1-µHz resolution<br>**$V_{OUT}$ ≤ 4 Vpp**<br>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<br>Pulse: 8.4 ns to 1 µs, independently variable,<br>100-ps resolution | Square: 2.9 ns<br>Pulse: 2.9 ns to 10 µs, independently variable,<br>100-ps resolution |
| Rise and fall times (nom) | | **$V_{OUT}$ > 4 $V_{pp}$** |
| | | Square: 4.0 ns<br>Pulse: 3.3 ns to 10 µs, independently variable,<br>100-ps resolution |
| Overshoot (typ) | **$V_{OUT}$ ≤ 10 $V_{pp}$** | **$V_{OUT}$ ≤ 4 $V_{pp}$** |
| | < 2% | Square: < 4%<br>Pulse, min edge: < 4%<br>Pulse, 4-ns edge: < 2%<br>Pulse, ≥ 6-ns edge: < 2% |
| | | **$V_{OUT}$ > 4 $V_{pp}$** |
| | | Square: < 4%<br>Pulse, min edge: < 7%<br>Pulse, 4-ns edge: < 4%<br>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 20 MHz or 30 MHz band<br>Standard: < 40 ps | 10 Hz to 40 MHz band Standard: < 1 ps<br>Opt OCX: < 0.5 ps |

Footnotes referenced on page 30.

| | | |
|---|---|---|
| **Ramp and Triangle** | | |
| 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** | | |
| Variable bandwidth (typ) | **$V_{OUT}$ ≤ 10 $V_{pp}$**<br>1 mHz to 20 MHz or 30 MHz | **$V_{OUT}$ ≤ 10 $V_{pp}$**<br>1 mHz to 60 MHz |
| | | **VOUT ≤ 8 Vpp**<br>1 mHz to 80 MHz |
| | | **$V_{OUT}$ ≤ 4 $V_{pp}$**<br>1 mHz to 120 MHz [1] |
| Crest factor (nom) | 4.6 | 4.6 |
| Repetition period | > 50 years | > 100 years |
| **Pseudorandom Binary Sequence (PRBS)** | | |
| Bit rate | **$V_{OUT}$ ≤ 10 $V_{pp}$** | **$V_{OUT}$ ≤ 10 $V_{pp}$** |
| | 1 mbps to 50 Mbps, 1-mbps resolution | 1 mbps to 100 Mbps, 1-mbps resolution |
| | | **$V_{OUT}$ ≤ 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 and fall times (nom) | **$V_{OUT}$ ≤ 10 $V_{pp}$** | **$V_{OUT}$ ≤ 4 $V_{pp}$** |
| | 8.4 ns to 1 µs, variable, 100-ps or 3-digit resolution | 2.9 ns to 1 ms, independently variable, 100-ps resolution |
| | | **$V_{OUT}$ > 4 $V_{pp}$** |
| | | 3.3 ns to 1 ms, independently variable, 100-ps resolution |

Footnotes referenced on page 30.

| 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 (-3 dB)(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 and 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 | | |

| 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 and square | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ |
| Pulse | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Ramp and 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 and pulse | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Ramp and triangle | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Gaussian noise | ■ | ■ | ■ | ■ | | ■ | ■ | ■ |
| PRBS | ■ | ■ | ■ | ■ | ■ | | ■ | ■ |
| Arbitrary [20] | ■ | ■ | ■ | ■ | ■ | ■ | | ■ |

| Legend | |
|---|---|
| ■ | All models |
| □ | Only 33600A Series models |

Footnotes referenced on page 30.

## Modulation, burst, and sweep characteristics

Note: For all external modulation specification, kindly refer to Modulation input section for details.

| | |
|---|---|
| **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 | 0º to 360º, 0.1º resolution |
| **Frequency-shift key modulation (FSK) [12]** | |
| Source | Internal timer or rear-panel connector |
| Mark and 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 | 0º to 360º, 0.1º 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) |
| **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** | | |
|---|---|---|
| **Trueform Models** | **33500B Series, 2-channel models** | **33600A Series, 2-channel models** |
| 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 | |
| Crosstalk (typ) | < –85 dB | |

Footnotes referenced on page 30.

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

| IQ player characteristics | | |
|---|---|---|
| **Trueform 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.
Footnotes referenced on page 30

## Sync/Marker output

| Trueform 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 |

## 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) [1] | < 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 | 0.9 V to 3.8 V into open circuit |
| | 1.5 Vpp (nom) into 50 Ω | 0.1 V resolution |
| Impedance (nom) | 50 Ω | |
| Duty cycle (nom) | 50% | |
| Fan-out | Up to four Keysight True*form* waveform generators | |

Note:
1. Only apply to 1kHz and above

## 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 | |
| Impedance | 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 | |

## 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<br>(~32 MSa of arbitrary waveform records) | 970 MB in file system<br>(~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 | 80% RH up to 40°C,<br>decreases linearly to 37.5% RH at 55°C, non-condensing | |
| Operating altitude | Up to 3,000 meters | |

| Trueform Series | 33500B Series | 33600A Series |
|---|---|---|
| **Regulatory** | | |
| | Refer to Declaration of Conformity for the latest revisions of regulatory compliance at: www.keysight.com/go/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 ± 10%, 50/60 Hz | |
| | 100 to 120 V ± 10%, 400 Hz | |
| Power consumption | < 45 W, < 130 VA | < 75 W, < 150 VA |

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 ºC 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 ºC).

## 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 ºC).

## 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 23ºC).

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