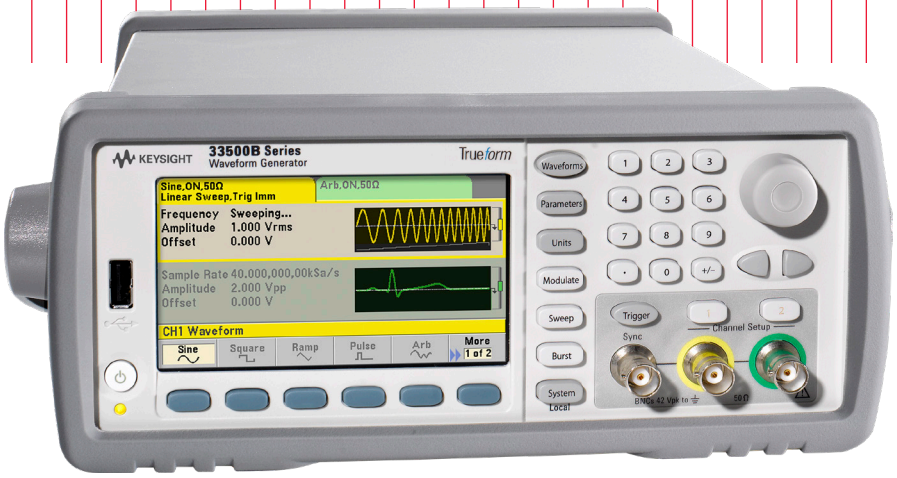
# Keysight Technologies
# 33500B Series
# Waveform Generators

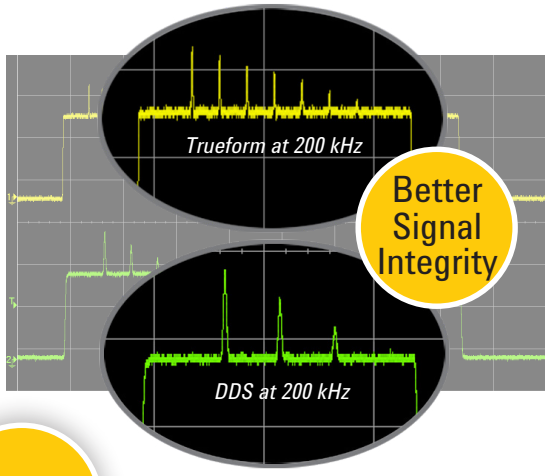
Data Sheet

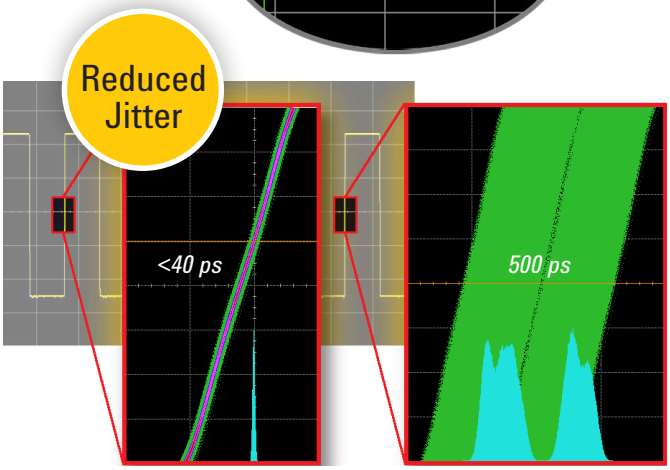



KEYSIGHT TECHNOLOGIES

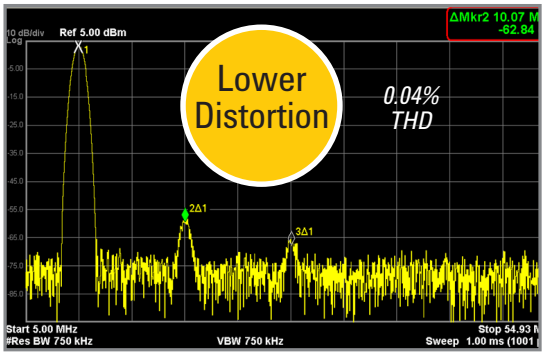
# Trueform Technology
# Generate true point-by-point arbitrary waveforms with less jitter, more fidelity and greater resolution

## Revolutionary advances over traditional DDS




*Trueform technology* *DDS technology*




33500B Series waveform generators with exclusive Trueform signal generation technology offer more capability, fidelity and flexibility than traditional DDS generators. Use them to accelerate your development process from start to fi nish.

Over the past two decades, direct digital synthesis (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.

As with any technology, DDS has intrinsic downsides and limitations as well. Engineers with exacting requirements have had to either work around the compromised performance or spend up to 10 times more for a high-end, point-by-point waveform generator.

The Keysight Technologies, Inc. Trueform technology offers a new alternative that blends the best of DDS and point-by-point architectures, giving you the benefits of both without the limitations of either. Trueform technology uses an exclusive digital sampling technique that delivers unmatched performance at the same low price you are accustomed to with DDS.

The table below highlights the revolutionary capabilities of Trueform technology.

| | **DDS: Traditional 25 MHz waveform generator** | **Trueform: Keysight 30 MHz 33511B waveform generator** | **Improvement** |
|---|---|---|---|
| Edge jitter | 500 ps | 40 ps | 12x better |
| Custom waveform replication | Skips waveform points | 100% point coverage | Exact waveform replication |
| Total harmonic distortion | 0.2% | 0.04% | 5x better |
| Anti-alias filtering | Must provide externally | Always anti-aliased | No anti-aliasing artifacts |
| Sequenced arb | Not possible | Standard | Easily create complex wave-form sequences |

For more information about Keysight Trueform technology please visit: www.keysight.com/find/trueform

# Revolutionary signal generation with unmatched capabilities and fidelity

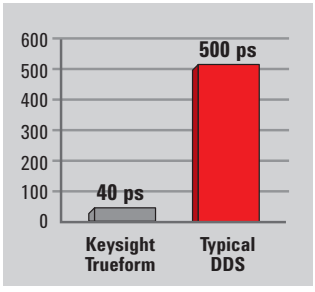


- Easily generate the full range of signals you need for the most demanding measurements
- Test your devices with confidence that the waveform generator is outputting the signals you expect
- Select just the capabilities you need now, then upgrade easily when your needs change

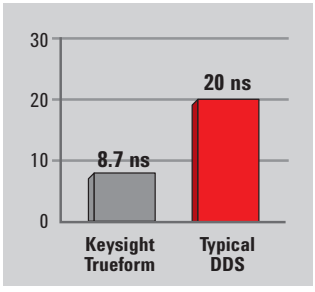
## Unique features of the 33500B Series waveform generators

| | |
|---|---|
| Full Bandwidth Pulse | Full-bandwidth pulse to 20 or 30 MHz<br>Set leading and trailing edge times independently |
| 2 Channels | Dual channel coupling, frequency and amplitude, equal and inverted<br>Set start phase for each channel, set phase shift between channels |
| Sum Modulate | Sum two signals together, frequency and amplitude independent<br>2-tone, square-sine, noise on pulse |
| Point-By-Point Arb | Create up to 1 million samples standard, 16 million optional<br>Connect arbs together, create up to 512 sequences |
| Voltage Settings | Lowest voltage range at 1 mVpp, a 10x improvement<br>Set high and low voltage limits to prevent overload on DUT |
| PRBS Patterns | Provides standard PRBS patterns, PN7 ... PN23<br>Select PN type, set bit rate, set edge time |

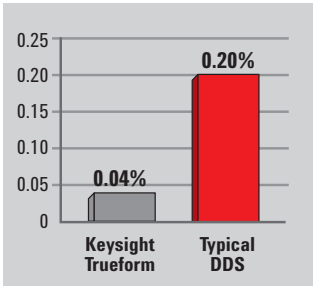
## Key attributes



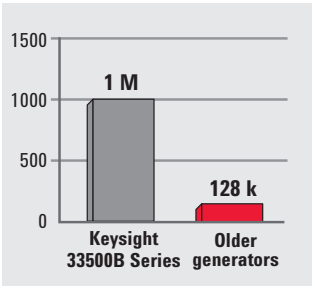

*Jitter*




*Risetime*




*Total harmonic distortion*




*Standard memory*

# Trueform Technology
# Unmatched capabilities for generating a full range of signals for the most demanding requirements

The 33500B Series waveform generators offer the common signals and features you expect, such as modulation, sweep, and burst. But the 33500B Series offers many more features that give you the capabilities and flexibility you need to get your job done. Like an intuitive front-panel user interface that makes it easy to quickly relearn it when you've been focused elsewhere. Like built-in LAN, USB and GPIB interfaces that make it easy to control your instruments or transfer your waveforms to your instrument.

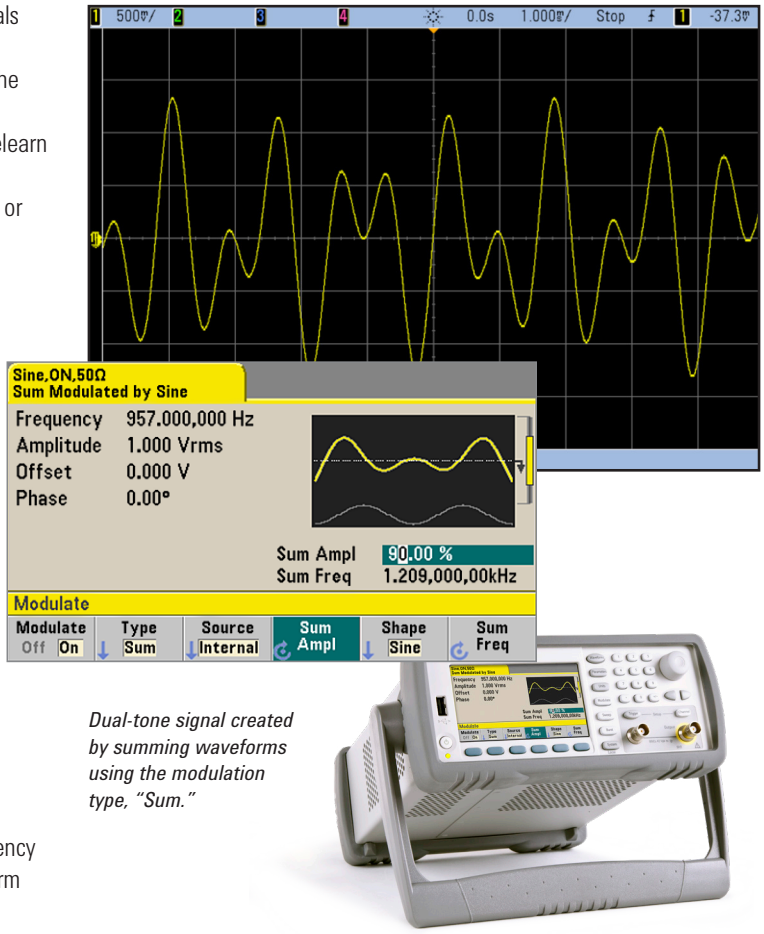
But the 33500B Series doesn't stop there. It offers a variety of capabilities you won't find elsewhere—capabilities that help you accelerate your testing and get your project wrapped up faster:

## Waveform summing and combining capability

Easily add noise to your signal for margin and distortion testing using only a single channel. You can create dual-tone multifrequency 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.

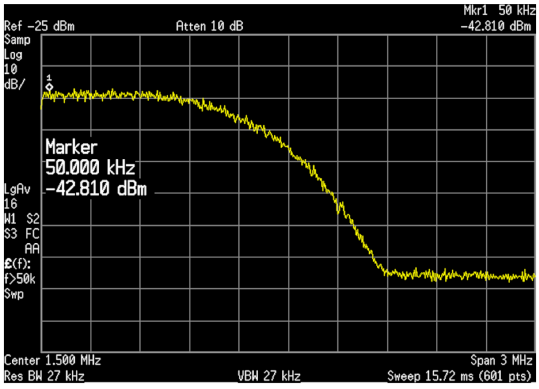
## Variable-bandwidth noise

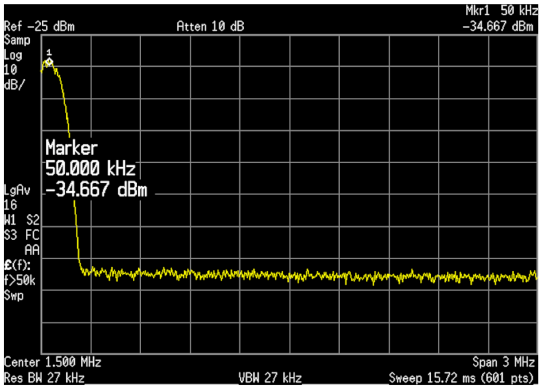
You can adjust the bandwidth of the built-in noise generator to control the frequency content of your signal. Apply just the frequency stimulus you need so you concentrate the energy of your waveform in frequency bands of interest.




*Dual-tone signal created by summing waveforms using the modulation type, "Sum."*

*The images at right show approximately 10 dB increase in amplitude at 50 kHz when the bandwidth is reduced 10x. You can see how the signal energy is increased in the frequencies of interest when the bandwidth is reduced, instead of being spread over a very wide bandwidth with lower amplitude at all frequencies.*

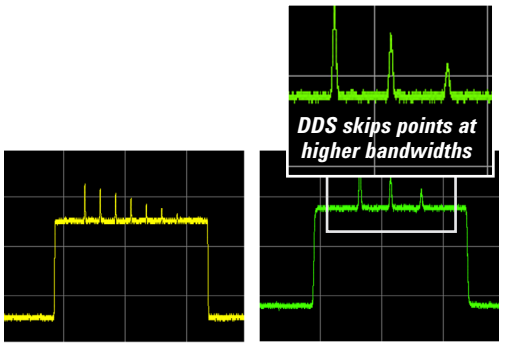


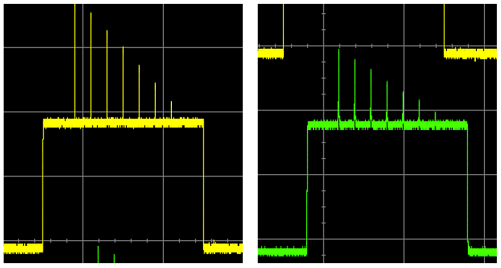
## DDS technology may skip points at higher frequencies

## Trueform never skips points, and is always anti-aliased

Define any waveform shape and any waveform length using point-by-point arbitrary waveform capability. Your waveforms are always anti-aliased for exceptional accuracy, and you can play them at any rate you select. 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.




*Trueform at 200 kHz* *DDS at 200 kHz misses details*



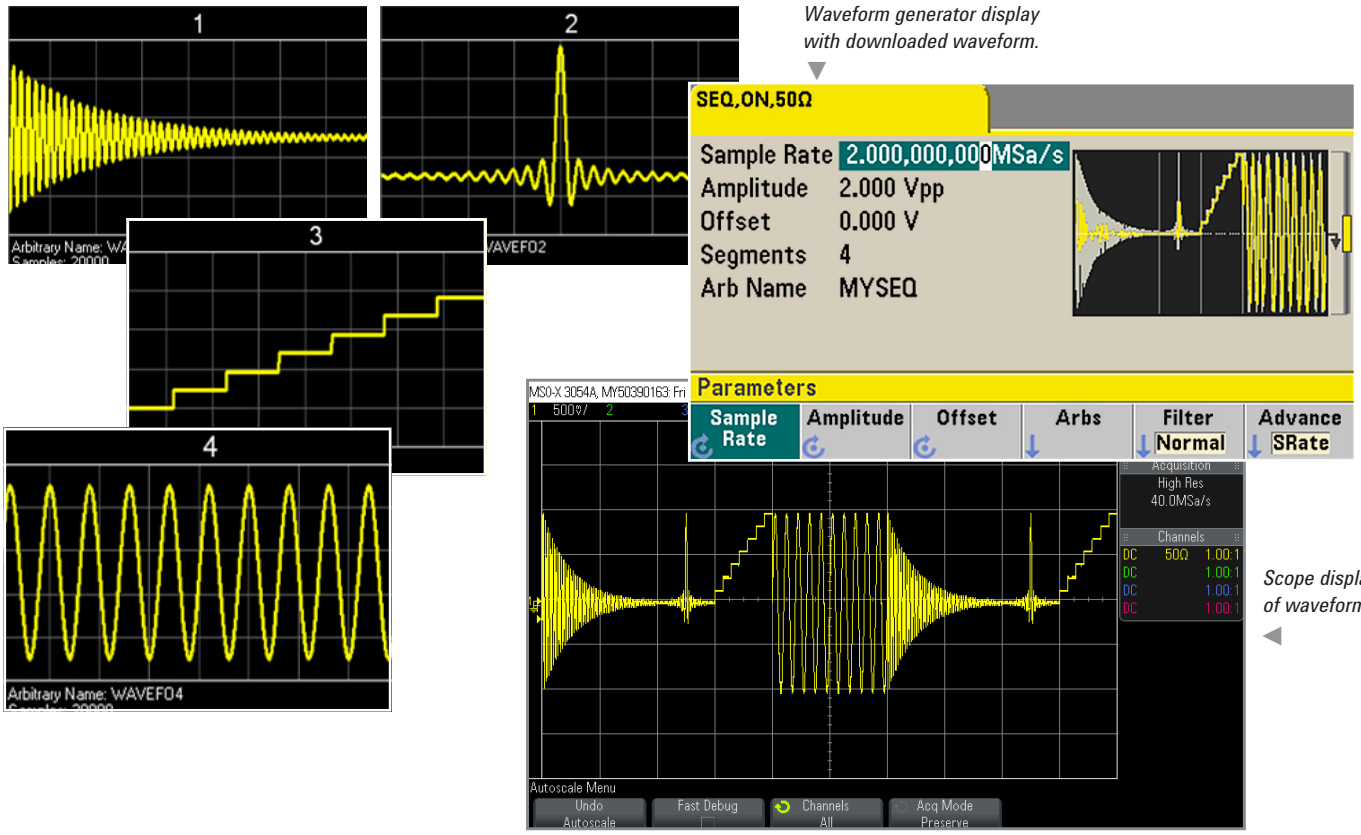
*Trueform at 50 kHz* *DDS at 50 kHz*

## 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.

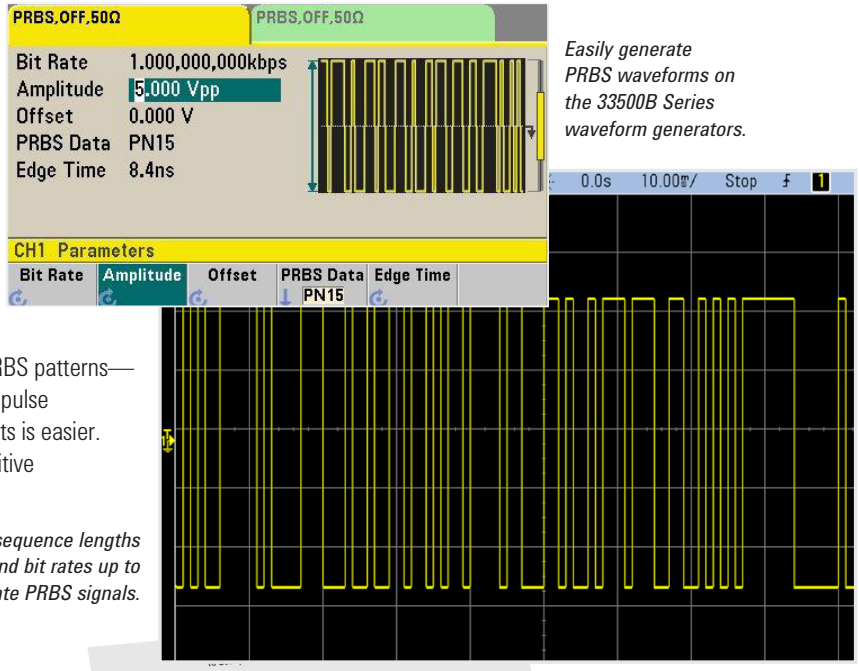
*Create the waveform in the 33503A Waveform Builder Pro and download it to the waveform generator.*

*Waveform generator display with downloaded waveform.*




*Scope display of waveform.*

# Trueform Technology Capabilities *continued*

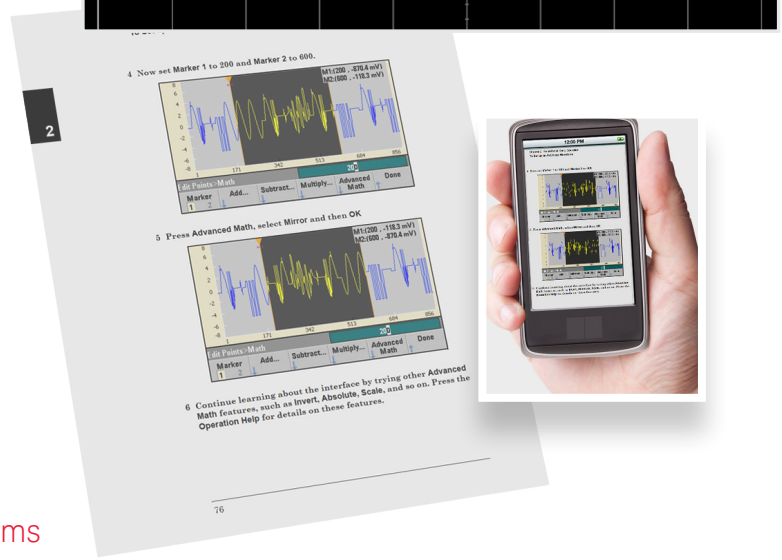



*Easily generate PRBS waveforms on the 33500B Series waveform generators.*

## Pseudo-random binary sequence (PRBS) pattern generation

Test your digital serial buses by streaming standard PRBS patterns—like PN7 and PN19—without the need for a separate pulse generator. With fewer instruments, setting up your tests is easier. You won't find these built-in PRBS patterns in competitive waveform generators.

*You can select multiple sequence lengths (such as PN15) and bit rates up to 50 Mbit/sec to create PRBS signals.*



## Smart phone and tablet access to full documentation

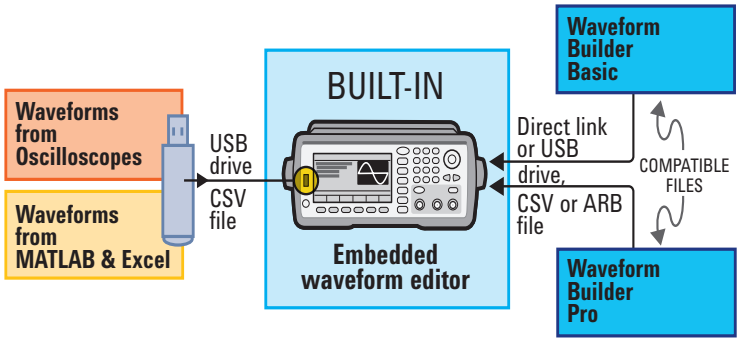
Need a quick answer? Get instant access to instrument documentation in seven different languages in smart-phone-friendly WebHelp format. You can access ***all*** user documentation in the palm of your hand—no PC or hardcopy manuals required. Another feature you won't find in competitive function/arb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

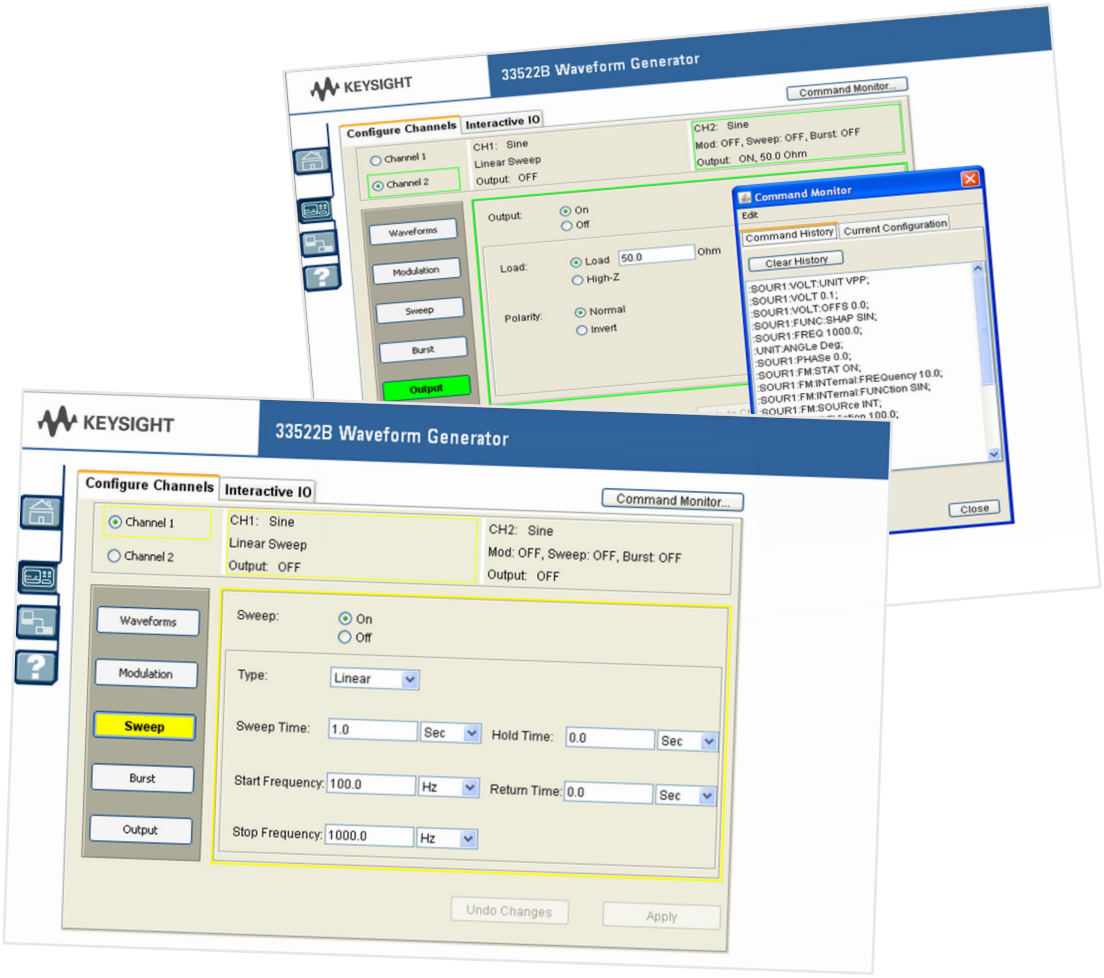
## Flexibility in creating and playing waveforms

There are five ways to create arbitrary waveforms for use with the 33500B generator.

1. Use the included Waveform Builder Basic software to edit and download a waveform file to the generator
2. Use 33503A Waveform Builder Pro software to create more complex waveforms and sequencing
3. Capture a waveform from an oscilloscope and download it to the generator
4. Create a waveform in MATLAB, Excel, etc. and download it to the generator
5. Use the generator's front panel to edit a waveform once it is in the generator

You have lots of flexibility to choose the way you want to work.



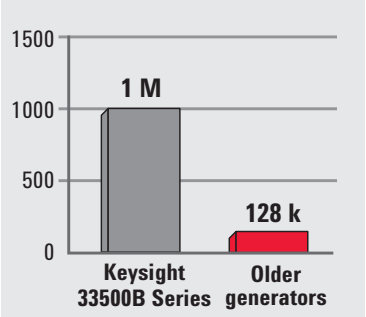



## Built-in Web browser

Easily set up and control your 33500B Series generator remotely over a LAN connection using the built-in LXI Web browser. You can monitor your tests and adjust settings from another office or room, or even from home.

## 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 Series' standard memory is 1 MSamples deep. Typical DDS generators offer only a fraction of that amount but with the 33500B Series there is even a 16 MSample memory option available.




## Use the optional high-stability timebase for even better accuracy

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

# Trueform Technology
# Signal integrity: Test your devices with confidence that your signal generator is outputting the signals you expect

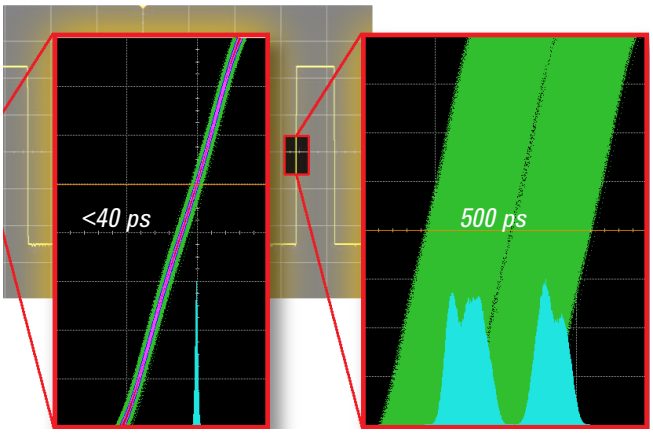
If your generator is introducing spurious signals or harmonics, you'll have a hard time producing reliable designs. To be successful, you need to test with clean, precise, low-noise signals. Keysight 33500B Series waveform generators offer the highest signal fidelity so you can generate the exact waveforms you need for your most challenging measurements. You can be confident you are seeing your design's characteristics, not your waveform generator's, in your measurements.

## 33500B Series waveform generators offer the following advantages:

### Lowest jitter

With 12x better jitter than anything in their class, 33500B Series waveform generators offer unparalleled 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.

*Trueform technology significantly improves jitter performance.*



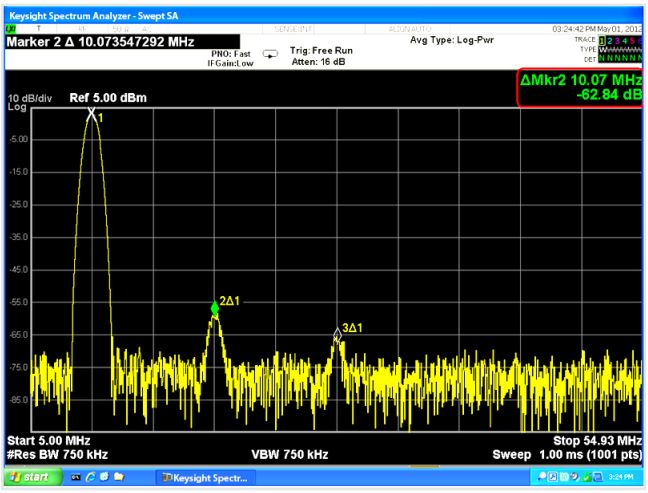

*Trueform technology.* *Traditional DDS technology.*

### Faster edge times

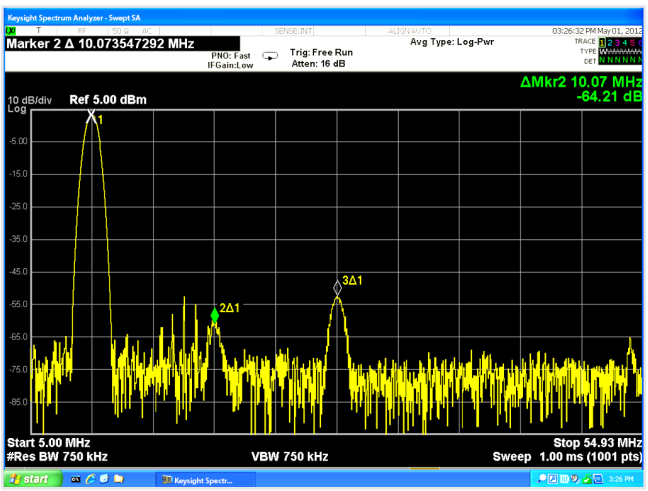
The 33500B Series' 8.4-ns rise and fall times are more than twice as fast as you'll find in typical waveform generators. You can place edges with more confidence and more accurately set trigger points. Because of the faster transition, higher harmonic content is created, which helps you expand your understanding of your circuit.

### Lowest harmonic distortion

With total harmonic distortion of just 0.04%, the 33500B Series offers 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.




*Keysight 33500B Series waveform generators offer the lowest total harmonic distortion (THD) in its class.*



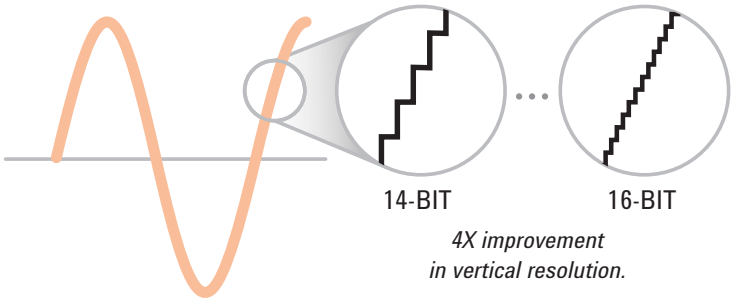

*Typical DDS generator has a higher noise floor and greater harmonics.*

## Reproduce lower-voltage output signals

Today's ultra-low-power products such as pacemakers, hearing aids and remote sensors use very low voltages. The 33500B Series lets you create signals as low as 1 mVpp. That's 10x better amplitude resolution than typical waveform generators offer.

## Highest amplitude resolution

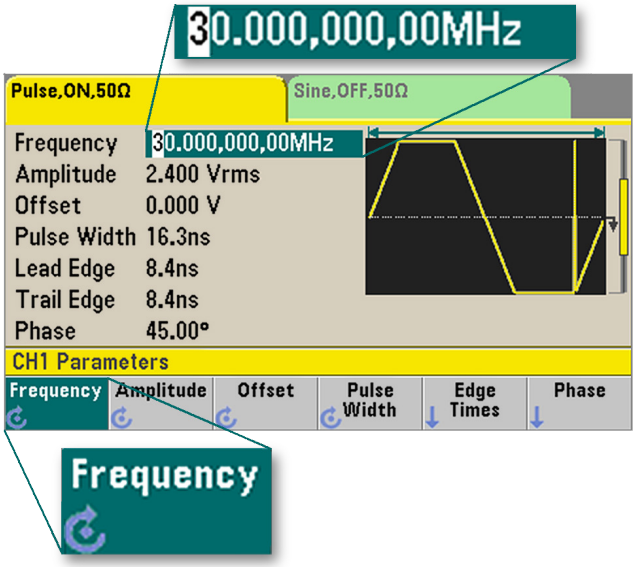
The 33500B Series' 16 bits of resolution is 4x that of most waveform generators. You can make output changes all the way down to 1 µV—exactly what you need for testing today's low-voltage circuits and designs.




*4X improvement in vertical resolution.*

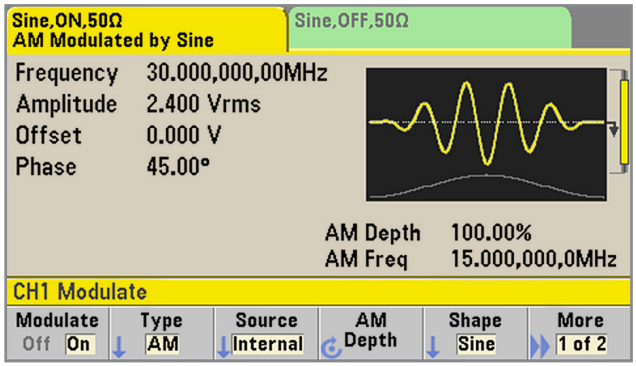
## Full bandwidth pulses

Create pulses up to 30 MHz with the 33500B Series. Most DDS-based generators offer reduced bandwidth when generating pulses. With a broader operating range, you have the frequency you need for a wider range of applications.




## Full bandwidth modulation sources

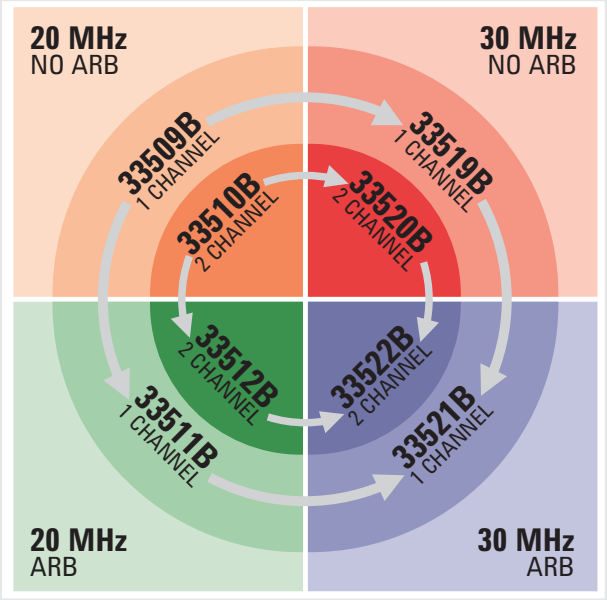
Eliminate the need for an external modulation source. The 33500B Series has a modulation frequency up to the frequency of the waveform being modulated. Existing DDS-based generators have a much lower internal modulation frequency. Now you can create your complex signals all within a single generator.



# Trueform Technology
# Select the capabilities you need now, then upgrade easily when your needs change

## Investment protection

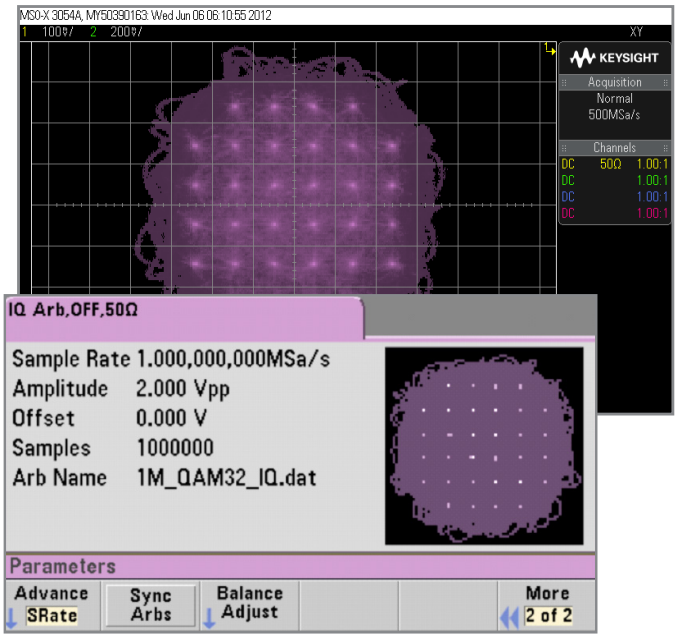
With most waveform generators, you get only what you pay for when you buy your instrument. But with 33500B Series waveform generators, there are eight different models to choose from so you can purchase the capability you need now and upgrade later when your project needs change. Your investment in test equipment is protected. If you need to generate 30 MHz waveforms or arbitrary waveforms, or if you need deeper memory for generating more complex signals, you can easily add the capability after the fact with software upgrades. And there's no price penalty for adding the capability later.




*Select from eight models to get the capability that fits your budget now—then take advantage of easy software upgrades to expand your instrument's capabilities when you are ready.*

## Application-specific options

If you are doing simple experiments in digital communications, use the optional IQ player to play IQ files on your 2-channel function generator.




*Optional IQ player allows you to play Q files on your 2-channel Arb function generator.*

| Model No. | Description | ARB |
|---|---|---|
| 33509B | 20 MHz, 1-channel | |
| 33510B | 20 MHz, 2-channel | |
| 33511B | 20 MHz, 1-channel | ■ |
| 33512B | 20 MHz, 2-channel | ■ |
| 33519B | 30 MHz, 1-channel | |
| 33520B | 30 MHz, 2-channel | |
| 33521B | 30 MHz, 1-channel | ■ |
| 33522B | 30 MHz, 2-channel | ■ |



*LAN (LXI Class C), USB and GPIB connectivity for quick and easy connectivity to a PC or network .*

## 8 models to choose from

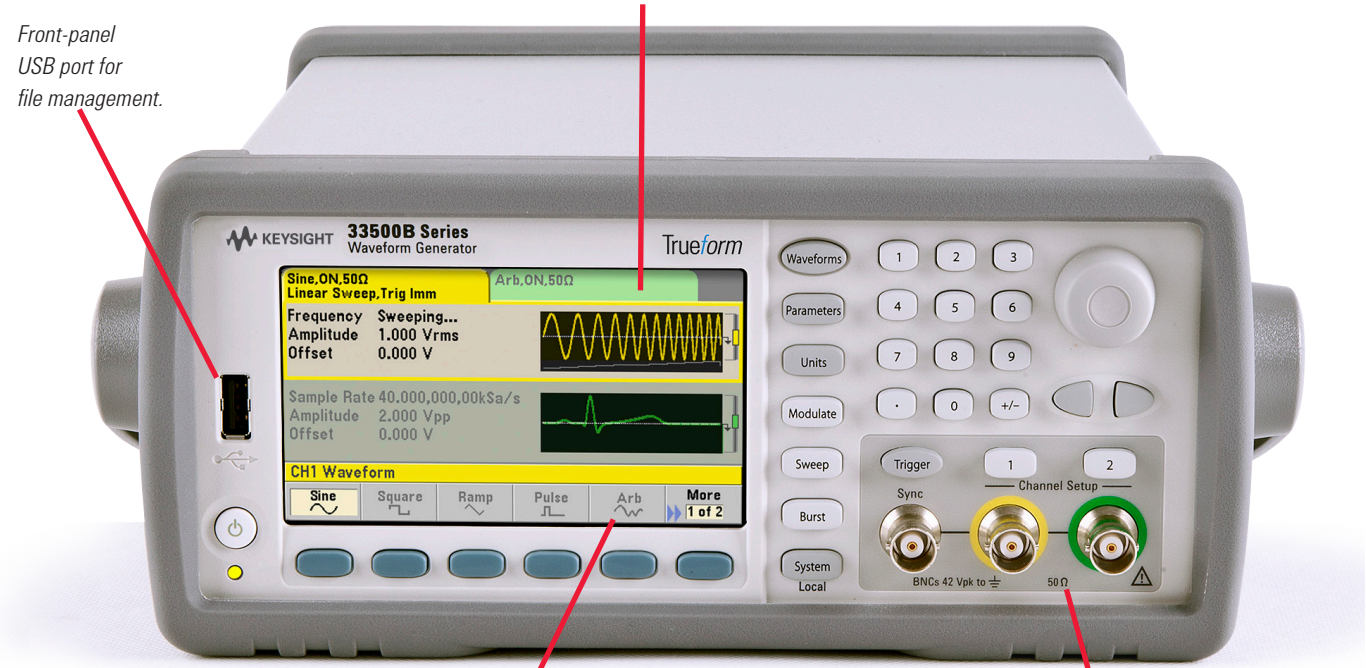
Choose the model with the capability you need now, knowing you can upgrade later. All models come with a rich set of built-in, standard features, including LAN, USB and GPIB interfaces, 1 MSample of memory, an external timebase input, and basic waveform generation software. You get everything you need to generate clean, precise, low-noise signals for testing your designs.

*Large, color, graphical display offers simultaneous parameter setup, signal viewing and editing for easy operation.*



*Supports remote operation using a web browser to connect to a built-in web page.*

*Front-panel USB port for file management.*




*True point-by-point arbitrary waveforms with sequencing for more accurate representation of user-defined signals.*

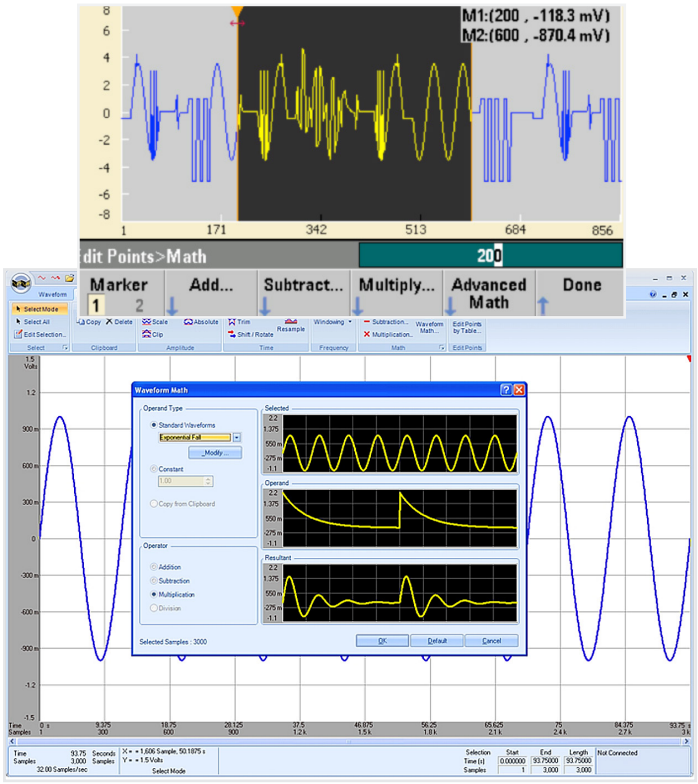
*Dual-channel mode with independent or coupled channels.*

# Other Productivity tools

## Easily create custom waveforms with advanced waveform creation and editing software

Get advanced signal creation/editing capability without tedious programming with optional 33503A BenchLink Waveform Builder Pro software. The Microsoft Windows-based program provides easy-to-use creation tools, such as an equation editor, waveform math and drawing tools, that make it easy to create custom signals. It features a standard function library, waveform sequencer and filters as well as windowing functions that allow you to easily modify and further refine your waveform. A library of built-in signals helps you quickly create more complex waveforms.

The result is quicker, easier creation of custom waveforms, coupled with deeper analysis insight into your signals. For additional information and to download a 30-day trial version of the software, visit: www.keysight.com/find/33503trial.




*Create and edit complex waveforms using 33503A Waveform Builder Pro software.*

# Configuration Guide

## Step 1. Choose your bandwidth, channel count, and arbitrary waveforms

| **33500B Series waveform generators with Trueform technology** | | | | |
|---|---|---|---|---|
| Bandwidth | 20 MHz | 20 MHz | 30 MHz | 30 MHz |
| Number of channels | 1 | 2 | 1 | 2 |
| Waveform generator | 33509B | 33510B | 33519B | 33520B |
| Waveform generator with arb capability | 33511B | 33512B | 33521B | 33522B |

## Step 2. Tailor your waveform generator for more demanding applications

| **Application** | **Order option** |
|---|---|
| Additional memory for long waveforms | MEM (only available on models with arb) |
| Baseband IQ Player with adjustments | IQP (only available on 33512B/33522B) |
| Security features with NISPOM | SEC |
| Ultra-high stability timebase | OCX |

## Step 3. Upgrade your waveform generator in the future

| **Upgrade desired** | **Order upgrade option** |
|---|---|
| Increase bandwidth to 30 MHz | 335BW1U on 1-channel models<br>335BW2U on 2-channel models |
| Add arbitrary waveform capability | 335ARB1U on 1-channel models<br>335ARB2U on 2-channel models |
| Add 16M memory to arb | 335MEM1U on 1-channel arb models<br>335MEM2U on 2-channel arb models |
| Add NISPOM and file security | 335SECU |
| Add IQ baseband signal player to 2-channel arb | 335IQPU |
| Add high-stability timebase | 33500U-OCX (Must return to Keysight) |
| NOTE: Cannot upgrade a 1-channel generator to a 2-channel generator | |

# Specifications

Unless otherwise stated, all specifications apply with a 50 Ω resistive load and auto range ON.

## Instrument characteristics

| | |
|---|---|
| **Models & options** | |
| 33509B/11B/19B/21B | 1-channel |
| 33510B/12B/20B/22B | 2-channel |
| Option MEM | Increases arbitrary waveform memory to 16 MSa/channel* |
| Option OCX | OCXO timebase for ultra-high stability |
| Option IQP | IQ player (Only available on 33512B and 33522B) |
| **Waveforms** | |
| Standard | Sine, square, ramp, pulse, triangle, Gaussian noise, PRBS (Pseudorandom Binary Sequence), DC |
| Built-in arbitrary* | Cardiac, exponential fall, exponential rise, Gaussian pulse, Haversine, Lorentz, D-Lorentz, negative ramp, sinc |
| User-defined arbitrary* | Up to 1 MSa (16 MSa with Option MEM) with multi-segment sequencing |
| **Operating modes & modulation types** | |
| Operating modes | Continuous, modulate, frequency sweep, burst, output gate |
| Modulation types | AM, FM, PM, FSK, BPSK, PWM, Sum (carrier + modulation) |

## Waveform characteristics

| | | |
|---|---|---|
| **Sine** | | |
| Frequency range | 1 µHz to 20 MHz or 30 MHz, 1 µHz resolution | |
| Amplitude flatness (spec)[1, 2] (relative to 1 kHz) | < 100 kHz:<br>100 kHz to 5 MHz:<br>5 to 20 MHz:<br>20 to 30 MHz:** | ± 0.10 dB<br>± 0.15 dB<br>± 0.30 dB<br>± 0.40 dB |
| Harmonic distortion (typ) [2, 3] | < 20 kHz:<br>20 to 100 kHz:<br>100 kHz to 1 MHz:<br>1 to 20 MHz:<br>20 to 30 MHz:** | < -70 dBc<br>< -65 dBc<br>< -50 dBc<br>< -40 dBc<br>< -35 dBc |
| THD (typ) | 20 Hz to 20 kHz: | < 0.04% |
| Non-harmonic spurious (typ) [2, 3] | 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)* | |
| Phase noise (SSB) (typ) | Standard | Option OCX |
| 1 kHz offset: | -105 | -110 dBc/Hz |
| 10 kHz offset: | -115 | -125 dBc/Hz |
| 100 kHz offset: | -125 | -135 dBc/Hz |

**Only available on 33511B/12B/21B/22B*

***Only available on 33519B/20B/21B/22B*

*NOTE: See page 22 for footnotes 1 through 10*

# Specifications

## Waveform characteristics, *continued*

| | |
|---|---|
| **Square & pulse** | |
| Frequency range | 1 µHz to 20 MHz or 30 MHz, 1 µHz resolution |
| Rise and fall times (nom) | Square: 8.4 ns, fixed<br>Pulse: 8.4 ns to 1 µs, independently variable, 100-ps or 3-digit resolution |
| Overshoot (typ) | < 2% |
| Duty cycle | 0.01% to 99.99% [8] |
| Pulse width | 16 ns minimum, 100-ps resolution |
| Jitter (cycle-to-cycle, typ) | < 40 ps rms |
| **Ramp & triangle** | |
| Frequency range | 1 µHz to 200 kHz, 1 µHz resolution |
| Ramp symmetry | 0.0% to 100.0%, 0.1% resolution<br>(0% is negative ramp, 100% is positive ramp, 50% is Triangle) |
| Nonlinearity (typ) | < 0.05% from 5% to 95% of the signal amplitude |
| **Gaussian noise** | |
| Bandwidth (typ) | 1 mHz to 20 MHz or 30 MHz, variable |
| Crest factor (nom) | 4.6 |
| Repetition period | > 50 years |
| **Pseudorandom binary sequence (PRBS)** | |
| Bit rate | 1 mbps to 50 Mbps, 1 mbps resolution |
| Sequence length | $2^m$-1, m=7, 9, 11, 15, 20, 23 |
| Rise and fall times (nom) | 8.4 ns to 1 µs, variable, 100-ps or 3-digit resolution |

## Arbitrary waveform characteristics

| | |
|---|---|
| **General** | |
| Waveform length | 8 Sa to 1 MSa per channel (16 MSa with Option OCX) in increments of 1 sample |
| Sample rate | 1 µSa/s to 250 MSa/s, 1 µSa/s resolution |
| Voltage resolution | 16 bits |
| Bandwidth (-3 dB, nom) | Filter Off: 40 MHz<br>"Normal" Filter On: 0.27 x (Sample Rate)<br>"Step" Filter On: 0.13 x (Sample Rate) |
| Rise and fall time | 0.35 / Bandwidth (10 ns min) with "Normal" or "Step" filter On |
| Settling time (typ) | < 200 ns to 0.5% of final value |
| Jitter (typ) | Filter Off: < 40 ps rms<br>"Normal" or "Step" filter On: < 5 ps |

## IQ Player Characteristics

| | |
|---|---|
| **Balance Adjust** | |
| Amplitude Gain<br>(channel to channel amplitude balance) | -30% to +30% |
| Delta Offset Ch 1 and Ch 2 | ± (5 VDC - Peak AC) into 50 Ω<br>± (10 VDC - Peak AC) into open circuit |
| IQ Signal Skew<br>(adjusts channel to channel skew) | -4.00 ns to +4.00 ns |
| **Views** | |
| Amplitude vs. Time | |
| X-Y (constellation diagram) | |

# Specifications

## Arbitrary waveform characteristics, continued

| | |
|---|---|
| **Waveform sequencing (Available only on 33511B/12B/21B/22B)** | |
| 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 it indefinitely, to repeat it until a Trigger event occurs, or to stop and wait for a Trigger event. Additionally, the behavior of the Sync output can be specified in each step.<br>To improve throughput, up to 32 sequences totalling up to 1,024 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 sample |
| Sequence length | 1 to 512 steps |
| Segment repeat count | 1 to $1x10^6$, or infinite |

## Output characteristics

| | |
|---|---|
| **Isolation** | |
| Outputs | 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 shells is ±42 Vpk |
| **Signal output** | |
| Output impedance (nom) | 50 Ω |
| On, off, inverted | User-selectable for each channel |
| Voltage limit | User-definable VMAX and VMIN limits |
| Overload protection | Output turns off automatically when an overload is applied<br>Instrument will tolerate a short-circuit to ground indefinitely |
| **Amplitude** | |
| Range | 1 mVpp to 10 Vpp into 50 Ω<br>2 mVpp to 20 Vpp into open circuit |
| Resolution | 4 digits |
| Units | Vpp, Vrms, or dBm, selectable |
| Accuracy [1, 2] (spec) | ±1% of setting ±1 mVpp at 1 kHz |
| **DC offset** | |
| Range [5] | ±(5 VDC - Peak AC) into 50 Ω<br>±(10 VDC - Peak AC) into open circuit |
| Resolution | 4 digits |
| Units | VDC |
| Accuracy [1, 2] (spec) | ±1% of Offset setting ±0.25% of Amplitude setting ±2mV |

### Frequency accuracy

| | |
|---|---|
| **Standard frequency reference (spec)** | |
| 1 year, 23° C ± 5° C | ±1 ppm of setting ± 15 pHz |
| 1 year, 0° C to 55° C | ±2 ppm of setting ± 15 pHz |
| **High-stability frequency reference (spec): Option OCX** | |
| 1 year, 0° C to 55° C | ±0.1 ppm of setting ± 15 pHz |

# Specifications

## Modulation types and operating modes

| Carrier | AM | FM | PM | FSK | BPSK | PWM | Sum | Burst | Sweep |
|---|---|---|---|---|---|---|---|---|---|
| Sine and Square | ● | ● | ● | ● | ● | | ● | ● | ● |
| Pulse | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Triangle and Ramp | ● | ● | ● | ● | ● | | ● | ● | ● |
| Gaussian Noise | ● | | | | | | ● | ●[a] | |
| PRBS | ● | ● | ● | | | | ● | ● | |
| Single ARB* | ● | | ●[b] | | ●[b] | | ● | ● | |
| Sequenced ARB* | ● | | | | | | ● | | |

*a. Gated burst only. b. Applies to sample clock, not whole waveform.*

### Modulating signals

| Carrier | Sine | Square | Triangle / Ramp | Noise | PRBS | ARB* | External |
|---|---|---|---|---|---|---|---|
| Sine | ● | ● | ● | ● | ● | ● | ● |
| Square and Pulse | ● | ● | ● | ● | ● | ● | ● |
| Triangle and Ramp | ● | ● | ● | ● | ● | ● | ● |
| Gaussian Noise | ● | ● | ● | | ● | ● | ● |
| PRBS | ● | ● | ● | ● | | ● | ● |
| ARB* | ● | ● | ● | ● | ● | | ● |

** Only applies to 33511B/12B/21B/22B*

## Modulation characteristics

| | |
|---|---|
| **Amplitude modulation (AM)** | |
| Source | Internal or external, or either channel with 2-channel models |
| Type | Full-carrier or double-sideband suppressed-carrier |
| Depth [1] | 0% to 120%, 0.01% resolution |
| **Frequency modulation (FM) 7** | |
| Source | Internal or external, or either channel with 2-channel models |
| Deviation | 1 µHz to 15 MHz, 1 µHz resolution |
| **Phase modulation(PM)** | |
| Source | Internal or external, or either channel with 2-channel models |
| Deviation | 0° to 360°, 0.1° resolution |
| **Frequency shift key modulation (FSK) 7** | |
| Source | Internal timer or ext trig connector |
| Mark & space | Any frequency within the carrier signal's range |
| Rate | 0 Hz to 1 MHz |
| **Binary phase shift key modulation (BPSK)** | |
| Source | Internal timer or ext trig connector |
| Phase shift | 0° to 360°, 0.1° resolution |
| Rate | 0 Hz to 1 MHz |
| **Pulse width modulation (PWM)** | |
| Source | Internal or external, or either channel with 2-channel models |
| Deviation [8] | 0% to 100% of pulse width, 0.01% resolution |
| **Additive modulation (Sum)** | |
| Source | Internal or external, or either channel with 2-channel models |
| Ratio [6] | 0% to 100% of carrier amplitude, 0.01% resolution |

# Specifications

## Burst [9]

| | |
|---|---|
| Type | Counted or gated |
| Count | 1 to $1x10^8$ cycles, or infinite |
| Gated | Produces complete cycles while Ext Trig is asserted |
| Start/stop phase [4] | -360° to 360°, 0.1° resolution |
| Trigger source | Internal Timer or Ext Trig connector |
| Marker | Adjustable to any cycle; indicated by the trailing edge of the Sync pulse |

## Sweep [7]

| | |
|---|---|
| Type | Linear, Logarithmic, 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. |
| Direction | Up (Start freq < Stop freq) or Down (Start freq > Stop freq) |
| Start and stop frequencies | Any frequency within the waveform's range |
| Sweep time | Linear: 1 ms to 3600 s, 1 ms resolution; 3601 s to 250,000 s, 1 s resolution<br>Logarithmic: 1 ms to 500 s |
| Hold time | 0 s to 3600 s, 1 ms resolution |
| Return time | 0 s to 3600 s, 1 ms resolution |
| Trigger source [10] | Immediate (continuous), external, single, bus, or timer |
| Marker | Adjustable to any frequency between Start and Stop for Linear and Logarithmic types or any frequency in the list for List type; indicated by the trailing edge of the sync pulse |

## Internal timer for FSK, BPSK, BURST, and SWEEP

| | |
|---|---|
| Range | 1 µs to 8000s, 6-digit or 4 ns resolution |

## 2-channel characteristics (Only applies to 33519B/20B/21B/22B)

| | |
|---|---|
| Operating modes | Independent, coupled parameter(s), combined (Ch 1 + Ch 2), Equal (Ch 2 = Ch 1), or differential (Ch 2 = -Ch 1) |
| Parameter coupling | None, frequency (ratio or difference) and/or amplitude and DC offset |
| Relative phase | 0° to 360°, 0.1° resolution |
| Skew (typ) | < 200 ps (when performing identical operations) |
| Crosstalk (typ) | < -85 dB |

# Specifications

## Sync/marker output

| | |
|---|---|
| Connector | Front-panel BNC, isolated from chassis |
| Functions | Sync, sweep marker, burst marker, or arbitrary waveform marker |
| Assignment | Channel 1 or channel 2 |
| Polarity | Normal or inverted |
| Voltage level (nom) | 3 Vpp into open circuit, 1.5 Vpp into 50 Ω |
| Output impedance (nom) | 50 Ω |
| Minimum pulse width (nom) | 16 ns |

## External trigger/gate

| | |
|---|---|
| Connector | Rear-panel BNC, chassis-referenced |
| Function | Input or output |
| Assignment | Channel 1, channel 2, or both (as input)<br>Channel 1 or channel 2 (as output) |
| Polarity | Positive or negative slope |
| Voltage level (nom) | 0 V to 0.4 V for low, > 2.3 V for high, 3.5 V maximum (as input)<br>3 Vpp (nom) into open circuit, 1.5 Vpp (nom) into 50 Ω (as output) |
| Impedance (nom) | 10k Ω, DC-coupled (as input)<br>50 Ω (as output) |
| Minimum pulse width (nom) | 16 ns |
| Input rate | DC to 1 MHz |
| Minimum pulse width | 100 ns (as input) |
| Duty cycle (nom) | 50% (as output) |
| Trigger delay | 0 s to 1000 s, 4 ns resolution; applies to all trigger events |
| Input latency (typ) | < 135 ns with Trigger Delay set to zero |
| Input jitter (typ) | < 2.5 ns, rms |
| Fanout | ≤ 4 total Keysight 33500B Series waveform generators |

## Modulation input

| | |
|---|---|
| Connector | Rear-panel BNC, isolated |
| Assignment | Channel 1, Channel 2, or both |
| Voltage level | ±5 V full-scale |
| Input impedance (nom) | 5k Ω |
| Bandwidth (-3 dB, typ) | 0 Hz to 100 kHz |

## Frequency reference input

| | |
|---|---|
| Connector | Rear-panel BNC, isolated from chassis and all other connectors |
| Reference selection | Internal, external, or auto |
| Frequency range | Standard: 10 MHz ± 20 Hz<br>Option OCX: 10 MHz ± 1 Hz |
| Lock time (typ) | <2 s |
| Voltage level | 200 mVpp to 5 Vpp |
| Input Impedance (nom) | 1k Ω \|\| 20 pF, AC-coupled |

# Specifications

## Frequency reference output

| | |
|---|---|
| Connector | Rear-panel BNC, chasis-referenced |
| Frequency (nom) | 10 MHz |
| Output impedance (nom) | 50 Ω, AC-coupled |
| Level (nom) | 0 dBm, 632 mVpp into 50 Ω |

## Real-time clock/calendar

| | |
|---|---|
| Set and read | Year, month, day, hour, minute, second |
| Battery | CR-2032 coin-type, replacable, >5-year life (typ) |

## Programming times (meas.)

| **Configuration change speed** | | | | |
|---|---|---|---|---|
| | LAN (socket) | LAN (VXI-11) | USB 2.0 | GPIB |
| Change function | 5 ms | 6 ms | 5 ms | 5 ms |
| Change frequency | 2 ms | 3 ms | 2 ms | 3 ms |
| Change amplitude | 20 ms | 20 ms | 19 ms | 22 ms |
| Select user arb (16 k) | 9 ms | 11 ms | 9 ms | 9 ms |

| **Arbitrary waveform download speed to volatile** | | | | |
|---|---|---|---|---|
| (binary transfer) | LAN (socket) | LAN (VXI-11) | USB 2.0 | GPIB |
| 4 k sample | 6 ms | 18 ms | 8 ms | 39 ms |
| 1 M sample | 1.3 s | 2.6 s | 13 s | 9.1 s |

## Memory

| | |
|---|---|
| **Arbitrary waveform and instrument state memory** | |
| Volatile | $1x10^6$ samples per channel or $16x10^6$ samples per channel (Option MEM)<br>512 sequence steps per channel |
| Non-volatile | File sytem file space is limited to 64 MB<br>(~32 MSa of arbitrary waveform records) |
| **Instrument state** | |
| Store / Recall | User defined instrument states |
| Power Off | Power Off state automatically saved |
| Power On | Factory default settings or last power off settings |
| **USB File System** | |
| Front-panel port | USB 2.0 high-speed mass storage (MSC) class device |
| Capability | Read or write instrument configuration settings, instrument states and user arbitrary waveform and sequence files. |
| Speed | 10 MB/s (nom) |

# Specifications

## General characteristics

| | |
|---|---|
| **Computer interfaces** | |
| LXI- C (rev1.3) | 10/100Base-T Ethernet (Sockets & VXI-11 protocol)<br>USB2.0 (USB-TMC488 protocol)<br>GPIB/IEEE-488.1, IEEE-488.2 |
| Web user interface | Remote operation and monitoring |
| Programming language | SCPI-1999, IEEE-488.2<br>Keysight 33210A / 33220A compatibile |
| Graphical display | 4.3" Color TFT WQVGA (480x272) with LED backlight |
| **Mechanical** | |
| Size | 261.1mm W x 103.8mm H x 303.2mm D (with bumpers installed)<br>212.8mm W x 88.3mm H x 272.3mm D (with bumpers removed)<br>2U x ½ rack width |
| Weight (nom) | 3.3 kg (7.2 lbs) |
| **Environmental** | |
| Storage temperature | -40˚C to 70˚C |
| Warm-up time | 1 hour |
| Operating environment | EN61010, polution degree 2; indoor locations |
| Operating temperature | 0˚C to 55˚C |
| Operating humidity | 5% to 80% RH, non-condensing |
| Operating altitude | up to 3000 meters |

| | |
|---|---|
| **Regulatory** | |
| Safety | Complies with European Low Voltage Directive and carries the CE-marking.<br>Conforms to UL 61010-1, CSA C22.2 61010-1, and IEC 61010-1:2001 |
| EMC | Complies with European EMC Directive for test and measurement products.<br>- IEC/EN 61326-1<br>- CISPR Pub 11 Group 1, class A<br>- AS/NZS CISPR 11<br>- ICES/NMB-001<br>*Complies with Australian standard and carries C-Tick mark*<br>*This ISM device complies with Canadian ICES-001.*<br>*Cet appareil ISM est conforme a la norme NMB-001 du Canada* |
| Acoustic Noise (nom) | *SPL 35 dB(A)* |
| **Line power** | |
| Voltage | 100 V - 240 V 50/60 Hz -5%, +10%<br>100 V - 120 V 400 Hz ±10% |
| Power consumption (typ) | < 45 W, < 130 VA |

# Definitions

## Specification (spec)

The warranted performance of a calibrated instrument that has been stored for a minimum of 2 hours within the operating temperature range of 0° C – 55° C and after a 45-minute warm up period. All specifications include measurement uncertainty and were created in compliance with ISO-17025 methods.

Data published in this document are specifications (spec) only where specifically indicated.

## Typical (typ)

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

## Nominal (nom)

The mean or average characteristic performance, or the value of an attribute that is determined by design such as a connector type, physical dimension, or operating speed.

This data is not warranted and is measured at room temperature (approximately 23°C).

## Measured (meas)

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

## Accuracy

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

Random measuremet errors are combined using the root-sum-square method and are multiplied by M for the desired Confidence Level. Syatematic errors are added linearly and include time skew errors, trigger timing errors, and timebase errors as appropriate for each measurement type.

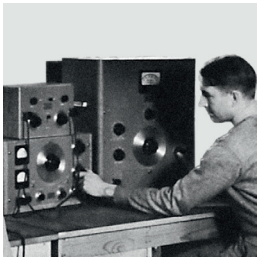
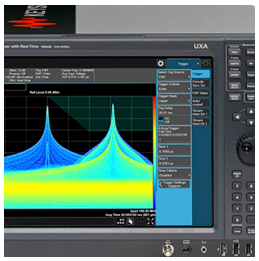
## Confidence Level

For 99% Confidence use k= 2.5 in accuracy calculations.
For 95% Confidence use k= 2.0 in accuracy calculations.

*1. Add 1/10th of the output amplitude and offset accuracy specification per °C for operation at temperatures beyond 23°C ± 5°C.*
*2. Auto range ON.*
*3. DC Offset set to zero.*
*4. limited to arbitrary waveforms that are < 1 million points; phase resolution limited by number of points in arbitrary waveforms < 3,600 points.*
*5. Output noise is typically 20 dB lower when (DC + Peak AC) < 320 mV (into 50 Ω) or 640 mV (into open circuit).*
*6. Subject to maximum output voltage limits.*
*7. All frequency changes are phase-continuous.*
*8. Subject to pulse width limits.*
*9. Counted Burst operation is not allowed for Gaussian Noise.*
*10. External trigger only for sweep time > 8000 sec.*

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

**Asia Pacific**

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

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| Austria | 0800 001122 |
| Belgium | 0800 58580 |
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| Germany | 0800 6270999 |
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