DATA SHEET

30 MHz Function/Arbitrary Waveform Generators

33521A 1-Channel Function/Arbitrary Waveform Generator
33522A 2-Channel Function/Arbitrary Waveform Generator

Lowest jitter and total harmonic distortion in its class and true point-by-point arbitrary waveforms that are always alias-protected for exceptional accuracy

33500 Series Function/Arbitrary Waveform Generators

Achieving a new level of accuracy and flexibility

Everyday you're developing new technologies that are faster, more efficient, smaller, greener and require more accuracy than ever before. Keysight Technologies, Inc. 33500 Series function/arbitrary waveform generators offer the highest signal fidelity and implement a new breakthrough technology that provides you with the ability to generate more accurate arbitrary waveforms. With 10x better jitter than anything in their class, they offer unparalleled control of signal frequency for your most challenging measurements.

KEYSIGHT TECHNOLOGIES

Key features

- 30 MHz sine, square, and pulse bandwidth cover more applications
- < 40 ps jitter and less than .04% total harmonic distortion for more precise signals
- 250 MSa/s, 16-bit sampling rate for higher time-resolution arbitrary waveforms
- True point-by-point arbitrary waveforms with sequencing for more accurate representation of user-defined signals
- Dual-channel mode with independent or coupled channels
- 1 MSa waveform memory standard, 16 MSa (optional) for more complicated arbitrary waveforms
- LXI Class C compliant
- Large, color, graphical display allows for simultaneous parameter setup and signal viewing/editing for intuitive operation
- Optional BenchLink Waveform Builder Pro software for custom user-defined waveforms

Signal fidelity

You depend upon the fidelity of generated signals to verify the development of your designs. The higher the fidelity of the generated signal, the more assurance the device under development will perform to your exacting standards. The 33500 Series function/arbitrary waveform generators have < 40 ps jitter for any signal — ten times better than existing function/arbitrary waveform generators. They provide 16-bit resolution, which is the highest resolution in their class. Combined with less than .04% total harmonic distortion and 250 MSa/s, 16-bit sampling, optional high-stability timebase and optional arbitrary waveform memory expansion, you now have access to an affordable new family of generators with unparallel signal fidelity.

Flexible signal generation

The 33521A and 33522A have the ability to create two-tone signals for dual-tone multi-frequency (DTMF) signal applications used in telecommunication device test. A feature specific to the 33522A generator is a flexible, dual-channel mode with frequency and amplitude coupling, differential channels, and combined output channels. This functionality is useful in applications where testing a device, such as a pacemaker, relies on the timing and interaction of two distinct signals to operate properly.

Point-by-point waveforms

The 33500 Series expands your signaling capability with true point-by-point arbitrary waveforms that are always alias-protected for exceptional accuracy. The 33521A and 33522A are first in their class to generate 30 MHz signals, including common waveforms, arbitrary waveforms and sophisticated modulated waveforms. Both models leverage proprietary technology to provide you with unprecedented input control when defining arbitrary waveforms. That control equates to the ability to define more complex point-by-point waveforms with sequencing.

User interface

A large, color, graphical display offers simultaneous parameter setup, signal viewing, and editing for easy operation. The 33500 Series is fully compliant with the LXI Class C specifications and offers USB 2.0 and 10/100 Base-T Ethernet connectivity for quick and easy connectivity to a PC or network. The 33500 Series also supports remote operation using a browser to connect to a built-in Web page. GPIB is offered as an optional interface.

Optional 33503A BenchLink Waveform Builder Pro Software

BenchLink Waveform Builder Pro is ideal for R&D engineers characterizing new designs and test system engineers validating production units. The software is a Microsoft Windows-based program that provides easy-to-use creation tools, such as an equation editor, waveform math and drawing tools, which can be used to create custom signals. It features a standard function library, waveform sequencer, and filters and; as well as windowing functions that allow you to easily modify and further refine your waveform. A library of built-in signals supports fast creation of more complex waveforms. With BenchLink Waveform Builder Pro, you gain access to advanced signal creation and editing capabilities, without requiring hours of programming. 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/33503

Specifications

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

Instrument characteristics

Models & options	
33521A	1-channel
33522A	2-channel
Option 002	Increases arbitrary waveform memory to 16 MSa/channel
Option 010	OCXO timebase for ultra-high stability
Option 400	GPIB interface
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 002) 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 30 MHz, 1-µHz resolution	
Amplitude flatness (spec)[1, 2] (relative to 1 kHz)	< 100 kHz:	± 0.10 dB
	100 kHz to 5 MHz:	± 0.15 dB
	5 to 20 MHz:	± 0.30 dB
	20 to 30 MHz:	± 0.40 dB
Harmonic distortion (typ)[2, 3]	< 20 kHz:	< –70 dBc
	20 to 100 kHz:	< –65 dBc
	100 kHz to 1 MHz:	< –50 dBc
	1 to 20 MHz:	< –40 dBc
	20 to 30 MHz:	< –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 Option 010: < –75 dBc, increasing +20 dB/decade above 10 MHz *(or < –100 dBm, whichever is greater, below 500 MHz)*	
Phase noise (SSB) (typ)	Standard	Option 010
1 kHz offset:	–105	–110 dBc/Hz
10 kHz offset:	–115	–125 dBc/Hz
100 kHz offset:	–125	–135 dBc/Hz
Square & pulse		
Frequency range	1 µHz to 30 MHz, 1 µHz resolution	
Rise and fall times (nom)	Square: 8.4 ns, fixed 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 Jitter (cycle-to-cycle, typ)	16 ns minimum, 100-ps resolution < 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 (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 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 (16 MSa with Option 002) 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 “Normal” Filter On: 0.27 x (Sample Rate) “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 “Normal” or “Step” filter On: < 5 ps
Waveform sequencing	
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. To improve throughput, up to 32 sequences totaling up to 1,024 segments can be pre-loaded into volatile memory.
Segment length	8 Sa to 1 MSa (16 MSa with Option 002) 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) On, off, inverted Voltage limit Overload protection	50 Ω User-selectable for each channel User-definable V_{MAX} and V_{MIN} limits Output turns off automatically when an overload is applied Instrument will tolerate a short-circuit to ground indefinitely
Amplitude	
Range	1 mVpp to 10 Vpp into 50 Ω 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 ±(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 010	
1 year, 0 °C to 55 °C	±0.1 ppm of setting ± 15 pHz

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	●	●	●	●	●		●

Modulation characteristics

Amplitude modulation (AM)	
Source	Internal or external, or either channel with 33522A
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 33522A
Deviation	1 µHz to 15 MHz, 1 µHz resolution
Phase modulation (PM)	
Source	Internal or external, or either channel with 33522A
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

Modulation characteristics, *continued*

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 33522A
Deviation [8]	0% to 100% of pulse width, 0.01% resolution
Additive modulation (Sum)	
Source	Internal or external, or either channel with 33522A
Ratio [6]	0% to 100% of carrier amplitude, 0.01% resolution

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 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 (33522A only)

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

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) 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) 3 Vpp (nom) into open circuit, 1.5 Vpp (nom) into 50 Ω (as output)
Impedance (nom)	10 k Ω, DC-coupled (as input) 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 33521A and 33522A

Modulation input

Connector	Rear-panel BNC, isolated
Assignment	Channel 1, Channel 2, or both
Voltage level	±5 V full-scale
Input impedance (nom)	5 k 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 Option 010: 10 MHz ± 1 Hz
Lock time (typ)	<2 s
Voltage level	200 mVpp to 5 Vpp
Input Impedance (nom)	1 k Ω | | 20 pF, AC-coupled

Frequency reference output

Connector	Rear-panel BNC, chassis-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, replaceable, >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 002) 512 sequence steps per channel
Non-volatile	File system file space is limited to 64 MB (~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)

General characteristics

Computer interfaces	
LXI- C (rev1.3)	10/100Base-T Ethernet (Sockets & VXI-11 protocol) USB2.0 (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 compatible
Graphical display	4.3" Color TFT WQVGA (480x272) with LED backlight
Mechanical	
Size	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)-
Environmental	
Storage temperature	–40 to 70 °C
Warm-up time	1 hour
Operating environment	EN61010, pollution degree 2; indoor locations
Operating temperature	0 to 55 °C
Operating humidity	5% to 80% RH, non-condensing
Operating altitude	Up to 3000 meters

Regulatory	
Safety & EMC	Refer to Declaration of Conformity for the latest revisions of regulatory compliance at: www.keysight.com/go/conformity
Acoustic Noise (nom)	SPL 35 dB(A)
Line power	
Voltage	100 V - 240 V 50/60 Hz –5%, +10% 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 - 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 measurement errors are combined using the root-sum-square method and are multiplied by M for the desired Confidence Level. Systematic 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.*

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications, or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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