

# FG33530 Series

100 MHz function / arbitrary waveform generators

## Introduction

The Keysight FG33530 Series function / arbitrary waveform generators offer up to 100 MHz with all the essential signals and features you expect, including modulation, sweep, and burst capabilities. Enjoy seamless navigation through the intuitive front-panel interface, allowing you to effortlessly adjust and review your settings for maximum efficiency. The Trueform technology replicates every waveform point, providing up to 16 Mega Samples (MSa) record length per channel. Enhance your waveform creation process with Keysight BenchVue software and BenchLink Waveform Builder Pro software, making it simple to create and edit even your most complex waveforms.

## Features

- Seven-inch color display for parameter setup, signal viewing, and editing.
- Jitter of less than 50 ps.
- Total harmonic distortion of less than 0.06%.
- Six built-in modulation types and seventeen popular waveforms to simulate typical applications for testing.
- 16-bit arbitrary waveform capability with maximum sampling rate of 320 MSa/s and memory of up to 16 MSa per channel.



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**Figure 1.** Keysight FG33531A 100 MHz, single-channel function / arbitrary waveform generator



**Figure 2.** Keysight FG33532A 100 MHz, dual-channel function / arbitrary waveform generator

## Ease of use: Simple setup and operation

The seven-inch color display shows the waveform setting and other parameter details in one view. The large display also accommodates dual-channel displays, providing an uncluttered view and making complex tasks seamless, such as setting up sync, sum, track, or differential waveform generation from both channels. Color-coded keypads, display, and output connectors help prevent setup and connection errors.

The FG33530 Series ships standard with USB and LAN connectivity, making it easy to access and control remotely. It supports operation using Standard Commands for Programmable Instruments (SCPI) language, Interchangeable Virtual Instruments (IVI) driver, web browser, or Keysight's Pathwave BenchVue software.

Additionally, it features a built-in USB memory port, enabling you to store setup parameters with a USB flash drive. This feature maximizes efficiency when restoring the same setup into all the function / arbitrary waveform generators in your lab. It also lets you quickly import your arbitrary waveform file to the function generator.



## Modulation and built-in waveforms

The FG33530 Series has all the fundamental waveforms plus seventeen built-in arbitrary waveforms. The waveform functions include — sine, square, ramp, triangle, pulse, PRBS, DC, Gaussian noise, and more (Figures 3 and 4). Additional specialty waveforms such as cardiac (Figure 5), exponential fall, exponential rise, Gaussian pulse, haversine, Lorentz, D-Lorentz, negative ramp, and sinc are also available. There are six built-in analog and digital modulations including Amplitude Modulation (AM) (Figure 6), Frequency Modulation (FM), Phase Modulation (PM), Frequency-Shift Keying (FSK), Binary Phase Shift Keying (BPSK), and Pulse Width Modulation (PWM).

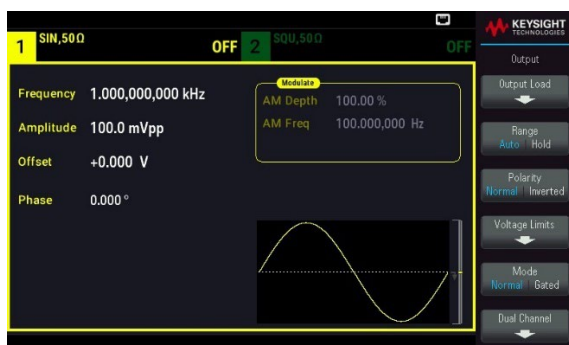


Figure 3. Standard sine wave and parameter settings

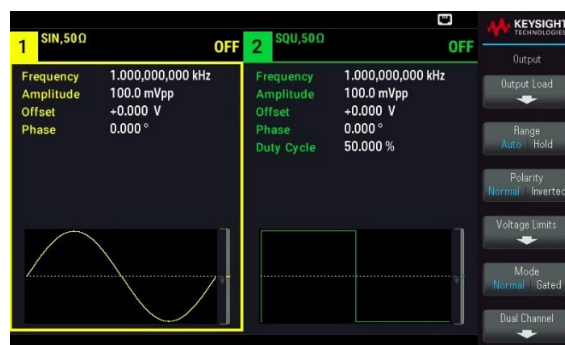


Figure 4. Dual-screen display of standard sine and square wave

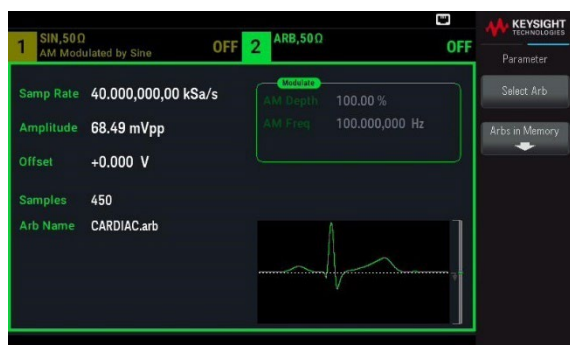


Figure 5. Cardiac specialty waveform

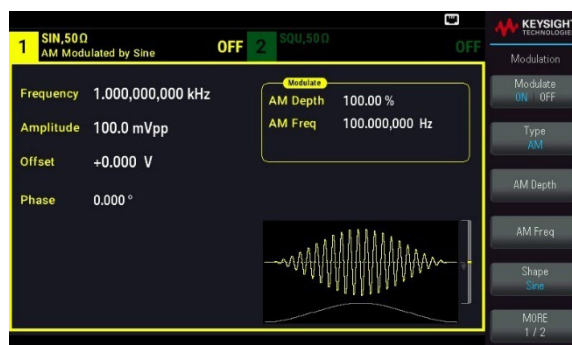


Figure 6. AM modulated with a standard sine wave

## Standard deep memory

If you want to test your design with long, complex waveforms with various anomalies, you must ensure your waveform generator has sufficient memory. The FG33530 Series comes standard with 8 MSa memory and 320 MSa/s sampling rate. In addition, a higher memory upgrade option of up to 16 MSa is available to handle your most complex waveforms.

# Keysight BenchVue Software

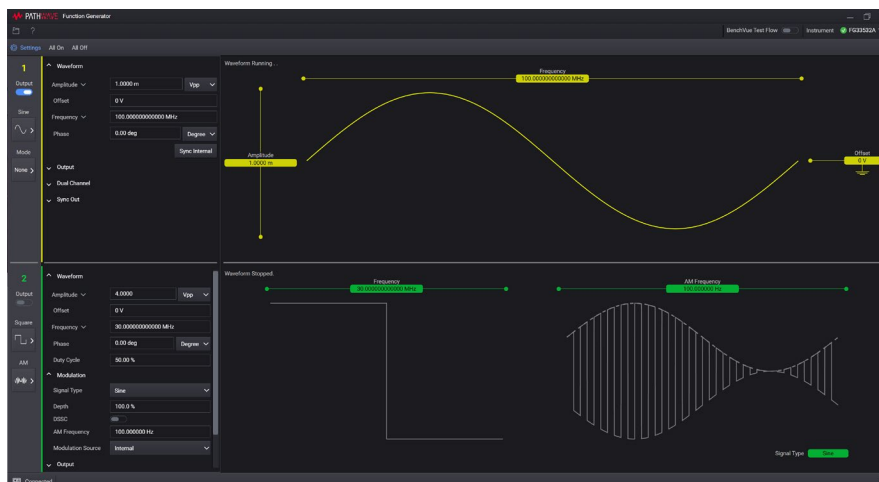
Keysight BenchVue software for the PC makes it simple to connect, control instruments, and automate test sequences. With just a few clicks, you can quickly move past the test development phase and access results faster.

**Note:** We have fully transitioned the BenchVue Included license that comes with your instrument purchase to the BenchVue Basic App, making it easier for you to access and use BenchVue software. You can now download PathWave BenchVue Basic for free. PathWave BenchVue Basic apps provide unlimited access and features that are available in the version just before the latest version of the BenchVue software. Visit [www.keysight.com/find/BVBasic](http://www.keysight.com/find/BVBasic) for more information.

## BV0002B PathWave BenchVue Function Generator app

You can purchase BV0002B separately or get the basic version free at [www.keysight.com/find/BVBasic](http://www.keysight.com/find/BVBasic). The BV0002B enables you to:

- Point and click to control your function generators
- Create and edit advanced waveforms with 33503B Keysight BenchLink Waveform Builder Pro (purchased separately)
- 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
- Access deeper instrument controls with Command Expert integration
- Intuitively control, automate, and simplify testing with your function generators and hundreds of other Keysight instruments



**Figure 7.** The PathWave BenchVue function generator app helps control function generators intuitively, load/design arbitrary waveforms, and build automated tests quickly.

# 33503B Keysight BenchLink Waveform Builder Pro software

The FG33530 Series is supported by the **33503B Keysight BenchLink Waveform Builder Pro** software, therefore allowing you to create any arbitrary waveform, whether building from scratch or combining several common segments with the software's comprehensive editing tools. Now you can build long, complex waveforms to simulate any signals or scenarios.

In addition, you can easily modify and save your waveforms in various formats, including .csv, for example, scaling into a specific sample rate, adjusting the amplitude, or converting into an .arb file format in which you can quickly and accurately load to the FG33530 series.

Purchase the 33503B separately to unlock your FG33530 Series' full potential and create your custom waveforms with advanced waveform creation and editing software. Visit [www.keysight.com/find/33503](http://www.keysight.com/find/33503) for more information. The 33503B enables you to:

- Waveform libraries provide quick and easy access to both common signals (sine, square, triangle, ramp, pulse, exponential) and complex signals
- Free-hand, point, and line-draw modes to create custom shapes
- Equation editor allows you to create waveforms with exact polynomials
- Filtering and windowing functions allow you to smooth transitions between waveforms
- Fast Fourier Transform (FFT) allows you to view the frequency characteristics of your signals
- Complimentary Cumulative Distribution Function (CCDF) curves allow you to view the power characteristics of your signals

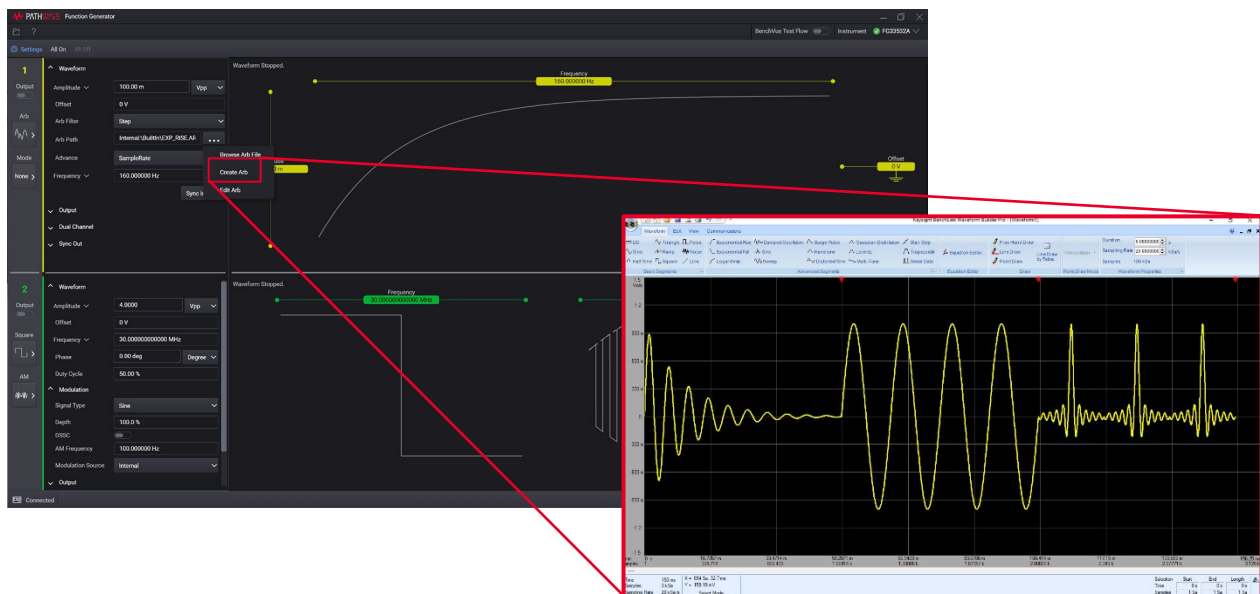


Figure 8. Design and build arbitrary waveforms with BenchLink Waveform Builder Pro

# Specifications

Unless otherwise stated, all specifications apply with a 50  $\Omega$  resistive load and automatic amplitude range selection enabled.

## Instrument characteristics

### Models and options

Model number	FG33531A	FG33532A
Maximum frequency	100 MHz	100 MHz
Number of channels	1	2
Standard	Sine, square, ramp, pulse, triangle, Gaussian noise, pseudorandom binary sequence (PRBS), DC	
Built-in arbitrary	Cardiac, exponential fall, exponential rise, Gaussian pulse, Haversine, Lorentz, D-Lorentz, negative ramp, sinc	
User-defined arbitrary	Up to 8 MSa (16 MSa with Option MEM)	

### Operating modes and modulation types

Operating modes	Continuous, modulate, frequency sweep, counted burst, gated burst
Modulation types	Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM), Frequency Shift Keying (FSK), Binary Phase Shift Keying (BPSK), Pulse Width Modulation (PWM), sum (carrier + modulation)



# Waveform characteristics

## Sine

Frequency range	$V_{out} \leq 10 V_{pp}$ : 1 $\mu$ Hz to 30 MHz, 1 $\mu$ Hz resolution $V_{out} \leq 4 V_{pp}$ : 1 $\mu$ Hz to 100 MHz, 1 $\mu$ Hz resolution
Amplitude flatness (specification) <sup>1,2,3</sup> (relative to 1 kHz)	$1 V_{pp} \leq V_{out} \leq 10 V_{pp}$ (50 $\Omega$ load) $f_{out} \leq 5$ MHz: $\pm 0.1$ dB 5 MHz $\leq f_{out} < 15$ MHz: $\pm 0.2$ dB 15 MHz $\leq f_{out} < 20$ MHz: $\pm 0.3$ dB 20 MHz $\leq f_{out} < 30$ MHz: $\pm 0.4$ dB 30 MHz $\leq f_{out} < 100$ MHz: $\pm 0.6$ dB
Harmonic distortion (typical) <sup>1,3</sup>	$1 V_{pp} \leq V_{out} \leq 10 V_{pp}$ (50 $\Omega$ load) $f_{out} \leq 100$ KHz: -60 dBc 100 kHz to 1 MHz: < -50 dBc 1 MHz to 20 MHz: < -40 dBc 20 MHz to 30 MHz: < -35 dBc 30 MHz to 100 MHz: < -30 dBc
Total Harmonic Distortion (typical) <sup>1</sup>	$f_{OUT} = 10$ Hz to 20 kHz: < 0.06%
Non-harmonic spurious (typical) <sup>1,3,4</sup>	$f_{OUT} \leq 2$ MHz: < -70 dBc $f_{OUT} > 2$ MHz: < -70 dBc + 20 dB/decade
Phase noise (SSB) (typical) <sup>5</sup>	<ul style="list-style-type: none"> <li>1 kHz offset: -105 dBc/Hz</li> <li>10 kHz offset: -105 dBc/Hz</li> <li>100 kHz offset: -105 dBc/Hz</li> </ul>

## Square and pulse

Frequency ranges	1 $\mu$ Hz to 30 MHz, 1 $\mu$ Hz resolution
Rise and fall times (nominal)	Square at 8.4 ns, fixed Pulse at 8.4 ns to 1 $\mu$ s, independently variable, 100 ps resolution
Overshoot (typical)	$\leq 3\%$
Duty cycle <sup>6</sup>	0.01% to 99.99%, 0.01% resolution
Pulse width	16 ns minimum (adjustable with 100 ps resolution)
Jitter (rms) (measured) <sup>7</sup>	$\leq 5$ MHz: 2ppm of the period + 50ps > 5 MHz: < 50 ps

## Ramp and triangle

Frequency range	1 $\mu$ Hz to 200 kHz, 1 $\mu$ Hz resolution
Ramp symmetry	0% to 100%, 0.1% resolution (0% is a negative ramp, 100% is a positive ramp, 50% is a triangle)
Linearity (typical)	$\leq 0.1\%$ from 5% to 95% of the signal amplitude ( $V_{out} \geq 1 V_{pp}$ )

<sup>1</sup> DC offset set to zero

<sup>2</sup> Add 1/10 of the specification per °C for operation at temperatures below 18 °C or above 28 °C

<sup>3</sup> Auto range "ON"

<sup>4</sup> At low amplitude, the non-harmonic spurious level is -100 dBm (typical)

<sup>5</sup> Measured with a Keysight N9030B PXA X-Series signal analyzer

<sup>6</sup> Subject to pulse width limits

<sup>7</sup> Measured with a Keysight N9030B PXA X-Series signal analyzer

## Gaussian noise

Variable bandwidth	$V_{out} \leq 10 V_{pp}$ : 1 MHz to 30 MHz
Crest factor (nominal)	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	8.4 ns to 1 $\mu$ S, independently variable, 100 ps resolution

## Arbitrary waveforms

Waveform length	8 MSa per channel (Upgradeable to 16 MSa per channel with MEM option)
Sample rate	1 $\mu$ Sa/s to 320 MSa/s, 1 $\mu$ Sa/s resolution
Voltage resolution	16 bits

## General

Connector	The front-panel BNC, chassis reference, functions as an output.
Function	On, off, or inverted
Output impedance (nominal)	50 $\Omega$
Isolation	Connector shells for channel output(s), sync, and modulation "in" are connected.
Overload protection	The output turns off automatically when an overload is applied; the instrument will tolerate a short circuit to the ground indefinitely.

## Amplitude

Range <sup>1</sup>	1 mV <sub>pp</sub> to 10 V <sub>pp</sub> into 50 $\Omega$ , 4-digit resolution 2 mV <sub>pp</sub> to 20 V <sub>pp</sub> into open circuit, 4-digit resolution
Units	V <sub>pp</sub> , V <sub>rms</sub> , or dBm
Accuracy (at 1 kHz sine) (specification) <sup>2,3</sup>	$\pm$ (2% of setting in V <sub>pp</sub> ) $\pm$ (10 mV <sub>pp</sub> )
Accuracy (at 1 kHz sine) (typical) <sup>3</sup>	$\pm$ (2% of setting in V <sub>pp</sub> ) $\pm$ (5 mV <sub>pp</sub> )
Voltage limit function	User-definable maximum and minimum voltage limits

## DC offset

Range <sup>4</sup>	$\pm$ (5 VDC minus peak AC) into 50 $\Omega$ , 4-digit resolution $\pm$ (10 VDC minus peak AC) into open circuit, 4-digit resolution
Units	VDC
Accuracy (into 50 $\Omega$ ) (typical) <sup>2,3</sup>	$\pm$ (1% of offset setting) $\pm$ (1% of amplitude in V <sub>pp</sub> ) $\pm$ 5 mV
Resolution	0.1 mV <sub>pp</sub> or 4 digits

## Frequency accuracy (spec)

Standard frequency reference	$\pm$ (1 ppm of setting + 15 pHz), 1 year, 23 $^{\circ}$ C $\pm$ 5 $^{\circ}$ C $\pm$ (2 ppm of setting + 15 pHz), 1 year, 0 $^{\circ}$ C to 55 $^{\circ}$ C
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<sup>1</sup> Maximum amplitude is less at high frequency for specific waveforms

<sup>2</sup> Add 1/10 of the specification per  $^{\circ}$ C for operation at temperatures below 18  $^{\circ}$ C or above 28  $^{\circ}$ C

<sup>3</sup> Auto range "ON"

<sup>4</sup> Output noise is typically 20 dB lower when DC and peak AC are < 320 mV and 50  $\Omega$  or 640 mV into open circuits



# Modulation, burst, and sweep

## Amplitude Modulation (AM)

Source	Internal only
Carrier waveform	Sine, square, ramp, arb
Modulating waveform	Sine, square, ramp, noise, arb
Depth <sup>1,2</sup>	0% to 120%, 0.01% resolution

## Frequency Modulation (FM)<sup>3</sup>

Source	Internal only
Carrier waveform	Sine, square, ramp, arb
Modulating waveform	Sine, square, ramp, noise, arb
Deviation	1 $\mu$ Hz to 15 MHz, 1 $\mu$ Hz resolution

## Phase Modulation (PM)

Source	Internal only
Carrier waveform	Sine, square, ramp, arb
Modulating waveform	Sine, square, ramp, noise, arb
Modulation frequency	2 mHz to 1 MHz
Deviation	0° to 360°, 0.1° resolution

## Frequency-Shift Key modulation (FSK)<sup>4</sup>

Source	Internal only
Carrier waveform	Sine, square, ramp, arb
Modulating waveform	Square with 50% duty cycle
Rate	$\leq$ 1 MHz

## Binary Phase-Shift Key modulation (BPSK)

Source	Internal or external connector
Phase shift	0° to 360°, 0.1° resolution
Rate	$\leq$ 1 MHz

## Pulse Width Modulation (PWM)

Source	Internal only
Carrier waveform	Pulse
Modulating waveform	Sine, square, ramp, noise, arb
Deviation <sup>5</sup>	0% to 100% of pulse width, 0.01% resolution

<sup>1</sup> Add 1/10 of the specification per °C for operation at temperatures below 18 °C or above 28 °C

<sup>2</sup> Subject to amplitude limits

<sup>3</sup> All frequency changes are phase continuous

<sup>4</sup> Auto range "ON"

<sup>5</sup> Subject to pulse width limits

**Burst characteristics <sup>1</sup>**

Type	Counted or gated
Counted burst operation	Each trigger event causes the instrument to produce from 1 to 10 <sup>8</sup> or an infinite number of waveform cycles.
Gated burst operation	The 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 after the completion of a cycle; more than one cycle might elapse before generation stops.
Start/stop phase <sup>2</sup>	-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 <sup>3</sup>**

Type	Linear, logarithmic, or list (up to 128 user-defined frequencies)
Operation	Characterization of linear and logarithmic sweeps occur 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.
Direction	Up (start frequency < stop frequency) or down (start frequency > stop frequency)

**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 <sup>4,5</sup>	Immediate (continuous), external (rear-panel connector), manual (front-panel button), bus or internal timer

<sup>1</sup> Counted burst is not available for Gaussian noise

<sup>2</sup> Limited to arbitrary waveforms that are < 1 million points; phase resolution limited by the number of points in arbitrary waveforms < 3,600 points

<sup>3</sup> All frequency changes are phase continuous

<sup>4</sup> External trigger only for sweep time > 8,000 seconds

<sup>5</sup> 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 the output frequency

## Two-channel characteristics – FG33532A only

### Standard

Operating modes	Independent, coupled parameter(s), combined (Channels 1 and 2); equal (Channel 1 = Channel 2) or differential (Ch 1 = -Ch 2)
Relative phase	0° to 360°, 0.1° resolution
Channel-to-channel skew (typical); both channels configured identically	< 0.8 ns
Crosstalk (typical)	< -75 dB

## Sync out / trigger out

### General

Connector	Front BNC, chassis-referenced; functions as an output
Minimum output high voltage	Minimum 1.3 V
Maximum output low voltage	Maximum 0.1 V

## External trigger input/gate, input/burst, input/FSK input

### General

Connector	Front BNC, chassis-referenced; functions as an input
Polarity	Positive or negative slope
Maximum rate	1 MHz

### Input

Minimum input high voltage	2.2 V
Maximum input low voltage	0.6 V
Minimum pulse width	16 ns
Variable trigger delay	0 to 1,000 s; 4 ns resolution
Latency (typical) <sup>1</sup>	< 160 ns with trigger delay set to zero
Jitter	< 2.5 ns, rms

<sup>1</sup> Only apply to 1 kHz and above

# Memory

## Instrument state

Store / recall	User-defined instrument states with user-defined names in the 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
Speed (nominal)	10 MB/s

# General characteristics

## USB file system

LXI-C (rev1.5)	10/100Base-T (sockets and VXI-11 protocols); USB 2.0 (USB-TMC488 protocol)
Web user interface	Remote operation and monitoring
Programming language	SCPI-1999, IEEE-488.2
Real-time clock / calendar battery	CR-2032 coin type, replaceable, > 5-year life (typical)

## Mechanical

Size (nominal)	314 mm W x 165 mm H x 125 mm D (12.36 in W x 6.50 in H x 4.92 in D)
Weight (nominal)	3.1 kg (6.8 lbs.)

## Environmental

Storage temperature	-40 °C to 70 °C
Warm-up time	1 hour
Operating environment	Indoor use, installation category II for AC input; pollution degree 2
Operating temperature	0 °C to 55 °C
Operating humidity	Up to 80% RH at 40 °C non-condensing
Altitude	Up to 3,000 meters (9842.5 ft)

## Regulatory

Electromagnetic compatibility	Compliant with EMC directive (2014/30/EU) IEC 61326-1/EN 61326-1 Group 1 Class A Canada: ICES/NMB-001 Australia / New Zealand: AS/NZS CISPR 11 South Korea: KC mark (South Korean Class A EMC declaration: Information to the user: This equipment has been conformity assessed for use in business environments. In a residential environment, this equipment may cause radio interference.)
Safety	IEC 61010-1 / EN 61010-1 USA: ANSI/UL Std. No. 61010-1 Canada: CAN/CSA-C22.2 No.61010-1
Acoustic noise	Sound pressure level (1 m free field) (nominal) 31 dB(A) at ambient $\leq 28\text{ }^{\circ}\text{C}$
<b>Line power</b>	
Line voltage	100 to 240 V, 50 / 60 Hz; 100 to 120 V, 50 / 60 Hz
Power consumption	< 45 W

## Definitions

### Specification (spec)

The specification refers to the warranted performance of a calibrated instrument stored for at least two hours within the operating temperature range of 0 to 55 °C and after a one-hour warm-up period. Measurement and calibration uncertainties comply with ISO-17025 methods. The data published in this document are specified as indicated.

### Typical (typ)

The characteristic performance that 80% or more of the manufactured instruments will meet. Warranty for this is not available and does not include measurement or calibration uncertainty, and is valid only at approximately 23 °C (room temperature).

### Nominal (nom)

Nominal represents the mean or average characteristic performance, or the value of an attribute determined by design, such as a connector type, physical dimension, or operating speed. The warranty for this data is unavailable, and the measurement is at approximately 23 °C (room temperature).

### Measured (meas)

Measured is an attribute taken during product development to communicate expected performance. Warranty for this data is unavailable, and the measurement is at approximately 23 °C (room temperature).

# Ordering Information

## FG33530A Series function / arbitrary waveform generators

FG33531A	Waveform generator, 100 MHz, 1-channel
FG33532A	Waveform generator, 100 MHz, 2-channel

## Standard shipped accessory

AC power cord (based on destination country)
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## Optional upgrade model

MEM33531U	Memory upgrade to 16 MSa for 1-channel FG33531A waveform generators
MEM33532U	Memory upgrade to 16 MSa for 2-channel FG33532A waveform generators

## Other Smart Bench Essential Plus series products

E36441A	Four-outputs autoranging DC power supply
DM34460A	Digital multimeter, 6 ½ digits
DM34461A	Digital multimeter, 6 ½ digits, with digitizer

# Keysight Services

Smart Bench Essentials Plus products include three years of extended warranty and three years of KeysightCare technical support, which provides unlimited access to technical experts with committed response times. Receive personalized, proactive, and priority support. Find answers in the Knowledge Center, manage service requests, and interact with Keysight experts.

Upgrading to KeysightCare Enhanced can extend your peace of mind and eliminate budgetary surprises for up to five years, and includes a calibration service of choice with prioritized turnaround times. Trust your test results with calibrated in-tolerance instruments and accurate measurements.



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