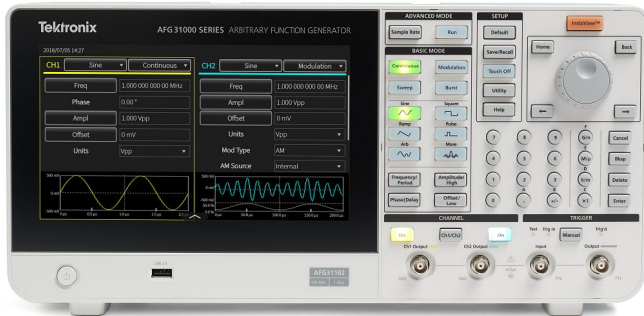# Arbitrary Function Generators
## AFG31000 Series Datasheet



The Tektronix AFG31000 Series is a high-performance AFG with built-in arbitrary waveform generation, real-time waveform monitoring, and the largest touchscreen on the market. Providing advanced waveform generation and programming capabilities, waveform verification, and a modern touch-screen interface, the new AFG31000 is sure to delight and simplify the job of every researcher and engineer.

## Key performance specifications

- 1 or 2 channel models

- Output amplitude range 1 mV$_{P-P}$ to 10 V$_{P-P}$ into 50 Ω loads

- Basic (AFG) mode:
  - 25 MHz, 50 MHz, 100 MHz, 150 MHz, or 250 MHz sine waveforms
  - 250 MSa/s, 1 GSa/s or 2 GSa/s sample rates
  - 14-bit vertical resolution
  - Built-in waveforms include sine, square, ramp, pulse, noise, and other frequently used waveforms
  - Sweep, Burst, and Modulation modes (AM, FM, PM, FSK, and PWM)

- Advanced (Sequence) mode:
  - Continuous mode (optional Sequence, Triggered and Gated modes)
  - 16 Mpts arbitrary waveform memory on each channel (128 Mpts optional)
  - Up to 256 steps in sequence mode with loop, jump and wait events
  - Variable sampling clock 1 µSa/s to 2 GSa/s

## Key features

- Patented InstaView™ technology enables engineers to see the actual waveform at the Device Under Test (DUT) in real time, without the need of an oscilloscope and probe, eliminating the uncertainty caused by mismatched impedance

- Sequencing option adds the ability to program long, complex waveforms with up to 256 steps

- The 9-inch capacitive touch screen works like a smart phone and has short-cuts to frequently used settings

- Built-in ArbBuilder lets you create and edit arbitrary waveforms on the instrument, eliminating the need to connect to a PC

- Outputs are protected from over voltage and current to minimize potential instrument damage

- Compatible with TekBench™ software to help students set up, control, and analyze test results in the lab

## Applications

- Advanced research

- Clock and system synchronization

- Replication of real world signals

- Component and circuit characterization and validation

- Embedded circuit design and test

- General purpose signal generation

## Basic and Advanced Modes

The AFG31000 series is the industry's first arbitrary function generator with full function Basic (AFG) and Advanced (Sequence) modes.

In Basic mode, the AFG31000 generates traditional functions and arbitrary waveforms. The touchscreen and front-panel controls make it simple to set up.

Basic mode lets you change frequency without the need to worry about waveform length and sample rate. This feature is useful in analog designs that characterize filter/amplifier frequency responses or in digital designs where clock rates change frequently.
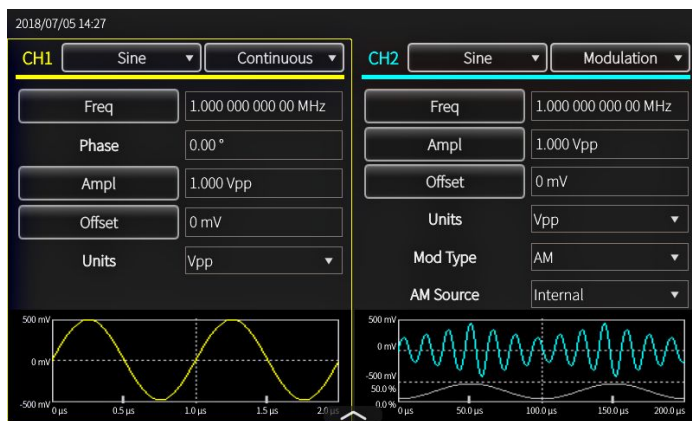


*Key settings are visible at a glance, and are easy to adjust using touch, numeric keypad, or rotary controls*

New with the AFG31000, Advanced mode provides the ability to generate multiple waveforms with complex timing. In this mode, you can compose a list (or a sequence) of 1 to 256 waveforms, with total waveform length up to 16 Mpts/ch (128 Mpts/ch optional) and define the ouput sequence of these waveforms. Repeat, go-to, wait, jump, and triggered events are all supported and the large memory provides space to store many waveforms or long waveforms.

This feature is very useful in applications where many test cases need to be performed sequentially. Instead of loading the test cases one by one, you can put all of them in a sequence and load at one time, switching from one to another seamlessly to greatly improve the test efficiency.
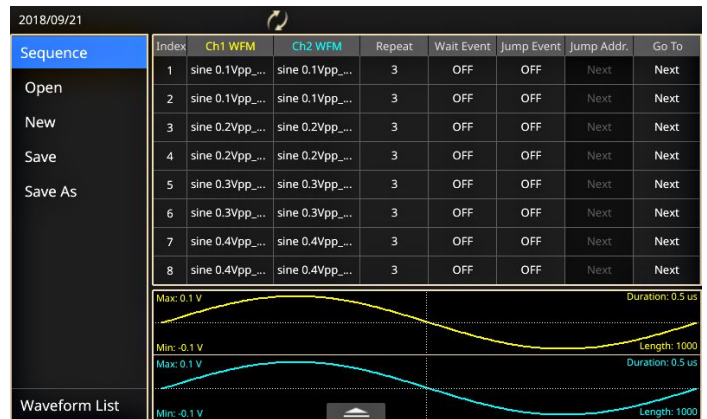


*Advanced mode lets you build complex waveform sequences with flexible step controls*
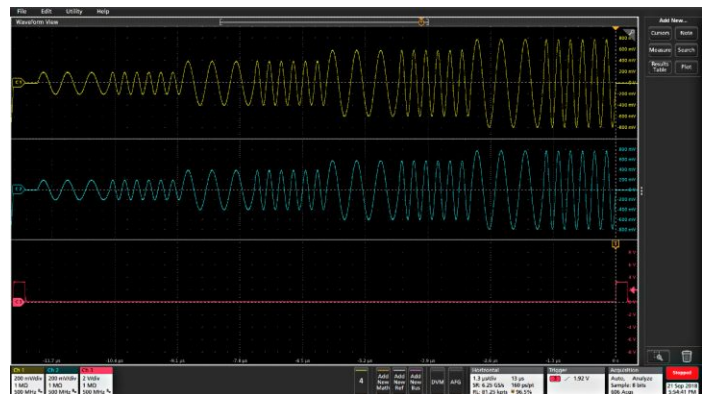


*Sequenced sine waveforms with different frequency and amplitude.*

Additionally, Advanced mode uses variable sample rate technology. Every sample in a waveform is output once and only once in each cycle, synchronized to the sample rate. Since there is no skipping or repetition, all details in the waveforms are kept. This feature is very useful for applications in which signal fidelity is extremely critical, such as IQ modulation and pulse train generation.

## InstaView™ technology shows the actual waveform at the DUT

Most waveform generators assume they are driving a 50 Ω impedance. However, most devices under test do not have a 50 Ω impedance. This mismatch results in an inconsistency between the waveform as set on the AFG and the signal at the DUT.
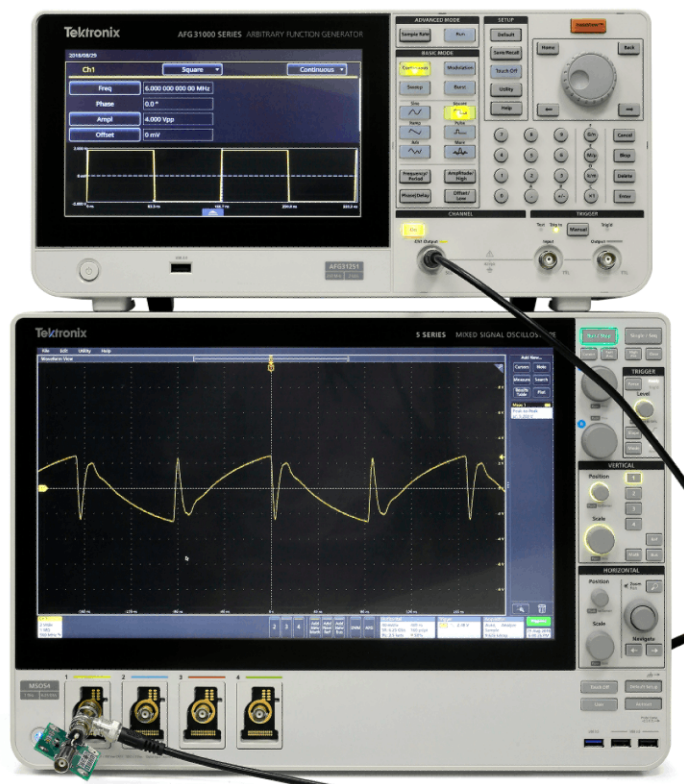
*With InstaView turned off, the AFG31000 works like a traditional function generator. Due to an impedance mismatch, the AFG display shows a different waveform from the one observed at the DUT.*

With the patented InstaView ™ technology, the AFG31000 Series can display the actual waveform at the DUT, instead of just the nominal waveform as set on the AFG. The waveform displayed on the AFG instantly responds to changes in frequency, amplitude, waveform shape, and impedance changes at the DUT. InstaView helps eliminate the uncertainty and measurement risk caused by impedance mismatches, without requiring additional cables, instruments, or effort.
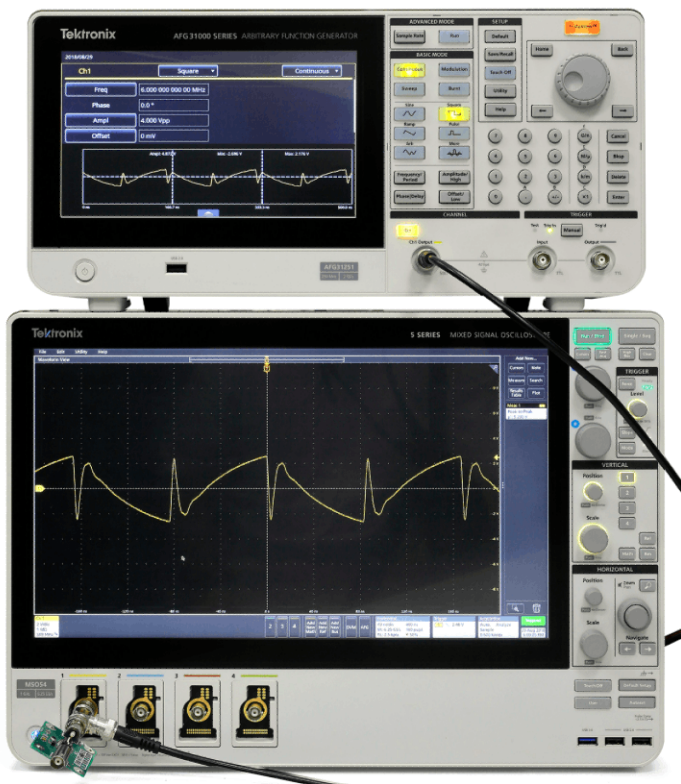


*With InstaView turned on, the AFG31000 shows the waveform as observed at the DUT.*

## A large touch screen and smart user interface

The large 9-inch capacitive touch screen displays all related settings and parameters on a single screen. Similar to smart devices, you can tap or swipe to easily select, browse, locate and change settings and parameters. Frequently-used functions are immediately accessible. Familiar buttons and rotary knob controls are available for more traditional navigation.
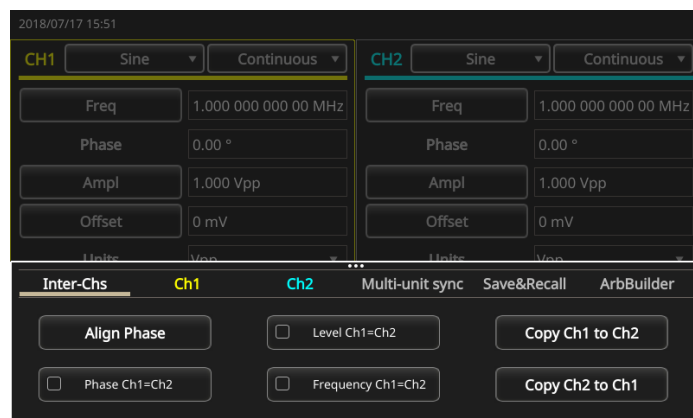


*Frequently used settings are easy to access from the swipe-up menu*

## Built-in ArbBuilder tool makes creating and editing arbitrary waveforms easier than ever

In the past, you needed a PC with waveform editing software to create or edit your arbitrary waveforms. The waveform would then need to be downloaded to the AFG using either a USB stick or a data cable connection. The process was time-consuming, especially when waveforms required frequent changes.

ArbBuilder is a built-in application on the AFG31000 series that lets you create and edit your arbitrary waveforms directly on the generator. You can create arbitrary waveforms with the Equation Editor tool or start from a library of standard templates. Thanks to the large capacitive touch screen, you can drag, pinch and zoom to get the detail you need.

You can quickly replicate real-world waveforms captured with oscilloscopes or created by third-party software by loading CSV format data files directly into ArbBuilder from a USB memory stick.
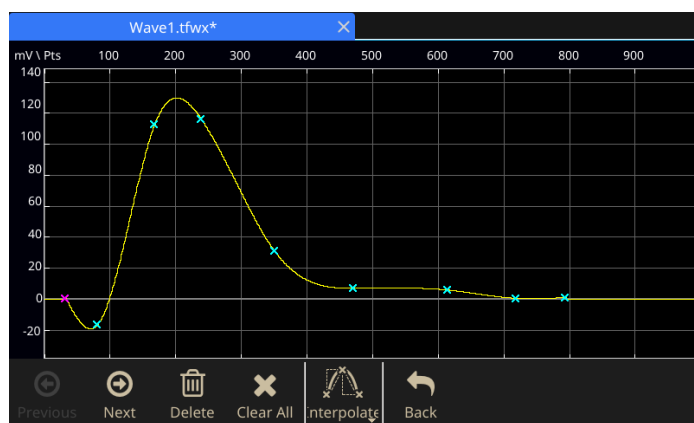


*Creating an arbitrary waveform using the easy touch screen interface*

## Simplified multi-unit synchronization

Most applications need one or two channels of output, but some applications require more channels. For example, in order to simulate 3-phase power signals, engineers often need to synchronize three 2-channel generators; one for the voltage and current on each phase. To do this used to be time-consuming, as it required many cable connections between the AFG units, and making changes in deep branches of the menu trees on all instruments.

The AFG31000 simplifies this process with an onscreen wizard that leads you through the process of making cable connections and configuring settings to synchronize multiple generators.
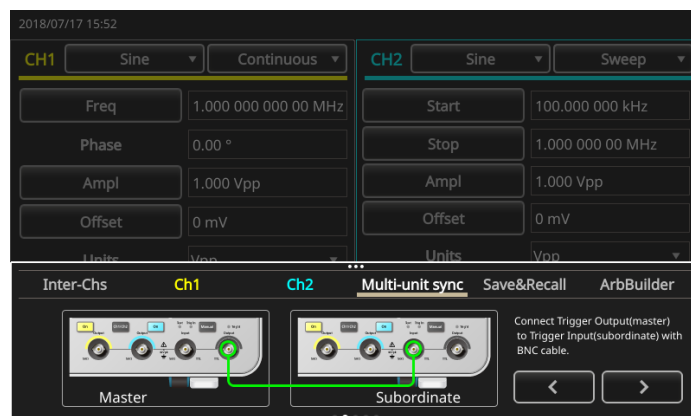


*An on-screen wizard guides you through the process of multiple-unit synchronization*

## Upgradability protects your investment

The AFG31000 provides upgrade options for bandwidth, memory extension, and sequence mode support. These options can be installed at the factory or at any time after purchase. This upgradability helps to reduce the product ownership threshold. And when your test requirements change, you can purchase and install upgrade software licenses to add higher performance features. Upgrades eliminate the concern about the return on investment during the instrument lifetime.

# Specifications

All specifications are guaranteed unless noted otherwise. All specifications apply to all models unless noted otherwise.

## Model overview

| Model | Sine frequency range | Number of channels |
|---|---|---|
| AFG31021 | 25 MHz | 1 |
| AFG31051 | 50 MHz | |
| AFG31101 | 100 MHz | |
| AFG31151 | 150 MHz | |
| AFG31251 | 250 MHz | |
| AFG31022 | 25 MHz | 2 |
| AFG31052 | 50 MHz | |
| AFG31102 | 100 MHz | |
| AFG31152 | 150 MHz | |
| AFG31252 | 250 MHz | |

## Output characteristics

**Amplitude**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Range (into 50 Ω) | ≤ 60 MHz: 1 $mV_{P-P}$ to 10 $V_{P-P}$ <br> > 60 MHz to ≤ 80 MHz: 1 $mV_{P-P}$ to 8 $V_{P-P}$ <br> > 80 MHz to ≤ 100 MHz: 1 $mV_{P-P}$ to 6 $V_{P-P}$ | | | ≤ 200 MHz: 1 $mV_{P-P}$ to 5 $V_{P-P}$ <br> > 200 MHz to ≤ 250 MHz: 1 $mV_{P-P}$ to 4 $V_{P-P}$ | |
| Range (into open circuit or High-Z) | ≤ 60 MHz: 2 $mV_{P-P}$ to 20 $V_{P-P}$ <br> > 60 MHz to ≤ 80 MHz: 2 $mV_{P-P}$ to 16 $V_{P-P}$ <br> > 80 MHz to ≤ 100 MHz: 2 $mV_{P-P}$ to 12 $V_{P-P}$ | | | ≤ 200 MHz: 2 $mV_{P-P}$ to 10 $V_{P-P}$ <br> > 200 MHz to ≤ 250 MHz: 2 $mV_{P-P}$ to 8 $V_{P-P}$ | |
| Accuracy | ± (1% of setting +1 $mV_{P-P}$) <br> (1 kHz sine, 0 V offset, amplitude > 1 $mV_{P-P}$) | | | | |
| Resolution | 0.1 $mV_{P-P}$, 0.1 $mV_{RMS}$, 1 mV, 0.1 dBm or 4 digits | | | | |
| Units | Vpp, Vrms (excluding Arb and Noise), dBm (sine wave only), Volt (High Level and Low Level) | | | | |

**Offset**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Range (into 50 Ω) | ±(5 $V_{PK}$ - Amplitude$_{P-P}$ ÷ 2) | | | ±(2.5 $V_{PK}$ - Amplitude$_{P-P}$ ÷ 2) | |
| Range (into open circuit or High-Z) | ±(10 $V_{PK}$ - Amplitude$_{P-P}$ ÷ 2) | | | ±(5 $V_{PK}$ - Amplitude$_{P-P}$ ÷ 2) | |
| Accuracy | ± (1% of |setting| +1 mV + 0.5% of Amplitude ($V_{P-P}$)) | | | | |
| Resolution | 1 mV or 4 digits | | | | |

**Output impedance**   50 Ω

**Load impedance setting**   Selectable: 50 Ω, 1 Ω to 10.0 kΩ, High Z (Adjusts displayed amplitude according to selected load impedance)

**Isolation**   42 Vpk maximum to earth ground

**Short-circuit protection**   Signal outputs are robust against permanent shorts against floating ground

**Overcurrent protection**   When incoming current is greater than 250 mA, the output channels are protected with relays that disconnect the AFG from the device under test. Connection can be resumed by user after removing the incoming current

## General characteristics - Basic mode

**Basic (AFG)**

| | |
|---|---|
| **Run modes** | Continuous, Modulation, Sweep and Burst |
| **Standard waveforms** | Sine, Square, Pulse, Ramp, More (Noise, DC,Sin(x)/x, Gaussian, Lorentz, Exponential Rise, Exponential Decay, Haversine ) |
| **Arbitrary waveforms** | Sampling clock: 250 MSa/s, 1 GSa/s or 2 GSa/s (model and waveform length apply) |
| | Vertical resolution: 14 bits |
| | Waveform length: 2 to 131,072 points |

**Sine**

**Frequency range**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Continuous mode | 1 µHz to 25 MHz | 1 µHz to 50 MHz | 1 µHz to 100 MHz | 1 µHz to 150 MHz | 1 µHz to 250 MHz |
| Burst mode | 1 µHz to 12.5 MHz | 1 µHz to 25 MHz | 1 µHz to 50 MHz | 1 µHz to 75 MHz | 1 µHz to 125 MHz |

**Effective maximum frequency out**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 25 MHz | 50 MHz | 100 MHz | 150 MHz | 250 MHz |

**Amplitude flatness (1 V$_{P-P}$, relative to 1 kHz)**

| Frequency range | AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|---|
| < 5 MHz | ±0.2 dB | ±0.2dB |
| ≥ 5 MHz to 25 MHz | ----- | ±0.3 dB |
| ≥ 5 MHz to 100 MHz | ±0.3 dB | ----- |
| > 25 MHz to 100 MHz | ----- | ±0.5 dB |
| > 100 MHz to 200 MHz | ----- | ±1.0 dB |
| > 200 MHz to 250 MHz | ----- | ±2.0 dB |

**Amplitude flatness (1 V$_{P-P}$, relative to 1 kHz), typical**

| AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102, AFG31151, AFG31152 | AFG31251 / AFG31252 |
|---|---|
| ±0.1 dB | ≤ 150 MHz: ±0.1 dB<br>> 150 MHz to 250 MHz: ±0.3 dB |

## General characteristics - Basic mode

Harmonic distortion (1 $V_{P-P}$), typical

| Frequency range | AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 |
|---|---|
| 10 Hz to <20 kHz | < -70 dBc |
| ≥20 kHz to <1 MHz | < -60 dBc |
| ≥1 MHz to <5 MHz | < -50 dBc |
| ≥5 MHz to ≤100 MHz | < -37 dBc |

| Frequency range | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|
| 10 Hz to < 1 MHz | < -60 dBc |
| ≥ 1 MHz to < 5 MHz | < -50 dBc |
| ≥ 5 MHz to ≤ 25 MHz | < -37 dBc |
| ≥ 25 MHz to ≤ 250 MHz | < -30 dBc |

THD, typical

≤ 0.1%, 10 Hz to 20 kHz, 1 $V_{P-P}$

Spurious noise (1 $V_{P-P}$), typical

| Frequency range | AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 |
|---|---|
| ≥ 10 Hz to <1 MHz | < -60 dBc |
| ≥ 1 MHz to <25 MHz | < -50 dBc |
| ≥ 25 MHz to ≤100 MHz | < -50 dBc + 6 dBc/octave |

| Frequency range | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|
| 10 Hz to < 1 MHz | < -60 dBc |
| ≥ 1 MHz to ≤25 MHz | < -47 dBc |
| ≥25 MHz to ≤250 MHz | < -47 dBc + 6 dBc/octave |

Phase noise, typical

< -110 dBc/Hz at 20 MHz, 10 kHz offset, 1 $V_{P-P}$

Residual clock noise, all models

-63 dBm

### Square

Frequency range

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 1 µHz to 20 MHz | 1 µHz to 40 MHz | 1 µHz to 80 MHz | 1 µHz to 120 MHz | 1 µHz to 160 MHz |

Rise/fall time, typical

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Amplitude ≤ 5 Vpp | ≤ 7.0 ns | ≤ 5.0 ns | ≤ 3.5 ns | ≤ 3.0 ns | ≤ 2.0 ns |
| Amplitude > 5 Vpp | ≤ 8.0 ns | ≤6.0 ns | ≤ 4.2 ns | ----- | ----- |

Overshoot, typical

< 5%

Jitter (RMS), typical

2.5 ps

## General characteristics - Basic mode

### Ramp

**Frequency range**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 1 µHz to 500 kHz | 1 µHz to 800 kHz | 1 µHz to 1 MHz | 1 µHz to 1.5 MHz | 1 µHz to 2.5 MHz |

**Linearity, typical (1 kHz, 1 V$_{P-P}$, 100% symmetry)**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| ≤ 0.1% of peak output | ≤ 0.1% of peak output | ≤ 0.15% of peak output | ≤ 0.2% of peak output | ≤ 0.2% of peak output |

**Symmetry**   0% to 100%

### Pulse

**Frequency range**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 1 µHz to 20 MHz | 1 µHz to 40 MHz | 1 µHz to 80 MHz | 1 µHz to 120 MHz | 1 µHz to 160 MHz |

**Pulse width**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 16 ns to 999.99 s | 10 ns to 999.99 s | 6 ns to 999.99 s | 5 ns to 999.99 s | 4 ns to 999.99 s |

**Pulse width resolution**   10 ps or 5 digits

**Pulse Duty**   0.001% to 99.999% (limitations of pulse width apply)

**Edge transition time**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 8 ns to 0.625 * Pulse Period | 6 ns to 0.625 * Pulse Period | 4 ns to 0.625 * Pulse Period | 3 ns to 0.625 * Pulse Period | 2 ns to 0.625 * Pulse Period |

**Edge transition time resolution**   10 ps or 4 digits

**Lead delay range**

| Mode | Characteristic |
|---|---|
| Continuous | 0 ps to Period |
| Burst | 0 ps to Period – [ Pulse Width + 0.8 * (Leading Edge Time + Trailing Edge Time)] |

**Lead delay resolution**   10 ps or 8 digits

**Overshoot, typical**   < 5%

**Jitter (RMS), typical**   2.5 ps

### DC

**Range (into 50 Ω)**

| AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|
| -5 V to 5 V | -2.5 V to 2.5 V |

**Resolution (into 50 Ω)**   1 mV or 4 digits

**Accuracy**   ± (1% of |setting | +1mV)

# General characteristics - Basic mode

**Noise**

**Bandwidth (-3 dB)**

| AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|
| 150 MHz | 360 MHz |

**Noise type** White Gaussian

**Internal noise**

| | Characteristic |
|---|---|
| Add | When activated, output signal amplitude is reduced to 50% |
| Level | 0.0% to 50% of amplitude ($V_{P-P}$) setting |
| Resolution | 1% |

**Other waveforms** Frequency range

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| 1 µHz to 500 kHz | 1 µHz to 800 kHz | 1 µHz to 1 MHz | 1 µHz to 1.5 MHz | 1 µHz to 2.5 MHz |

**Arbitrary waveforms**

**Frequency range**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Normal | 1 mHz to 12.5 MHz | 1 mHz to 25 MHz | 1 mHz to 50 MHz | 1 mHz to 75 MHz | 1 mHz to 125 MHz |
| Burst mode | 1 mHz to 6.25 MHz | 1 mHz to 12.5 MHz | 1 mHz to 25 MHz | 1 mHz to 37.5 MHz | 1 mHz to 62.5 MHz |

**Effective analog bandwidth (-3 dB)**

| AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|
| 150 MHz | 360 MHz |

**Waveform length** 2 to 131,072

**Sample rate**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Waveform length ≤ 16,384 | 250 MSa/s | 1 GSa/s | 1 GSa/s | 2 GSa/s | 2 GSa/s |
| Waveform length > 16,384 | 250 MSa/s | 250 MSa/s | 250 MSa/s | 250 MSa/s | 250 MSa/s |

**Vertical resolution** 14 bit

**Rise/fall time, typical**

| | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Amplitude ≤ 5Vpp | ≤ 3.5 ns | ≤ 3.5 ns | ≤ 3.5 ns | ≤ 2 ns | ≤ 2 ns |
| Amplitude > 5Vpp | ≤ 4.2 ns | ≤ 4.2 ns | ≤ 4.2 ns | ----- | ----- |

**Jitter (RMS), typical** 2.5 ps

# Datasheet

## General characteristics - Basic mode

**Modulation**

**AM, FM, PM**

| Specification | Characteristic |
|---|---|
| Carrier | All except pulse, noise, DC |
| Source | Internal or external |
| Internal modulating waveform | Sine, Square, Ramp, Noise, ARB (maximum waveform length: AM 131,072 pts; FM/PM/PWM 2,048 pts) |
| Internal modulating frequency | 1 mHz to 1 MHz |

**AM modulation depth**    0.0 % to 120 %

**AM modulation resolution**    0.1%

**Minimum FM peak deviation**    DC

**Maximum FM peak deviation**

|  | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| Sine | 12.5 MHz | 25 MHz | 50 MHz | 75 MHz | 125 MHz |
| Square, | 10 MHz | 20 MHz | 40 MHz | 60 MHz | 80 MHz |
| Arb | 6.25 MHz | 12.5 MHz | 25 MHz | 37.5 MHz | 62.5 MHz |
| Others | 250 kHz | 400 kHz | 500 kHz | 750 kHz | 1.25 MHz |

**PM phase deviation range**    0° to 180°

**PM phase resolution**    0.1°

**FSK**

| Specification | Characteristic |
|---|---|
| Carrier | All except pulse, noise, DC |
| Source | Internal or external |
| Number of keys | 2 |
| Internal key rate | 1 mHz to 1 MHz |

**PWM**

| Specification | Characteristic |
|---|---|
| Carrier | Pulse |
| Source | Internal or external |
| Internal modulating waveform | Sine, Square, Ramp, Noise, ARB (maximum waveform length: 2,048 pts) |
| Internal modulating frequency | 1 mHz to 1 MHz |
| Deviation range | 0% to 50.0% of pulse period |

**Sweep**

**Type**    Linear, Logarithmic

**Waveforms**    All, except Pulse, Noise, DC

**Sweep time**    1 ms to 500 s

**Hold/return time**    0 s to 500 s

## General characteristics - Basic mode

| | |
|---|---|
| **Maximum total sweep time** | 500 s |
| | Accuracy, typical: ≤ 0.4% |
| **Minimum start/stop frequency** | All except ARB: 1 µHz |
| | ARB: 1 mHz |

| **Maximum start/stop frequency** | | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|---|
| | Sine | 25 MHz | 50 MHz | 75 MHz | 125 MHz | 250 MHz |
| | Square | 20 MHz | 40 MHz | 80 MHz | 120 MHz | 160 MHz |
| | Arb | 12.5 MHz | 25 MHz | 50 MHz | 75 MHz | 125 MHz |
| | Others | 500 kHz | 800 kHz | 1 MHz | 1 MHz | 2.5 MHz |

### Burst

| | |
|---|---|
| **Waveform** | All except Noise, DC |
| **Type** | Triggered, gated |
| **Burst count** | 1 to 1,000,000 cycles or Infinite |
| **Intenal trigger rate** | 1 µs to 500.0 s |
| **Gate and trigger sources** | Internal, external, remote interface |

### InstaView™

| | |
|---|---|
| **Waveforms** | All except noise |
| **Cable (channel output to load)** | 50 Ω BNC to BNC |
| **Run mode** | Continuous in Basic mode |

| **Maximum measurement range (DC + peak AC voltage)** | AFG31021, AFG31022, AFG31051, AFG31052, AFG31101, AFG31102 | AFG31151, AFG31152, AFG31251, AFG31252 |
|---|---|---|
| | -10 V to 10 V | -5 V to 5 V |

| **DC level measurement** | Specification | Characteristic |
|---|---|---|
| | Accuracy (into 50Ω), typical | ± (2 % of \|setting\| + 20 mVpp) |
| | Resolution | 1 mV or 4 digits |

| **Amplitude measurement** | Specification | Characteristic |
|---|---|---|
| | Accuracy (sine, 1 kHz, 1 $V_{P-P}$, into 50 Ω, typical) | ± (2 % of setting + 20 mV) |
| | Resolution | 1 mV or 4 digits |

| | |
|---|---|
| **Bandwidth (-3 dB)** | 500 MHz |

## General characteristics - Basic mode

| Flatness, sine, 1 V<sub>P-P</sub>, into 50 ohm, relative to 1 kHz, typical | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| | 0 to 100 MHz: ±1 dB | | | 0 to 200 MHz: ±1 dB<br>200 MHz to 250 MHz: ±2 dB | |

| Cable propagation delay measurement, typical | Specification | Characteristic |
|---|---|---|
| | Range | 0 to 20 ns (approximately 4 m/13 feet in length) |
| | Accuracy, typical | ± 500 ps |

## General characteristics - Advanced mode

| Waveform memory size | 16 Mpts (128 Mpts optional) each channel |
|---|---|
| **Run mode** | Standard: Continuous<br><br>Optional: Sequence, Triggered, Gated |
| **Number of waveform entries** | Continuous, Triggered, Gated: 1<br><br>Sequence: 1 to 256 |
| **Minimum waveform length** | 168 pts |
| **Waveform granularity** | 1 pt |
| **Vertical resolution** | 14 bits |
| **Jump/trigger events** | External trigger (rising or falling edge), manual trigger, timer, SCPI commands |
| **Repeat count** | 1 to 1,000,000 or infinite |
| **Timer range** | 2 µS to 3600 S |
| **Timer resolution** | 4 ns or 8 digits |

| Variable sample rate | | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|---|
| | Range | 1 µSa/s to 250 MSa/s | 1 µSa/s to 500 MSa/s | 1 µSa/s to 1 GSa/s | 1 µSa/s to 2 GSa/s | 1 µSa/s to 2 GSa/s |
| | Accuracy | $10^{-6}$ Sa/s | | | | |
| | Resolution | 1 µSa/s or 12 digits | | | | |

| Rise/Fall time, typical | AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|---|
| | Amplitude ≥ 5 V<sub>P-P</sub>: ≤ 4.2 ns<br>Amplitude < 5 V<sub>P-P</sub>: ≤ 3.5 ns | | | ≤ 3.0 ns | ≤ 2.0 ns |

| Overshoot | < 4% |
|---|---|

## General characteristics - Advanced mode

**Level flatness, typical (sine, 1 V<sub>P-P</sub>, relative to 1 kHz)**

| Frequency range | All models |
|---|---|
| < 5MHz | ±0.3 dB |
| ≥ 5 MHz to 25 MHz | ±0.5 dB |
| ≥ 25 MHz to 50 MHz | ±0.6 dB |
| ≥ 50 MHz to 100 MHz | ±1.0 dB |
| ≥ 100 MHz to 150 MH | ±1.5 dB |
| ≥ 150 MHz to 250 MHz | ±2.3 dB |

**Harmonic distortion, typical (sine with 64 pts/cycle, 1 $V_{P-P}$)**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| < -60 dBc at 250 MSa/S or 3.90625 MHz | < -55 dBc at 500 MSa/S or 7.8125 MHz | < -50 dBc at 1 GSa/S or 15.625 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz |

**Spurious, typical (sine with 64 pts/ cycle, 1 $V_{P-P}$)**

| AFG31021 / AF 31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| < -60 dBc at 250 MSa/S or 3.90625 MHz | < -55 dBc at 500 MSa/S or 7.8125 MHz | < -50 dBc at 1 GSa/S or 15.625 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz |

**Spurious free dynamic range, typical (sine with 64 pts/cycle, 1 $V_{P-P}$)**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| < -60 dBc at 250 MSa/S or 3.90625 MHz | < -55 dBc at 500 MSa/S or 7.8125 MHz | < -50 dBc at 1 GSa/S or 15.625 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz | < -45 dBc at 2 GSa/S or 31.25 MHz |

**Phase noise, typical (sine with 64 pts/cycle, 1 $V_{P-P}$, at 10 kHz offset)**

| AFG31021 / AFG31022 | AFG31051 / AFG31052 | AFG31101 / AFG31102 | AFG31151 / AFG31152 | AFG31251 / AFG31252 |
|---|---|---|---|---|
| < -132 dBc at 250 MSa/S or 3.90625 MHz | < -130 dBc at 500 MSa/S or 7.8125 MHz | < -125 dBc at 1 GSa/S or 15.625 MHz | < -113 dBc at 2 GSa/S or 31.25 MHz | < -113 dBc at 2 GSa/S or 31.25 MHz |

**Skew control**

| | |
|---|---|
| **Range** | -320 ns to 320 ns (channel 1 to channel 2 on dual channel models, at maximum sample rate) |
| **Resolution** | 100 ps or 4 digits |
| **Accuracy, typical** | ±(1% of |setting| + 500 ps) |

**Initial skew, typical**    < 500 ps

## System characteristics

**Output Frequency Resolution**

| | |
|---|---|
| **Frequency accuracy** | $\pm10^{-6}$ of setting (all except ARB), 0 °C to 50 °C (32 °F to 122 °F) |
| | $\pm10^{-6}$ of setting ± 1 µHz (ARB), 0 °C to 50 °C (32 °F to 122 °F) |
| **Aging** | $\pm1.0 \times 10^{-6}$ per year |

**Phase**

| | |
|---|---|
| **Range** | -180° to +180° |
| **Resolution** | 0.01° (sine) |
| | 0.1° (other waveforms) |

**Remote program interface**    GPIB, Ethernet 10BASE-T / 100BASE-TX / 1000BASE-T, USB 2.0

## System characteristics

**Maximum configuration times, typical**

| | USB | LAN | GPIB |
|---|---|---|---|
| Function change | 61 ms | 61 ms | 63 ms |
| Frequency change (except Pulse) | 3 ms | 4 ms | 6 ms |
| Frequency change (Pulse) | 2.5 ms | 3 ms | 8 ms |
| Amplitude change | 65 ms | 66 ms | 77 ms |
| Select user ARB (4k points from USB Memory) | 43 ms | 40 ms | 53 ms |
| Select user ARB (128k points from USB Memory) | 86 ms | 92 ms | 92 ms |
| Data download time for 4k points | 36 ms | 21 ms | 21 ms |

**Power source**

**Source**       100-240 V, 47-63 Hz

115 V, 360-440 Hz

**Consumption**       120 W

**Warm up time, typical**       20 minutes minimum

**Power on self diagnosis time**       < 24 s

**Acoustic noise**       < 50 dBA

**Display**       9-inch capacitive touch screen with 800 * 480 resolution

**User interface and Help languages**       English, French, German, Japanese, Korean, Simplified and Traditional Chinese, Russian (user selectable)

## Auxiliary input characteristics

**External modulation input, channel 1 and channel 2**

**Input range**

| | Characteristic |
|---|---|
| AM, FM, PM, PWM | ±1 V full range |
| FSK | 3.3 V logic level |

**Input impedance**       5.2 kΩ

**Frequency range**       125 kHz (1 MSa/s)

**External Trigger input**

**Level**       TTL compatible

**Impedance**       10 kΩ

**Minimum pulse width**       100 ns

**Slope**       Positive or negative selectable

**Trigger delay range**       0 ns to 85 s

**Trigger delay resolution**       100 ps or 5 digits

**Trigger latency, typical**       390 ns (trigger input to signal output)

**Jitter (RMS), typical**       100 ps (signal output, with external trigger input in burst mode)

**10 MHz reference clock input**

**Impedance**       1 kΩ

**Input coupling**       AC

## Auxiliary input characteristics

| | |
|---|---|
| **Required input voltage swing** | 100 mV$_{P-P}$ to 5 V$_{P-P}$ |
| **Lock range** | 10 MHz ±35 kHz |

**Channel 1 external add input**

| | |
|---|---|
| **Impedance** | 50 Ω |
| **Input range** | -1 V to +1 V (DC + peak AC) |
| **Bandwidth** | DC to 10 MHz (-3 dB) at 1 V$_{P-P}$ |

## Auxiliary output characteristics

**Channel 1 trigger output**

| | |
|---|---|
| **Level** | Positive TTL level pulse into 1 kΩ |
| **Impedance** | 50 Ω |
| **Jitter, RMS, typical** | 10 ps for all models |

**Output frequency**

| | Characteristic |
|---|---|
| Waveform frequency < 4.9 MHz | Same as the waveform frequency |
| Waveform frequency ≥ 4.9 MHz < 50 MHz | A fraction of the waveform frequency |
| Waveform frequency ≥ 50 MHz | No output |

**10 MHz reference clock out**

| | |
|---|---|
| **Impedance** | 50 Ω, AC coupled |
| **Amplitude** | 1.2 V$_{P-P}$ into 50 Ω load |

## Physical characteristics

**Dimensions**

| | |
|---|---|
| **Height** | 191.8 mm (7.55 in.) |
| **Width** | 412.8 mm (16.25 in.) |
| **Depth** | 143.3 mm (5.64 in.) |

**Weight**

| | |
|---|---|
| **Net** | 4.7 kg (10.4 lb.) |
| **Shipping** | 7.0 kg (15.4 lb.) |

## EMC, environment, and safety

**Temperature**

| | |
|---|---|
| **Operating** | 0 °C to +50 °C (32 °F to 122 °F) |
| **Nonoperating** | -30 °C to +70 °C (-22 °F to 158 °F) |

**Humidity**

| | |
|---|---|
| **Operating** | ≤ 80%, 0 °C to 40 °C (32 °F to104 °F) |
| | ≤ 60%, > 40°C to 50°C (104 °F to 122 °F), noncondensing |
| **Nonoperating** | 5% to 90%, < 40 °C (< 104 °F), noncondensing |
| | 5% to 80%, ≥ 40 °C to 60 °C (≥ 104 °F to 140 °F), noncondensing |
| | 5% to 40%, > 60 °C to 70 °C (> 140 °F to 158 °F), noncondensing |

**Altitude**

| | |
|---|---|
| **Operating** | Up to 3,000 m (9,842 ft.) |
| **Nonoperating** | Up to 12,000 m (39,370 ft.) |

| | |
|---|---|
| **EMC compliance** | EN61326-1:2013, EN 61326-2-1:2013 |
| **European Union** | EU Council Directive 2004/108/EC |

| | |
|---|---|
| **Safety** | UL 61010-1:2004 |
| | CAN/CSA C22.2 No. 61010-1:2004 |
| | IEC 61010-1:2001 |

| | |
|---|---|
| **Over-temperature protection** | Instrument is protected from over-temperature by turning off outputs |

# Ordering Information

## Models

| | |
|---|---|
| **AFG31021** | 1 µHz to 25 MHz sine wave, 1-channel arbitrary function generator |
| **AFG31022** | 1 µHz to 25 MHz sine wave, 2-channel arbitrary function generator |
| **AFG31051** | 1 µHz to 50 MHz sine wave, 1-channel arbitrary function generator |
| **AFG31052** | 1 µHz to 50 MHz sine wave, 2-channel arbitrary function generator |
| **AFG31101** | 1 µHz to 100 MHz sine wave, 1-channel arbitrary function generator |
| **AFG31102** | 1 µHz to 100 MHz sine wave, 2-channel arbitrary function generator |
| **AFG31151** | 1 µHz to 150 MHz sine wave, 1-channel arbitrary function generator |
| **AFG31152** | 1 µHz to 150 MHz sine wave, 2-channel arbitrary function generator |
| **AFG31251** | 1 µHz to 250 MHz sine wave, 1-channel arbitrary function generator |
| **AFG31252** | 1 µHz to 250 MHz sine wave, 2-channel arbitrary function generator |

## Options

### Factory options

| | |
|---|---|
| **MEM** | Extends arbitrary waveform memory to 128 Mpts/ch in Advanced mode |
| **SEQ** | Enables Sequence, Triggered and Gated modes in Advanced mode |

### Feature upgrade after purchase

The AFG31000 products offer several ways to easily add functionality after the initial purchase.

| Description (node locked licenses) | For one channel instruments | For two channel instruments |
|---|---|---|
| Enables Sequence, Triggered, and Gated modes in Advanced mode | AUP-AFG3SEQ-1 | AUP-AFG3SEQ-2 |
| Extends arb memory to 128 Mpts/ch in Advanced mode | AUP-AFG3MEM-1 | AUP-AFG3MEM-2 |
| Bandwidth extension from 25 MHz to 50 MHz | AUP-AFG3BW25T50-1 | AUP-AFG3BW25T50-2 |
| Bandwidth extension from 25 MHz to 100 MHz | AUP-AFG3BW25T100-1 | AUP-AFG3BW25T100-2 |
| Bandwidth extension from 50 MHz to 100 MHz | AUP-AFG3BW50T100-1 | AUP-AFG3BW50T100-2 |
| Bandwidth extension from 150 MHz to 250 MHz | AUP-AFG3BW150T250-1 | AUP-AFG3BW150T250-2 |

## Power plug options

| | |
|---|---|
| **Opt. A0** | North America power plug (115 V, 60 Hz) |
| **Opt. A1** | Universal Euro power plug (220 V, 50 Hz) |
| **Opt. A2** | United Kingdom power plug (240 V, 50 Hz) |
| **Opt. A3** | Australia power plug (240 V, 50 Hz) |
| **Opt. A5** | Switzerland power plug (220 V, 50 Hz) |
| **Opt. A6** | Japan power plug (100 V, 50/60 Hz) |
| **Opt. A10** | China power plug (50 Hz) |
| **Opt. A11** | India power plug (50 Hz) |
| **Opt. A12** | Brazil power plug (60 Hz) |
| **Opt. A99** | No power cord |

## Language options

| | |
|---|---|
| **Opt. L0** | English front panel overlay (default) |
| **Opt. L1** | French front panel overlay |
| **Opt. L2** | Italian front panel overlay |
| **Opt. L3** | German front panel overlay |
| **Opt. L4** | Spanish front panel overlay |
| **Opt. L5** | Japanese front panel overlay |
| **Opt. L6** | Portuguese front panel overlay |
| **Opt. L7** | Simplified Chinese front panel overlay |
| **Opt. L8** | Traditional Chinese front panel overlay |
| **Opt. L9** | Korean front panel overlay |
| **Opt. L10** | Russian front panel overlay |
| **Opt. L99** | No front panel overlay |

## Service options

| | |
|---|---|
| **Opt. C3** | Calibration Service 3 Years |
| **Opt. C5** | Calibration Service 5 Years |
| **Opt. D1** | Calibration Data Report |
| **Opt. D3** | Calibration Data Report 3 Years (with Opt. C3) |
| **Opt. D5** | Calibration Data Report 5 Years (with Opt. C5) |
| **Opt. R5** | Repair Service 5 Years (including warranty) |
| **Opt. T3** | Three Year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support |
| **Opt. T5** | Five Year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS plus preventative maintenance. Including a 5 day turnaround time and priority access to customer support |

Accessories are not covered by the instrument warranty and Service Offerings.

## Accessories

### Standard accessories

| | |
|---|---|
| ----- | AFG31000 Series Arbitrary Function Generator Compliance, Installation, and Safety Instructions |
| **012-1732-xx** | BNC cable shielded, 3 ft. |
| **174-4401-xx** | USB cable, A to B, 3 ft. |
| ----- | Power cord |
| ----- | NIST-traceable calibration certificate |
| ----- | Three-year warranty on parts and labor |

### Recommended accessories

| | |
|---|---|
| **012-1732-xx** | BNC cable shielded, 3 ft. |
| **012-0991-xx** | GPIB cable, double shielded |
| **011-0049-02** | 50 Ω BNC terminator |
| **ACD4000B** | Soft transit case |
| **HCTEK54** | Hard transit case (requires ACD4000B) |

### Warranty

| | |
|---|---|
| **Product warranty** | Three-year warranty on parts and labor |

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

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ASEAN / Australasia (65) 6356 3900
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Russia & CIS +7 (495) 6647564
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Canada 1 800 833 9200
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