

# Arbitrary/Function Generators

► AFG3011 • AFG3021B • AFG3022B • AFG3101 • AFG3102 • AFG3251 • AFG3252



## Product Description

Unmatched performance, versatility, intuitive operation and affordability make the AFG3000 Series of Function, Arbitrary Waveform and Pulse Generators the most useful instruments in the industry.

### Superior Performance and Versatility

Users can choose from 12 different standard waveforms. Arbitrary waveforms can be generated up to 128 K in length at high sampling rates. On pulse waveforms, leading and trailing edge time can be set independently. External signals can be connected and added to the output signal. Dual channel models can generate two identical or completely different signals. All instruments feature a highly stable time base with only  $\pm 1$  ppm drift per year.

### Intuitive User Interface Shows More Information at a Single Glance

A large screen shows all relevant waveform parameters and graphical wave-shape at a single glance. This gives full confidence in the signal settings and lets you focus on the task at hand. Shortcut keys provide direct access to frequently used functions and parameters. Others can be selected conveniently through clearly structured menus. This reduces the time needed for learning and re-learning how to use the instrument. Look and feel are identical to the world's most popular TDS3000 Oscilloscopes.

### ArbExpress® Software Included for Creating Waveforms with Ease

With this PC software waveforms can be seamlessly imported from any Tektronix oscilloscope, or defined by standard functions, equation editor and waveform math.

## ► Features & Benefits

10 MHz, 25 MHz, 100 MHz or 240 MHz sine waveforms

14 bits, 250 MS/s, 1 GS/s, or 2 GS/s arbitrary waveforms

Amplitude up to  $20 V_{p-p}$  into  $50 \Omega$  loads

5.6" display for full confidence in settings and waveform shape

Multi-language and intuitive operation saves set-up time

Pulse waveform with variable edge times

AM, FM, PM, FSK, PWM

Sweep and burst

Dual channel models save cost and bench space

USB connector on front panel for waveform storage on memory device

USB, GPIB and LAN

LabVIEW and LabWindows/IVI-C drivers

## ► Applications

Electronic test and design

Sensor simulation

Functional test

Education and training

**Tektronix**<sup>®</sup>

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## ► Characteristics

### ► AFG3000 Series Characteristics

Model	AFG3011	AFG3021B/AFG3022B	AFG3101/AFG3102	AFG3251/AFG3252
<b>Channels</b>	1	1/2	1/2	1/2
<b>Waveforms</b>	Sine, Square, Pulse, Ramp, Triangle, Sin(x)/x, Exponential Rise and Decay, Gaussian, Lorentz, Haversine, DC, Noise			
<b>Sine Wave</b>	1 µHz to 10 MHz	1 µHz to 25 MHz	1 µHz to 100 MHz	1 µHz to 240 MHz
Sine Wave in Burst Mode	1 µHz to 5 MHz	1 µHz to 12.5 MHz	1 µHz to 50 MHz	1 µHz to 120 MHz
Effective maximum frequency out	10 MHz	25 MHz	100 MHz	240 MHz
<b>Amplitude Flatness (1 V<sub>p-p</sub>)</b>				
<5 MHz	±0.15 dB	±0.15 dB	±0.15 dB	±0.15 dB
5 MHz to 10 MHz	±0.3 dB	—	—	—
5 MHz to 20 MHz	—	±0.3 dB	±0.3 dB	±0.3 dB
20 MHz to 25 MHz	—	±0.5 dB	±0.3 dB	±0.3 dB
25 MHz to 100 MHz	—	—	±0.5 dB	±0.5 dB
100 MHz to 200 MHz	—	—	—	±1.0 dB
200 MHz to 240 MHz	—	—	—	±2.0 dB
<b>Harmonic Distortion (1 V<sub>p-p</sub>)</b>				
10 Hz to 20 kHz	<−60 dBc	<−70 dBc	<−60 dBc	<−60 dBc
20 kHz to 1 MHz	<−55 dBc	<−60 dBc	<−60 dBc	<−60 dBc
1 MHz to 5 MHz	<−45 dBc	<−50 dBc	<−50 dBc	<−50 dBc
5 MHz to 10 MHz	<−45 dBc	<−50 dBc	<−37 dBc	<−37 dBc
10 MHz to 25 MHz	—	<−40 dBc	<−37 dBc	<−37 dBc
>25 MHz	—	—	<−37 dBc	<−30 dBc
THD	<0.2% (10 Hz – 20 kHz, 1 V <sub>p-p</sub> )			
<b>Spurious (1 V<sub>p-p</sub>)</b>				
10 Hz to 1 MHz	<−60 dBc	<−60 dBc	<−60 dBc	<−50 dBc
1 MHz to 10 MHz	<−50 dBc	—	—	—
1 MHz to 25 MHz	—	<−50 dBc	<−50 dBc	<−47 dBc
>25 MHz	—	—	<−50 dBc + 6 dBc/octave	<−47 dBc + 6 dBc/octave
Phase Noise, typical	<−110 dBc/Hz at 10 MHz, 10 kHz offset, 1 V <sub>p-p</sub>	<−110 dBc/Hz at 20 MHz, 10 kHz offset, 1 V <sub>p-p</sub>		
Residual Clock Noise	−63 dBm	−63 dBm	−57 dBm	−57 dBm
<b>Square Wave</b>	1 µHz to 5 MHz	1 µHz to 12.5 MHz	1 µHz to 50 MHz	1 µHz to 120 MHz
Rise/Fall Time	≤50 ns	≤18 ns	≤5 ns	≤2.5 ns
Jitter (rms), typical	500 ps	500 ps	200 ps	100 ps
<b>Ramp Wave</b>	1 µHz to 100 kHz	1 µHz to 250 kHz	1 µHz to 1 MHz	1 µHz to 2.4 MHz
Linearity, typical	≤0.2% of peak output	≤0.1% of peak output	≤0.15% of peak output	≤0.2% of peak output
Symmetry	0.0% to 100.0%	—	0.0% to 100.0%	—
<b>Pulse Wave</b>	1 mHz to 5 MHz	1 mHz to 12.5 MHz	1 mHz to 50 MHz	1 mHz to 120 MHz
Pulse Width	80.00 ns to 999.99 s	30.00 ns to 999.99 s	8.00 ns to 999.99 s	4.00 ns to 999.99 s
Resolution	10 ps or 5 digits			
Pulse Duty	0.001% to 99.999% (Limitations of Pulse Width Apply)			
Edge Transition Time	50 ns to 625 s	18 ns to 625 s	5 ns to 625 s	2.5 ns to 625 s
Resolution	10 ps or 4 digits		10 ps or 4 digits	
Lead Delay				
Range	(Continuous Mode): 0 ps to Period (Triggered/Gated Burst Mode): 0 ps to Period – [Pulse Width + 0.8 * (Leading Edge Time + Trailing Edge Time)]			
Resolution	10 ps or 8 digits			
Overshoot, typical	<5%			
Jitter (rms, typical)	500 ps	500 ps	200 ps	100 ps

AFG3000 Series Characteristics (continued)

Model	AFG3011	AFG3021B/AFG3022B	AFG3101/AFG3102	AFG3251/AFG3252
<b>Other Waveforms</b>	1 µHz to 100 kHz	1 µHz to 250 kHz	1 µHz to 1 MHz	1 µHz to 2.4 MHz
<b>Noise Bandwidth (–3 dB)</b>	10 MHz	25 MHz	100 MHz	240 MHz
Noise Type	White Gaussian			
<b>DC (into 50 Ω)</b>	–10 V to +10 V	–5 V to +5 V	–5 V to +5 V	–2.5 V to +2.5 V
<b>Arbitrary Waveforms</b>	1 mHz to 5 MHz	1 mHz to 12.5 MHz	1 mHz to 50 MHz	1 mHz to 120 MHz
Arbitrary Waveforms in Burst Mode	1 mHz to 2.5 MHz	1 mHz to 6.25 MHz	1 mHz to 25 MHz	1 mHz to 60 MHz
Effective Analog Bandwidth (–3 db)	8 MHz	34 MHz	100 MHz	225 MHz
Non-volatile memory	4 waveforms	4 waveforms	4 waveforms	4 waveforms
Memory: Sample rate	2 to 128 K: 250 MS/s	2 to 128 K: 250 MS/s	>16 K to 128 K: 250 MS/s 2 to 16 K: 1 GS/s	>16 K to 128 K: 250 MS/s 2 to 16 K: 2 GS/s
Vertical resolution	14 bits	14 bits	14 bits	14 bits
Rise Time/Fall Time	≤80 ns	≤20 ns	≤8 ns	≤3 ns
Jitter (rms)	4 ns	4 ns	1 ns at 1 GS/s 4 ns at 250 MS/s	500 ps at 2 GS/s 4 ns at 250 MS/s
<b>Amplitude, 50 Ω Load</b>	20 mV <sub>p-p</sub> to 20 V <sub>p-p</sub>	10 mV <sub>p-p</sub> to 10 V <sub>p-p</sub>	20 mV <sub>p-p</sub> to 10 V <sub>p-p</sub>	≤200 MHz: 50 mV <sub>p-p</sub> to 5 V <sub>p-p</sub> >200 MHz: 50 mV <sub>p-p</sub> to 4 V <sub>p-p</sub>
<b>Amplitude, Open Circuit</b>	40 mV <sub>p-p</sub> to 40 V <sub>p-p</sub>	20 mV <sub>p-p</sub> to 20 V <sub>p-p</sub>	40 mV <sub>p-p</sub> to 20 V <sub>p-p</sub>	≤200 MHz: 100 mV <sub>p-p</sub> to 10 V <sub>p-p</sub> >200 MHz: 100 mV <sub>p-p</sub> to 8 V <sub>p-p</sub>
Accuracy	±(2% of setting +2 mV) (1 kHz sine wave, 0 V offset, >20 mV <sub>p-p</sub> amplitude)	±(1% of setting +1 mV) (1 kHz sine wave, 0 V offset, >10 mV <sub>p-p</sub> amplitude)		
Resolution	0.1 mV <sub>p-p</sub> , 0.1 mV <sub>RMS</sub> , 1 mV, 0.1 dBm or 4 digits			
Units	V <sub>p-p</sub> , V <sub>RMS</sub> , dBm (sine wave only)			
Output Impedance	50 Ω			
Load Impedance Setting	Selectable: 50 Ω, 1Ω to 10.0 kΩ, High Z (adjusts displayed amplitude according to selected load impedance)			
Isolation	42 Vpk maximum to earth			
Short-Circuit Protection	Signal outputs are robust against permanent shorts against floating ground			
External Voltage Protection	To protect signal outputs against external voltages use fuse adapter 013-0345-00			
DC Offset Range, 50 Ω Load	±(10 V <sub>pk</sub> – Amplitude <sub>pp</sub> /2)	±(5 V <sub>pk</sub> – Amplitude <sub>pp</sub> /2)	±5 V <sub>pk</sub> DC	±2.5 V <sub>pk</sub> DC
DC Offset Range, Open Circuit	±(20 V <sub>pk</sub> – Amplitude <sub>pp</sub> /2)	±(10 V <sub>pk</sub> – Amplitude <sub>pp</sub> /2)	±10 V <sub>pk</sub> DC	±5 V <sub>pk</sub> DC
Accuracy	±(2% of  setting  + 10 mV + 1% of amplitude (V <sub>p-p</sub> ))		±(1% of  setting  + 5 mV + 0.5% of amplitude (V <sub>p-p</sub> ))	
Resolution	1 mV			

**Modulation**

**AM, FM, PM**

**Carrier Waveforms** – All, except Pulse, Noise and DC.

**Source** – Internal/External.

**Internal Modulating Waveform** – Sine, square, ramp, noise, ARB (AM: maximum waveform length 4,096; FM/PM: maximum waveform length 2,048).

**Internal Modulating Frequency** – 2 mHz to 50.00 kHz.

**AM Modulation Depth** – 0.0% to +120.0%.

**Min FM Peak Deviation** – DC.

**Max FM Peak Deviation** – See chart, below.

**Frequency Shift Keying**

**Carrier Waveforms** – All, except Pulse, Noise and DC.

**Source** – Internal/External.

**Internal Modulating Frequency** – 2 mHz to 1.000 MHz.

**Number of Keys** – 2.

**Pulse Width Modulation**

**Carrier Waveform** – Pulse.

**Source** – Internal/External.

**Internal Modulating Waveform** – Sine, square, ramp, noise, ARB (maximum waveform length 2,048).

**Internal Modulating Frequency** – 2 mHz to 50.00 kHz.

**Deviation** – 0% to 50.0% of pulse period.

**Sweep**

**Waveforms** – All, except Pulse, Noise and DC.

**Type** – Linear, logarithmic.

**Sweep Time** – 1 ms to 300 s.

**Hold/Return Time** – 0 ms to 300 s.

**Max Total Sweep Time** – 300 s.

**Resolution** – 1 ms or 4 digits.

**Total Sweep Time Accuracy, typical** – 0.4%.

**Min Start/Stop Frequency** – All except ARB:

1 µHz, ARB: 1 mHz.

**Max Start/Stop Frequency** – See chart, below.

**Burst**

**Waveforms** – All, except Noise and DC.

**Type** – Triggered, gated (1 to 1,000,000 cycles or Infinite).

**Internal Trigger Rate** – 1 µs to 500.0 s.

**Gate and Trigger Sources** – Internal, external, remote interface.

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### ► Modulation: Max FM Peak Deviation

	AFG3011	AFG3021B/AFG3022B	AFG3101/AFG3102	AFG3251/AFG3252
Sine	5 MHz	12.5 MHz	50 MHz	120 MHz
Square	2.5 MHz	6.25 MHz	25 MHz	60 MHz
ARB	2.5 MHz	6.25 MHz	25 MHz	60 MHz
Others	50 kHz	125 kHz	500 kHz	1.2 MHz

PM Phase Deviation – 0.0° to +180.0°.

### ► Sweep: Max Start/Stop Frequency

	AFG3011	AFG3021B/AFG3022B	AFG3101/AFG3102	AFG3251/AFG3252
Sine	10 MHz	25 MHz	100 MHz	240 MHz
Square	5 MHz	12.5 MHz	50 MHz	120 MHz
ARB	5 MHz	12.5 MHz	50 MHz	120 MHz
Others	100 kHz	250 kHz	1 MHz	2.4 MHz

### ► Common Characteristics

#### Remote Programming

GPIB, LAN 10BASE-T/100BASE-TX, USB 1.1  
Compatible with SCPI-1999.0 and IEEE 488-2 standards

Configuration Times, typical	USB	LAN	GPIB
Function Change	95 ms	103 ms	84 ms
Frequency Change	2 ms	19 ms	2 ms
Amplitude Change	60 ms	67 ms	52 ms
Select User ARB	88 ms	120 ms	100 ms
Data Download Time for 4000 point waveform data, typical	20 ms	84 ms	42 ms

**Auxiliary Inputs****Modulation Inputs Channel 1, Channel 2**

**Input Range** – All except FSK:  $\pm 1$  V – FSK: 3.3 V logic level.

**Impedance** – 10 k $\Omega$ .

**Frequency Range** – DC to 25 kHz (122 KS/s).

**External Triggered/Gated Burst Input**

**Level** – TTL compatible.

**Impedance** – 10 k $\Omega$ .

**Pulse Width** – 100 ns minimum.

**Slope** – Positive/Negative, selectable.

**Trigger Delay** – 0.0 ns to 85.000 s.

**Resolution** – 100 ps or 5 digits.

**Jitter (rms), typical** – Burst: <50 ps (Trigger input to signal output).

**10 MHz Reference Input**

**Impedance** – 1 k $\Omega$ , AC coupled.

**Required Input Voltage Swing** – 100 mVp-p to 5 Vp-p.

**Lock Range** – 10 MHz  $\pm 35$  kHz.

**External Channel 1 Add Input** – AFG3101, AFG3102, AFG3251, AFG3252 only.

**Impedance** – 50  $\Omega$ .

**Input Range** –  $-1$  V to  $+1$  V (DC + peakAC).

**Bandwidth** – DC to 10 MHz ( $-3$  dB) at 1 Vp-p.

**Auxiliary Outputs****Channel 1 Trigger Output**

**Level** – Positive TTL level pulse into 1 k $\Omega$ .

**Impedance** – 50  $\Omega$ .

**Jitter (rms), typical** – AFG3011/21B/22B: 500 ps;

AFG3101/02: 200 ps; AFG3251/52: 100 ps.

**Max Frequency** – 4.9 MHz (4.9 MHz to 50 MHz: a fraction of the frequency is output; >50 MHz: no signal is output).

**10 MHz Reference Out** – AFG3101, AFG3102, AFG3251, AFG3252 only.

**Impedance** – 50  $\Omega$ , AC coupled.

**Amplitude** – 1.2 Vp-p into 50  $\Omega$  load.

**▶ Common Characteristics**

**Frequency Setting Resolution** – 1  $\mu$ Hz or 12 digits.

**Phase (except DC, Noise, Pulse) –**

Range –  $-180^\circ$  to  $+180^\circ$ .

Resolution – 0.01 $^\circ$  (sine), 0.1 $^\circ$

(other waveforms).

**Internal Noise Add** – When activated, output signal amplitude is reduced to 50%.

Level – 0.0% to 50% of amplitude

(Vp-p) setting.

Resolution – 1%.

**Main Output – 50  $\Omega$ .**

**Effective Frequency Switching Speed** – 2 ms via remote control (sequencing not available).

**Internal Frequency Reference –**

Stability – All except

ARB:  $\pm 1$  ppm, 0  $^\circ$ C to 50  $^\circ$ C.

ARB:  $\pm 1$  ppm  $\pm 1$   $\mu$ Hz, 0  $^\circ$ C to 50  $^\circ$ C.

Aging –  $\pm 1$  ppm per year.

**Power Source** – 100 to 240 V, 47 to 63 Hz or 115 V, 360 to 440 Hz.

**Power Consumption** – Less than 120 W.

**Warm-up Time, typical** – 20 minutes.

**Power On Self Calibration, typical** – <16 s.

**Acoustic Noise, typical** – <50 dBA.

**Display** – AFG3021B: 5.6" Monochrome LCD. All others: 5.6" Color LCD.

**User Interface and Help Language** – English, French, German, Japanese, Korean, Simplified and Traditional Chinese, Russian (user selectable).

**Physical Characteristics****▶ Benchtop Configuration**

Dimensions	mm	in.
Height	156.3	6.2
Width	329.6	13.0
Depth	168.0	6.6

Weight	kg	lbs.
Net	4.5	9.9
Shipping	5.9	12.9

**Environmental and Safety Characteristics****Temperature**

Operating 0  $^\circ$ C to  $+50$   $^\circ$ C

Nonoperating  $-30$   $^\circ$ C to  $+70$   $^\circ$ C

**Humidity**

Operating At or below  $+40$   $^\circ$ C:  $\leq 80\%$

$>+40$   $^\circ$ C to 50  $^\circ$ C:  $\leq 60\%$

Altitude Up to 10,000 feet/3,000 m

**EMC Compliance**

European Union EN 61326:1997 Class A  
EN 61000-3-2:2000 and  
EN 61000-3-3:1995  
IEC 61000-4-2:1999,  
-4-3:2002, -4-4:2004,  
-4-5:2005, -4-6:2003,  
-4-11:2004

Australia EN 61326:1997

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

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### ► Ordering Information

#### **AFG3011, AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252**

Arbitrary/Function Generator.

**Includes:** Quick-start user manual, power cord, USB cable, CD-ROM with programmer manual, service manual, LabView and IVI drivers, CD-ROM with ArbExpress® software, NIST-traceable calibration certificate. Please specify power plug when ordering.

#### **International Power Plugs**

- Opt. A0 – North America power.
- Opt. A1 – Universal EURO power.
- Opt. A2 – United Kingdom power.
- Opt. A3 – Australia power.
- Opt. A5 – Switzerland power.
- Opt. A6 – Japan power.
- Opt. A10 – China power.
- Opt. A11 – India power.
- Opt. A99 – No power cord or AC adapter.

#### **Manual Options**

Note: Includes front panel overlay.

- Opt. L0 – English (071-1631-xx).
- Opt. L1 – French (071-1632-xx).
- Opt. L2 – Italian (071-1669-xx).
- Opt. L3 – German (071-1633-xx).
- Opt. L4 – Spanish (071-1670-xx).
- Opt. L5 – Japanese (071-1634-xx).
- Opt. L7 – Simple Chinese (071-1635-xx).
- Opt. L8 – Traditional Chinese (071-1636-xx).
- Opt. L9 – Korean (071-1637-xx).
- Opt. L10 – Russian (071-1638-xx).
- Opt. L99 – No manual.

#### **Service**

- Opt. C3 – Calibration Service 3 Years.
- Opt. C5 – Calibration Service 5 Years.
- Opt. CA1 – Single calibration event or coverage for the designated calibration interval, whichever comes first.
- Opt. D1 – Calibration Data Report.
- Opt. D3 – Calibration Data Report 3 Years (with Option C3).
- Opt. D5 – Calibration Data Report 5 Years (with Option C5).
- Opt. R5 – Repair Service 5 Years.

#### **Warranty**

Three year warranty on parts and labor.

#### **Recommended Accessories**

- Rackmount Kit – RM3100.
- Fuse adapter, BNC-P to BNC-R. – 013-0345-00.
- Fuse set, 3 pcs, 0.125 A. – 159-0454-00.
- BNC cable shielded, 3 ft. – 012-0482-00.
- BNC cable shielded, 9 ft. – 012-1256-00.
- GPIB cable, double shielded – 012-0991-00.



► BNC Fuse Adapter and 0.125 A Fuse.



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## Contact Tektronix:

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### For Further Information

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Product(s) are manufactured in ISO registered facilities.

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

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