

# Arbitrary Waveform Generator

▶ AWG615

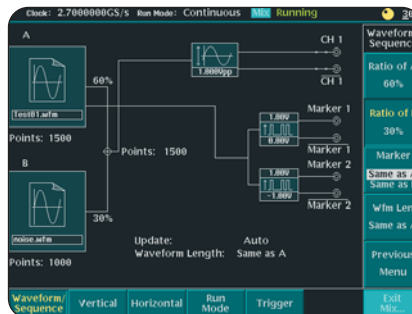


▶ AWG615.

## The AWG615 Arbitrary Waveform Generator Delivers World-class Signal Fidelity at 2.7 GS/s to Solve Ever-increasing Measurement Challenges

New two box synchronous operation function supports 2 ch 2.7 GS/s solution. The AWG615 combines world-class signal fidelity with high-speed mixed signal simulation, a powerful sequencing capability and graphical user interface with flexible waveform editor, to solve the toughest measurement challenges in the disk drive, communications and semiconductor design/test industries.

The built-in signal applications enable you to easily create standard waveforms for disk drive read channels, communications up to 2.7 Gb/s such as ITU-T, TI.102, Fibre Channel and SDH/SONET also various semiconductor applications.



▶ Waveform Mixing Function.



▶ 2.5 Gbps PCI express de-emphasis signal.

## ▶ Features & Benefits

2.7 GS/s Sample Rate  
Simulates Real-world Signals  
Up To 1.35 GHz

2 Markers With 2.1 ps<sub>RMS</sub>  
(@2.7 GS/s, Typical) Jitter  
Deliver Stable Timing to the  
Device-under Test (DUT)

32.4 M (32,400,000) or  
64.8 M (64,800,000) Point  
Record Length Provide  
Longer Data Streams

Analog Bandwidth to 2 GHz  
(Option 02, Calculated Based  
on Rise Time) Provides the  
Highest Signal Fidelity of All  
High-speed AWGs

Direct External Clock  
Input Allows Jittered and  
Non-jittered Signals for High-  
speed Data Stream Timing  
Margin Test up to 2.7 Gb/s

Synchronous Operation  
Mode Supports Two AWG615  
outputs (2: analog, 4: marker)  
Synchronization for High Data  
Rate Wireless and Data  
Communication Test and  
Optical Write Channel  
Strategy Signal Test

Waveform Quick Editor  
with 400 fs Edge Timing  
Resolution Delivers Output  
Edge Control with Near  
Real-time Precision

Allows Two-signal Mix  
Function Digitally to  
Support Disk Drive Noise  
Performance Test and  
Pre/De-emphasis Serial  
Data Communication Test

Real-time Sequencing  
Creates Infinite Waveform  
Loops, Jumps, Patterns and  
Conditional Branches

## ▶ Applications

Disk Drive Read/Write  
Design and Test

Communications Design  
and Test

Arbitrary IF and IQ Base-  
band Signals

Standard Waveforms for  
Communications

Pulse Generation

High-speed, Low-jitter Data  
and Clock Source

Mixed Signal Design and Test

Real-world Simulations

Corruption and Enhancement  
of Ideal Waveforms

Timing and Amplitude Signal  
Impairments

COMPUTING

COMMUNICATIONS

VIDEO

# Arbitrary Waveform Generator

▶ AWG615

## ▶ Characteristics

### Arbitrary Waveforms

**Waveform Length** – 960 to 32,400,000 points (or 64,800,000 points, option 01) in multiples of four.

**Sequence Length** – 1 to 8,000 steps.

**Sequence Repeat Counter** – 1 to 65,536 or infinite.

### Run Modes

Gated mode, Event Jump, and Software Jump are disabled in the synchronous operation.

**Continuous** – Waveform is iteratively output. If a sequence is defined, the sequence order and repeat functions are applied.

**Triggered** – Waveform is output only once when an external, internal, GPIB, LAN, or manual trigger is received.

**Gated** – Waveform begins output when gate is true and resets to beginning when false.

**Enhanced** – Waveform is output as defined by the sequence.

## Extended Operation

### Function Generator

**Waveform Shape** – Sine, Triangle, Square, Ramp, Pulse, or DC.

**Frequency** – 1.000 Hz to 270.0 MHz.

### Amplitude –

Range:  $0.020 V_{p-p}$  to  $2 V_{p-p}$  into  $50 \Omega$ .  
Resolution: 1 mV.

### Offset –

Range:  $-0.500 V$  to  $+0.500 V$  into  $50 \Omega$ .  
Resolution: 1 mV.

### DC Level –

DC waveform only.  
Range:  $-0.500 V$  to  $+0.500 V$  into  $50 \Omega$ .  
Resolution: 1 mV.

**Polarity** – Normal, Invert.

### Duty Cycle –

Range: 0.1% to 99.9%, Pulse waveform only.  
Resolution:

1.000 Hz to 4.000 MHz: 0.1% step.  
4.001 MHz to 20.00 MHz: 0.5% step.  
20.01 MHz to 40.00 MHz: 1% step.  
40.01 MHz to 80.00 MHz: 2% step.  
80.01 MHz to 100.0 MHz: 2.5% step.  
100.1 MHz to 160.00 MHz: 4% step.  
160.1 MHz to 200.0 MHz: 5% step.  
200.1 MHz to 270.0 MHz: 10% step.

### Marker Out –

Marker1 Pulse Width:

Hi/Lo: 20% / 80% of Period.

Marker2 Pulse Width:

Hi/Lo: 50% / 50% of Period, except 100.1 MHz to 160.0 MHz.

Hi/Lo: 52% / 48% of Period, at 100.1 MHz to 160.0 MHz.

Marker Level:

Hi Level: 1V into  $50 \Omega$ .

Lo Level: 0V into  $50 \Omega$ .

**Waveform mixing operation** – Supports two-signals mixed output digitally.

**Synchronous operation** – Supports to synchronize two AWG615 signals output by two boxes.

**NOTE:** This operation is executed by Sync master and Sync slave operation combination.

**Sync master operation** – Set one AWG615 as a master box.

**Sync slave operation** – Set another AWG615 as a slave box.

### Clock Generator

**Sampling Frequency** – 50.000000 kS/s to 2.7000000 GS/s.

**Resolution** – 8 digits.

**Internal Clock** – Accuracy:  $\pm 1$  ppm.

### Phase Noise –

(VCO out)

At 2.7 GS/s, 10 kHz offset:  $-58$  dBc/Hz.

At 2.7 GS/s, 100 kHz offset:  $-93$  dBc/Hz.

### Internal Trigger Generator

#### Internal Trigger Rate –

Range: 1.0  $\mu$ s to 10.0 s.

Resolution: 3 digits, 0.1  $\mu$ s minimum.

Accuracy:  $\pm 0.1\%$ .

### Main Output

**Output Signal** – Complementary;

CH1 and channel inverse.

### Digital to Analog Converter –

Resolution: 8-bits.

Differential Non-linearity:  $\pm 1/2$ -LSB.

Integral Non-linearity:  $\pm 1$ -LSB.

**Output Connector** – Front Panel SMA.

### Normal Out\*1

#### Amplitude –

Output Voltage:  $-1.5 V$  to  $+1.5 V$  into  $50 \Omega$ .

Amplitude: 20 mV to 2.0 V into  $50 \Omega$ .

Resolution: 1 mV.

DC Accuracy:  $\pm(2.0\%$  of Amplitude + 2 mV)

at offset = 0 V.

#### Offset –

Range:  $-0.500 V$  to  $+0.500 V$  into  $50 \Omega$ .

Resolution: 1 mV.

Accuracy:  $\pm 1.5\%$  of offset  $\pm 10$  mV at

20 mV amplitude.

#### Pulse response –

(–1 and 1 waveform data, 0 V offset, through filter at  $1 V_{p-p}$ , clock 1 GS/s) using 20 GHz BW oscilloscope.

Rise time: (10 to 90%):  $\leq 480$  ps.

Fall time: (10 to 90%):  $\leq 480$  ps.

Aberations:  $\pm 10\%$  (at  $1.0 V_{p-p}$  amplitude).

Flatness:  $\pm 5\%$  (after 20 ns from rise/fall edge).

### Sine Wave Characteristics –

(2.7 GS/s clock, 32 waveform points, 84.375 MHz signal frequency, 1.0 V amplitude, 0 V offset, through filter).

Harmonics:  $\leq -40$  dBc, DC to 1000 MHz.

Noise:  $\leq -50$  dBc, DC to 1000 MHz.

Phase noise:  $\leq -85$  dBc/Hz at 10 kHz offset.

### Filter\*1

**Type** – 20, 50, 100, 200 MHz Bessel low-pass.

**Rise Time (10% to 90%)** – 20 MHz, 17 ns; 50 MHz, 7.0 ns; 100 MHz, 3.7 ns; 200 MHz, 2.0 ns.

**Group Delay** – 20 MHz, 18 ns; 50 MHz, 8 ns; 100 MHz, 4.7 ns; 200 MHz, 3 ns.

### Direct D/A Out\*1

**Amplitude** – 20 mV<sub>p-p</sub> to  $1.0 V_{p-p}$  into  $50 \Omega$ .

**Resolution** – 1 mV.

**DC Accuracy** –  $\pm(2\%$  of Amplitude + 2 mV).

**Offset** – no function.

**DC Offset Accuracy** – 0 V  $\pm 10$  mV at 20 mV amplitude (waveform data = 0).

### Pulse Response (–1 and 1 waveform data, at 0.5 V<sub>p-p</sub>) –

Rise Time (10% to 90%):  $\leq 280$  ps.

Fall Time (10% to 90%):  $\leq 280$  ps.

**Output Impedance** – 50  $\Omega$ .

\*1 Option 02 eliminates the ability to switch between normal and direct D/A out, as well as filter and offset control.

### Extended Bandwidth Output (Option 02)

**Amplitude** – 500 mV<sub>p-p</sub> to  $1.0 V_{p-p}$  into  $50 \Omega$ .

**Resolution** – 1 mV.

**DC Accuracy** –  $\pm(2.0\%$  of amplitude + 2 mV).

**Offset** – No function.

**DC Offset Accuracy** – 0 V  $\pm 10$  mV at 500 mV Amplitude (waveform data = 0).

**Pulse Response** – (–1 and 1 waveform data, at  $1.0 V_{p-p}$ ).

**Rise Time** – (10% to 90%):  $\leq 175$  ps.

**Fall Time** – (10% to 90%):  $\leq 175$  ps.

**Output Impedance** – 50  $\Omega$ .

### Auxiliary Outputs

#### Marker

**Number** – 2 (complementary).

#### Level –

High level:  $-1.00 V$  to 2.45 V into  $50 \Omega$  to GND.

Low level:  $-2.00 V$  to 2.40 V into  $50 \Omega$  to GND.

Amplitude:  $0.05 V_{p-p}$  to  $1.25 V_{p-p}$  max. into  $50 \Omega$  to GND.

**Resolution** – 0.05 V.

#### DC Accuracy –

Within  $\pm 0.1 V \pm 5\%$  of setting into  $50 \Omega$ .

Maximum Output current:  $\pm 80$  mA.

#### Rise/Fall Time (20% to 80%) –

$< 130$  ps into  $50 \Omega$  to GND ( $1.0 V_{p-p}$ , Hi +1.0 V, Lo 0 V).

#### Period Jitter (Typical) –

by 1010 clock pattern

At 2.7 GS/s 2.1 ps<sub>RMS</sub>, 15 ps peak to peak.

At 1.35 GS/s 2.1 ps<sub>RMS</sub>, 15 ps peak to peak.

At 0.675 GS/s 2.0 ps<sub>RMS</sub>, 14 ps peak to peak.

## Cycle-to-Cycle Jitter (Typical) –

by 1010 clock pattern.  
At 2.7 GS/s 3.6 ps<sub>RMS</sub>, 26 ps peak to peak.  
At 1.35 GS/s 3.6 ps<sub>RMS</sub>, 26 ps peak to peak.  
At 0.675 GS/s 3.3 ps<sub>RMS</sub>, 23 ps peak to peak.

## Marker Skew –

< 20 ps (typical).

## Delay (between analog output and marker output) –

(Marker Level: 1 V<sub>p-p</sub> (Hi + 1V/Lo 0V), Analog Output: At 1 V<sub>p-p</sub>).  
Normal Output: 2.4 ns (Offset 0 V, Filter = “Through”).  
Direct Output: –1 ns.

**Connector** – Front-panel SMA.

## VCO Out

### Amplitude –

CML, AC coupling, 0.4 V<sub>p-p</sub> into 50 Ω to GND.  
Impedance: 50 Ω, AC coupling.

**Connector** – Rear-panel SMA.

## 10 MHz Reference Clock Out

**Amplitude** – 1.2 V<sub>p-p</sub> into 50 Ω. Max 2.5 V<sub>p-p</sub> open.

**Impedance** – 50 Ω, AC coupling.

**Connector** – Rear-panel BNC.

## C Out 1 and 2

For 2 boxes synchronous usage.  
**Connector**: SMA, Rear.  
Output signal style: Complementary.

## T Out 1 and 2

For 2 boxes synchronous usage.  
**Connector**: SMA, Rear.  
Output signal style: Complementary.

## Auxiliary Inputs

### Trigger In

**Trigger Mode** – Minimum Pulse Width: 10 ns, 0.2 V amplitude.

**Impedance** – 1 kΩ or 50 Ω.

**Polarity** – POS or NEG.

**Connector** – Rear-panel BNC.

### Input Voltage Range –

1 kΩ: ±10 V.  
50 Ω: ±5 V.

### Threshold –

Level: –5.0 V to 5.0 V.  
Resolution: 0.1 V.

**Trigger Mode** – Minimum Pulse Width: 10 ns, 0.2 V amplitude.

### Trigger Hold-off –

One box operation: ≤109.5 clocks + 500 ns.  
Two boxes synchronous operation: ≤109.5 clocks + 700 ns.  
Delay to Analog Out: 275.5 clocks + 17 ns (Normal Output, Filter “Through”).

## Gate Mode –

(for one box operation)  
Minimum Pulse Width (0.2 V amplitude): 1152 clocks + 10 ns.  
Gate Hold Off: ≤1920 clocks + 20 ns.  
Delay to Analog Out: 1355 to 1563.5 clocks + 9 ns (Normal Output, Filter “Through”).

## Event Input –

(for one box operation)  
Number of Events: 7-bits.  
Input Signals: 7 event bits, strobe.  
Threshold: TTL level.  
Maximum Input: 0 V to +5 V (DC + peak AC).  
Impedance: 1 kΩ, pull-up to +3.3 V.  
**Connector**: Rear-panel 9-Pin D-sub.

## Enhanced Mode –

Minimum Pulse Width: 320 clocks + 10 ns.  
Event Hold Off: ≤ 896 clocks + 20 ns.  
Delay to Analog Out (Jump timing: Async, Output Norm, Filter Through):  
Strobe: ON, 1691.5 clocks + 10 ns.  
Strobe: OFF, 1947.5 clocks + 6 ns.  
Event Input to Strobe Input:  
Setup Time: 192 clocks + 10 ns.  
Hold Time: 192 clocks + 10 ns.

## External Clock IN

**Input Voltage Range** – 0.4 V<sub>p-p</sub> to 2.0 V<sub>p-p</sub>,

**Impedance** – 50 Ω, AC coupled.

**Frequency Range** – 125 MHz to 2.7 GHz.

**NOTE**: need >10 mV/ns signal slew rate.

**Connector** – Rear-panel SMA.

## Reference 10 MHz Clock IN

**Input Voltage Range** – 0.2 V<sub>p-p</sub> to 3.0 V<sub>p-p</sub>, ±10 V maximum.

**Impedance** – 50 Ω, AC coupled.

**Frequency Range** – 10 MHz ±0.1 MHz.

**Connector** – Rear-panel BNC.

## C IN

For 2 boxes synchronous usage.  
**Connector**: SMA, Rear.  
Input signal style: Complementary.

## T IN

For 2 boxes synchronous usage.  
**Connector**: SMA, Rear.  
Input signal style: Complementary.

## General Characteristics

**Display** – Color TFT LCD.

**Display Area** – Horizontal: 13.06 cm (5.14 in.),  
Vertical: 9.70 cm (3.81 in.)

**Resolution** – 640x480.

## Data Storage

**Internal Hard Disk** – ≥20.0 GB.

**Flash Disk** – 256 MB (Option 10).

**Floppy Disk** – 3.5 inch, 1.44 MB.

## Environment

### Temperature –

Operating: 10 °C to +40 °C.  
Nonoperating: –20 °C to +60 °C.

### Humidity –

Operating: 20% to 80%.  
Nonoperating: 5% to 90%.

### Altitude (Hard Disk Restriction) –

Operating: Up to 3,000 m (10,000 ft.).  
Nonoperating: up to 12,000 m (40,000 ft.).

### Random Vibration –

Operating: 2.65 m/s<sup>2</sup><sub>RMS</sub> (0.27 G<sub>RMS</sub>, 5 Hz to 500 Hz, 10 minutes).  
Nonoperating: 22.36 m/s<sup>2</sup><sub>RMS</sub> (2.28 G<sub>RMS</sub>, 5 Hz to 500 Hz, 10 minutes).

**Shock** – Nonoperating: 294 m/s<sup>2</sup> (30 G), half-sine, 11 ms duration (three times each axis, in each direction, 18 total).

**EMC Compliance** – EC Council Directive 89/336/EEC (EC-92), AS/NZS2064-1/ 2.

**Safety** – UL 61010B-1, CSA C22.2 No. 1010.1, EN61010-1 second edition.

## Power Supply

**Rating** – 100 to 240 VAC.

**Range** – 90 to 250 VAC.

**Maximum Power and Current** – 240 VA and 5 A.

**Frequency** – 48 to 63 Hz.

## Physical Characteristics

Dimensions	mm	in.
Height	193	7.6
Width	434	17.1
Depth	508	20
<b>Weight</b>	<b>kg</b>	<b>lb.</b>
Without package	14.1	31.1
With package	24.5	54

**Interfaces** – GPIB, Ethernet: 10/100Base-T, RJ-45.

**PC Keyboard** – 6-Pin mini-DIN, rear.

# Arbitrary Waveform Generator

▶ AWG615

## ▶ Ordering Information

### AWG615

2.7 GS/s, 8-bit, 32 M point, single-channel arbitrary waveform generator.

**Includes:** User manual, Programmer's manual, Floppy disk: sample waveform library (063-3779-00), performance verification (063-3780-00), Sample Program (062-A258-50), Certificate of Calibration, power cable. 50  $\Omega$  SMA Terminator 2 each (015-1022-01).

Please specify power plug when ordering.

### Options

**Opt. 01** – 64 M points waveform memory.

**Opt. 02** – Extends analog bandwidth to 2 GHz (calculated based on rise time).

**Opt. 10** – Flash disk and standby switch (alternative for standard hard disk drive).

**NOTE:** Option 10 is for ATE and system usage needing 7x24 hour operation. Also adds capability to power on/off by rear panel main switch.

**Opt. 1R** – Rack mount kit.

### Service

**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 Option C3).

**Opt. D5** – Calibration Data Report 5 Years (with Option C5).

**Opt. R3** – Repair Service 3 Years.

**Opt. R5** – Repair Service 5 Years.

## Recommended Accessories

**Service Manual** – 071-1516-xx.

**Protective Cover** – 200-3696-01.

## Power Plug Options

**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. A99** – No Power Cord or AC Adapter.

## Language Option

**Opt. L0** – English (User, Programmer).

**Opt. L5** – Japanese (User, Programmer).

## Warranty

One year parts and labor.

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Our most up-to-date product information is available at:  
[www.tektronix.com](http://www.tektronix.com)

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in ISO registered facilities.



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04/04 HB/SFI

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