

# Arbitrary Waveform Generators

## ▶ AWG520



▶ AWG520.

## AWG520 Solves Communications Physical Layer and Media Storage Design and Test Challenges

The AWG520's unique design combines a graphical editing display with powerful output capabilities to simplify the creation of arbitrary and complex waveforms and enable easy on-screen waveform editing. With the AWG520's many built-in intuitive and powerful features, you can easily develop and edit custom waveforms. Option 03 adds an independent 10-bit-wide digital data port that can be used in conjunction with marker outputs for data generation up to 14-bits wide at up to 1 GHz (14-bits, AWG520). Direct waveform transfer capability makes the AWG520 the perfect complement to selected Tektronix oscilloscopes.



▶ *The AWG520 can easily generate telecom signals which complement masks from a digital oscilloscope.*

## ▶ Features & Benefits

Two Channels with 10-Bit Vertical Resolution

Independent 10-Channel, 1 GHz Digital Data Generation (Opt. 03)

Built-in Independent Real-time Noise Generation

External Clock Input Permits Jitter Insertion and Synchronization

Supports Direct External Clock and 10 MHz Reference Input

Unique Real-time Sequencing Links Multiple Waveform Files Creating Waveforms of Nearly Infinite Length

Built-in Application Generates Jitter, Data Communication and Disk Drive Waveforms

User Modified Isolation Pulse for Disk Drive Testing

Built-in 10 GB Hard Drive for Mass Data Storage that Can Optionally Be Made Removable for Secure Applications (using Opt. 11)

Optional 128 MB Flash Disk for ATE Applications (Opt. 10)

Replace Standard Function and Sweep Generators in Wide Range of Applications

## ▶ Applications

Communications Design and Test:

- Low Frequency Modulated RF with Components Using AM and FM Modulation
- Digital Information Encoding Using FSK, PSK and QAM (Quadrature Modulation) for Cellular, Fax and Modem Communications

Optical Communications Design and Test:

- Reflections, Crosstalk and Ground Bounce Simulation

Pulse Generation:

- Duty Cycle Ranges from 0% to 100% for NRZ Data
- Testing Clock/Gating Width Variations

Real-world Simulations:

- Corrupt Ideal Waveforms
- Add Jitter to Waveforms
- EMP/EMI and Other System Noise
- Power Supply Noise and Ripple
- Transducer Simulation

COMPUTING

COMMUNICATIONS

VIDEO

# Arbitrary Waveform Generators

▶ AWG520

## ▶ Characteristics

### Operating Modes

**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/Ethernet 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.

### Arbitrary Waveforms

**Waveform Length** – 256 to 4,194,048 points in multiples of four.

**Sequence Length** – 1 to 8,000 steps. Both CH1 and CH2 operate from the same sequence.

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

### Function Generator Waveforms

**Operation Mode** – Continuous mode only.

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

**Frequency** – 1.000 Hz to 100.0 MHz.

### Amplitude –

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

### Offset –

Range: –1.000 V to +1.000 V into 50  $\Omega$ .  
Resolution: 1 mV.

**DC Level** – DC waveform only.

Range: –1.000 V to +1.000 V into 50  $\Omega$ .  
Resolution: 1 mV.

### Phase –

Range: –360° to +360°.  
Resolution:

- 1.000 Hz to 100.0 kHz: 0.036° step.
- 100.01 kHz to 1.000 MHz: 0.36° step.
- 1.001 MHz to 5.000 MHz: 1.8° step.
- 5.001 MHz to 10.00 MHz: 3.6° step.
- 10.001 MHz to 20.00 MHz: 7.2° step.
- 20.001 MHz to 25.00 MHz: 9° step.
- 25.001 MHz to 40.00 MHz: 14.4° step.
- 40.001 MHz to 50.00 MHz: 18° step.
- 50.001 MHz to 100.0 MHz: 36° step.

**Polarity** – Normal, Invert.

### Duty Cycle –

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

- 1.000 Hz to 1.000 MHz: 0.1% step.
- 1.001 MHz to 5.000 MHz: 0.5% step.
- 5.001 MHz to 10.00 MHz: 1% step.
- 10.01 MHz to 20.00 MHz: 2% step.
- 20.01 MHz to 25.00 MHz: 2.5% step.
- 25.001 MHz to 40.00 MHz: 4% step.
- 40.01 MHz to 50.00 MHz: 5% step.
- 50.01 MHz to 100.00 MHz: 10% step.

### Marker Out –

Marker1 Pulse Width: Hi/Lo: 20%/80% of Period.

Marker2 Pulse Width:

- Hi/Lo: 50%/50% of Period, except 5.001 MHz to 8.000 MHz.
- Hi/Lo: 52%/48% of Period, at 5.001 MHz to 8.000 MHz.

Marker Level:

- Hi Level: 2 V into 50  $\Omega$ .
- Lo Level: 0 V into 50  $\Omega$ .

### Clock Generator

**Sampling Frequency** – 50.000000 kHz to 1.0000000 GHz.

**Resolution** – 8 digits.

### Internal Clock –

Accuracy:  $\pm 1$  ppm.

Phase Noise:

- At 1 GHz, 10 kHz offset: –80 dBc/Hz.
- At 1 GHz, 100 kHz offset: –100 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** – Single-ended; CH1 and CH2.

### DA Converter –

Resolution: 10-Bit.  
Differential Non-linearity:  $\pm 1$  LSB.  
Integral Non-linearity:  $\pm 1$  LSB.

### Normal Out –

Pulse Response (–1 and 1 waveform data, 0 V offset, Through filter):

- Rise time (10 to 90%): Amplitude >1.0 V,  $\leq 2.5$  ns; Amplitude  $\leq 1.0$  V,  $\leq 1.5$  ns.
- Fall time (10 to 90%): Amplitude >1.0 V,  $\leq 2.5$  ns; Amplitude  $\leq 1.0$  V,  $\leq 1.7$  ns.
- Aberrations (at 500 MHz): Amplitude >1.0 V,  $\pm 10\%$ ; Amplitude  $\leq 1.0$  V,  $\pm 7\%$ .
- Flatness (after 50 ns from rise/fall edge):  $\pm 3\%$ .
- Small signal bandwidth (–3 dB, Amplitude 0.5 V): 300 MHz.

Sinewave Characteristics (1 GS/s clock, 32 waveform points, 31.25 MHz signal frequency, 1.0 V amplitude, 0 V offset, Through filter):

- Harmonics:  $\leq -50$  dBc, DC to 400 MHz.
- Noise:  $\leq -53$  dBc, DC to 400 MHz.
- Phase Noise:  $\leq -90$  dbc/Hz at 10 kHz offset.

Filter:

- Type: 10, 20, 50, 100 MHz Bessel low-pass.
- Rise time (10 to 90%): 10 MHz, 35 ns; 20 MHz, 17 ns; 50 MHz, 7.0 ns; 100 MHz, 3.5 ns.
- Delay from trigger: 10 MHz, 77 ns +1 clock; 20 MHz, 57 ns +1 clock; 50 MHz, 45 ns +1 clock; 100 MHz, 42 ns +1 clock; Through, 37 ns +1 clock.

### Direct DA Out –

Output Voltage: 0.5  $V_{p-p}$  (with –0.27 V offset) into 50  $\Omega$ .

Amplitude Accuracy: 0.5  $V_{p-p}$   $\pm 10\%$ .

DC Offset Accuracy: –0.27 V  $\pm 10\%$  (waveform data = 0).

Pulse Response (–1 and 1 waveform data):

- Rise time (10 to 90%):  $\leq 700$  ps.
- Fall time (10 to 90%):  $\leq 700$  ps.

**Output Impedance** – 50  $\Omega$ .

**Connector** – Front panel BNC.

## Channel Output Summary

Output Type	AWG520
Analog	2
Complement	N/A
Marker	CH1: M1, M2 CH2: M1, M2
Digital (Opt. 03)	2 Analog (CH2 Analog = D0 to D9, CH1 and CH2 Analog independent), D0 to D9, 4 Markers

## Auxiliary Outputs

### Marker –

Number: AWG520: 4.

Level:

Hi/Lo:  $-2.0\text{ V}$  to  $2.0\text{ V}$  ( $0.05\text{ V}_{p-p}$  to  $4\text{ V}_{p-p}$ ) into  $50\ \Omega$ ;  $-4.0\text{ V}$  to  $4.0\text{ V}$  ( $0.1\text{ V}_{p-p}$  to  $8\text{ V}_{p-p}$ ) into  $1\text{ M}\Omega$ .

Resolution:  $0.05\text{ V}$ .

Accuracy: Within  $\pm 0.1\text{ V} \pm 5\%$  of setting.

Rise/Fall Time (10 to 90%, typical):

At  $1\text{ V}_{p-p}$ , Hi  $+0.5\text{ V/Lo} -0.5\text{ V}$ :  $0.5\text{ ns}$ .

At  $2\text{ V}_{p-p}$ , Hi  $+1\text{ V/Lo} -1\text{ V}$ :  $1.0\text{ ns}$ .

At  $4\text{ V}_{p-p}$ , Hi  $+2\text{ V/Lo} -2\text{ V}$ :  $2.0\text{ ns}$ .

Variable Delay:

Range:  $0\text{ ns}$  to  $+2\text{ ns}$ .

Resolution:  $20\text{ ps}$ .

Marker Skew:  $32\text{ ps}$ .

Connector: Rear-panel SMB.

### Clock Out –

Level: ECL 100 K compatible.

Connector: Front-panel BNC.

### Noise –

Level:

Range:  $-145\text{ dBm/Hz}$  to  $-105\text{ dBm/Hz}$ .

Resolution:  $1\text{ dB}$ .

Accuracy:  $\pm 2.5\text{ dB}$  at  $100\text{ MHz}$ .

Flatness:  $\pm 2.5\text{ dB}$ ,  $1\text{ MHz}$  to  $300\text{ MHz}$  (referenced to  $-105\text{ dBm/Hz}$  at  $100\text{ MHz}$ ).

Type: Gaussian.

Connector: Front-panel BNC.

### Digital Data Out (Opt. 03) –

Output Signals: D0 to D9 (10-Bits).

Level:

Hi/Lo:  $-2.0\text{ V}$  to  $2.0\text{ V}$  ( $0.1\text{ V}_{p-p}$  to  $4\text{ V}_{p-p}$ ) into  $50\ \Omega$ ;  $-4.0\text{ V}$  to  $4.0\text{ V}$  ( $0.2\text{ V}_{p-p}$  to  $8\text{ V}_{p-p}$ ) into  $1\text{ M}\Omega$ .

Resolution:  $0.1\text{ V}$ .

Accuracy: Within  $\pm 0.1\text{ V} \pm 5\%$  of setting.

Rise/Fall Time (10 to 90%) typical:

At  $1\text{ V}_{p-p}$ , Hi  $+0.5\text{ V/Lo} -0.5\text{ V}$ :  $0.5\text{ ns}$ .

At  $2\text{ V}_{p-p}$ , Hi  $+1\text{ V/Lo} -1\text{ V}$ :  $1.0\text{ ns}$ .

At  $4\text{ V}_{p-p}$ , Hi  $+2\text{ V/Lo} -2\text{ V}$ :  $2.0\text{ ns}$ .

Skew Between Data:  $\leq 1\text{ ns}$ ,  $330\text{ ps}$  typical.

Delay:

Data to marker:  $4.4\text{ ns}$ .

Clock to data:  $3.7\text{ ns}$ .

Connector: Rear-panel SMB.

## Auxiliary Inputs

### Trigger In –

Impedance:  $1\text{ k}\Omega$  or  $50\ \Omega$ .

Polarity: POS or NEG.

Input Voltage Range:

$1\text{ k}\Omega$ :  $\pm 10\text{ V}$ .

$50\ \Omega$ :  $\pm 5\text{ V}$ .

Threshold:

Level:  $-5.0\text{ V}$  to  $5.0\text{ V}$ .

Resolution:  $0.1\text{ V}$ .

Accuracy:  $\pm(5\%$  of level  $+ 0.1\text{ V})$ .

Pulse Width (0.2 V amplitude):  $10\text{ ns}$  minimum.

Trigger Holdoff:  $500\text{ ns}$  maximum.

Delay to Marker:  $30\text{ ns} + 1\text{ clock}$ .

Connector: Front-panel BNC.

### Event Trig Input –

Number of Events: 4 Bits.

Input Signals: 4 event bits, strobe.

Threshold: TTL level.

Pulse Width: 64 clocks minimum.

Maximum Input:  $0\text{ V}$  to  $+5\text{ V}$  (DC + peak AC).

Delay to Analog Out:  $\leq 384\text{ clock} + 20\text{ ns}$ .

Impedance  $2.2\text{ k}\Omega$ , pull-up to  $+5\text{ V}$ .

Connector: Rear-panel 9-Pin D-sub.

### CH1 ADD Input –

Input Voltage Range:  $-1\text{ V}$  to  $1\text{ V}$  (DC + peak AC).

Impedance:  $50\ \Omega$ .

Bandwidth ( $-3\text{ dB}$ ): DC to  $200\text{ MHz}$  at  $1\text{ V}_{p-p}$  input.

Amplitude Accuracy:  $\pm 5\%$ .

Connector: Front-panel BNC.

### Reference 10 MHz Clock IN –

Input Voltage Range:  $0.2\text{ V}$  to  $3.0\text{ V}_{p-p}$ .

$\pm 10\text{ V}$  maximum.

Impedance:  $50\ \Omega$ , AC coupled.

Frequency Range:  $10\text{ MHz} \pm 0.1\text{ MHz}$ .

Connector: Rear-panel BNC.

### External Sample Clock In

Input Voltage Range –  $0.25\text{ V}_{p-p}$  to  $1\text{ V}_{p-p}$ .

Maximum Input Voltage Range –  $\pm 10\text{ V}_{max}$ .

Impedance –  $50\ \Omega$ , AC coupling.

Frequency Range –  $10\text{ MHz}$  to  $900\text{ MHz}$ .

Duty Cycle Ratio –  $40\%$  to  $60\%$ .

Pulse Width –  $0.5\text{ ns}$  minimum.

Connector – Rear panel BNC.

### Display

Area –  $13.2\text{ cm}$  ( $5.2\text{ in.}$ ) horizontal by  $9.9\text{ cm}$  ( $3.9\text{ in.}$ ) vertical.

Resolution –  $640$  horizontal by  $480$  vertical pixels.

### Data Storage

Internal Hard Disk Drive –  $10.0\text{ GB}$  (standard).

Floppy Disk Drive –  $3.5\text{ in.}$ ,  $1.44\text{ MB}$ .

**Option 10** – Substitute flash disk ( $128\text{ MB}$ ) for HDD, add standby switch. (Opt. 10 is best suited for ATE and system usage requiring  $7 \times 24$  hour operation.)

**Option 11** – Substitute Internal Hard Disk Drive with removable  $10.0\text{ GB}$  Hard Disk Drive mounted on top of the instrument

## Environmental, EMC, Safety

### Temperature –

Operating:  $10\text{ }^\circ\text{C}$  to  $+40\text{ }^\circ\text{C}$ .

Nonoperating:  $-20\text{ }^\circ\text{C}$  to  $+60\text{ }^\circ\text{C}$ .

### Humidity –

Operating:  $20$  to  $80\%$ , noncondensing.

Nonoperating:  $5$  to  $90\%$ , noncondensing.

### Altitude –

Operating: Up to  $4,500\text{ m}$ . ( $15,000\text{ ft}$ ). Maximum operating temperature decreases  $1\text{ }^\circ\text{C}$  per  $300\text{ m}$  above  $1.5\text{ km}$ .

Nonoperating: Up to  $15,000\text{ m}$  ( $50,000\text{ ft}$ ).

### Vibration (test limits) –

Operating:  $0.27\text{ G}_{RMS}$  from  $5$  to  $500\text{ Hz}$ ,  $10$  minutes duration.

Nonoperating:  $2.28\text{ G}_{RMS}$  from  $5$  to  $500\text{ Hz}$ ,  $10$  minutes duration.

### Shock (test limits) –

Nonoperating:  $294\text{ m/s}^2$  ( $30\text{ G}$ ), half-sine,  $11\text{ ms}$  duration.

### EMC Compliance –

EN50081-1.

EN50082-1.

FCC Part 15, Subchapter B Class A.

AS/NZS 20641/2.

**Safety** – UL3111-1, CSA1010.1, EN61010-1, IEC61010-1.

### Power

#### Source Power –

Line Voltage Range:  $100$  to  $240\text{ VAC}$ .

Line Frequency:  $48$  to  $63\text{ Hz}$ .

**Power Consumption** –  $600\text{ W}$  at  $8\text{ A}$  maximum.

## Physical Characteristics

Dimensions	mm	in.
Height	178	7.0
Height with Opt. 11	215.5	8.48
Width	422	17.5
Depth	560	25.8
<b>Weight</b>	<b>kg</b>	<b>lbs.</b>
Net	17	37.5

**Warranty** – One year parts and labor.

### Other

#### Programmable Interface –

GPIO:  $24$ -Pin IEEE488.1 connector.

Ethernet:  $10\text{Base-T}$ ,  $\text{RJ-45}$  connector.

**Keyboard Connector** –  $6$ -Pin mini-DIN connector.

# Arbitrary Waveform Generators

▶ AWG520

## ▶ Ordering Information

### AWG520

Programmable Dual-channel Arbitrary Waveform Generator.

**Includes:** User manual (071-0099-00), Programmer manual (071-0100-00), GPIB programming examples disk (063-2982-00), sample waveform library disk (063-2981-00), AXW100 ArbExpress Software Utility CD (063-3763-00), performance verification disk (063-2983-00), power cord, fuse (159-0239-00). Please specify power plug when ordering.

### Recommended Accessories

**Service Manual** – Order 071-0101-01.

**Protective Cover** – Order 200-3696-01.

**GPIB Cable** – Order 012-0991-01.

**50 Ω BNC Cable (36-inch)** – Order 012-1341-00.

**50 Ω BNC Cable (98-inch)** – Order 012-1256-00.

**50 Ω SMB Cable** – Order 012-1458-00.

**50 Ω SMB-to-BNC Cable** – Order 012-1459-00.

**50 Ω BNC Termination** – Order 011-0049-02.

**800 MHz BNC Low-pass Filter** – Order 015-0660-00.

**400 MHz BNC Low-Pass Filter** – Order 015-0659-00.

**200 MHz BNC Low-Pass Filter** – Order 015-0658-00.

**100 MHz BNC Low-Pass Filter** – Order 015-0657-00.

**Rackmount Conversion Kit** – Order 016-1675-01.

**Keyboard** – IBM-compatible 4-Pin mini DIN connector.

**Spare Removable Hard Disk Kit** – Order 650-4643-00 (Opt. 11 must be installed).

### Options

**Opt. 03** – CH. 2 10-Bit output up to 1 GHz.

**Opt. 10** – Flashdisk (128 MB) and standby switch – removes HDD.

(Opt. 10 is best suited for ATE and system usage requiring 7x24 hour operation.)

**Opt. 11** – Removable Hard Disk (exclusive to Option 10 and/or Option 3).

**Opt. 1R** – Rackmount.

### Power Plug Options

**Opt. A0** – North America Power.

**Opt. A1** – Universal EURO Power.

**Opt. A2** – United Kingdom Power.

**Opt. A3** – Australia Power.

**Opt. A4** – 240 V, North America Power.

**Opt. A5** – Switzerland Power.

### 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.

### Warranty

One year parts and labor.

### Contact Tektronix:

ASEAN / Australasia / Pakistan (65) 6356 3900

Austria +43 2236 8092 262

Belgium +32 (2) 715 89 70

Brazil & South America 55 (11) 3741-8360

Canada 1 (800) 661-5625

Central Europe & Greece +43 2236 8092 301

Denmark +45 44 850 700

Finland +358 (9) 4783 400

France & North Africa +33 (0) 1 69 86 80 34

Germany +49 (221) 94 77 400

Hong Kong (852) 2585-6688

India (91) 80-22275577

Italy +39 (02) 25086 1

Japan 81 (3) 6714-3010

Mexico, Central America & Caribbean 52 (55) 56666-333

The Netherlands +31 (0) 23 569 5555

Norway +47 22 07 07 00

People's Republic of China 86 (10) 6235 1230

Poland +48 (0) 22 521 53 40

Republic of Korea 82 (2) 528-5299

Russia, CIS & The Baltics +358 (9) 4783 400

South Africa +27 11 254 8360

Spain +34 (901) 988 054

Sweden +46 8 477 6503/4

Taiwan 886 (2) 2722-9622

United Kingdom & Eire +44 (0) 1344 392400

USA 1 (800) 426-2200

USA (Export Sales) 1 (503) 627-1916

For other areas contact Tektronix, Inc. at: 1 (503) 627-7111

13 August 2004

Our most up-to-date product information is available at:

[www.tektronix.com](http://www.tektronix.com)



Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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

Copyright © 2004, Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks or registered trademarks of their respective companies.

08/04 DV/WWW

76W-11846-5