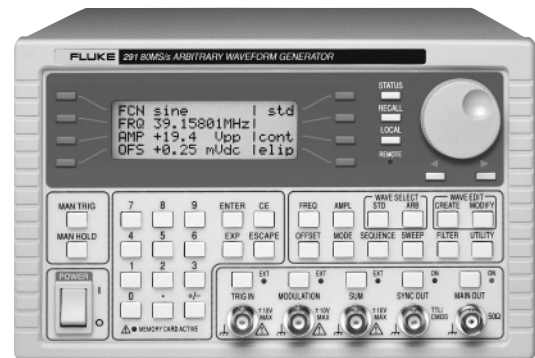


# 291/292/294 Universal Waveform Generators

## Technical Data



294 Waveform Generator



291 Waveform Generator

These universal waveform generators combine many generators in one instrument. Their extensive signal simulation capabilities include arbitrary waveforms, function generator, pulse/pulse train generator, sweep generator, trigger generator, tone generator, noise generator and amplitude modulation source.

The 290 series uses Direct Digital Synthesis techniques as well as variable clock sampling technology to provide a fully featured programmable function and arbitrary waveform capability.

The 291, 292 and 294 are 100 MS/s arbitrary waveform generators designed to handle real world requirements by test experts. These models can easily simulate complex signals while being easy to use, compact and affordable. On multi-channel units each channel can be operated fully independently, or multiple channels can be linked using simple or complex relationships.

Waveform Manager Plus software provides all the features needed for creation, manipulation and management of arbitrary waveforms within a single Windows based programs.

### Linked-sequence operation

Up to 1024 arbitrary waveforms may be linked in a sequence. Each waveform can have a loop count of up to 32,768 and the whole sequence can be run continuously or repeated more than a million times. For multi-channel models, waveforms on different channels can be "daisy chained" and looped. By summing the channel outputs, up to 64 segments can be used to create highly complex waveforms.

### 1, 2, or 4 Channel 100 MS/s waveform generator

- 100 MS/s 12-bit arbitrary waveform capability
- 256 K point waveform memory
- 40 MHz function generator capabilities using DDS (50 MHz for square waves)
- 10 ns pulse pattern generator
- Waveform sequencing with up to 1024 segments
- Unlimited waveform storage using CF memory cards
- Waveform Manager Plus for Windows software
- USB interface in addition to RS-232 and GPIB

### Arbitrary Waveform

Waveforms	The maximum arbitrary waveform size is 262,144 points. Up to 500 user-defined waveforms may be stored on the removable memory card. Arbitrary waveforms can be defined by front panel editing controls, by downloading of waveform data via RS-232,USB or GPIB, or by writing directly to the removable memory card using the USB card reader/writer connected to a PC.
Waveform memory	256 K points. Minimum waveform size is 8 points.
Vertical resolution	12 bits
Sample clock range	100 mHz to 100 MHz
Resolution	4 digits
Accuracy	± 1 digit of setting
Output filter	Selectable between 40 MHz Elliptic, 20 MHz Bessel or none
Sequence	Up to 1024 waveforms may be linked. Each waveform can have a loop count of up to 32,768. A sequence of waveforms can be looped up to 1,048,575 times or run continuously.
Noise function	Digital noise generated by a 35-bit linear feedback register clocked at 100 MHz. User's external filter defines bandwidth and response.

## Standard Waveforms

Waveforms	Sine, square, triangle, DC, positive ramp, negative ramp, sin(x)/x, pulse, pulse train, cosine, haversine and havercosine
<b>Sine, Cosine, Haversine, Havercosine</b>	
Range	0.1 mHz to 40 MHz
Resolution	0.1 mHz or 10 digits
Accuracy	Better than 10 ppm for 1 year
Temperature stability	Typically < 1 ppm/°C
Output level	5 mV to 20 V p-p from 50 Ω
Harmonic distortion	< 0.15 % THD to 100 kHz; < -60 dBc to 20 kHz, < -50 dBc to 1 MHz, < -40 dBc to 10 MHz, < -30 dBc to 40 MHz
Non-harmonic spuri	< -60 dBc to 1 MHz, < -60 dBc + 6 dB/octave 1 MHz to 40 MHz
<b>Square</b>	
Range	1 mHz to 50 MHz
Resolution	1 mHz (4 digits)
Accuracy	± 1 digit of setting
Output level	5 mV to 20 V p-p from 50 Ω
Rise and fall times	< 8 ns
<b>Triangle</b>	
Range	0.1 mHz to 500 kHz
Resolution	0.1 mHz or 10 digits
Accuracy	Better than 10 ppm for 1 year
Output level	5 mV to 20 V p-p from 50 Ω, linearity error: < 0.1 % to 30 kHz
<b>Ramps and Sin(x)/x</b>	
Range	0.1 mHz to 500 kHz
Resolution	0.1 mHz or 10 digits
Accuracy	Better than 10 ppm for 1 year
Output level	5 mV to 20 V p-p from 50 Ω
Linearity error	< 0.1 % to 30 kHz
<b>Pulse and Pulse Train</b>	
Output level	5 mV to 20 V p-p from 50 Ω
Rise and fall times	< 8 ns
Period	Range: 40 ns to 100 s; Resolution: 4-digits; Accuracy: ± 1 digit of setting
Delay	Range: -99.9 s to + 99.99 s; Resolution: 0.001 % of period or 10 ns
Width	Range: 10 ns to 99.99 s; Resolution: 0.001 % of period or 10 ns

Trains of up to 10 pulses may be specified, each having independently defined width, delay and level. The baseline voltage is separately defined and the sequence repetition rate is set by the pulse train period.

## Operating Modes

<b>Continuous</b>	
Waveform runs continuously	
<b>Triggered Burst</b>	
Each active edge of the trigger signal will produce one burst of the waveform	
Carrier waveforms	All standard and arbitrary
Max. carrier frequency	The smaller of 2.5 MHz or the maximum for the selected waveform. 100 Msamples/s for ARB or Sequence.
Number of Cycles	1 to 1048575
Trigger rep. rate	0.005 Hz to 100 kHz internal, dc to 1 MHz external
Trigger source	Internal from keyboard or trigger generator. External from TRIG IN or remote interface.
Start/stop phase	± 360 ° settable with 0.1 ° resolution, subject to waveform frequency and type
<b>Gated</b>	
Waveform will run while the Gate signal is true and stop while false	
Carrier waveforms	All standard and arbitrary
Max. carrier frequency	The smaller of 2.5 MHz or the maximum for the selected waveform. 100 Msamples/s for ARB or Sequence.
Trigger rate	0.005 Hz to 100 kHz internal, dc to 1 MHz external
Gate signal source	Internal from keyboard or trigger generator. External from TRIG IN or remote interface.
Start/stop phase	± 360 ° settable with 0.1 ° resolution, subject to waveform frequency and type
Capability provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to perform the sweep.	
Carrier waveforms	All standard and arbitrary except pulse, pulse train and sequence. Sweep mode: Linear or logarithmic, continuous or triggered.
Sweep direction	Up, down, up/down or down/up

## Operating Modes continued

Sweep range	1 mHz to 40 MHz in one range. Phase continuous. Independent setting of start/stop frequency.
Sweep time	1 ms to 999 s (3 digit resolution)
Marker	Variable during sweep.
Sweep trig. source	The sweep may be free run or triggered from the following sources: Manually from keyboard. Externally from TRIG IN input or remote interface.
Sweep hold	Sweep can be held and restarted by HOLD key
<b>Tone Switching</b>	
Capability provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques used to allow instantaneous frequency switching.	
Carrier waveforms	All waveforms bar pulse, pulse train, sequence
Frequency list	Up to 16 frequencies from 1 mHz to 40 MHz
Trigger rep. rate	0.005 Hz to 100 kHz internal, dc to 1 MHz external. Usable repetition rate and waveform frequency depend on the tone switching mode.
Source	Internal from keyboard or trigger generator. External from TRIG IN or remote interface.
<b>Tone switching modes</b>	
Gated	The tone is output while the trigger signal is true and stopped, at the end of the current waveform cycle, while the trigger signal is false. The next tone is output when the trigger signal is true again.
Triggered	The tone is output when the trigger signal goes true and the next tone is output, at the end of the current waveform cycle, when the trigger signal goes true again.
FSK	The tone is output when the trigger signal goes true and the next tone is output, immediately, when the trigger signal goes true again.
<b>External Amplitude Modulation</b>	
Carrier frequency	Entire range for selected waveform
Carrier waveforms	All standard and arbitrary waveforms
Modulation source	Modulation socket
Frequency range	DC to 500 kHz
Signal range	Approx. 1 V pk-pk for 100 % level change at maximum output
<b>External Signal Summing</b>	
Carrier frequency	Entire range for selected waveform
Carrier waveforms	All standard and arbitrary waveforms
Sum source	Sum socket
Frequency range	DC to 16 MHz
Signal range	Approximately 2 Vpk-pk input for 20 Vpk-pk output.
<b>Trigger Generator</b>	
Internal source 0.005 Hz to 100 kHz squarewave adjustable in 10 us steps. 3 digit resolution. Available for external use from the SYNC OUT socket.	

## Outputs

<b>Main Outputs - One for each channel</b>	
Output impedance	50 Ω
Amplitude	5 mV to 20 V pk-pk open circuit (2.5 mV to 10 V pk-pk into 50 Ω. Amplitude can be specified open circuit (Hi Z) or into an assumed load of 50 Ω or 60 Ω, in Vpk-pk, Vrms or dBm.
Ampl. accuracy	Better than 2 % ± 1 mV at 1 kHz into 50 Ω
Ampl. flatness	± 0.2 dB to 1 MHz; ± 0.4 dB to 40 MHz
DC offset range	± 10 V. DC offset plus signal peak limited to ± 10 V from 50 Ω
Offset accuracy	Typically within ± 3 % ± 10 mV, unattenuated
Resolution	3 digits or 1 mV for both Amplitude and DC Offset
<b>Sync Out - One for each channel</b>	
Multifunction output user definable or automatically selected to be any of the following:	
Waveform sync (All waveforms)	A square wave with 50 % duty cycle at the main waveform frequency, or a pulse coincident with the first few points of an arbitrary waveform.
Position markers (Arbitrary only)	Any point(s) on the waveform may have associated marker bit(s) set high or low
Burst done	Produces a pulse coincident with the last cycle of a burst
Sequence sync	Produces a pulse coincident with the end of a waveform sequence
Trigger	Selects the current trigger signal. Useful for synchronising burst or gated signals.
Sweep sync	Outputs a pulse at the start of sweep to synchronise an oscilloscope or recorder. Can additionally output a sweep marker.
Phase lock out	Used to phase lock two generators. Produces a positive edge at the 0° phase point.
Output signal level	Logic level of < 0.8 V to > 3 V for all outputs except Sweep Sync. Sweep Sync is a 3-level waveform.

## Inputs

Trig In	
Frequency range	DC to 1 MHz
Signal range	Threshold nominally TTL level; max. input $\pm 10$ V
Min. pulse width	50 ns for Trigger and Gate modes; 50 $\mu$ s for Sweep mode
Input impedance	10 k $\Omega$
Modulation In	
Frequency range	DC to 500 kHz
Signal range	VCA: Approximately 1 Vpk-pk for 100 % level change at maximum output SCM: Approximately $\pm 1$ Vpk for maximum output
Input impedance	Typically 1 k $\Omega$
Sum In	
Frequency range	DC to 30 MHz (291) DC to 16 MHz (292/294)
Signal range	Approximately 2 Vpk-pk input for 20 Vpk-pk output
Input impedance	Typically 1 k $\Omega$
Hold	Holds an arbitrary waveform at its current position. A TTL low level or switch closure causes the waveform to stop at the current position and wait until a TTL high level or switch opening which allows the waveform to continue. The front panel MAN/HOLD key or remote command may also be used to control the Hold function.
Input impedance	10 k $\Omega$
Ref Clock In/Out	
Set to input	Input for an external 10 MHz reference clock. TTL/CMOS threshold level.
Set to output	Buffered version of the internal 10 MHz clock. Output levels nominally 1 V and 4 V from 50 $\Omega$ .
Set to phase lock	Used together with SYNC OUT on a master and the TRIG IN on a slave to synchronize (phase lock) two generators
ARB Clock In	
Frequency range	DC to 50 MHz
Max. input voltage	+5 V, -1 V

## Inter-Channel Operation

Inter-Channel Modulation	
The waveform from any channel may be used to Amplitude Modulate (AM) or Suppressed Carrier Modulate (SCM) the next channel. Alternatively any number of channels may be Modulated (AM or SCM) with the signal at the MODULATION input socket.	
Carrier frequency	Entire range for selected waveform
Carrier waveforms	All standard and arbitrary waveforms
Modulation types	AM: Double sideband with carrier. SCM: Double sideband suppressed carrier
Modulation source	Internal from the previous channel. External from Modulation input socket. The external modulation signal may be applied to any number of channels simultaneously.
Frequency range	DC to > 100 kHz
Internal AM depth	0 % to 105 %
Internal AM resolution	1 %
Carrier Suppression (SCM)	> 40 dB
External modulation signal range	VCA: Approximately 1 V pk-pk for 100 % level change at maximum output SCM: Approximately $\pm 1$ Vpk for max. output
Inter-Channel Analogue Summing	
Waveform Summing sums the waveform from any channel into the next channel. Alternatively any number of channels may be summed with the signal at the SUM input socket.	
Carrier frequency	Entire range for selected waveform
Carrier waveforms	All standard and arbitrary waveforms
Sum source	Internal from the previous channel. External from SUM IN socket.
Frequency range	DC to > 16 MHz
Ext. signal range	Approx. 5 Vpk-pk input for 20 Vpk-pk output
Inter-Channel Phase Locking	
Two or more channels may be phase locked together. Each locked channel may be assigned a phase angle relative to the other locked channels. Arbitrary waveforms and waveform sequences may be phase locked but certain constraints apply to waveform lengths and clock frequency ratios. With one channel assigned as the Master and other channels as Slaves a frequency change on the master will be repeated on each slave thus allowing multiphase waveforms at the same frequency to be easily generated. DDS waveforms are those with 7 digits of frequency setting resolution, while Non-DDS waveforms have 4 digits.	
Phase resolution	DDS waveforms: 0.1 degree
Non-DDS waveforms	0.1 degree or 360 degrees/number of points whichever is the greater
Phase error	< $\pm 10$ ns all waveforms.

**Inter-Channel Operation** continued

**Inter-Channel Triggering**

Any channel can be triggered by the previous or next channel. The previous/next connections can be used to 'daisy chain' a trigger signal from a 'start' channel, through a number of channels in the 'chain' to an 'end' channel. Each channel receives the trigger out signal from the previous (or next) channel, and drives its selected trigger out to the next (or previous) channel. The 'end' channel trigger out can be set up to drive the 'start' channel, closing the loop. In this way, complex and versatile interchannel trigger schemes may be set up. Each channel can have its trigger out and its output waveform set up independently. Trigger out may be selected from Waveform End, Position Markers, Sequence Sync or Burst Done. Using the scheme above it is possible to create a sequence of up to 64 waveform segments, each channel producing up to 16 segments and all channels being summed to produce the complete waveform at the output of channel 4. The signals from the REF IN/OUT socket and the SYNC OUT socket can be used to phase lock two instruments where more than 4 channels are required.

**Interfaces**

RS-232	Variable Baud rate, 9600 Baud maximum
IEEE488	Conforms with IEEE488.1 and IEEE488.2
USB	Conforms with USB 1.1

**General Specifications**

Display	20 character x 4 row alphanumeric LCD
Data entry	Keyboard selection of mode, waveform etc.; value entry by numeric keys or by rotary control.
Memory card	Removable memory card conforming to the Compact Flash memory card standard. Sizes from 32 MB to 1 GB can be used.
Stored settings	Up to 500 complete instrument set-ups may be stored and recalled from the memory card. Up to 500 arbitrary waveforms can also be stored independent of the instrument settings.
Size	130 mm (3U) high; 335 mm long; 350 mm wide (292/294), 212 mm wide (291)
Weight	292/294: 7.2 kg (16 lb); 291: 4.1 kg (9 lb)
Power	110 to 120 V or 100 V nominal 50/60/400 Hz; 220 to 240 V nominal, 50/60 Hz. Voltage adjustable internally; operating range ± 10 % of nominal; 60 VA max. Installation Category II.
<b>Compliance</b>	
Operating range	+5 °C to 40 °C, 20 to 80 % RH
Storage range	-20 °C to +60 °C
Environmental	Indoor use at altitudes to 200 m, Pollution Degree 2
Safety	Complies with EN61010-1
EMC	Complies with EN61326
Instrument drivers	Labview and LabWindows CVI drivers are either supplied with the instrument or are available via your local Fluke Office
Supplied Items	IEC Mains Lead. Printed manual (partly multi-language), multi-language manual on CD, Waveform Manager Plus software, compact Flash memory card, compact Flash card reader/writer (USB connection to PC)
Options	19 inch rack mounting kit

**Ordering Information**

**Models**

**291** 1 Channel 100 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software. Compact Flash Memory Card and USB Card Reader/Writer.

**292** 2 Channel, 100 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software. Compact Flash Memory Card and USB Card Reader/Writer.

**294** 4 Channel, 100 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software. Compact Flash Memory Card and USB Card Reader/Writer.

**Options and Accessories**

**Y200H** RackMount Kit Half Rack 271/281/291

**Y200F** RackMount Kit Full Rack 282/284/292/294

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Printed in U.S.A. 8/2007 3095658 D-EN-N Rev A  
Pub\_ID: 11290-eng Rev 01