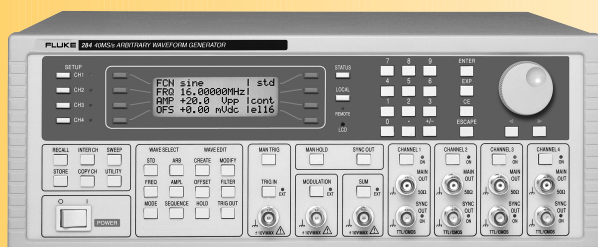# 281/282/284 Waveform Generators

Universal Waveform Generators

A selection of universal waveform generators offering superior performance and excellent value

284 Waveform Generator

281 Waveform Generator

- Choice of 1, 2 and 4 independent or linked channels
- 40 MS/s max. sampling speed
- 16 MHz function generator
- 10 MHz pulse generator
- Pulse train pattern generator
- Arbitrary waveforms of up to 65 k points
- Powerful modulation capabilities
- Built-in trigger generators
- Waveform Manager Plus for Windows® software
- Multiple standard waveforms recalled from internal memory
- RS-232 and GPIB interfaces

Tech Tip

A true arbitrary gener–ator provides a fully variable clock frequency to read data out of the waveform memory. This variable–clock type of arbitrary generator can faithfully reproduce the stored waveform at any repe–tition rate within the limits of its maximum and minimum clock frequencies. The wave–form can potentially have any length up to the maximum of the storage memory.

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 280 use Direct Digital Synthesis techniques as well as variable clock sampling technology to provide a fully featured programmable function and arbitrary waveform capability. The 281, 282 and 284 are 40 MS/s arbitrary waveform generators with one, two, and four channels, respectively.

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

Waveforms

Standard Waveforms: sine, square, triangle, dc, positive ramp, negative ramp, sine(x)/x, pulse, pulse train, cosine, haversine and havercosine.

Specifications apply at 18–28 ºC after 30 minutes warm–up, at maximum output into 50 Ω

Arbitrary Waveforms

Waveforms	Maximum waveform size is 65,536 points; minimum waveform size is 4 points. Up to 100 user defined waveforms may be stored in the 256 K point nonvolatile RAM. Waveforms can be defined by front panel editing controls or by downloading of waveform data via RS–232 or GPIB.
Waveform memory	64 k points per channel
Vertical resolution	12 bits
Sample clock	100 mHz to 40 MHz
Resolution	4 digits
Accuracy	± 1 digit of setting
Sequencing	Up to 16 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.
Output filter	Selectable between 16 MHz Elliptic, 10 MHz Elliptic, 10 MHz Bessel or none

Standard Waveforms

All Waveforms	
Accuracy	10 ppm for 1 year
Temp. stability	Typically < 1 ppm/°C.
Output level	2.5 mV to 10 Vpp into 50 Ω
Sine, Cosine, Haversine, Havercosine	
Range	0.1 mHz to 16 MHz
Resolution	0.1 mHz or 7 digits
Harmonic distortion	< 0.1 % THD to 100 kHz; < −65 dBc to 20 kHz, < −50 dBc to 300 kHz, < −35 dBc to 10 MHz < −30 dBc to 16 MHz
Nonharmonic spurii	< −65 dBc to 1 MHz, < −65 dBc + 6 dB/octave 1 MHz to 16 MHz
Square	
Range	1 mHz to 16 MHz
Resolution	1 mHz (4 digits)
Accuracy	± 1 digit of setting
Rise/fall times	< 25 ns
Pulse and Pulse Train	
Rise/fall times	< 25 ns
Period range	100 ns to 100 s
Period resolution	4 digit
Accuracy	± 1 digit of setting
Delay range	−99.99 s to + 99.99 s
Delay resolution	0.002 % of period or 25 ns, whichever is greater
Width range	25 ns to 99.99 s
Width resolution	0.002 % of period or 25 ns, whichever is greater
Triangle	
Range	0.1 mHz to 100 kHz
Resolution	0.1 mHz or 7 digits
Linearity error	< 0.1 % to 30 kHz
Ramps and Sin(x)/x	
Range	0.1 mHz to 100 kHz
Resolution	0.1 mHz (7 digits)
Linearity error	0.1 % to 30 kHz

Note: The pulse width and absolute value of the delay may not exceed the pulse period at any time. Pulse trains of up to 10 pulses may be specified, each pulse 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

Continuous	
Waveform runs continuously	
Triggered Burst	
Each active edge of the trigger signal will produce one burst of the waveform	
Carrier waveforms	All standard and arbitrary
Max. Carrier Frequency	40 Msamples/s for ARB and Sequence. 1 MHz or the maximum for the selected waveform.
Number of cycles	1 to 1,048,575
Trigger repetition	0.005 Hz to 100 kHz internal dc to 1 MHz external
Trigger signal source	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.
Trigger start/stop phase	± 360 ° settable with 0.1 ° resolution, subject to waveform frequency and type
Gated	
Waveform will run while the Gate signal is true and stop while false	
Carrier waveforms	All standard and arbitrary
Max. carrier frequency	40 Msamples/s for ARB and Sequence. 1 MHz or the maximum for the selected waveform.
Number of cycles	1 to 1,048,575
Trigger repetition	0.005 Hz to 100 kHz internal dc to 1 MHz external
Gate signal source	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.
Gate start/stop phase	± 360 ° settable with 0.1 ° resolution, subject to waveform frequency and type

Operating Modes continued

Sweep	
Frequency sweep capability is 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, triggered or continuous
Sweep direction	Up, down, up/down or down/up
Sweep range	From 1 mHz to 16 MHz in one range. Phase continuous. Independent setting of the start and stop frequency.
Sweep time	30 ms to 999 s
Marker	Variable during sweep
Sweep trigger 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 the HOLD key
Multi channel sweep	Any number of channels may be swept simultaneously but the sweep parameters will be the same for all channels. Amplitude, Offset and Waveform can be set independently for each channel.

Tone Switching	
Capability provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to allow instantaneous frequency switching.	
Carrier waveforms	All except pulse, pulse train and sequence
Frequency list	Up to 16 frequencies from 1 mHz to 10 MHz
Trigger repetition 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, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.

Tone switching modes	
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. Using 2 channels with their outputs summed together it is possible to generate DTMF test signals.

Trigger Generator	
Internal source 0.005 Hz to 100 kHz square wave adjustable in 10 us steps. 3-digit resolution. Available for external use from any SYNCOUT socket.	

Outputs

Main Output — One for each channel	
Output impedance	50 Ω
Amplitude	5 mV to 20 Vpp open circuit (2.5 mV to 10 Vpp into 50 Ω). Amplitude can be specified open circuit (hi Z) or into an assumed load of 50 Ω or 600 Ω Vpkpk, Vrms or dBm.
Amplitude accuracy	2 % ± 1 mV at 1 kHz into 50 Ω
Amplitude flatness	± 0.2 dB to 200 kHz; ± 1 dB to 10 MHz; ± 2.5 dB to 16 MHz
DC offset range	± 10 V from 50 Ω. Offset plus signal peak limited to ± 10 V
DC offset accuracy	Typically 3 % ± 10 mV, unattenuated
Resolution	3 digits or 1 mV for both amplitude and dc offset

Sync Out — One for each channel	
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	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 synchronizing burst or gated signals.
Sweep sync	Outputs a pulse at the start of sweep to synchronize an oscilloscope or recorder.
Phase lock out	Used to phase lock two generators. Produces a positive edge at the 0 ° phase point.
Output signal level	TTL/CMOS logic levels from typically 50 Ω.
Cursor/marker out	Adjustable output pulse for use as a marker in sweep mode or as a cursor in arbitrary waveform editing mode. Can be used to modulate the Z axis of an oscilloscope or be displayed on a second 'scope channel. Output Signal Level: Adjustable from nominally 2 V to 14 V, normal or inverted; adjustable width as a cursor.
Output impedance	600 Ω typical

Inputs

Trig In	
Frequency range	DC to 1 MHz
Signal range	Threshold nominally TTL level; maximum input ± 10 V
Min. pulse width	50 ns, for Trigger/Gate; 50 us for Sweep mode
Polarity	Selectable as high/rising edge or low/falling edge
Input impedance	10 kΩ
Modulation In	
Frequency range	DC to 100 kHz
VCA signal range	Approximately 1 V pkpk for 100 % level change at maximum output
SCM signal range	Approximately ± 1 V pk for maximum output
Input impedance	Typically 1 kΩ
Sum In	
Frequency range	DC to 8 MHz
Signal range	Approximately 2 V pk–pk input for 20 V pk–pk output
Input impedance	Typically 1 kΩ
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. While held the front panel MAN TRIG key or remote command may be used to return the waveform to the start. The Hold input may be enabled independently for each channel.	
Input impedance	10 kΩ
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 Ω
Set to phase lock	Used together with SYNC OUT on a master and TRIG IN on a slave to synchronise (phase lock) two separate generators.

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 ± 1 V pk 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 > 8 MHz
Ext. signal range	Approx. 5 V pk–pk input for 20 V pk–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 Non-DDS waveforms	DDS waveforms: 0.1 degree or 360 degrees/number of points whichever is the greater
Phase error	< ± 10 ns all waveforms
	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.

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.

Interfaces

RS-232	Variable Baud rate, 9600 Baud maximum
IEEE-488	Conforms with IEEE488.1 and IEEE488.2
Software included	Windows™-based software for waveform creation, editing and management is supplied.
Instrument drivers	LabView and LabWindows CVI drivers are either supplied with the instrument or are available via your local Fluke office

General Specifications

Display	20 character x 4 row alphanumeric LCD
Data entry	Keyboard selection of mode, waveform etc.; value entry direct by numeric keys or by rotary control
Stored settings	Up to 9 complete instrument setups may be stored and recalled from battery-backed memory. Up to 100 arbitrary waveforms can also be stored independent of the instrument settings.
Size	130 mm (3 U) height; 335 mm long; width 350 mm (282/284), 212 mm (281)
Weight	7.2 kg. (16 lb) (282/284); 4.1 kg (9 lb) (281)
Power	230 V, 115 V or 100 V nominal 50/60 Hz, adjustable internally; operating range ± 14 % of nominal;100 VA max. for 4 channels, 75 VA max. for 2 channel, 40 VA max. for 1 channel. Installation Category II.
Operating range	+5 °C to 40 °C, 20–80 % RH
Storage range	−20 °C to + 60 °C
Environmental	Indoor use at altitudes to 2000 m, Pollution Degree 2
Options	19-in rack mounting kit
Safety	Complies with EN61010-1
EMC	Complies with EN61326

Ordering Information

Models

281 1 Channel 40 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software

282 2 Channel, 40 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software

284 4 Channel, 40 MS/s Arbitrary Waveform Generator and Waveform Manager Plus Software

Options and Accessories

Y2801 (was 39A-001) 281 and 291 Rackmount Kit

Y2824 (was 195/002) 282, 284, 292 and 294 Rackmount Kit Calibration Results (required)