

## 280 Series Waveform Generators

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

### Technical Data

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, and amplitude modulation source.



284 Waveform Generator



281 Waveform Generator

#### Key features:

- Choice of one, two and four 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

The 281, 282, and 284 Waveform Generators 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.

#### Single or multiple channels

The 28x series comprises a single-channel model (281), two-channel (282) and four-channel (284). Each channel can be operated fully independently, or multiple channels can be linked using simple or complex relationships.

#### Waveforms

Standard waveforms include: sine, square, triangle, dc, positive ramp, negative ramp, sine(x)/x, pulse, pulse train, cosine, haversine and havercosine. Output frequency range is 0.1 mHz to 16 MHz for sine and square and up to 100 kHz for triangle, ramps and sine(x)/x. Rise time for pulse is < 25 ns with a period range of 100 ns to 100 s. Output amplitude range can be adjusted from 2.5 mV to 10 V p-p into 50 Ω.

### Versatile pulse generator capabilities

Each channel can generate not just pulses but complex pulse trains. A pattern of up to 10 pulses can be quickly defined with each pulse having its own amplitude, width and delay. The whole pulse train pattern can then be replayed at a user-defined repetition rate. Where variable rise time pulses are required, the full arbitrary function can be used.

### Arbitrary capability unmatched at this price

The 280 Series are highly sophisticated 12-bit arbitrary generators, capable of recreating virtually any waveform. True variable clock architecture is used, with clock speeds between 0.1 Hz and 40 MHz. This architecture avoids the clock jitter associated with DDS arbitrary generators and permits waveform linking, looping and sequencing. Waveforms may be defined with up to 4,096 vertical points and from 4 to 65,536 horizontal points. Arbitrary waveforms may be replayed at a specified waveform frequency, period or sample rate. Up to 100 user-defined waveforms can be stored within the instrument's 256 K of nonvolatile memory.

### Linked-sequence operation

Up to sixteen 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.

### Multi-channel phase locking

Any number of channels can be phase locked with offsets defined to a resolution of 0.1 degree (or 360 degrees/waveform points for arbitrary waveforms). For applications requiring more than four channels, multiple generators can be phase locked. The 280 Series also has the facility for phase locking to another generator.

### Multi-channel summing

Waveform summing sums the waveform from any channel into the next channel. Alternatively, any number of channels can be summed with an external signal. This permits complex modulations, such as noise superimposition, to be created.

### Inter-channel triggering and modulation

Because any channel can be triggered by the previous or next channel, waveforms on different channels can be daisy chained and looped. By summing the channel outputs, up to 64 segments can be used (32 segments for 282). A channel can be used to AM modulate or SCM modulate another channel.

### Wide frequency sweep range

All waveforms can be swept over their full frequency range at a rate variable between 30 milliseconds and

15 minutes. Sweep can be linear or logarithmic, single or continuous. Single sweeps can be triggered from the front panel, the trigger input, or the digital interfaces. Multiple channels can be swept simultaneously.

### Amplitude modulation

Amplitude modulation and suppressed carrier modulation are available for all waveforms. Any channel can be used to modulate another channel. Alternatively, all channels can be modulated simultaneously via the modulation input.

### Built-in trigger generator

All waveforms are available as a triggered burst, whereby each trigger edge will produce one burst of the carrier. Start and stop phase is fully variable. Both triggered and gated modes can be operated from the internal trigger generator, from an adjacent channel, an external source or a key press or remote command. The trigger generator signal is available as a separate output if required.

### Tone switching

The 280 Series can provide triggered switching between up to 16 frequencies of standard or arbitrary waveforms. Tone switching modes can be gated, triggered or FSK using any trigger source. By summing two channels together it is possible to generate precise DTMF test signals.

### Windows®-based waveform editing

Each generator is supplied complete with sophisticated Windows-based software for the creation, editing and management of waveforms. This powerful software can be used to create arbitrary waveforms from scratch using drawing tools, equations or both together. Real-world waveforms imported from DSOs or other sources can be modified and combined with other waveforms using editing functions. A library of standard waveforms is included which can be used as "elements" when creating or modifying waveforms. A powerful Equation Editor provides an array of mathematical functions, including logarithmic and geometric operands. Waveform creation and editing can make use of drawing tools in combination with equations, insertion and manipulation. Multiple waveforms can be further combined using mathematical operators to create new waveforms.

### Import from DSOs and other instruments

The Windows software incorporates direct support for uploading waveforms from Tektronix digital oscilloscopes. A driver for LabWindows™/CVI from National Instruments is available which enables imports from other equipment to be achieved within the LabWindows environment.

### Fully programmable via RS-232 or GPIB

The 280 Series incorporates both an RS-232 interface and a GPIB (IEEE-488) interface as standard. These can be used for loading arbitrary waveforms and for remote control of all instrument functions.

# 280 Series Specifications

Specifications apply at 18 °C to 28 °C 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

<b>All Waveforms</b>	
Accuracy	10 ppm for 1 year
Temp. stability	Typically < 1 ppm/°C.
Output level	2.5 mV to 10 Vpp into 50 Ω
<b>Sine, Cosine, Haversine, Haversine</b>	
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 spuri	< -65 dBc to 1 MHz, < -65 dBc + 6 dB/octave 1 MHz to 16 MHz
<b>Square</b>	
Range	1 mHz to 16 MHz
Resolution	1 mHz (4 digits)
Accuracy	± 1 digit of setting
Rise/fall times	< 25 ns
<b>Pulse and Pulse Train</b>	
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
<b>Triangle</b>	
Range	0.1 mHz to 100 kHz
Resolution	0.1 mHz or 7 digits
Linearity error	< 0.1 % to 30 kHz
<b>Ramps and Sin(x)/x</b>	
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.

# 280 Series Specifications cont.

## 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	40 Ms/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
<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	40 Ms/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
<b>Tone Switching</b>	
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.
<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 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.
<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. Using 2 channels with their outputs summed together it is possible to generate DTMF test signals.
<b>Trigger Generator</b>	
Internal source 0.005 Hz to 100 kHz square wave adjustable in 10 us steps. 3-digit resolution. Available for external use from any SYNC OUT socket.	

# 280 Series Specifications cont.

## Outputs

Main Output — One for each channel	
Output impedance	50 Ω
Amplitude	5 mV to 20 V <sub>pp</sub> open circuit (2.5 mV to 10 V <sub>pp</sub> into 50 Ω). Amplitude can be specified open circuit (hi Z) or into an assumed load of 50 Ω or 600 Ω V <sub>p-p</sub> , V <sub>rms</sub> 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 p-p input for 20 V p-p 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.

# 280 Series Specifications cont.

## 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 p-p for 100 % level change at maximum output SCM: Approximately $\pm 1$ 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 p-p input for 20 V p-p 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	< $\pm 10$ 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 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

# 280 Series Specifications cont.

## 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 $\pm 14\%$ 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

**Y200H** Rackmount Kit – half rack (281)

**Y200F** Rackmount Kit – full rack (282, 284)

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