Ordering Information

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
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

Additional included accessories (290 Series)
IEC Mains Lead
RS-232 Lead
Manual

Additional included accessories (280 Series)
IEC Mains Lead
RS-232 Lead
Manual

Options and accessories
19-inch rack mounting kit for one multi-channel generator
19-inch rack mounting kit for one or two single- channel generators

Fluke. *Keeping your world up and running.®*

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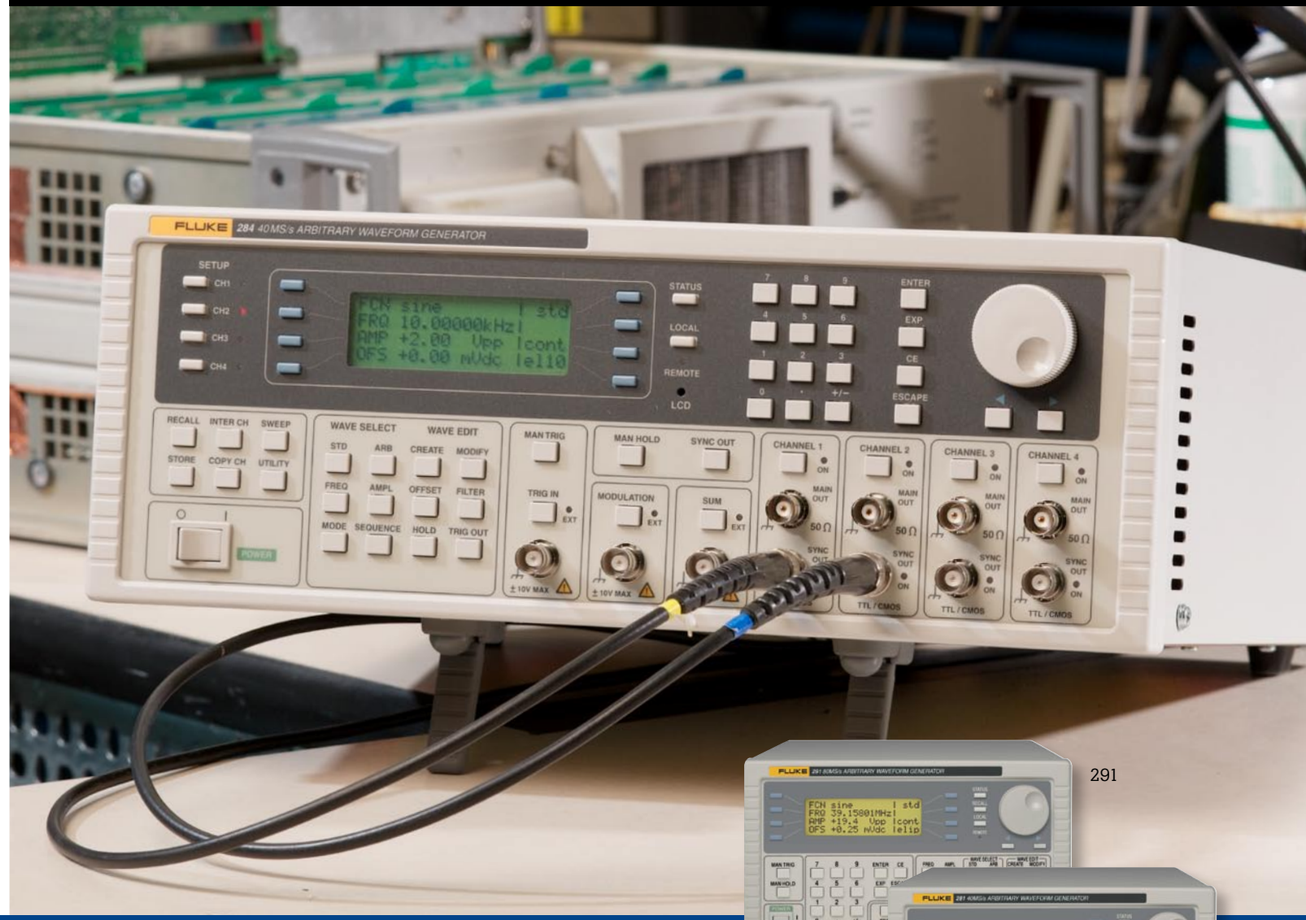
FLUKE®

Fluke 280 and 290 Series Single and Multi-Channel Universal ARB Generators



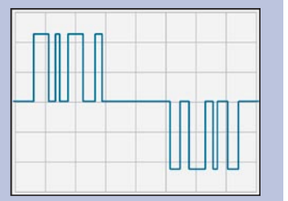
- **One, two or four independent or inter-linked channels**
- **40 MS/s or 100 MS/s, up to 1 M words per channel**
- **Function generator and pulse generator capabilities**

291

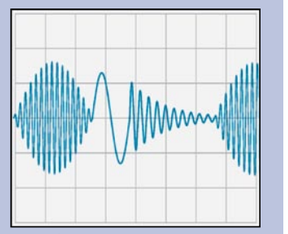

281


294

Universal waveform generators offering superior performance and excellent value



Pulse generator



Waveform sequencing

The Fluke 280 Series and 290 Series Waveform Generators combine a true variable clock arbitrary waveform generator with a high performance DDS function generator and pulse generator in a single instrument.

Wide model range

The Fluke 280 Series and 290 Series comprise of six models:

- **281** 40 MS/s single-channel waveform generator in 3U half rack size case.
- **282** 40 MS/s two-channel waveform generator in 3U case.
- **284** 40 MS/s four-channel waveform generator in 3U case.
- **291** 100 MS/s single-channel waveform generator in 3U half rack size case.
- **292** 100 MS/s two-channel waveform generator in 3U case.
- **294** 100 MS/s four-channel waveform generator in 3U case.

On multi-channel units, each channel can be operated fully independently, or multiple channels can be linked using simple or complex relationships.

A true arbitrary generator

The 280 and 290 Series are highly sophisticated 12-bit arbitrary waveform generators capable of recreating virtually any waveform. True variable clock architecture is used with clock speeds between 0.1 Hz and 100 MHz (40 MHz on 280 Series units). 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 4096 vertical points and from 8 M to 1 M horizontal points (4 K to 64 K points on 280 Series units).

Arbitrary waveforms may be replayed at a specified waveform frequency, period or sample clock rate. An external sample clock can also be used on 290 Series units allowing seamless on the fly changes to output frequency.

The 290 series waveform storage is on removable Compact Flash cards, making waveform management easy and effectively unlimited.

Function generator

Each channel can operate as a full DDS function generator. High quality sine, cosine, haversine, havercosine and square waves are available between 1 mHz and 16 MHz (280 Series) or up to 50 MHz (290 Series). Triangle, ramp and sine(x)/x waveforms are available from 0.1 mHz up to 500 kHz.

Pulse generator

Each channel can generate not just pulses, but also 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.

Features

- 1, 2 or 4 waveform channels, independent or linked
- 40 MS/s or 100 MS/s 12-bit arbitrary waveform capability using true variable clock architecture
- 64 K or 1 M point waveform memory per channel
- 16 MHz or 50 MHz function generators using direct digital synthesis (DDS)
- Multiple standard waveforms including sine, square, triangle, haversine, ramp, pulse and sin(x)/x
- Pulse train pattern generation for up to 10 pulses
- Complex waveform sequencing and looping capability using up to 1024 waveform segments
- Wide range sweep, AM, tone switching, signal summing
- Inter-channel triggering, summing and phase control
- Multiple generators can be easily phase locked
- External ARB clock input (290 Series only)
- Waveform creation/editing tools built in; sophisticated external Windows based software included
- Built-in trigger generator, gated and triggered burst modes
- Tone switching facilitates precision DTMF generation
- Unlimited waveform storage using CF memory cards (290 Series only)
- GPIB (IEEE-488.2), RS-232 and USB interfaces (280 Series units have GPIB and RS-232 only)

40 MS/s or 100 MS/s
one, two or four channels

Waveform creation and editing

Waveform creation and editing features are incorporated within the instrument. These include waveform insert, point edit, line draw, amplitude adjust and invert.

A wide range of standard waveforms are available for insertion within an arbitrary waveform. Sections of existing arbitrary waveforms can also be inserted. For more sophisticated waveform creation and editing, Waveform Manager Plus software for the Windows® operating system is provided.

Waveforms created on a PC can be downloaded to the instrument via the digital interfaces (or memory card where fitted).

Memory card storage

Fluke 290 Series units incorporate a CompactFlash memory card, giving effectively unlimited storage for waveforms and setups. Waveform data can be transferred directly from a PC to the memory card using the USB card reader/writer supplied.

GPIB, RS-232, USB

The 280 and 290 Series incorporate both RS-232 and GPIB (IEEE-488) interfaces as standard. 290 Series units also have a USB interface. These can be used for loading arbitrary waveforms and for remote control of all the instrument functions.

Waveform sequencing

The variable clock architecture of the 280 and 290 Series enables waveforms to be sequenced. Up to 1024 arbitrary waveforms may be linked in a sequence (16 waveforms on 280 Series). 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, multiple segments from multiple channels can be used to create highly complex waveforms.

Wide range sweep

All waveforms can be swept over their full frequency range at a rate variable between milliseconds and 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 Fluke 280 and 290 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.

Fast and easy to use

All of the main information is clearly displayed on a backlit 80 character LCD. Eight soft keys enable fast data editing. Parameters can be entered directly from the numeric keypad or changed with the spin wheel. On the 2 and 4 channel models, a Copy Channel key enables similar setups to be created across multiple channels with ease.

Multi-channel phase locking

Any number of channels can be phase locked with offsets defined to a resolution of 0.1° (or 360°/waveform points for arbitrary waveforms). For applications requiring more than four channels, multiple generators can be phase locked. 290 Series models can be phase locked to an external clock and offer phase continuous frequency changes.

All models, including the 281 and 291, have the facility for phase synchonising to another similar generator.

Multi-channel summing

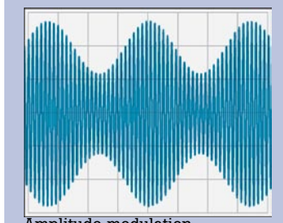
Waveform summing sums the waveform from any channel into the next channel. Alternatively any number of channels can be summed with an external signal. This permits complex modulations, such as noise superimposition, to be created.

Inter-channel triggering and modulation

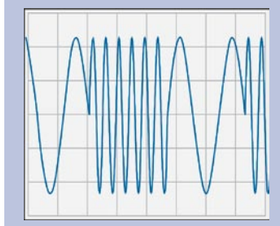
Because any channel can be triggered by the previous or next channel, waveforms on different channels can be "daisy chained" and looped. By summing the channel outputs, many segments from different channels can be used to generate the final waveform. A channel can be used to AM modulate or SCM modulate another channel.

Digital modulation

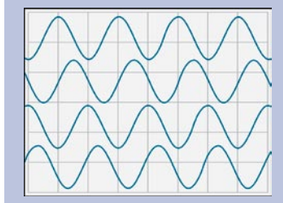
Inter-channel modulation and summing allows the simulation of various telecom digital modulation systems.



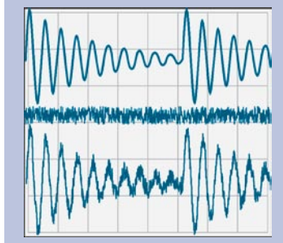
Amplitude modulation



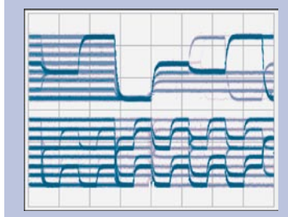
Tone switching



Multi-channel phase locking



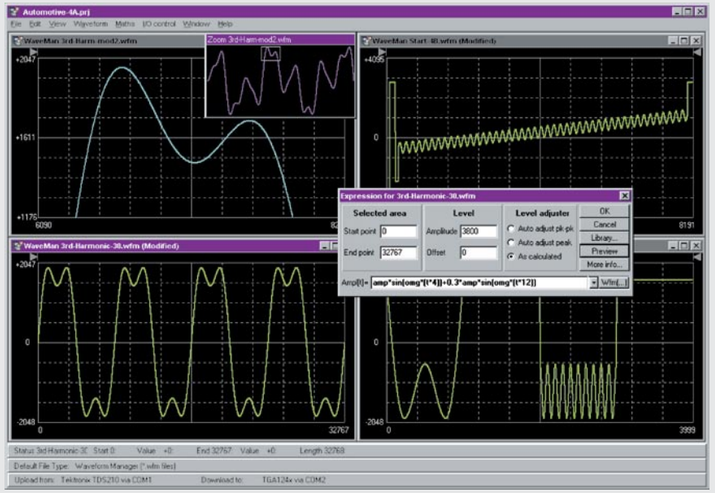
Multi-channel summing



Digital modulation

Advanced waveform creation, editing and management software included with all 280 and 290 Series generators

- Full waveform building tools including standard waveforms, mathematical expressions, and freehand drawing
- Full waveform building tools including standard waveforms, mathematical expressions, and freehand drawing
- Operates under Windows 95, 98, Millennium, NT, 2000 and XP
- Supports vertical resolutions up to 16 bits (65536 points)
- Supports horizontal resolutions to over one million points
- Provides waveform import and export via clipboard functions
- Directly supports waveform upload from some Tektronix DSOs
- Supports download and upload via RS-232, GPIB and USB



Waveform building tools

Toolkit

Waveforms can be built in any number of sections using any combination of the following: standard waveforms, mathematical expressions, drawn waveforms, uploaded waveforms, imported waveforms (using clipboard), existing stored waveforms.

Waveform section limits can be defined via moveable cursors, which can be dragged or positioned numerically.

Standard waveforms

The following waveforms are available directly from the Waveforms dialogue box: Sine, square, triangle, pulse, ramp, sinc [sin(x)/x], gaussian, exponent, noise. The mathematical expression for any standard waveform can be examined by opening the expression editor window.

Expression editor functions

The following mathematical operators are available within the expression editor: add, subtract, multiply, divide, xn, sin, cos, arcsin, arccos, abs, log10, loge, en, square root, floor, ceiling, random, pulse, in conjunction with constants and waveforms.

The expressions used for each section of a waveform are retained and can be displayed in a drop-down window.

Expression libraries

The mathematical expressions used for waveform creation can be stored in libraries. A default library is created for each project that includes a number of useful examples, including waveshapes and modulations.

Waveform drawing functions

Waveforms can be created or edited using freehand drawing and/or point-to-point line drawing.

Smoothing

Waveforms can be smoothed using a running average filter. Start and end points can be specified as well as the number of points to average.

Waveform editing/conversion

Toolkit

All of the waveform building tools previously mentioned can be used to edit existing waveforms. In addition, waveforms can be manipulated directly using the following functions:

Resize waveform

Allows a waveform to be resized horizontally to any length between 4 K to 64 K for 280 and 8 M to1 M for 290. Note: The vertical resolution of a waveform is automatically adjusted when it is downloaded to the generator. Thus an 8-bit waveform from a DSO will be expanded to 12 bits if it is downloaded to a 12-bit generator (and vice versa)

Waveform mathematics

The Waveforms Maths function allows waveforms to be combined and manipulated independently of the expression editor. Waveforms can be scaled, offset, added, subtracted or multiplied using dialogue boxes. Waveforms can also be combined and manipulated within the expression editor, giving access to the full range of mathematical functions.

Input/output functions

File formats

Waveforms can be read from and saved as any of the following formats: WFM (binary), NRM (normalised data in ASCII), WAV (WaveCAD), ASC (WaveCAD), DSF (Tektronix DSO).

Waveform download/upload

Waveforms can be downloaded/uploaded to/from Fluke arbitrary generators (or certain Tektronix DSOs) using either an RS-232 or GPIB (IEEE-488) interface or, for the 290 Series, a USB interface.

Clipboard functions

Waveforms can be imported to the program and exported from the program using the Windows® Clipboard.

Waveform import uses the "Text" clipboard format (i.e. numeric lists). This enables waveforms to be imported from spreadsheets such as Excel® software and from mathematical programs such as MathCad. Values are automatically normalised and re-scaled.

Waveform export creates multiple clipboard formats of Text (normalised numeric values between ± 1), Bitmap (as per on-screen display) and Picture (metafile retaining waveform vector properties). Pictures or bitmaps can be pasted into programs such as Word for documentation purposes.

Display area and printing

Multiple waveform windows can be open simultaneously. Each window is fully scaleable. Variable zoom is provided with panning from a "navigator" sub-window.

Waveform section limits can be defined via moveable cursors that can be dragged or positioned numerically. Waveforms can be printed with automatic annotation and scaling.

Management and utilities

Projects

To maintain good housekeeping, waveforms can be organized into "projects" with separate directory structures. Each project maintains its own library of expressions. Waveforms and expressions can be imported and exported from other projects.

Instrument setup

The instrument setup screen enables options for the waveform generator to be set from the program. Examples of settable options are output amplitude, clock frequency and trigger source.

Help

Full on-screen Help is available with a hyperlinked contents table.

FLUKE®

Technical specifications

Variable-clock ARB architecture

Direct replay for jitter-free waveforms

All Fluke 280 and 290 Series units generate arbitrary waveforms using a variable clock architecture rather than DDS. This ensures that every point in the waveform is replayed exactly as it was defined, the rate of replay being set by the clock frequency.

By contrast, a DDS arbitrary generator uses a fixed clock frequency and varies the replay rate by duplicating or omitting waveform points. Unless there is an integer relationship between the desired replay rate, clock frequency and waveform length, each "cycle" of the waveform will differ from the previous one, resulting in jitter.

Sequencing for increased waveform length

Variable clock architecture also allows sequencing and looping. The 64K words of waveform memory per channel provided in Fluke 280 Series units can be used to create arbitrary waveforms with many more than 65536 points.

Many real-world waveforms include repetitive elements. By using a segment of the memory to recreate each repeating element, the waveform can be constructed by a "sequence" in which the individual elements are replayed in a defined order and with a defined number of repetitions (loop count). In this way waveforms can be created with a much greater number of points than the waveform memory size.

DDS arbitrary generators cannot do this and the effective waveform length is limited to the actual waveform memory size.

Fluke 290 Series: the next step forward

The design of the new Fluke 290 Series generators is based upon extensive experience of actual user requirements. So in addition to raising the maximum clock speed from 40 MHz to 100 MHz, a number of other important features have been added that meet the needs of particular groups of customers.

1 M word waveform memory

Some users require very long arbitrary waveforms. 290 Series units incorporate 1,048,576 words of waveform memory per channel. Thus, even long and complex waveforms that have no repetitive elements can be accommodated. Compact Flash memory card storage provides effectively unlimited storage for waveforms. Greater sequencing capability (up to 1024 segments) gives even more flexibility in waveform reconstruction.

External ARB clock input

Some applications require that the arbitrary waveform is clocked in direct synchronism with an external signal. Fluke 290 Series units incorporate an external ARB clock input that can be used to clock any number of channels at any rate from dc up to 50 MHz.

It should be noted that DDS arbitrary generators have no such capability.

System clock architecture

All Fluke 290 Series units incorporate a separate clock generator for each channel, allowing completely independent operation.

On the Fluke 282 and Fluke 284, channel synchronization is achieved by defining one channel as the master channel and driving the other channel(s) from its clock.

The Fluke 292 and 294 provide a further option by incorporating an additional independent system clock generator. The system clock creates an internal version of the external ARB clock signal and can generate frequencies between 0.1 Hz and 50 MHz.

When the system clock (or external ARB clock) is used to drive multiple channels, phase skew is significantly reduced and frequency changes can be made without any discontinuities.

The system clock output is also available on the rear panel to drive external circuitry or the external ARB input of another generator when more than four channels are required.

Auxiliary sinewave output

The output of the master clock generator is also available as a fixed level sinewave. When not being used as the master for channel synchronization, this can be used as another independent variable frequency generator over the range 0.1 Hz to 50 MHz, providing the equivalent of three or five channel outputs.

Specifications apply between 18 °C to 28 °C after 30 minutes warm up, at maximum output into 50 Ω.

Arbitrary waveforms

Waveform parameters

	280 Series	290 Series
Waveform memory	64k points/ch	1M points/ch
Waveform length	4 to 65,536 points	8 to 1,048,576 points
Vertical resolution	12 bits (4096 levels)	
Sample clock rate	0.1 Hz to 40 MHz	0.1 Hz to 100 MHz (1)
Clock resolution	4 digits	8 digits
Clock accuracy	< 10 ppm for 1 year (± 1 digit of setting)	
Clock temp. stability	Typically < 1 ppm/ °C	
Waveform storage	256K Words Non-volatile RAM	CF Memory Cards (32 MB to 1 GB size)
Max. waveforms	100	500 per card

Note 1: 290 Series generators can also use an external sample clock, dc to 50 MHz.

Waveform creation and editing

	All Models
Internal	Basic arbitrary waveform creation and editing tools are built into the instrument. Arbitrary waveforms can be built-up using insertion of standard waveforms between points, point by point value setting, and straight line drawing between points.
External	All Fluke 280 and 290 series units are supplied with Waveform Manager Plus software for Windows which provides full waveform creation, editing and management. Waveforms are transferred using the digital interfaces or memory card.

Sequence

A number of waveforms can be linked and played as a sequence. 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.

	280 Series	290 Series
Max. waveforms in a sequence	16	1024

Output filter

The output filter type is selectable. This can be used to optimize a particular waveshape.

	280 Series	290 Series
Filter choice	16 MHz elliptic, 10 MHz elliptic, 10 MHz Bessel or none	40 MHz elliptic, 20 MHz Bessel or none

Standard waveforms

Sine, square, triangle, dc, positive ramp, negative ramp, sin(x)/x, pulse, pulse train, cosine, haversine and havercosine.

All waveforms

	280 Series
Frequency accuracy	< 10 ppm for 1 year
Temp. stability	Typically < 1 ppm/ °C
Output level	2.5 mV to 10 V pp into 50 Ω (5 mV to 20 V pp e.m.f.)

Sine, cosine, haversine, havercosine

	280 Series	290 Series
Frequency range	0.1 mHz to 16 MHz	0.1 mHz to 40 MHz
Freq. resolution	0.1 mHz or 7 digits	0.1 mHz or 10 digits
Harmonic distortion	< 0.1 % THD to 100 kHz; < –65dBc to 20 kHz, < –50dBc to 300 kHz, < –35dBc to 10 MHz < –30 dBc to 16 MHz	< 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
Nonharmonic spurii	< –65 dBc to 1 MHz, < –65 dBc + 6 dB/octave 1 MHz to 16 MHz	< –60 dBc to 1 MHz, < –60 dBc + 6 dB/octave 1 MHz to 40 MHz

Square

	280 Series	290 Series
Frequency range	1 mHz to 16 MHz	1 mHz to 50 MHz
Freq. resolution	1 mHz or 4 digits	1 mHz or 8 digits
Freq. accuracy	± 1 digit of setting	
Rise and fall times	< 25ns	< 8ns

Pulse and pulse train

	280 Series	290 Series
Period range	100 ns to 100 s	40 ns to 100 s
Period resolution	4 digits	8 digits
Period accuracy	± 1 digit of setting	
Delay range	-99.99s to + 99.99s	
Delay resolution	0.002 % of period (25 ns minimum)	0.001 % of period (10 ns minimum)
Width range	25 ns to + 99.99 s	10 ns to + 99.99 s
Width resolution	0·002 % of period (25 ns minimum)	0.001 % of period (10 ns minimum)
Rise and fall times	< 25 ns	< 8 ns

Note that 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.

Triangle

	280 Series	290 Series
Frequency range	0.1 mHz to 100 kHz	0.1 mHz to 500 kHz
Frequency resolution	0.1 mHz or 7 digits	0.1 mHz or 10 digits
Linearity error	< 0.1 % to 30 kHz	

Ramps and sin(x)/x

	280 Series	290 Series
Frequency range	0.1 mHz to 100 kHz	0.1 mHz to 500 kHz
Frequency resolution	0.1 mHz or 7 digits	0.1 mHz or 10 digits
Linearity error	< 0.1 % to 30 kHz	

Noise function (290 Series only)

Digital noise generated by a 35-bit linear feedback register clocked at 100 MHz. User's external filter defines bandwidth and response.

Operating modes

Continuous

Waveform runs continuously.

Triggered burst

Each active edge of the trigger signal will produce one burst of the waveform.

	280 Series	290 Series
Carrier waveforms	All standard and arbitrary waveforms	
Max. carrier frequency	1 MHz or the maximum for the selected waveform if lower. 40 Msamples/s for ARB and Sequence.	2.5 MHz or the maximum for the selected waveform if lower. 100 Msamples/s for ARB and Sequence.
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.

	280 Series	290 Series
Carrier waveforms	All standard and arbitrary waveforms	
Max. carrier frequency	1 MHz or the maximum for the selected waveform if lower. 40 Msamples/s for ARB and Sequence	2.5 MHz or the maximum for the selected waveform if lower. 100 Msamples/s for ARB and Sequence
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	

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.

	280 Series	290 Series
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	From 1 mHz to 40 MHz in one range
Sweep time	30 ms to 999 s	1 ms to 999 s
Marker	Variable during sweep	
Sweep trigger source	The sweep may be free run or triggered from the following: Manually from keyboard. Externally from TRIG IN input or remote interface	
Sweep hold	Sweep can be held / restarted by the HOLD key	

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 SYNC OUT socket.

Multi channel sweep (multi-channel units only)

Any number of channels may be swept simultaneously. Amplitude, Offset and Waveform can be set independently for each channel. For Fluke 280 units the sweep parameters will be the same for all channels. For Fluke 290 units the sweep parameters 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.

	280 Series	290 Series
Carrier waveforms	All except pulse, pulse train and sequence	
Frequency list	Up to 16 frequencies from 1 mHz to 10 MHz	Up to 16 frequencies from 1mHz to 40 MHz
Trigger repetition rate	0.005 Hz to 100 kHz internal. dc to 1MHz external. Usable repetition rate and waveform frequency depend on the tone switching mode.	
Trigger source	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.	
Tone switching modes	Gated, Triggered or FSK (see box top right)	

Outputs

Main output—One for each channel

	280 Series	290 Series
Output impedance	50 Ω	
Amplitude range	5 mV to 20 V pp open circuit (2.5 mV to 10 V pp into 50 Ω). Amplitude can be specified open circuit (hi Z) or into an assumed load of 50 Ω or 600 Ω in Vpk-pk, Vrms or dBm.	
Amplitude accuracy	2 % ± 1 mV at 1 kHz into 50 Ω	
Amplitude flatness	± 0.2 dB to 200 kHz; ± 1dB to 10 MHz; ± 2.5 dB to 16 MHz	± 0.2 dB to 1 MHz; ± 0.4 dB to 40 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	

Auxiliary sine output

280 Series	290 Series	292/294
n/a	n/a	Nominal 1V p-p sinewave, frequency set by system clock, frequency 0.1 Hz to 50 MHz

Sync out—One for each channel

Multifunction output user definable or automatically selected to be any of the following:

	280 Series	290 Series
Waveform sync: (all waveforms)	Square wave with 50 % duty cycle at the main waveform frequency, or 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 synchronizing burst or gated signals.	
Sweep sync	Outputs a pulse at the start of sweep to synchronize an oscilloscope or recorder	
Sweep marker	N/A	Additional pulse for use as sweep marker
Phase lock out	Used to phase lock two generators. Produces a positive edge at the 0° phase point.	
Signal level	Logic levels of < 0.8 V and > 3 V for all outputs	Logic levels of < 0.8 V and > 3 V for all outputs except Sweep Sync
Signal level: (sweep sync. only)	N/A	3 level waveform – as above but plus narrow +1 V pulse at marker

Inputs

Trig in

	280 Series	290 Series
Frequency range	DC to 1 MHz	
Signal range	Threshold nominally TTL level; maximum input ± 10 V	Threshold adjustable over ± 5 V range; 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	Typically 10 kΩ	

Modulation in

	280 Series	290 Series
Frequency range	DC to 100 kHz	DC to 100 kHz
VCA signal range	Approximately 1 V pk-pk for 100 % level change at maximum output	
SCM signal range	Approximately ± 1 V pk for maximum output.	
Input impedance	Typically 1 kΩ	

Sum in

	280 Series	291	292/294
Frequency range	DC to 8 MHz	DC to 30 MHz	DC to 16 MHz
Signal range	Approximately 2 V pk-pk input for 20 V pk-pk output		
Input impedance	Typically 1 kΩ		

Ref clock in/out

	280 Series	290 Series
Set to input	Input for an external 10MHz 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 synchronize (phase lock) two separate generators	

ARB clock in/out

290 Series generators can use an external signal as the arbitrary waveform clock. The 292 and 294 also include an internal system clock generator (in addition to the individual channel clock generators). The output of this system clock can be made available to drive external circuitry or the input of another generator.

	280 Series	291	292/294
Set to input	N/A	Input for an external Arb clock. TTL/CMOS threshold level.	
Set to output	N/A	N/A	Outputs System Clock, logic level < 0.8 V to > 3 V
Frequency range	N/A	DC to 50 MHz.	
Max. input voltage	N/A	+5 V, -1 V	

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 is10kΩ.

Channel relationships

The channels of a multi-channel unit can be operated entirely independently, as if they were separate generators. The "copy" key allows the settings of any channel to be instantly copied to another when required.

Alternatively, inter-channel relationships of modulation, summing, triggering, or phase locking can be set up.

Multi channel sweep

Any number of channels may be swept simultaneously. Amplitude, Offset and Waveform can be set independently for each channel. For 280 Series units, the sweep parameters will be the same for all channels. For 290 Series units,the sweep parameters can be set independently for each channel.

ARB clock out

See ARB clock In/Out within INPUTS section.

Cursor/marker out (280 Series units only)
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.

	280 Series	290 Series
Signal level:	Adjustable from nominally 2 V to 14 V, normal or inverted; adjustable width as a cursor	N/A
Output impedance:	600 Ω typical	N/A

System clock (292/294 only)

The 292/294 units incorporate an additional frequency generator, which can be used as a clock source for multi-channel arbitrary waveforms and as an auxiliary output.

	280 Series	291	292/294
Frequency range	N/A	N/A	DC to 50 MHz
Frequency resolution	N/A	N/A	0.1 Hz

The output of the system clock is available as a 1 volt pk-pk sinewave at the Auxiliary Sine Out socket, and as a logic level squarewave at the Ext. ARB In/Out socket.

When not being used as a clock source for multi-channel arbitrary waveforms, the system clock provides an independent fixed amplitude sine or square output which is additional to the two or four main channel outputs.

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.

	282/284/292/294
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 1V pk-pk for 100 % level change at maximum output. SCM: Approximately ± 1 V pk for max. output.

Inter-channel analog 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.

	282/284	292/294
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.	DC to > 16 MHz.
External signal range	Approx. 5 V pk-pk input for 20 V pk-pk output	Approx. 2 V pk-pk input for 20 V pk-pk output
Input impedance	Typically 1 kΩ	

Multi-channel operation

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. 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. 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. Different condition apply to Standard waveforms generated using DDS techniques (sine, cosine, haversine, havercosine, triangle, ramps and sinex/x), and those generated using variable clock arbitrary waveform techniques which include square, pulse and pulse train. Arbitrary waveforms and waveform sequences may be phase locked to the Master channel, but certain constraints apply to waveform lengths and clock frequency ratios. 292/294 arbitrary waveforms and waveform sequences can alternatively be clocked from a separate internal clock generator (System clock), or from an external clock input (external ARB clock). When using these clock sources, the restrictions that apply when using the Master channel as the clock source are eliminated. In addition, frequency changes require no settling time to re-establish phase locking, and thus phase continuous frequency changing or sweeping is possible.

	282/284	292/294
Phase resolution: (DDS waveforms)	0.1 degree	
Phase resolution: (Non DDS waveforms)	0.1 degree or 360 degrees/number of points	
Clock source	Master channel	Master Channel, System Clock or Ext. ARB clock
Phase error	< ± 10 ns	< ± 5 ns (internal clock) < +/-2 ns (external ARB or system clock)

N.B. DDS waveforms are Sine, Cosine, Haversine, Havercosine, Triangle, Ramps and Sin(x)/x. Non DDS waveforms are Pulse, Pulse Train, and all Arbitrary waveforms.

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 inter-channel 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.

Interfaces

Full remote control and waveform transfer is available through the digital interfaces.

	280 Series	290 Series
IEEE488	Conforms with IEEE488.1 and IEEE488.2	
RS232	Variable baud rate, 9600 baud maximum	Variable baud rate, 38400 baud maximum
USB	N/A	Conforms with USB1.1

General

	280 Series	290 Series
Display	20 character x 4 row alphanumeric LCD	
Data Entry	Keyboard selection of mode, wave etc., value entry direct by numeric keys or by rotary control	
Memory Card	N/A	Removable card slot conforming to the Compact Flash standard. Sizes 32 MB to 1 GB.
Waveform Storage: (non volatile)	Up to 100 waveforms within 256 K words	Up to 500 waveforms per CF card
Stored Settings	Up to 9 full setups	Up to 500 full setups per CF card

Mechanical, power, compliance

	281	291	282	292	284	294
Width	212 mm (½ rack)		350 mm			
Height	130 mm (3 U)		130 mm (3 U)			
Length	335 mm		335 mm			
Weight	4.1 kg	4.2 kg	7.1 kg	5.9 kg	7.2 kg	6.0 kg
Power	A	B	A	C	A	C
A = 230 V, 115 V or 100 V ± 14 %, 50/60 Hz, adjustable internally B = 230 V, 115 V or 100 V ± 14 %, 50/60/400 Hz, adjustable internally C =100 V to 230 V ± 14 %, 50/60/400 Hz, universal input						
Maximum VA	40	60	75	150	100	150
Temperature	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					
Safety	Complies with EN61010-1					
EMC	Complies with EN61326					

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