Models 296 and 295

50 MS/s Synthesized Multichannel Arbitrary Waveform Generators

- Up to 4 Independent Channels
- 10 Standard Functions (sine to 20 MHz, square to 25 MHz)
- Up to 50 MS/s Sampling with 12-Bit Vertical Resolution
- Waveform Sequencing of up to 4,096 Segments (Model 296 only)
- Frequency Control of Individual Sequence Segments (Model 296 only)
- 16-Bit Digital Output to 50 MS/s (Model 296 only)
- Optional 100 Vpp Output
- Versatile Interchannel Triggering, Summing and Phase Control
- Frequency Sweep
- Amplitude and Suppressed Carrier Modulation
- Graphical User Interface
- Front Panel Waveform Creation/Editing Tools
- Floppy Disk Drive
- GPIB and RS-232 Interfaces
- Compatible with Waveform DSP
- SCPI Compatible

Model 296 and 295 combine sophisticated performance with ease of use in a way previously not available in arbitrary waveform generators. Model 295 is the basic model. Model 296 adds advanced waveform sequencing capability up to 4,096 waveform segments for complex waveform generation. It also provides a 16-bit digital output on each channel.

Both models can contain up to four separate channels. When run independently, each channel is essentially a stand-alone arbitrary waveform generator. When in master/slave mode, phase relationships between channels can be set by the user. Each channel outputs 15 Vp-p (into 50 Ω load) at 50 MS/s sampling frequency maximum or can output 100 volts peak-to-peak when Option 007 is installed. Each channel has a high-speed clock output that runs at a maximum of 100 MHz.

Arbitrary waveforms can be created and stored to nonvolatile RAM or on the standard MS-DOS™ compatible 3.5-inch, high-density disk drive. In addition, ten commonly used synthesized functions are built in.

The graphic user interface greatly simplifies creating and editing waveforms, which can be viewed on an oscilloscope. A mouse (provided) is used to draw on a scope when creating waveforms and to make selections on the graphical interface when setting up the instrument.

Arbitrary waveforms may be created from the front panel using the mouse and any of four modes: free hand, line draw, line list, and mathematical expressions. In addition, extensive waveform editing tools enable the user to control waveform shapes precisely. The editing tools make it easy to modify existing waveforms. This is particularly useful in such applications as characterization testing. For instance, amplitude may be modified continually in order to characterize performance of the unit under test. For more complex applications, waveform linking, looping, and sequencing allow users to create long, complex waveforms.

Versatile interchannel capabilities are provided. An internal summing bus allows waveforms from multiple channels to be summed together. Other interchannel capabilities include setting phase shift between channels, linking waveforms together and triggering one channel from another.

Waveforms, sequences, and entire instrument set-ups can be stored in the internal nonvolatile 60 kB RAM or on disk via the disk drive.

It’s Easy to Create Any Waveform. Models 296 and 295 take the limits off your ability to simulate the signals you are faced with in the real world.

Built-in features make interactive control of complex waveforms and instrument set-up simple. Waveforms can be created, copied, edited, downloaded, and sequenced, all with a few clicks of the mouse. The 296 and 295 provide a complete set of tools that enables you to specify all kinds of waveforms in a number of ways, from precise mathematical description to “what-if” freehand sketching. And modifying waveforms is a snap with tools such as Vertical Resize and Vertical Move. The sophisticated user interface gives you access to all the power of the 296 and 295, with a flexibility in waveform creation never before
Model 296

An internal memory of 60 kB is provided for storing the waveforms you create. Storing waveforms created or captured elsewhere is no problem either. Simply download waveforms over the GPIB or RS-232 interface or through the standard 3.5-in disk drive. You can download waveforms generated in Wavetek’s WaveForm DSP arbitrary waveform creation software or directly from a DSO (with Option 005). Or use the disk drive to load ASCII files generated from spreadsheet programs such as Microsoft Excel® or Borland’s Quattro Pro®.

Use Math Expressions. You can create waveforms with mathematical precision by entering math expressions using the numerical keys on the front panel.

Use Line Draw/Line List and Freehand Draw. For waveforms with straight lines, as in pulse or digital applications, Line Draw allows you to use the mouse to draw the lines on an oscilloscope. Lines may also be created using Line List, which allows you to enter the vertices of each line with amplitude and time value. For other kinds of applications, Freehand Draw gives the flexibility of using the mouse to draw a waveform on the oscilloscope in much the same way as with a pencil on paper. This makes tasks like inserting spikes on waveforms easy.

Sum Multiple Channels to Create Complex Waveforms. With the internal analog sumbus, you can sum waveforms from two channels together and output the sum as a complex or modulated waveform. The optional high voltage and external summing module allows three channels and an external signal to be summed.

Create Long, Complex Waveforms with Linked Sequence Operation. Up to 4,096 waveforms can be linked together with the Model 296. Up to 4 waveforms can be linked together with the Model 295. Loop count and advance conditions for each waveform are user programmable.

Trigger Operation. Each channel has its own internal trigger generator and external trigger input. Multiple channel triggering and versatile interchannel triggering are also provided.

More Tools Make Editing Easy. Models 296 and 295 give you easy ways to modify waveforms you’ve created. For example, you can copy and insert portions of existing waveforms, move individual waveform points, and increase or decrease the amplitude of all or part of the waveform.

Digital Output (296 only). Each channel provides a 16-bit digital output programmable to 50 MHz.

Specifications
NOTE: Specifications apply after a 20-minute warm-up.

Standard Waveforms
Sine, square, triangle, pseudo-random noise, positive ramp, negative ramp, positive haversine, negative haversine, sin x/x and DC.
Model 296

**Frequency Range**
- Sine: 1 mHz to 20 MHz
- Square: 1 mHz to 25 MHz
- Haversines: 1 mHz to 20 MHz
- All Others: (25 pt. waveform) 1 mHz to 2 MHz

**Resolution:**
- 8 digits limited by 1 mHz,
- 5 digits for frequencies > 20 MHz

**Accuracy:**
- \( \pm 2 \) ppm over temperature range of 0 \(^\circ\)C to \( \pm 50 \) \(^\circ\)C using internal reference

**Waveform Quality**

**Square Transition Time:**
- For \( \leq 10 \) Vp-p: < 9.0 ns
- For > 10 Vp-p: < 9.5 ns

**Square Aberrations:** <5% ± 20 mV

**Square Symmetry (0 \(^\circ\)C to \( \pm 50 \) \(^\circ\)C):**
- < 10 MHz: 50 % ± 1 %
- \( \geq 10 \) MHz: 50 % ± 2 %

**Square cycle to cycle time jitter:**
- < 0.4% peak to peak

**Sine Distortion:** (Elliptic filter selected)
- <100 kHz, \( \leq 15 \) Vp-p: No harmonic > -55 dBc
- <100 kHz, \( \leq 10 \) Vp-p: No harmonic > -60 dBc
- <5 MHz, \( \leq 10 \) Vp-p: No harmonic > -45 dBc
- <5 MHz, >10 Vp-p: No harmonic > -40 dBc
- <20 MHz, \( \leq 10 \) Vp-p: No harmonic > -35 dBc
- <20 MHz, >10 Vp-p: No harmonic > -28 dBc

**Intermodulation Products (Spurs), (Elliptic filter selected):**
- <5 MHz: no spur > - 60 dBc
- <10 MHz: no spur > - 40 dBc
- <20 MHz: no spur > - 35 dBc

**SSB Phase Noise:**
- At 20 MHz: (Standard Sine):
  - <70 dBc/Hz at 100 Hz offset
  - <70 dBc/Hz at 1 kHz offset
  - <80 dBc/Hz at 10 kHz offset
  - <105 dBc/Hz at 100 kHz offset
  - <120 dBc/Hz at 1 MHz offset

**Arbitrary Waveforms**

**Max. number of user defined waveforms:** 450

**Resolution:**
- Horizontal Resolution (296): 128k points standard (512k points optional), minimum waveform size 5 points
- Horizontal Resolution (295): 32k points standard (128k/512k points optional), minimum waveform size is 5 points

**Vertical Resolution:** 12 bits (4096 points)

**Sampling Frequency**
- Range: 0.2 S/s to 50 MS/s
- Resolution: 5 digits or 0.1 MHz

**Accuracy:**
- \( \pm 2 \) ppm over temp. range of 0 \(^\circ\)C to 50 \(^\circ\)C using internal reference

**Digital Output (296 only)**
- 16-bit differential ECL updated at up to 50 MHz.
- Frequency Range: 0.2 Hz to 50 MHz
- Resolution: 5 digits or 0.1 mHz

**Clock Output (Each channel)**
- Range: 0.2 Hz to 100 MHz
- Resolution: 5 digits or 0.1 mHz
- Accuracy: \( \pm 2 \) ppm over temp range of 0 \(^\circ\)C to 50 \(^\circ\)C using internal reference

**Amplitude**
- Range: 0 to 15 Vp-p into 50Ω,
- 0 to 30 Vp-p into >10kΩ
- Note: Maximum amplitude is 100 Vpp when option 007 is installed

**Resolution:** 3.5 digits

**Monotonicity:** 0.2%

**Sinewave Flatness** (relative to 1 kHz amplitude, Elliptic filter selected, non sweep modes):
- < 5 MHz: 25°C ± 10°C: ± 2 %
- < 5 MHz: 0 to 50°C: ± 5 %
- < 20 MHz: 25°C ± 10°C: ± 5 %
- < 20 MHz: 0 to 50°C: ± 10 %

**Accuracy:** \( \pm 1 \) %

**Offset**
- Range: ±7.5 Vdc into 50Ω, ±15 Vdc into >10 kΩ
- Resolution: 3.5 digits
- Accuracy: \( \pm 1 \) %

**Filters (user selectable):**
- 20 MHz 4 pole Bessel
- 20 MHz 7 pole, 6 zero Elliptic

**Operational Modes**

**Continuous:** Output runs continuously

**Triggered:** Output is quiescent until triggered by selected trigger source, then generates the number of cycles set by the trigger count.

**Gated:** Output is quiescent until gate (trigger) signal goes true. Output is continuous for duration of gate signal.

**Frequency Sweep:** Standard functions and arbitrary waveforms may be swept from 1 mHz to 20 MHz.

**Trigger (Burst) Count:**
- For waveforms: 1 to 1,048,575
- For sequences: 1 to 65,536
- Note: Triggered and Gated limited to 10 MHz waveform frequency. Sweep frequencies limited to < 20 MHz.
Model 296

Frequency Sweep
Sweep capability is provided for standard waveforms and Arbitrary waveforms with a length that is a multiple of 4096 points. Any or all channels may be swept simultaneously. A system horizontal sweep output voltage is also provided.

Sweep Time: 30 ms to 1000 Sec (12 frequency points at 30 ms)
Sweep Modes: Continuous up or down, Continuous up/down, Triggered up or down, Triggered up/down, Triggered Sweep & Hold and Triggered Sweep & Hold with Reverse
Sweep Spacing: Linear or Log
Sweep Count: 1 to 1,000,000

Triggering
Trigger Sources
System Trigger Input Connector, Manual Trigger Key, Remote Interface Trigger, Channel Trigger Input Connector(s), Channel Internal Trigger Generator(s), Master Internal Trigger Generator (Derived from Channel 1’s internal trigger generator), Previous Channel Trigger Output, Internal Trigger Generator(s)
Period: 200 ns to 1,000,000
Resolution: 200 ns
Trigger Delays and Jitter
Specified for System Trigger and Channel Trigger input connectors with TTL input signal.
Delay:
- During Standard Functions: <250 ns
- During User Waveforms: <400 ns
Jitter:
- During Standard Functions: <20 ns
- During User Waveforms: <40 ns
Note: trigger delays and jitter specified with internal sample clock only. If external clock is used:
- Delay 7 x clock period ±100 nS
- Jitter ±1 clock period

Multichannel Phase Relationships
Any or all channels can be assigned a fixed phase relationship. Selected channels must be driven by the System clock generator and the waveforms must be of the same length and frequency. Any change in phase angle between channels will require one waveform cycle to re-acquire phase lock.

Phase Resolution:
User Waveforms: 360 degrees / Waveform points
Standard Waveforms: 0.1 degrees

Phase Accuracy:
User Waveforms: ± Time Skew
Standard Waveforms: ± (0.05° ± Time Skew)

Channel to Channel Time Jitter:
<0.4% peak to peak

Auto-Cal/Diagnostics
Each Arb Channel Module contains DC measurement capability. This feature provides the ability to conduct a limited autocal and self diagnostic. Some parts of the calibration (e.g. amplifier flatness) require the use of external measurement equipment. The calibration data is stored in EEPROM on each Arb Channel module. The Processor accesses the data and uses it to correct each channel output as required to maintain the specified performance.

Remote Interfaces
GPIB and RS-232 interfaces are provided.

System Inputs
Trigger: Triggers one or multiple channels.
Adjustable threshold -10 V to 10 V.

Reference: Accepts external 10 MHz reference signal.

System Outputs
Reference: Accepts external 10 MHz reference signal.
Horizontal Sweep: 0 to 10 V ramp proportional to sweep frequency between start and stop limits.
Z-Axis: Oscilloscope intensity modulation. Used for waveform editing on an oscilloscope.

Channel Inputs
Trigger: TTL level.
AM Modulation: Used for amplitude and suppressed carrier modulation.
Clock: External signal’s frequency used as sampling frequency for arbitrary waveforms.

Channel Outputs
Main: Outputs waveform.
Clock: TTL signal. Frequency range 0.2 Hz to 100 MHz.
Digital (Model 296 only): 16-bit differential ECL updated at up to 50 MHz.
Segment (Model 296 only): This output is setup to be used as a source for the AM input.
Sync: TTL signal output synchronous with the main output waveform.
Posn: TTL level position markers placed at user selected waveform points.

General
Dimensions: 42.5 cm (16.75 in) wide; 13.3 cm (5.22 in); 54.1 cm (17.8 in) deep.
Weight: 18 kg (40 lb.)
Power: 85 to 270 Vac. 60 VA plus 60 VA per channel.
Operating Temperature: 0°C to 50°C. 10°C for specified operation.
Display: 5 in, 320 x 200 pixel, LCD screen.

Ordering Information
Model 296: 50 MHz Arbitrary Waveform Generator. Includes 1 arb channel with 128k waveform memory, DOS compatible 3 1/2 inch floppy disk drive.
Model 296-EM: 50 MHz Arbitrary Waveform Generator. Includes 1 arb channel with 512k waveform memory, DOS compatible 3 1/2 inch floppy disk drive.
Model 295: 50 MHz Arbitrary Waveform Generator (1 channel w/32k memory and Floppy Disk Drive)
Model 295-EM: 50 MHz Arbitrary Waveform Generator (1 channel w/128k memory and Floppy Disk Drive)
Model 295 EM512: 50 MHz Arbitrary Waveform Generator (1 channel w/512k memory and Floppy Disk Drive)
Model 295 EM512: 50 MHz Arbitrary Waveform Generator (1 channel w/512k memory and Floppy Disk Drive)

Model 296,295 Comparison Chart

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<thead>
<tr>
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<th>296</th>
<th>295</th>
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</thead>
<tbody>
<tr>
<td>Waveform Memory</td>
<td>128k (512k opt.)</td>
<td>32k (128k/512k opt.)</td>
</tr>
<tr>
<td>Maximum Sequencing Segments</td>
<td>4,096</td>
<td>4</td>
</tr>
<tr>
<td>Frequency Control of Segments</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>16 Bit Digital Output</td>
<td>yes</td>
<td>no</td>
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