

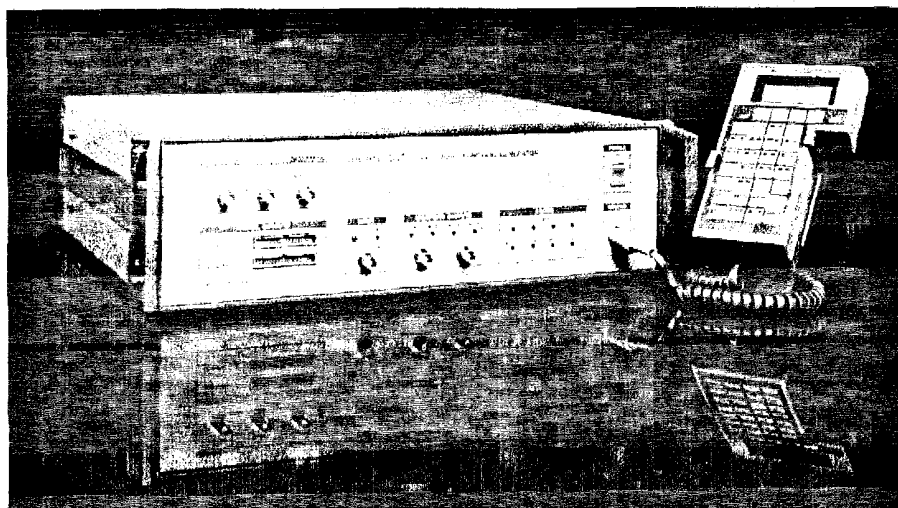
9100 Series Arbitrary Function Generators

Main Features

- Custom waveforms from 5 nsec per point
- Analog outputs of 8- and 12-bit resolution
- High-speed waveform memory lengths to 2 Mbytes (512 kbytes standard)
- Waveform linking and looping with real time dynamic simulation options
- Six standard waveforms
- 10 V p-p waveform outputs (50 Ω)
- Dual or single channel versions
- GPIB interface
- EASYWAVE® waveform creation software (optional)
- Easy waveform capture from digital oscilloscopes

Generates Custom or Standard Waveforms

The LeCroy 9100 Series of Arbitrary Function Generators (AFGs) are high performance ATE or benchtop instruments which can generate either standard or user defined, complex waveforms with fine point-to-point time resolution. They are fully programmable via either GPIB or RS-232. Waveform generation and editing software is offered for PC-DOS compatible computers. Applications include: scientific research, medical instrumentation, disk



drive testing, communication link testing, radar and sonar testing, ultra-sound testing and video testing.

HIGH SPEED WAVEFORMS

Custom waveform outputs using digital generation techniques can now be created from amplitude points separated by as little as 5 nsec. Wide-band amplifiers coupled with high-speed DACs yield fast rise times and settling times. Built-in filters eliminate point-to-point steps to present smooth output shapes at your option. Analog signals to 100 MHz can be created.

DUAL CHANNEL OPERATION

In the dual output versions, each channel has independent amplitude, offset, and phase delay, providing the ability to simultaneously generate two different signals. Also, generating the same signal on both channels and inverting one results in differential output signals. The

excellent phase match between channels permits the generation of precise, phase related signals for use in such applications as testing logic set up times or synchro resolvers. It is especially suited for mixed signal automated testing for products such as digital filters, A/D converters, D/A converters, video systems, and data communications circuits.

INTERNAL CHANNEL SUMMING

With the 8-bit Model 9109, internally summing the two channels together makes it possible to combine two waveforms and control the amplitude of one portion of the resultant composite waveform independently of the rest of it. This also provides expanded dynamic range because one portion of the waveform can be attenuated relative to the rest without losing resolution (bits). Also, by setting the amplitude range of each channel to half the desired total amplitude and summing, a resolution of 9 bits can be achieved.

STANDARD AND ARBITRARY FUNCTIONS

In addition to the primary function of arbitrary function generation, the Series 9100 units also provide both standard function generation and pulse generation capabilities. Sine, square, triangular, ramp, pulse and DC-waveform functions are built-in standards. Function selection and parameter manipulation can be implemented from the control panel or via the GPIB or RS-232-C interface.

DIGITAL AS WELL AS ANALOG OUTPUTS

Both dual channel models of Series 9100 generate custom or standard waveforms and their equivalent digital data patterns. Their high speeds up to 200 Mpoints/sec make it possible to produce "real world" custom waveforms for testing digital filters, RADAR and SONAR signal processing systems, disk drives, A/D-D/A converters, video systems, and data communications systems.

VERSATILE MEMORIES FOR WAVEFORM GENERATION AND NON-VOLATILE STORAGE

The AFGs use a high-speed waveform memory (512 kbytes, expandable to 2 Mbytes) to generate waveforms. This memory can be down-loaded with a variety of different waveform files or segments. Waveform elements can be repeated and linked together to create larger composite waveforms. There is no dead time between linked segments. Each custom waveform can be repeated up to 65,535 times.

FLEXIBLE OPERATION AND TRIGGER MODES

Waveforms can be output as a single shot, as a triggered burst of up to 64K cycles, as an auto-triggered recurrent waveform with programmed delays

between cycles, as a continuous waveform, or gated under control of an external signal. Triggering can be manual, bus operated, or external, with selectable slope, polarity, level, and delay. Timemark, sync'd, waveform start, and clock outputs provide flexible timing reference for synchronized operation.

WAVEFORM AND COMMAND SEQUENCING SPEED TEST SETUP AND THROUGHPUT

LeCroy arbitrary function generators let you store hundreds of waveform generation commands in a single "Sequence File". By activating just one sequence file, the most complex waveforms can be output easily and automatically.

OPTIONAL HAND-HELD CONTROL PANEL

An optional hand-held control panel allows test technicians full access to stored waveforms and permits flexible manipulation of these waveforms without the use of a computer.

WAVEFORM CREATION SOFTWARE

LeCroy's optional EASYWAVE software simplifies creation of custom waveforms or digital data patterns. With EASYWAVE you can easily and quickly create almost any conceivable "real world" waveform required for comprehensive and realistic testing of your circuits.

Waveforms can be created directly from the mathematical equation which describes the waveform. Or, it may be easier to simply select the needed shapes from EASYWAVE's library of simple waveform elements, link them together, and then stretch them to desired amplitudes and time durations. A spreadsheet-like array editor is used for point-by-point waveform or pattern entry in decimal or hexadecimal form. Waveforms may also be captured using

any of LeCroy's digital oscilloscopes, digitizers, or transient recorders, and transferred to the AFGs.



Custom waveforms can be captured by a digital scope or digitizer, and then edited and regenerated with the Series 9100 AFGs. Or, they can be created from scratch from simple elements or equations with our user-friendly EASYWAVE® software.

9100 Series Models	
Model 9101	Single-channel, 200 Mpoints/sec, 8-bit analog outputs.
Model 9109	Dual-channel, 200 Mpoints/sec, 8-bit analog outputs, 8-bit digital outputs.
Model 9112	Dual-channel, 50 Mpoints/sec, two 12-bit analog outputs, two 16-bit digital outputs.

9100 Series Specifications

Waveform Output Characteristics

	9101	9109	9112
Output Channels	1	2	2
Output Impedance	50 Ω $\pm$ 0.5 Ω	50 Ω $\pm$ 0.5 Ω	50 Ω $\pm$ 0.5 Ω
DC Accuracy	The greater of 1% of level or 1% of full scale amplitude or 20 mV	The greater of 1% of level or 1% of full scale amplitude or 20 mV	0.5% of full scale amplitude into 50 Ω for amplitude $\geq$ 500 mV
Vertical Resolution	8 bits	8 bits	12 bits
Minimum Full Scale Output Voltage	5 mV p-p into 50 Ω 10 mV p-p into high-Z	5 mV p-p into 50 Ω 10 mV p-p into high-Z	100 μ V p-p into 50 Ω 200 μ V p-p into high-Z
Maximum Full Scale Output Voltage	10 V p-p into 50 Ω (-5 V to +5 V) 20 V p-p into high-Z	10 V p-p into 50 Ω (-5 V to +5 V) 20 V p-p into high-Z	10 V p-p into 50 Ω (-5 V to +5 V) 20 V p-p into high-Z
Offset Voltage Range	+5 V p-p into 50 Ω +10 V p-p into high-Z	$\pm$ 5 V p-p into 50 Ω $\pm$ 10 V p-p into high-Z	$\pm$ full scale amplitude (must be within output voltage range)
Offset Voltage Resolution	< 6 mV steps	< 6 mV steps	0.05% of full scale amplitude
Total Harmonic Distortion	< -50 dBc for sinusoidal output at frequencies $\leq$ 1 MHz	< -50 dBc for sinusoidal output at frequencies $\leq$ 1 MHz	< -65 dBc for sinusoidal output at frequencies $\leq$ 200 kHz
Spurious and Non-Harmonic Distortion	< -65 dBc for frequencies $\leq$ 1 MHz, excluding band within 1 kHz of carrier	< -65 dBc for frequencies $\leq$ 1 MHz, excluding band within 1 kHz of carrier	< -65 dBc for frequencies $\leq$ 1 MHz, excluding band within 1 kHz of carrier
Signal-to-Noise Ratio	$\geq$ 45 dB for full scale amplitudes $\geq$ 75 mV 0 V offset	$\geq$ 45 dB for full scale amplitudes $\geq$ 75 mV 0 V offset, sum off	> 70 dB RMS (p-p noise $\leq$ 0.1% of full scale amplitude + 2 mV excluding glitch energy of 50 pV $\cdot$ sec amplitude)
Transition Times	< 5 nsec, 10% - 90%, filters off	< 5 nsec, 10% - 90%, filters off	< 8 nsec, 10% - 90% (5.5 nsec typ)
Overshoot and Ringing	5% of full scale amplitude max, 3% typ	5% of full scale amplitude max, 3% typ	5% of full scale amplitude max, 2% typ
Settling Time	< 20 nsec to 3% of amplitude change for 5 V transition, including rise time (filters off)	< 20 nsec to 3% of amplitude change for 5 V transition, including rise time (filters off)	< 50 nsec to 1% of amplitude change, 20 nsec typ
Crosstalk Between Channels	N/A	< 1%	< 0.05% with both channels set for 10 V amplitude
Channel 1 to Channel 2 Phase Accuracy	N/A	$\pm$ 1 nsec, dual mode, $\pm$ 0.5 nsec, channels summed	$\pm$ 1 nsec
Output Protection	$\pm$ 40 V	$\pm$ 40 V	$\pm$ 40 V

OUTPUT CHARACTERISTICS

Output smoothing (filtering): The 9101 and 9109 have built-in 18 dB/octave (3 pole Bessel) filters for each channel with independently programmable cutoff frequencies of 100 MHz, 30 MHz, 10 MHz, 3 MHz or 1 MHz. Filters may also be turned off. The 9112 is provided with one external 8-pole Butterworth low-pass filter. Cutoff frequency (-3 dB point) 36 MHz, rolloff = 48 dB/octave. Additional filter for 2nd channel optional.

OUTPUT CLOCKING CHARACTERISTICS

Clock resolution: 0.035% (350 ppm).

Clock accuracy: < 5.0 ppm at achievable set points, at 23°C. 115 VAC/60 Hz. after a 30 minute warm-up period.

Clock stability: < 0.5 ppm/°C.

Clock jitter: 0.05% max., 0.0125% typical.

Interval range:

	9101	9109	9112
Maximum Output Rate	200 Mpoints/sec	200 Mpoints/sec	50 Mpoints/sec
Single Channel	5 nsec - 10 sec/pt	5 nsec - 10 sec/pt	20 nsec - 40 sec/pt
Dual Channel	N/A	10 nsec - 20 sec/pt per channel	20 nsec - 40 sec/pt per channel

External clocking: Output point rate may also be controlled by an external clock source. When external clocking is selected, the internal clock is bypassed and the waveform is generated using the external clock. The External Clocking Performance table describes the relationship between the external clock frequency and the output point rate in various configurations.

External clock input impedance: 50 Ω.

External clock threshold: Variable over the range of ±2.5 V. Resolution < 20 mV.

External Clocking Performance

	9101, 9109 Single Channel Mode	9109 in Dual Channel Mode	9112 in Single Channel Mode	9112 in Dual Channel Mode
Maximum External Clock Frequency	200 MHz	200 MHz	200 MHz	100 MHz
Clock Divider	None	:2	:4	:2
Maximum Output Sample Rate	200 Mpoints/sec	100 Mpoints/sec per channel	50 Mpoints/sec	50 Mpoints/sec per channel

This table describes the relationship between the external clock frequency and the output point rate in various configurations.

TRIGGERING CHARACTERISTICS

Trigger Modes

Continuous: The generator runs continuously at the selected frequency.

Recurrent: The waveform is cycled with a programmable delay between cycles. The number of waveforms per cycle is programmable up to 65,535.

Single: Upon receipt of a trigger, the selected waveform is generated only once. The start of the waveform can be programmably delayed from the trigger point.

Burst: Upon receipt of a trigger, the selected waveform is generated a programmable number of times, up to 65,535. The start of the burst can be programmably delayed from the trigger point.

Gated: The waveform is triggered by the leading edge of the gate signal, and stops at the completion of the waveform cycle occurring during the trailing edge of the gate signal.

Trigger delay: Programmable; limits depend on generator model and single or dual

channel operation. The limits are given in the Trigger Delay Limits table. In the table, the term "point" indicates one sample interval's duration.

Trigger arming sources:

Auto: Generator automatically rearms itself at the end of the waveform.

Bus: Generator is rearmed only via command from the GPIB, RS-232 or the 9100/CP Hand-held Control Panel.

Triggering sources:

Manual: Front panel push-button.

External: External trigger applied via a front panel BNC.

Bus: Trigger from GPIB or RS-232.

Control Panel: Trigger key.

External trigger input:

Impedance: 50 Ω.

Slope: Positive or negative threshold.

Range: ±2.5 V.

Threshold resolution: < 20 mV.

Trigger Delay Limits

	9101, 9109 Single Channel Mode	9109 in Dual Channel Mode	9112 in Single Channel Mode	9112 in Dual Channel Mode (min.)
Minimum	4 points	2 points	2 point	1 point
Maximum	1 Mpoint	500 kpoints	500 kpoints	250 kpoints

WAVEFORM MEMORY CHARACTERISTICS

All LeCroy 9100 Series Arbitrary Function Generators (AFGs) have 512 kbytes of high speed waveform memory as a standard feature.

Waveform memory may optionally be extended to 1 Mbyte with the /MM1 option or 2 Mbytes with the /MM2 option.

The 9101 and the 9109 use one high speed memory byte per waveform point. The 9112 uses 2 bytes per point. Therefore, with the 9112 the standard configuration provides 256 kpoints, the /MM1 option provides 512 kpoints and the /MM2 option provides 1 Mpoint.

Individual waveform files, or segments, may be linked to create larger composite waveforms. There is no dead time between linked segments.

The maximum number of links in a composite waveform is 2048. Each linked segment can be repeated up to 4095 times before advancing to the next linked segment. Regardless of how many times a given linked segment is used in a composite waveform, it appears in high-speed memory only once. The Memory Segment Length Requirements table describes segment length requirements.

REAL-TIME OPERATING MODE

The 9100/RT option allows immediate, interactive access to any waveform file in the AFG's high-speed waveform memory. This gives the user the ability to change the output waveform "on the fly", in a smooth and continuous fashion. The option consists of a First-In, First-Out (FIFO) memory and support

hardware. Data written to the FIFO is used instead of the contents of the generator's Control Memory, which normally controls the sequencing of output waveforms.

Compatibility: This option is fully compatible with all LeCroy 9100 Series AFGs.

Maximum real-time waveform selection rate: 2.77 MHz, for 72 point single channel waveforms at 200 MHz sample rate in 9101 and 9109, or for 18 point dual-channel waveforms at 50 MHz sample rate in 9112.

Fetch time for waveform change instruction: 72 sample clock periods.

Throughput delay: (from rising edge of write to output change) 121 sample clock periods + 120 nsec, relative to the end of the waveform currently being output.

DIGITAL OUTPUT CHARACTERISTICS

Two digital output channels are standard features of LeCroy's 9109 and 9112 Arbitrary Function Generators. Each of the two channels has both a digital and an analog output port. This allows users to utilize data in both the digital and analog domains. This feature is useful in mixed signal test and development applications.

The 9212 uses a 16-bit memory architecture. The four least significant bits of each of the 9112's data words are not delivered to their respective DACs, and may therefore contain time-correlated data which do not affect the analog waveform generated by that channel. (The Digital Output feature is unavailable in Model 9101.)

Memory Segment Length Requirements

	9101, 9109 Single Channel Mode	9109 in Dual Channel Mode	9112 in Single Channel Mode	9112 in Dual Channel Mode
Minimum Linkable Segment Length	72 points	36 pts/ch	36 points	18 pts/ch
Maximum Segment Length	65,536 points	32,768 pts/ch	32,768 points	16,384 pts/ch
Segment Length Resolution	8 points blocks	4 pts/ch blocks	4 points blocks	2 pts/ch blocks

9109 and 9112 Digital Output Specifications

	9109 ECL*	9109 TTL*	9112
Maximum Data Rate	200 Mbytes/sec	80 Mbytes/sec	50 Mwords/sec
V _{out high} (min)	-1.0 V	+2.7 V @ +1 mA	+2.7 V @ 1 mA
V _{out low} (max)	-1.55 V	+0.75 V @ -3.2 mA	+0.75 V @ -3.2 mA
Maximum Safe External Voltage	+0.5 V -2.0 V	+5.5 V -0.5 V	+5.5 V -0.5 V
Output Word Length	Two 8-bit words or one 16-bit word	Two 8-bit words or one 16-bit word	Two 16-bit words or one 32-bit word
Digital Clock Output	differential	single-ended	single-ended

* Each channel individually configurable for ECL or TTL output by internal jumper selection.

AUXILIARY INPUTS AND OUTPUTS

Outputs: All of the AFGs in LeCroy's 9100 Series feature five timing outputs which may be used to help synchronize other devices in your test system to the AFG's output. Two Sample Clock outputs (located on the rear panel) are provided, as well as three timing pulse outputs (located on the front panel).

Timing outputs: The Time Marker, Sync Trigger and Waveform Start Outputs are described below.

Time marker output: Occurs at a programmable time after the trigger. Limits are the same as for Trigger Delay (see the table in the Trigger Characteristics section of this Specification).

Sync trigger output: Occurs at the next sample clock edge after receiving a Trigger.

Waveform start output: Occurs at the start of the waveform. This is the only timing output available in Continuous trigger mode.

Output impedance: 50 Ω .

Output levels: TTL into a high impedance, 1.5 V into 50 Ω . Outputs are positive-going pulses of approximately 75 nsec duration.

Output protection: Externally applied voltages should not exceed -0.5 V or +5.0 V.

Clock outputs: These outputs are squarewaves at the sample frequency for single channel waveforms in the 9101 and 9109, at twice the sample frequency for dual channel waveforms in the 9109 and for single channel waveforms in the 9112, or at 4 times the clock frequency for dual channel waveforms in the 9112.

Clock Out 1: Present in all modes including Ext. Clock. Active even if no waveform is being generated.

Clock Out 2: Active only when waveform is being generated. Quiescent during trigger delay, re-arm interval, etc. Used as Master clock for Master-Slave operation.

Output impedance: 50 Ω .

Output levels: NIM logic levels (0 to -0.8 V) into 50 Ω . Can be configured at factory for ECL levels into 50 Ω .

Output protection: Externally applied voltages should not exceed ± 2.5 V.

Inputs: The following characteristics apply to the inputs of LeCroy's 9100 Series Arbitrary Function Generators.

Protection: The maximum input voltage level for all inputs should not exceed ± 5 V.

External trigger/gate input: Input impedance 50 Ω . Threshold level ± 2.5 V, < 20 mV resolution. See Triggering Characteristics section for more detail.

External clock input: Input impedance 50 Ω . Threshold level ± 2.5 V, < 20 mV resolution. See Output Clocking Characteristics section for more detail.

Sum input: (not available on 9112)

Impedance: 50 Ω .

Gain: $\times 1$, $\pm 5\%$ for > 350 mV full scale output ranges.

Bandwidth: > 80 MHz at 3 dB.

Hand-held keypad (control panel) input: A DIN connector is provided for attaching the optional hand held control panel and display.

STANDARD FUNCTIONS

Any member of LeCroy's 9100 Series of AFGs can be operated as a standard function generator, a pulse generator, or a precision DC source, as well as an arbitrary function generator.

Standard Function Mode

The user selects the desired function (sine, square, ramp or triangle), and frequency. The AFG uses these selections to calculate the data file and sample rate most suitable for generation of the requested output signal, in a manner transparent to the user. In the dual-channel generators (9109 and 9112), the phase of the signal on Channel 2 is independently programmable. The Standard Function Frequencies table describes the frequencies obtainable for the various standard functions in each generator type.

Pulse Generator Mode

The user specifies the repetition rate, delay and width of the desired pulse output, and the AFG calculates the best sample rate and data pattern to meet those characteristics. Note that the Pulse function is only available in Single Channel mode (i.e., even in the 2-channel generators, pulses will only be output on Channel 1). The table below gives the pulse parameter limits.

DC Mode

Allows the AFG to operate as a source of precise DC voltages. Any DC output voltage within the range of ± 10 V into 50 Ω (± 20 V into a high-Z) may be programmed.

Standard Function Frequencies

	9101	9109	9112
Sine	0.01 Hz to 25 MHz	0.01 Hz to 25 MHz	0.01 Hz to 6.25 MHz
Triangle	0.01 Hz to 25 MHz	0.01 Hz to 25 MHz	0.01 Hz to 6.25 MHz
Square*	0.01 Hz to 100 MHz	0.01 Hz to 100 MHz	0.01 Hz to 25 MHz
Ramp**	40 nsec to 100 sec	40 nsec to 100 sec	160 nsec to 100 sec

* In the 9101 and 9109, frequencies up to 100 MHz may be programmed, but 5 nsec rise and fall time limits still apply.

** Ramp orientation may be positive- or negative-going.

PROGRAMMABILITY

All of LeCroy's 9100 Series Arbitrary Function Generators feature both GPIB (IEEE-488) and RS-232 interfaces as standard equipment.

GPIB: IEEE 488-1978 compatible.

Implemented interface functions are SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, and C0

DMA rates: Typically ≥ 200 kbytes/sec.

Data formats:

9101 & 9109:

Waveforms:

#A Binary or #L ASCII HEX "00" to "FF" (double the length of internally stored binary data files).

Other Files:

#I Arbitrary length ASCII

9112:

Waveforms:

#9 Binary or #L ASCII HEX "0000" to "FFFF" (double the length of internally stored binary data files).

Other Files:

#0 Arbitrary length ASCII

RS-232: Implemented as Data Communications Equipment (DCE).

Baud rates: 300, 1200, 2400, 4800, or 9600.

Data bits: 7 or 8.

Stop bits: 1 or 2.

Parity: None, even, or odd.

Protocol: Full duplex, Xon/Xoff (DC1/DC3) handshake.

Commands: Full conversational, same as GPIB plus: RS_SRQ, Define character equivalent to SRQ in GPIB (default is "Bell"), ESC commands, ECHO on/off, Trig remote/local.

ENVIRONMENTAL & GENERAL CHARACTERISTICS

Temperature range: 15°C. to 35°C, full specification; 0°C to 40°C, operating.

Humidity: 40°C, 10% to 95% relative, non-condensing.

Power: 115/220 VAC, $\pm 20\%$, 47-63 Hz. Approximately 147 W. For 440 Hz operation, contact factory.

Size: 5.25" H x 19" W x 15" D.

Weight: 26 lbs. (approximately).

WAVEFORM DEVELOPMENT SOFTWARE

LeCroy currently offers two different software packages to support our arbitrary function generator products. EASYWAVE is a menu-driven system designed to get new AFG users "up to speed" on their new tool quickly and easily. W.A.V.E. is an extended programming environment for the creation of advanced, complex waveforms and test programs involving multiple instruments. Each of these packages is described in more detail on separate data sheets as Models 9100/SW and 9100/SP respectively.

ORDERING INFORMATION

9101	8-bit, 200 MS/sec, single-channel arbitrary function generator with 512 kbyte waveform memory.
9109	8-bit, 200 MS/sec dual-channel arbitrary function generator with digital word outputs and 512 kbyte waveform memory.

9112	12-bit, 50 MS/sec, dual-channel arbitrary function generator with digital word outputs and 512 kword waveform memory.
9100/MM1	Waveform memory expansion to 1 Mbyte (512 kword).
9100/MM2	Waveform memory expansion to 2 Mbyte (1 Mword).
9100/RT	Real-time, interactive waveform selection.
9100/SW	EASYWAVE™ menu driven waveform creation software.
9100/SP	W.A.V.E.™ advanced waveform creation and analysis software.
9100/CP	Hand-held control panel for arbitrary function generators with 6 ft. connecting cable.
9100/EC	Extender cable for 9100/CP.
FILTER/36 MHz	Extra 36 MHz, 8 pole low-pass Butterworth filter for 9112 (one supplied with unit).
9100/SM	Arbitrary function generator service manual.
9100/OM	Extra arbitrary function generator operator's manual (one supplied with unit).
9100/GPIB2	National Instruments PCII® GPIB InterfacCard and Software for IBM PC/XT/AT® and compatible computers
DC/GPIB	GPIB cable, 2 meters.

Pulse Parameters

	9101	9109	9112	Comments
Period	40 nsec to 10 sec	40 nsec to 10 sec	160 nsec to 10 sec	—
Width	5 nsec to 10 sec	5 nsec to 10 sec	20 nsec to 10 sec	Width + Delay must be < Period
Delay	25 nsec to 5 msec	25 nsec to 5 msec	35 nsec to 5 msec	Width + Delay must be < Period