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OPERATOR'S MANUAL

MODEL 9100 SERIES

April 1993

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Appendix 1

Index

1 GENERAL INFORMATION

PURPOSE

This manual is intended to provide instruction regarding the setup and operation of the covered instruments. In addition, it describes the theory of operation and presents other information regarding its functioning and application.

The Service Documentation, packaged separately, should be consulted for the schematics, parts lists and other materials that apply to the specific version of the instrument as identified by its ECO number.

UNPACKING AND INSPECTION

LeCroy recommends that the shipment be thoroughly inspected immediately upon delivery. All material in the container(s) should be checked against the enclosed Packing List and shortages reported to the carrier promptly. If the shipment is damaged in any way, please notify the carrier. If the damage is due to mishandling during shipment, you must file a damage claim with the carrier. The LeCroy field service office can help with this. LeCroy tests all products before shipping and packages all products in containers designed to protect against reasonable shock and vibration.

WARRANTY

LeCroy warrants its instrument products to operate within specifications under normal use and service for a period of one year from the date of shipment. Component products, replacement parts, and repairs are warranted for 90 days. This warranty extends only to the original purchaser. Software is thoroughly tested, but is supplied "as is" with no warranty of any kind covering detailed performance. Accessory products not manufactured by LeCroy are covered by the original equipment manufacturers warranty only.

In exercising this warranty, LeCroy will repair or, at its option, replace any product returned to the Customer Service Department or an authorized service facility within the warranty period, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and has not been caused by misuse, neglect, accident or abnormal conditions or operations.

The purchaser is responsible for the transportation and insurance charges arising from the return of products to the servicing facility. LeCroy will return all in-warranty products with transportation prepaid.

This warranty is in lieu of all other warranties, express or implied, including but not limited to any implied warranty of mer-

chantability, fitness, or adequacy for any particular purpose or use. LeCroy shall not be liable for any special, incidental, or consequential damages, whether in contract, or otherwise.

PRODUCT ASSISTANCE

Answers to questions concerning installation, calibration, and use of LeCroy equipment are available from the SSD Customer Services Department, 700 Chestnut Ridge Road, Chestnut Ridge, New York 10977-6499, (914) 578-6020, or your local field service office.

MAINTENANCE AGREEMENTS

LeCroy offers a selection of customer support services. For example, Maintenance agreements provide extended warranty that allows the customer to budget maintenance costs after the initial warranty has expired. Other services such as installation, training, on-site repair, and addition of engineering improvements are available through specific Supplemental Support Agreements. Please contact the Customer Service Department or the local field service office for details.

DOCUMENTATION DISCREPANCIES

LeCroy is committed to providing state-of-the-art instrumentation and is continually refining and improving the performance of its products. While physical modifications can be implemented quite rapidly, the corrected documentation frequently requires more time to produce. Consequently, this manual may not agree in every detail with the accompanying product and the schematics in the Service Documentation. There may be small discrepancies in the values of components for the purposes of pulse shape, timing, offset, etc., and, occasionally, minor logic changes. Where any such inconsistencies exist, please be assured that the unit is correct and incorporates the most up-to-date circuitry.

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Software products are licensed for a single machine. Under this license you may:

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- Transfer the software and the license to another party if the other party accepts the terms of this agreement and you relin-

quish all copies, whether in printed or machine readable form, including all modified or merged versions.

SERVICE PROCEDURE

Products requiring maintenance should be returned to an authorized service facility. If under warranty, LeCroy will repair or replace the product at no charge. The purchaser is only responsible for the transportation charges arising from return of the goods to the service facility.

For all LeCroy products in need of repair after the warranty period, the customer must provide a Purchase Order Number before any inoperative equipment can be repaired or replaced. The customer will be billed for the parts and labor for the repair as well as for shipping.

All products returned for repair should be identified by the model and serial numbers and include a description of the defect or failure, name and phone number of the user. In the case of products returned, a Return Authorization Number is required and may be obtained by contacting the Customer Service Department in your area.

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East Coast Regional Service	(914) 578-6059
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California	(415) 463-2600

2 PRODUCT DESCRIPTION

9100 SYSTEM DESCRIPTION

The LeCroy 9100 Series Arbitrary Function Generators (AFG) are high performance ATE or benchtop instruments which can generate either standard or user-defined, complex waveforms with unparalleled point-to-point resolution. They are fully programmable via either GPIB or RS-232. Waveform creation and editing software is offered for PC-DOS compatible computers.

The products in the 9100 Series are:

9100 high speed dual channel Arbitrary Function Generator

9101 high speed single channel Aribitrary Function Generator

9109 high speed dual channel Arbitrary Function Generator with digital outputs.The common elements of the 9100 Series are described in the early chapters of this manual. Product specific information for the 9109 and 9101 is located in Chapter 7 and 8 respectively.

The 9100 Series instruments are part of a complete custom waveform generation system. The main products which support this system are listed below.

9100, 9101, 9109 ARBITRARY FUNCTION GENERATOR MAINFRAME. This is the basic mainframe unit. The standard unit is remotely programmable over GPIB. This unit has local control ONLY through use of the optional 9100/CP control panel.

9100R 9100 REAR PANEL CONNECTOR MAINFRAME. Same as 9100 except all signal input and output connectors are brought to the rear panel.

9100/CP 9100 HAND-HELD CONTROL PANEL. This is the control panel which adds local operation of all features of the 9100 with the exception of waveform file creation, editing and downloading. Metal brackets are included to allow control panel to be free-standing or attached to side of the 9100 mainframe.

The EASYWAVE® Operating Manual covers the following products:

9100/SW EASYWAVE SOFTWARE. An optional software package for PC-DOS compatible computers which provides easy waveform creation and editing. This includes creating waveforms from a simple waveform element library, equations, tabular editing, or direct acquisition from LeCroy Oscilloscopes. Without this package waveform files must be created on a host computer either with a text editor or a user written program and then downloaded either over GPIB or RS-232.

9100GPIB2 IBM PC COMPATIBLE GPIB CARD AND SOFTWARE. This GPIB card and driver software are required to run EASYWAVE

from an IBM XT/AT compatible. Manuals are included with this for detailed operation of GPIB without EASYWAVE.

Operation of the 9100 AFG via the EASYWAVE software package provides full capability without compromise. All waveforms may be edited at any time and the 9100 can be operated via a full-screen interface on the host IBM XT/AT.

NOTE: Waveform editing capability has not been provided in the 9100 Series mainframe.

Some applications may not need to have waveform creation or editing facilities on hand at all times. In these cases, after the waveforms have been created with EASYWAVE (or other user supplied program) and downloaded to the AFG non-volatile RAM disk the host computer may be disconnected and the AFG can be used as a "custom" waveform generator with all control accessible via the 9100/CP control panel.

Some users may need to use other host computers to operate their test systems. In this case the basic waveform shapes needed for testing may be edited using EASYWAVE and downloaded into the 9100 or transferred to the test system host computer.

9100 WAVEFORM GENERATION CONCEPT

The 9100 is a signal source whose output voltage as a function of time can be programmed via an array of data values and various control settings. The instrument generates the waveform by sequentially stepping through the array and outputting a voltage proportional to each data value for a fixed time interval or sample period (point). Selecting or specifying the contents of the data array are performed separately from entering the control settings commands so the user has a great deal of flexibility in modifying a waveform without having to change its basic shape (the waveform data array).

A simple way of thinking about the operation of an AFG is shown in Figure 2.1. Basically, an oscillator clocks a counter which in turn advances the address applied to a memory. The memory data value which is stored in the next sequential location is then output to the digital-to-analog converter (DAC). Finally the DAC converts the data value to an analog level. As the counter steps through the memory addresses, the associated data values are converted by the DAC. This results in a voltage waveform being output which is proportional to the data array which resides in the memory.

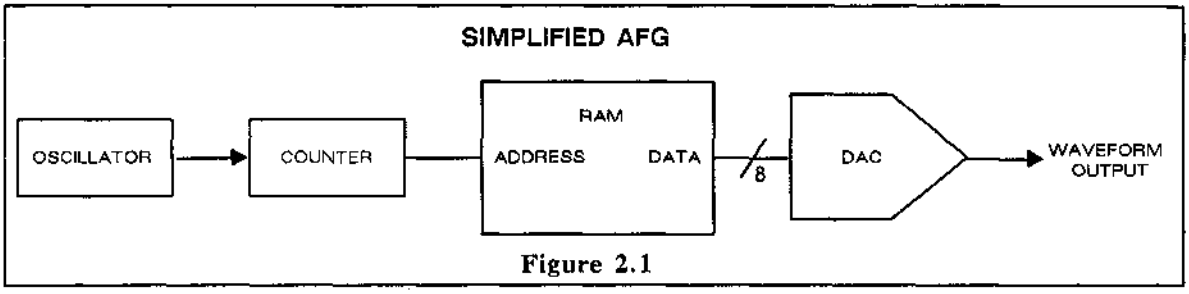


Figure 2.1

The 9100 can emulate standard types of generators without the use of a host computer to edit the data arrays. The available standard waveforms are sine, square, triangle, ramp, pulse and DC.

9100 ARCHITECTURE

The 9100 Series mainframe and CP is most easily visualized in four main blocks (Figure 2.2):

1. RAM DISK
2. INSTRUMENT CONTROL
3. CONTROL PANEL
4. WAVEFORM GENERATOR CIRCUIT

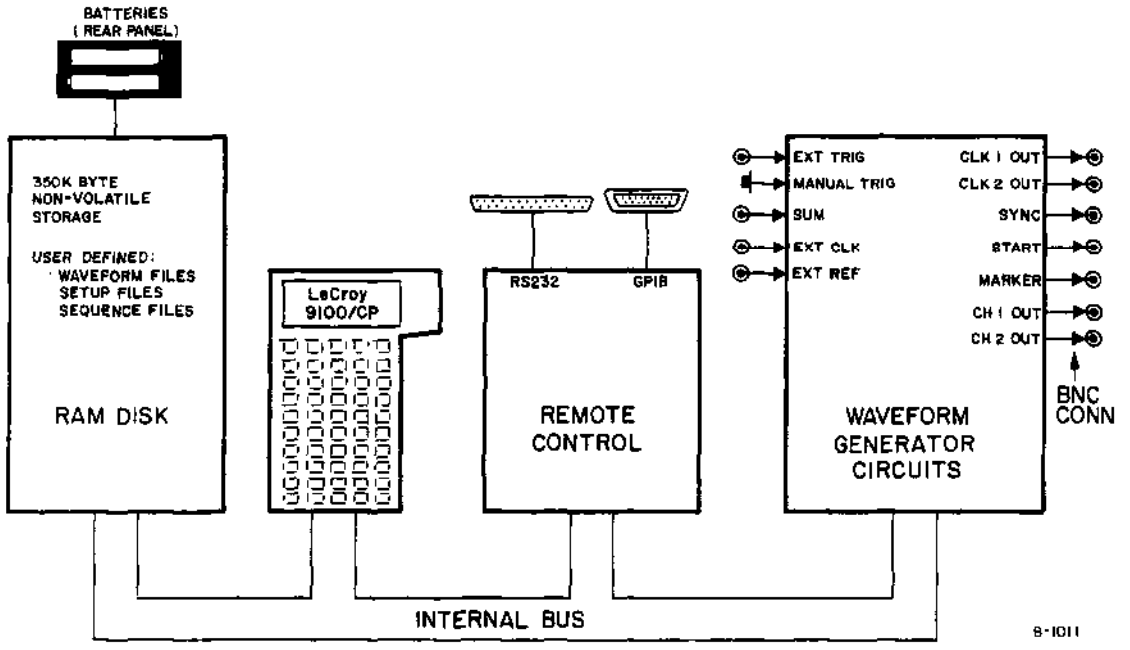


Figure 2.2

RAM DISK

The RAM disk is used for storage of the waveform data arrays which are referred to as "waveform files". The RAM disk is 350Kbytes of non-volatile storage. All waveform files must be stored in the RAM disk before they can be loaded into the waveform generator circuit.

Depending on the size of the waveform files and the number that are needed on the RAM disk at any one time, all files may be kept on the RAM disk so they don't have to be reloaded every time they need to be generated or when the unit is powered on. Other types of files are used for automating the setup of waveform data and waveform control settings, these are referred to as "sequence files" and "setup files". All standard file handling commands are available such as delete, directory, etc. For summary of file handling commands see Chapter 5.

INSTRUMENT CONTROL

All functions of the instrument are accessible remotely via either GPIB or RS-232. All details of operation over GPIB are located in Chapter 5 of this manual. The command syntax and operation over GPIB and RS-232 are identical with a few exceptions outlined in the section covering RS-232.

CONTROL PANEL

Once arbitrary waveform files are transferred into the RAM disk via the GPIB interface or the RS-232, all other operations can be controlled locally from the control panel. This includes loading waveforms from the RAM disk into the Waveform Generating Circuit, setting all waveform attributes and executing "sequence files" and "setup files" as well as accessing status summaries. Operation of all standard functions are supported via the 9100/CP control panel. For complete instructions on operating via the control panel refer to Chapter 4.

WAVEFORM GENERATOR CIRCUIT

This is the block which takes the waveform files and converts them into an analog waveform. Brief block diagrams are shown in Figures 2.3 and 2.4. The five main subcircuits are the trigger, time base, waveform memory, digital-to-analog converter, and signal conditioner.

An understanding of some of the internal architecture will help explain the response of the analog output to various combinations of output amplitude and offset while in different operating modes.

Refer to the signal conditioning section of Figure 2.4. Under ideal circumstances the 9100 will choose the post-amplifier attenuators to achieve the requested amplitude. This allows the amplifier to produce large swings. The post amp attenuators attenuate all three aspects of the signal: the signal itself, the offset and any background noise. To offer extra versatility, there are preamplifier attenuators which may be selected in lieu of or in addition to the post-amplifier attenuators. The preamplifier attenuators attenuate only the signal; any offset or background noise of the amplifier is not attenuated. When using the preamplifier attenuators to accommodate large offsets, the apparent Signal-to-Noise ratio of the output may decrease slightly.

Amplitude always refers to the peak-to-peak swing at the output for a digital change of 255 counts in a waveform field. Offset is the voltage level that will be output when a digital value equal to the ZREF level is generated by a waveform file. In the following text ideal calibration of the analog circuits is assumed. In actual 9100 units, the internal calibration will create transitional points which may differ from the exact values discussed below. This is normal.

If there is a conflict in requested amplitude and offset settings, the 9100 always tries to achieve the requested amplitude in preference to the requested offset. A general guideline relating maximum offset to requested amplitude is that you can always achieve an offset of between 8 and 16 times the requested amplitude as long as all points of the waveform are within the ±5 V limitation (assuming a 50 Ω load) of the output amplifier.

To calculate the exact value of maximum offset achievable for a given amplitude you first divide the requested amplitude into 10 V. This gives you the total attenuation factor that is required. If this value is less than 32 then the achievable output levels will be anywhere within the ±5 V range. For attenuation factors greater than or equal to 32, divide the required attenuation factor by 32 and choose the next higher power of 2 than the result. For example, if the division yields a result of 11.32 the next higher power of 2 would be 16. This power of 2 is the least amount of post–amplifier that will be utilized up to a maximum of 64 (2^6). The maximum achievable output level is ±5 V divided by post–amplifier attenuation.

In requesting an offset value you should be aware that any point of the output waveform which exceeds the achievable output levels due to the combination of amplitude, offset and ZREF will generate an error message. A clipped or distorted output may also result from exceeding the maximum output levels.

NOTE: The amplifier will appear to operate, with reduced performance, for levels up to 125% of the calculated maximum levels.

When the 9100 detects an output programming which exceeds the maximum levels an warning code of 202 is set into STB4 and bit 4 of STB7 (a warning) is set. The facts described above can be quickly understood with the following example. Start by generating any convenient waveform with the 9100 and set the offset to 4.8 V and ZREF to 127.5. Set the amplitude to 10 V. Clearly the top half of the waveform is cutoff or clipped due to the limitation of the amplifier and an error message has been generated. Reduce the amplitude to 1 V. The output will appear correct since the amplifier has some usable range beyond the 5 V limitation described above, but an error message will again be generated. Further reduce the amplitude to 330 mV. At this point the offset to amplitude ratio is near the maximum achievable value of 16.

A reduction in the requested amplitude to 300 mV requires additional post–amplifier attenuation. As a result, the 300 mV amplitude request will allow for only a 2.5 V offset even though the unit has been requested to generate a 4.8 V offset. An error

message will be generated. Also at this point the amplifier is being driven well above its 25% safety margin and the output is fully saturated; no visible signal appears, only insufficient offset is perceived. The unit will not indicate the erroneous offset value if queried, but instead returns the requested offset value. If the requested amplitude is changed back to 330 mV, then the 9100 will again generate 4.8 V of offset. As a final example, if the requested amplitude is 40 mV, then the maximum achievable offset is 625 mV.

Similar concerns apply to attenuator selection when sum modes are utilized. When external sum mode is selected, the sum signal is injected at the input of the output amplifier. To avoid attenuating the external sum signal, the 9100 chooses to use the preamplifier attenuators in preference to the post-amplifier attenuators. This tends to cause a slight reduction in signal-to-noise ratio. However, when the requested amplitude for the internal generated signal is less than 312 mV, some post-amplifier attenuators are required. This causes the external portion of the summed signal to be attenuated.

NOTE: No error message is generated.

The 312 mV comes from the fact that the pre-amp attenuators offer an attenuation factor of 16 and the fine gain control of the Signal DAC offers a factor of 2 for a total attenuation of 32 without using the post-amplifier attenuators. 10 V divided by 32 equals 312.5 mV.

When the two channels are summed, the summing is done at the preamplifier point of the circuit. To be certain that the correct gain will be applied to each channel's contribution to the summed signal you should verify that both channels' amplitudes can be generated with the same amount of post-amplifier attenuation. This typically limits the ratio of the two channels' amplitudes to a value between 16 and 32. A safe method is to limit the ratio of the two channels' amplitudes to less than or equal to 16. If this is not done, then the amplitude contribution of the lower amplitude channel will be greater than programmed.

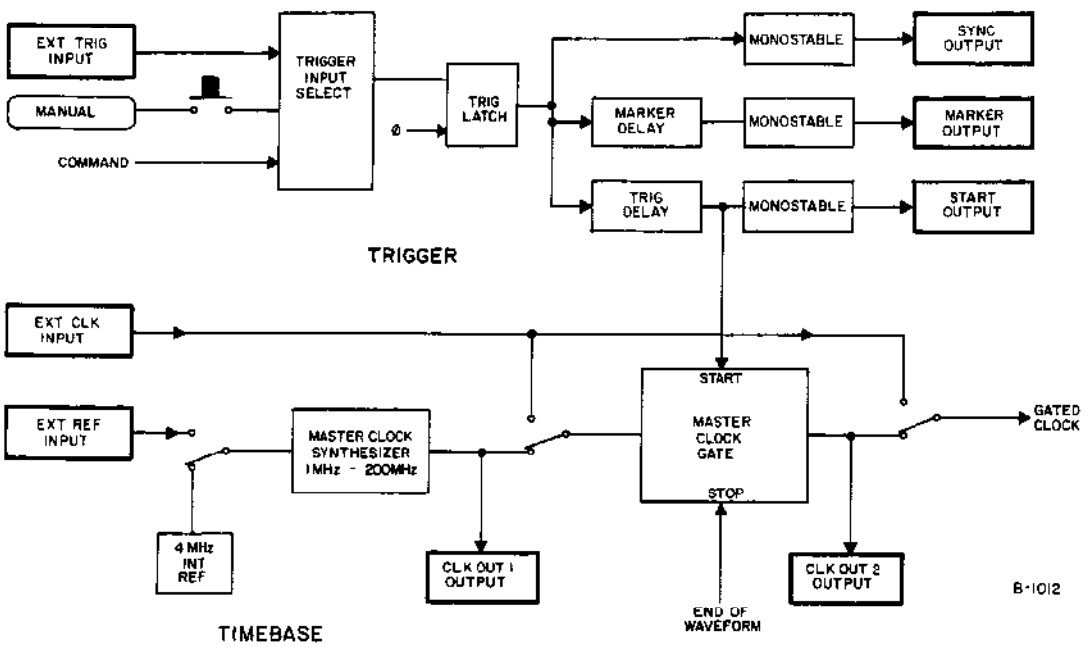

EXT TRIG INPUT
MANUAL
COMMAND
TRIGGER INPUT SELECT
Ø
TRIG LATCH
MONOSTABLE
SYNC OUTPUT
MARKER DELAY
MONOSTABLE
MARKER OUTPUT
TRIG DELAY
MONOSTABLE
START OUTPUT
TRIGGER
EXT CLK INPUT
EXT REF INPUT
MASTER CLOCK SYNTHESIZER 1MHz - 200MHz
START
MASTER CLOCK GATE
STOP
GATED CLOCK
4 MHz INT REF
CLK OUT 1 OUTPUT
CLK OUT 2 OUTPUT
END OF WAVEFORM
TIMEBASE
B-1012

Figure 2.3

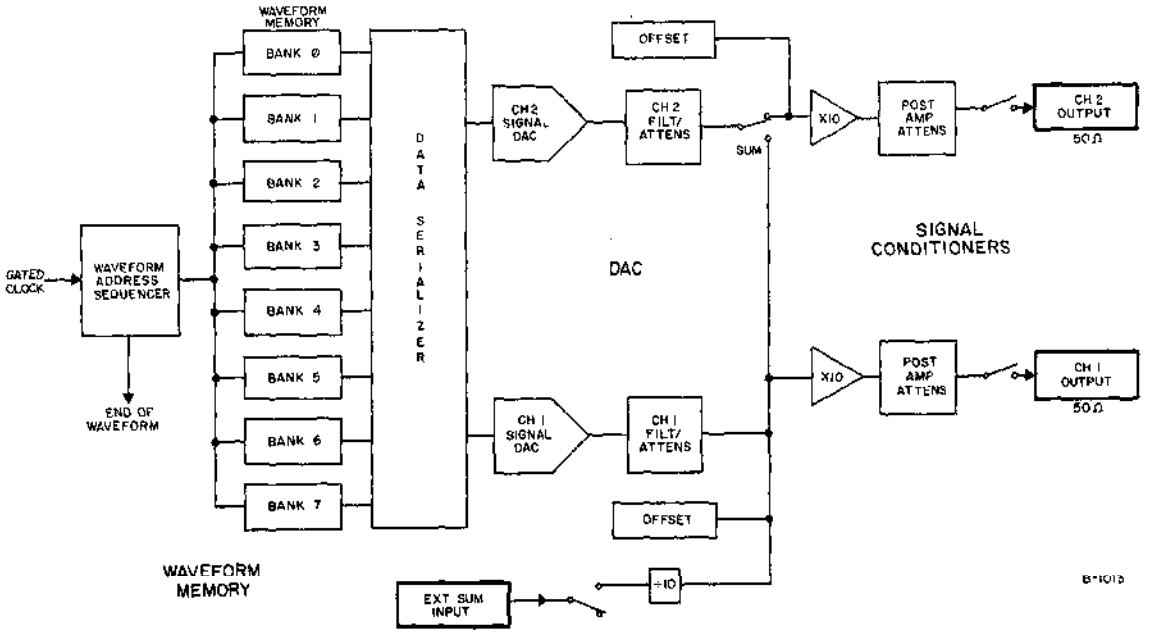

WAVEFORM MEMORY
BANK 0
BANK 1
BANK 2
BANK 3
BANK 4
BANK 5
BANK 6
BANK 7
DATA SERIALIZER
CH 2 SIGNAL DAC
CH 2 FILT/ ATTENS
OFFSET
SUM
X10
POST AMP ATTENS
CH 2 OUTPUT
50Ω
GATED CLOCK
WAVEFORM ADDRESS SEQUENCER
END OF WAVEFORM
DAC
SIGNAL CONDITIONERS
CH 1 SIGNAL DAC
CH 1 FILT/ ATTENS
X10
POST AMP ATTENS
CH 1 OUTPUT
50Ω
OFFSET
WAVEFORM MEMORY
EXT SUM INPUT
÷10

Figure 2.4

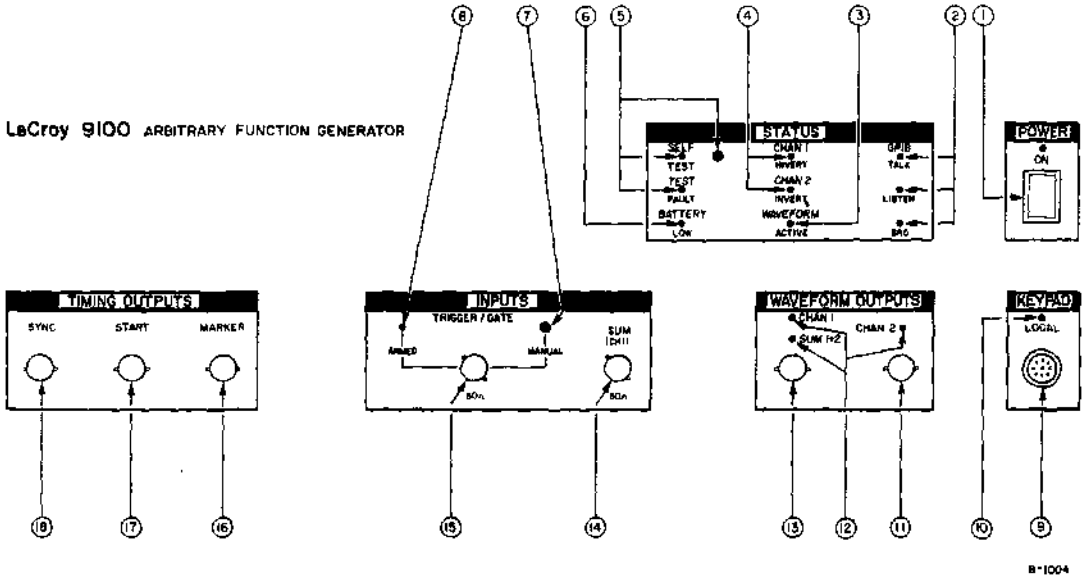

LeCroy 9100 ARBITRARY FUNCTION GENERATOR
8
7
6
5
4
3
2
1
STATUS
SELF TEST
TEST FAULT
BATTERY LOW
CHAN 1 INVERT
CHAN 2 INVERT
WAVEFORM ACTIVE
GPIB TALK
LISTEN
SRQ
POWER
ON
TIMING OUTPUTS
SYNC
START
MARKER
INPUTS
TRIGGER / GATE
ARMED
MANUAL
SUM (CH II)
50Ω
WAVEFORM OUTPUTS
CHAN 1
SUM 1+2
CHAN 2
KEYPAD
LOCAL
18
17
16
15
14
13
12
11
10
9
B-1004

Figure 2.5

FRONT PANEL CONTROLS, CONNECTIONS AND INDICATORS

[1] **Power Switch** Rocker switch that turns AC power on or off. LED above switch indicates power is on.

[7] **Manual Trigger Pushbutton:** Will cause a single shot trigger when pressed, if it is enabled via trigger source selection. If held down it will cause continuous triggers at a rate of about 2 per second.

[8] **Armed LED:** Indicates trigger is armed, that is, if a trigger is received on an enabled trigger source the waveform will be output. Meaningful only if 9100 is in a triggered mode (not free-running) and a waveform is active.

[2] GPIB Status LED's

Talk: Indicates 9100 is currently addressed to talk.

Listen: Indicates 9100 is currently addressed to listen.

SRQ: Indicates 9100 is asserting SERVICE REQUEST.

STATUS LED's

[3] **Waveform Active LED:** When lit, indicates waveform is loaded and running.

[4] **CHAN 1 or CHAN 2 invert LED's:** The waveform for the indicated channel is inverted if one of these is lit.

[5] **Self-Test Controls:** The self-test is performed automatically on power-up, and can be invoked at any other time by pressing the pushbutton to the right of the self-test LED. The self-test LED is lit when the Model 9100 is performing the self-test. If the self-test procedure identifies a fault the test-fault LED will flash temporarily. If the test fault LED is lit steadily, it indicates that the 9100's CPU has stopped functioning.

[6] **Battery Low LED:** Indicates when the RAM disk back-up battery is low. When this LED is lit, the batteries should be replaced by an equivalent pair of 3 V lithium cells.

[10] **Local LED:** When lit means the 9100 is being controlled via the 9100/CP control panel or RS-232. When off, the 9100 is capable of responding to commands from GPIB. The 9100 is in the local state on power-up.

[12] Waveform Output Status LED's

CHAN 1: Indicates waveform being output on Channel 1. When blinking an overload has occurred. The overload can be cleared by enabling the channel's output.
CHAN 2: Indicates waveform being output on Channel 2. When

blinking an overload has occurred.
SUM 1+2: Indicates that the 2 channels of a dual waveform are being summed and output on Channel 1 output. A flashing indication is caused by an overload on the External Sum input. An overload can be cleared by reasserting the Sum On command.

Input/Output Connectors

[9] **Keypad Connector:** The cable from the 9100/CP plugs into this connector.

[13] CHAN 1 Waveform Output: BNC connector for Channel 1 output. Active when either CHAN 1 LED or SUM 1+2 LED is lit.

[11] CHAN 2 Waveform Output: BNC connector for Channel 2 output. Only active when the CHAN 2 LED is lit.

[14] SUM(CH 1): Input connector for summing an external analog signal in with the signal being generated on Channel 1. The external sum input must be enabled using the XSUM command or selection on the 9100/CP.

[15] TRIGGER/GATE: External trigger or gate input connector. Acts as trigger or gate input depending on trigger mode selected.

[16] MARKER: Timing pulse which can be programmed to be output in the range from 2 to 1 million clock cycles after receipt of trigger. The marker output is functional only in Single, Burst, or Recurrent trigger modes. Note that if the Marker delay is programmed for a number greater than the sum of the trigger delay and the total number of points that will be output (including segment repetitions, links, and waveform repetitions), no Marker pulse will be generated. Also, at clock rates greater than 10 MHz, the width of the Marker pulse (nominally 100 nsec) may be reduced if it is positioned within 100 nsec of the last point generated.

[17] START: Timing pulse which is output at the beginning of each iteration of the waveform.

[18] SYNC: Is a pulse that occurs approximately 2 clock cycles after receipt of trigger and is synchronized to the selected clock source.

REAR PANEL CONNECTIONS AND CONTROLS

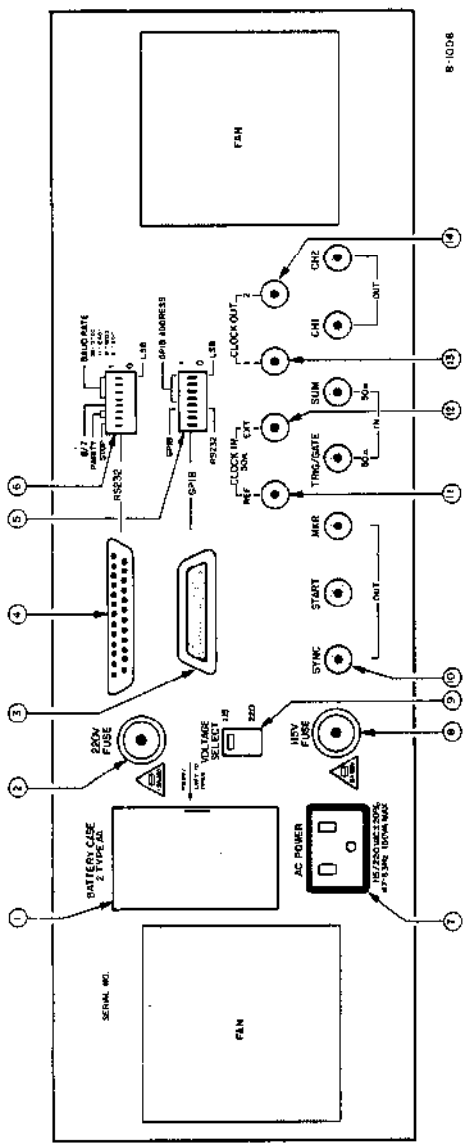


Figure 2.6

[1] **Batteries:** This compartment contains 2 Lithium batteries for powering the RAM disk memory. The compartment door is easily opened for battery replacement.

[3] **GPIB Connector:** Standard IEEE-488 connector.

[4] **RS-232:** 25 pin DIN (panel mounted female) connector.

[5] **GPIB Address Configuration Dip-switch:** The right-most 5 switches (bits) are used to set the address. Note the LSB is marked and is the rightmost bit. A switch in the up position is a 1 and in the down position a 0. The sixth switch from the right is used to specify whether the 9100 powers up with the GPIB or RS-232 as the default active interface. The last 2 switches are unused.

[6] **RS-232 Configuration Dip-switch:** This switch is used to set up the RS-232 parameters.

[7] **AC Power Connector:** IEC type.

[8] **115 V FUSE:** Used only for 115 V operation. 3A fuse required.

[2] **220 V Fuse:** Used only for 220 V operation. 1.5A fuse required.

[9] **Line Voltage Selector Switch:** This switch should be properly set before inserting line cord into power receptacle. Upper position for 115 and lower position for 220.

[10] **9100R BNC Mounting Holes:** In the Model 9100 the blank holes are covered with metal plugs. In the Model 9100R, the normal front panel signal BNC connectors are located here and a special front panel without connectors is mounted.

[11] CLOCK IN REF: A 4 MHz reference oscillator, amplitude between 1 and 4 V p-p, may be used as the 9100 reference oscillator instead of the internal crystal. It is input here and the signal is AC coupled.

[12] CLOCK IN EXT: The internal synthesizer may

be bypassed altogether and the 9100 can be driven by a clock signal that is input to this connector. This input is selected via the CLOCK_SOURCE command.

[13] CLOCK OUT 1: Ungated clock output at the point rate for single channel waveforms, or twice the point rate for dual channel waveforms.

[14] CLOCK OUT 2: Gated clock output for master-slave operation.

SPECIFICATIONS

WAVEFORM OUTPUTS

Channels: 2

D.C. Accuracy: 1.0% of level or 1.0% of Full Scale amplitude or 20 mV (whichever is greater).

Resolution: 8 bits (256 levels).

Dynamic Range: Single or dual channel – 8 bits; Channels summed – 9 or more bits, depending on wave shape, filtering, offset requirements.

Total Harmonic Distortion: < –50 dBc for output frequency of 1 MHz or less. < –35 dBc @ 10 MHz, Typically < –38 dBc @ 10 MHz for output levels < 5V p p

Spurious and non-harmonic distortion:

< –65 dBc, f ≤ 1 MHz
< –60 dBc, f > 1 MHz
excluding the band within
1 kHz of carrier.

Intermodulation distortion: Two tone intermodulation (CH1: 10 MHz, 1 V p-p; CH2: 10.25 MHz, 1 V p p, summed mode) typical –58 dBc 3rd order; –70 dBc 5th order.

Signal to Noise Ratio:

Full Scale Amplitude	S/N
75 mV or greater	≥45 dB
30 mV	40 dB
5 mV	25 dB

S/N specified at 0 V offset, sum mode off.

Maximum Output Voltage: 10 V p-p (± 5 V) into 50 Ω, 20 V p-p into high impedance.

Minimum Output Voltage: 5 mV p-p into 50 Ω.

Risetime: <5 nsec, 10% to 90% (no filter)

Overshoot and Ringing: 5% of p-p amplitude, maximum; 3% of p-p amplitude, typical

Settling Time: 20 nsec to 3% for 5 V transition, including risetime (filters off).

Offset: Individually programmable for each channel.

Offset Resolution: < 6 mV steps

Offset Accuracy: Same as D.C. accuracy

Maximum Offset Voltage:

External Load:	Max. Offset V:
50 Ω	±5 V
Open Circuit	±10 V

Output Smoothing: Built-in filters with programmable cutoff frequencies: bypassed, 1, 3, 10, 30, 100 MHz; 18 dB/octave (Bessel)

Crosstalk between channels: < 1%

Ch 1 to Ch 2 Phase Accuracy: Internal Summing ±.5 nsec
Dual Outputs ±1 nsec

STANDARD FUNCTIONS (WAVEFORMS)

Sinewave – Frequency Range: 0.01 Hz to 25 MHz
Frequency Resolution: 0.035%

Squarewave – Frequency Range: 0.01 Hz to 100 MHz (50 MHz dual channel)
Frequency Resolution: 0.035%

Triangle – Frequency Range: 0.01 Hz to 25MHz
Frequency Resolution: 0.035%
Linearity: ±1%

Pulse – (single channel only) Period: 40 nsec to 10 sec; Width: variable, 5 nsec to 10 sec (not to exceed period); Orientation: selectable, positive or negative going.

Ramp – Period: 40 nsec to 100 sec; Resolution: 0.035%; Linearity: ±1%; Orientation: selectable, positive or negative going.

DC – Generates a D.C. level, the value of which is the offset level. Accuracy: the greater of 1% or 20 mV.

TIME BASE (Clock Rate)

Range: 5 nsec to 20 sec per point

Resolution: 0.035%

Accuracy: 5 ppm, at achievable set points, 23° C, 115 VAC/60 Hz, after 30 minute warmup

Stability: < 0.5 ppm/° C

TRIGGER

Modes

Continuous: The generator runs continuously at the selected frequency.

Recurrent: The waveform is cycled with a programmable delay of up to 1 million points (1/2 million in dual channel) between cycles. 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 delayed from the trigger point by up to 1 million points (1/2 million in dual channel).

Burst: Upon receipt of a trigger, the selected waveform is generated the number of times set into the burst counter, up to 65,535. The start of the burst can be delayed up to 1 million points (1/2 million in dual channel).

Gated (uses the trigger threshold): Uses a triggered start and stops at the completion of the current waveform cycle after the gate closes.

External Trigger Threshold: Slope + or –
Range ±2.5 V
Resolution 20 mV (8 bits)

Source

Manual	Front-panel button
External	External trigger applied via a front panel BNC
Bus	Trigger from GPIB, RS-232 or Control Panel
	Control Panel Trigger Key

Arm Source: Auto – Automatically rearms itself.

Bus – Rearmed from the GPIB, RS-232 or the Control Panel.

Trigger sources and arm sources may be individually enabled or disabled.Internal triggering is automatically selected in continuous or recurrent trigger modes

Delay: Variable, from four to one million points (2 to 1/2 million in dual channel).

WAVEFORM MEMORY

Fast Memory Length: Single Channel – 64 Kpoints; Dual Channel – 32 kpoints each channel.

Storage Memory Length (RAM Disk): > 350 Kpoints for waveforms, setup and sequence files.

RAM Disk to Fast Memory Load Rate: 250 msec +0.7 µsec/byte.

Battery back-up: ≥3 years (non-rechargable Lithium cells).

Minimum Waveform Length: *Nonlinked waveform segment*, no looping - 8 points (4 points for each channel in dual mode); *linked waveforms* - Single channel operation - 72 points, Dual channel operation - 36 points for each channel.

Waveform Length Resolution: Single channel operation - 8 point blocks, Dual channel operation - 4 point blocks.

Waveform Loop Counter: One counter per linked waveform maximum repetitions - 4095.

OUTPUTS:

Protection: Waveform outputs are protected against applied voltages to ±40 V. If an externally applied overvoltage condition is detected, the output relay is opened, the LED for that channel is flashed and, if enabled, an SRQ is generated on the GPIB. The condition can be cleared by reconnecting the channel's output.

Front Panel:

Waveform Outputs - Output impedance, 50 Ω; All Timing Outputs - Output impedance, 50 Ω, source 1.5 V peak into 50 Ω, approximately 75 nsec duration.

Time Marker Output - Settable from two up to one million clock cycles, referenced to the trigger point.

Sync Output - Occurs at the next Sample Clock edge after receiving a trigger.

Waveform Start Output - Occurs at the start of the waveform.

Rear Panel:

Clock Outputs - 0 to -0.8 V into 50 Ω. Approximately a square wave. Present in all modes including External Clock.

INPUTS

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

Front Panel

External Gate/Trigger Input - Impedance: 50 Ω

Sum Input - Impedance: 50 Ω. Overload is indicated by flashing Sum 1 + 2 LED. Gain: X 1, ±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 hand-held control panel and display.

Rear Panel

External Clock Input - When this input is selected, the internal clock is deselected and the waveform is generated using the

external clock. Impedance: 50 Ω Threshold: Variable ±2.5 V, 8 bits resolution.

External Reference Input: Selection of this input causes the internal clock to phase lock to it. It requires a 4 MHz signal with 1 to 4 V p-p amplitude into 50 Ω, AC coupled.

FRONT-PANEL INDICATORS AND CONTROLS

Controls

Power ON/OFF

Manual Trigger Button

Manual Self Test Button

Hand-held Control Panel (optional)

Indicators

Power on LED – ON when power is applied to the instrument.

Trigger Armed LED – ON when awaiting a trigger signal.

Waveform Output LED's: Chan 1: ON when Channel 1 is turned on; **Chan 1 & 2**: ON when Channel 1 is being summed with channel 2. **Chan 2**: ON when Channel 2 is turned on.

Waveform Active LED: ON when a waveform is being clocked out of the fast memory to one or both waveform outputs or if the unit is armed and waiting for a trigger.

GPIB: Talk LED – ON when the instrument is in the talk mode.

Listen LED – ON when the instrument is in the listen mode.
SRQ LED – ON when the SRQ line is asserted and the instrument is awaiting action from a GPIB controller.
Remote – This word is spelled out in the hand-held control panel display whenever the instrument is put into remote by a GPIB controller.

Local LED – Located with the keypad input connector, it indicates when the instrument is in the LOCAL mode and the hand-held control panel is operative. When it is not ON, the instrument is in the GPIB remote state.

Self Test LED – ON when a self test or calibrate is in progress.

Test Fault LED – Flashes for 10 seconds when a self test or calibrate determines there is a fault or steady ON in the event of a microprocessor failure.

Battery Low LED – ON when the RAM Disk memory backup battery is too low.

Chan 1, Invert LED – ON when Ch 1 output is inverted.

Chan 2, Invert LED – ON when Ch 2 output is inverted.

REAR PANEL CONNECTORS AND SWITCHES

Connectors: GPIB: IEEE 488-1978 compatible; RS-232 Port: DB 25 S Connector.

Switches: GPIB Address Switch; RS-232 Port Configuration Switch, Line voltage selector and fuses.

WAVEFORM CREATION AND EDITING

LeCroy's EASYWAVE® software package is available for PC-DOS compatible computers*. It provides for waveform creation and editing in a menu driven environment. Waveform creation can be accomplished by any of the following methods:

1. Equation entry.
2. Selecting and combining simple waveform elements.
3. Waveforms can be acquired over the GPIB from LeCroy Oscilloscopes and then edited.

Editing may be accomplished as follows:

1. Modifying individual points from the keyboard.
2. Modifying the equation describing the waveform.
3. Deleting, moving and rescaling blocks of data.

* Minimum hardware configuration of host computer 640K RAM, 10 Mbyte Hard Disk, Graphics (CGA,HGA, or EGA) Display.

Other GPIB Compatible Controllers: Waveforms can be created and edited on other controllers using user supplied software.

INSTRUMENT CONTROL

PC-DOS Compatibles: The same software package used for waveform editing also can be used for controlling the 9100.

Local Control Panel: Once the waveforms have been loaded to RAM Disk, an optional, detachable control panel with a four line LCD display may be used for controlling the 9100.

Other GPIB or RS-232 Compatible Controllers: Other computers or terminals may be used to control the instrument using the remote commands.

GENERAL

GPIB Interface Functions: IEEE 488-1978 compatible. SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0

GPIB DMA Rates: Typically $\geq$200 kbytes/sec

RS-232C: Implemented as data communications Equipment (DCE).

Baud Rates: 300, 600, 1200, 2400, 4800, and 9600.
Data Bits: 7 or 8.
Stop Bits: 1 or 2.
Parity: None, Even, or Odd.
Protocol: Full Duplex, Xon/Xoff (DC1/DC3) handshake.
Data Formats: #I Arbitrary length ASCII #L ASCII HEX "00" to "FF" (double the length of internally stored binary data files)

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

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 +/- 20% VAC,47-63 Hz. approximately 147 watts

Size: 5-1/4" H X 19" W X 15" D.

Weight: 26 lbs. (approximately).

STANDARD ACCESSORIES 1 each Operator's Manual

ORDERING INFORMATION

9100	Dual Channel Arbitrary Function Generator
9100R	Dual Channel Arbitrary Function Generator with Rear Panel Connectors
9101	Single Channel Arbitrary Function Generator
9109	Dual Channel Arbitrary Function Generator with Digital Word Outputs

OPTIONAL ACCESSORIES

9100/CP	Detachable Hand-held Control Panel
9100/EC	6' Extender Cable (Control Panel)
9100/OM	Operator's Manual
9100/SM	Service Manual
9100/SW	EASYWAVE Software
9100/SP	Advanced Waveform Creation Software
9100/MM	Waveform Memory Expansion - 1/2 Mbyte
9100/MM1	Waveform Memory Expansion - 1 Mbyte
9100/MM2	Waveform Memory Expansion - 2 Mbyte
9100/RT	Real-Time Waveform Selection
9100 GPIB2	GPIB Interface Card and Software (National Instruments PCII Card and GPIB-PC Software)
DC/GPIB-2	GPIB Cable, 2 meters

EASYWAVE® is a trademark of LeCroy Corp
IBM XT/AT® is a registered trademark of International Business Machines Corp

3 OPERATIONS

PREPARATION FOR USE

OPERATING ENVIRONMENT

The Model 9100 should be operated only within the following environmental limits:

Temperature: 15°C to 35° C, in spec;

0°C to 40° C, in operating.

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

Specifications are rated from +15° C to +35° C.

Voltage Selection and Fuse Check

The Model 9100 has been designed to operate from either a 115 V or 220 V nominal power source. On the rear panel of the instrument, a switch permits user selection of either voltage. Also on the rear panel, separate fuses are provided for each voltage.

Prior to powering up the Model 9100, make certain that the voltage selector switch is set to whichever of those two voltages corresponds to the available power supply and that the fuse for that voltage is intact and properly installed.

CAUTION: *The Model 9100 will fail to operate and could be damaged if plugged into a voltage other than that which the voltage selector switch on the rear panel is set. Thus, correct line voltage selection MUST be made before plugging the instrument in or turning it on.*

Power Cable

The Model 9100 has been designed to operate from a single-phase power source with one of the current-carrying conductors (neutral conductor) at ground (earth) potential. Operation from power sources in which both current-carrying conductors are live with respect to ground (such as phase-to-phase on a tri-phase system) is not recommended.

The instrument is provided with a three-wire electrical cable containing a three-terminal polarized plug for line voltage and safety ground connection. The plug's ground terminal is connected directly to the frame of the unit. For adequate protection against electrical hazard, this plug must be inserted into a mating outlet containing a safety ground contact.

GPIB Address Selection

The Model 9100's 8-segment GPIB address switch is located on the instrument's rear panel. Segments 1 and 2 are unused. Segment 3 selects the communication source. A "1" selects GPIB and "0" selects RS-232.

Segments 4 through 8 on the switch are used for GPIB address selection as shown in Figure 3.1.

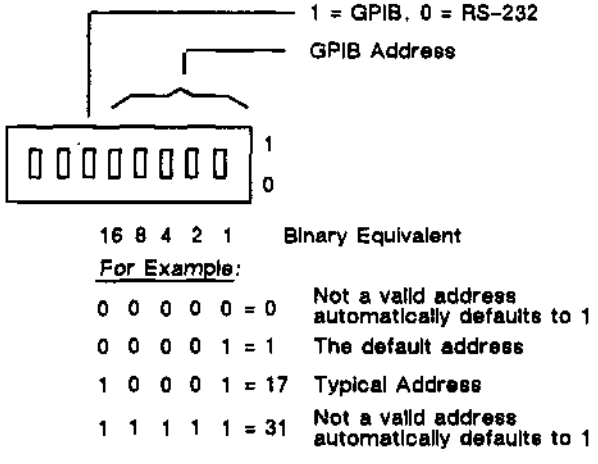


Figure 3.1
GPIB Selection and Addresses

RS-232 Switch Setup

Refer to Chapter 6.

Power-On Procedure

As described in the preceding sections, the first steps in operating the Model 9100 is to be sure that it is properly connected to line power, that it is properly fused, and that the selector switch on the rear panel is set to the same voltage as line power.

Once those steps are complete, press the power switch (in the upper right corner of the front panel) to the ON position. The LED above that switch will light to indicate that power is on.

Also on will be the SELF-TEST light in the STATUS rectangle to the left of the power switch. This light indicates that the instrument is undergoing calibration, which is part of self-test. When the calibration is complete the self-test LED will no longer be lit.

NOTE: It is normal for all front-panel lights to flash on prior to self-test.

After calibration, the instrument initializes all control settings, which takes several seconds. During this time the LOCAL LED will be on. The remote interfaces are ignored until initialization is complete, to avoid any possible conflicts. After initialization the message "LECROY 9100" appears on the 9100/CP, if it is attached. If a GPIB controller places the instrument in the REMOTE state during initialization, this will be recognized at the end of initialization. If the communications source is RS-232, a prompt "AFG\>" is sent over RS-232 at the end of initialization.

The instrument is now ready to use in its power-up mode. All instrument settings will be at their default values and only the POWER and LOCAL LED's will remain lit (the Model 9100 powers up in LOCAL mode, which means it is at that point set to be controlled by the 9100/CP).

When settings are changed to meet the needs of specific operations, and/or if appropriate commands are given to invoke REMOTE (computer) control of the instrument, different front-panel LED's will light up accordingly.

OPERATING THE 9100

In the following sections the general format of remote commands will be given to show how certain operations are invoked. The argument descriptor will often be shown as the argument name or explanation enclosed in angular brackets. For example:

Command: CLOCK_PERIOD,<desired period>;

The type of argument is not to be entered literally when the command is used. The angular brackets and text enclosed should be replaced by the properly formatted argument in accordance with the rules specified in Chapter 5. The argument is typically a number with a unit appended to it with no embedded spaces.

All commands except for those that transfer files into and out of the 9100 can also be given using the 9100/CP via its menu-driven command entry. See Chapter 4 for the 9100/CP menu description.

STANDARD FUNCTIONS

Standard functions may be generated with the 9100 using the 9100/CP or by command over the bus without loading or using any waveform files. The standard function modes completely emulate the usual function generator operation by automatically generating the waveforms needed in the waveform memory. In

all these modes the user simply enters the parameters needed (for example, frequency and phase for sine generation) and the rest is done automatically.

The standard functions are accessed under the FUNC main menu key on the 9100/CP. For detailed instructions on the menu driven operation of the standard functions see Chapter 4.

To operate standard functions under remote control, first send the command which forces the 9100 into the particular standard function mode (a single word command which is usually the name of the function, e.g., sine, pulse, ..) and then give the GO command. The function will then be output. For a detailed explanation of the operation of all related commands see Chapter 5.

Listed below are the commands for setting up dual channel 1 MHz sine waves with 20° phase difference between Channel 1 and Channel 2.

```
SINE;
SINE_MODE,DUAL;
SINE_FREQUENCY,1MHZ;
SINE_CH2_PHASE,20;
```

In standard function modes the clock is set automatically and cannot be controlled independently as with arbitrary functions. For this reason all clock related commands are disabled when in a standard function mode. When using a 9100/CP, if an external clock reference is needed in standard function mode it must be selected when in arbitrary mode and then it will be active when using standard functions. It cannot be selected when in standard mode.

ARBITRARY WAVEFORMS AND FILE CONVENTIONS

The LeCroy EASYWAVE software running on an IBM XT/AT computer is the recommended method of creating and transferring arbitrary waveform files to the 9100. The next section carefully explains how to format and transfer waveform files to the 9100, and Chapter 5 summarizes all the commands and formats used. All arbitrary waveforms are handled as files in the 9100. Once the files exist on the 9100 RAM disk all control can be accomplished via the 9100/CP control panel.

All files in the AFG have an extension which is necessary and significant. Below is a summary of the different types of files you will encounter. The file name, represented by xxxxxxxx, is the alphanumeric name that the user gives when creating the file.

xxxxxxxx.WAV - SINGLE CHANNEL WAVEFORM FILE Contains the data to generate a single channel waveform. May only be output on Channel 1.

xxxxxxxx.WAD - DUAL CHANNEL WAVEFORM FILE Contains the data to generate a dual channel waveform.

xxxxxxxx.SET - SETTINGS FILE Used to automatically establish all settings of the 9100 in conjunction with the SETUP command. The LEARN command automatically generates a setup file.

xxxxxxxx.SEQ - SEQUENCE FILE Used to contain a sequence of 9100 commands that may be executed automatically by giving the SEQUENCE command. This command is most necessary when defining a complex waveform using the LINK command.

Defining an Arbitrary Waveform in Terms of a Waveform File

Two types of waveform file formats are used by the 9100, one for single channel waveforms and one for dual channel waveforms. Both single channel and dual channel waveform files contain a single sequence of bytes which define the waveform data array to be generated. The bytes should be UNSIGNED, in other words range from 0 to 255. In general, when you calculate your waveform using your computer you will probably be using floating point numbers to represent the voltage values which you wish to generate. In order to convert these into 8-bit waveform data values and maintain the maximum amplitude resolution you should, in most cases, scale your waveform so that the minimum value corresponds to 0 and your maximum value corresponds to 255.

The basic constraints on the waveform files are:

1. The maximum number of bytes is 65536.
2. The number of bytes must be a multiple of 8. This is due to a hardware constraint in the waveform memory.
3. The number of bytes must be greater than or equal to 8 for a waveform file that will not be "linked" with other waveform files when loaded into the WAVEFORM GENERATOR CIRCUIT from the RAM DISK. (See page 3-9, for an explanation of waveform file linking.)
4. The number of bytes must be greater than or equal to 72 for a single-channel waveform file that will be "linked" with other single channel waveform files. Dual channel files that are to be linked must contain at least 36 bytes per channel.

5. Minimum data value is 0.

Maximum data value is 255.The single channel waveform file simply contains a series of bytes in the exact order in which you want them to be generated. The single channel waveform will always be output on Channel 1. The format is given below where the index specifies the interval (point in time) during which that value will be generated. The waveform file contains N data bytes.

a(1) a(2) a(3) a(4) a(5) a(6) ..... a(N)

The dual channel waveform file consists of interleaved pairs of data values which will be routed to Channel 1(a) and Channel 2(b). Below we designate bytes for Channel 1 as a and bytes for Channel 2 as b and the index specifies the interval during which that value will be generated starting with 1. This waveform file contains 2N data bytes and when run will result in N points being output on channel 1 and N points being output on Channel 2.a(1)

a(2) b(1) b(2) a(3) a(4) b(3) b(4) ..... a(N-1) a(N)b(N-1) b(N)

TRANSFERRING WAVEFORM DATA FILES INTO THE AFG RAM DISK VIA GPIB

NOTE: If you are using the EASYWAVE Program to create and load your waveform files, you may skip this section.

After you have defined the data array which will become your waveform file, you need to transfer it to the 9100. We do this with the STORE command.

First send the command to transfer the file.

For single channel waveforms: STORE filename.wav

For dual channel waveforms: STORE filename.wad

NOTE: The extension on the waveform is significant and lets the 9100 know what type of waveform will be contained in the file. Filename represents the name by which you will refer to the waveform file.

Next, send the file. The stream of bytes that you send consists of either a single block of bytes or a series of blocks. If the file is being sent in multiple blocks EOI must be asserted only with the last byte of the last block to indicate the end of the file.

The waveform files may be transferred to the 9100 in either of two block formats; binary (called #A format) or hex-ASCII (called #L format). Each individual block consists of a block

preamble, a count (the number of data bytes in #A and the number of data values in the #L case). Below are the block formats for the binary and hex ASCII file block transfers. In the table, each row corresponds to a byte sent over the GPIB to the 9100.

FOR BINARY TRANSFER:

Byte Number	Byte Value
1	# (ASCII #)
2	A (ASCII uppercase A)
3	<data byte count, most significant byte>*
4	<data byte count, least significant byte>*
5	<data byte 1>
6	<data byte 2>
7	<data byte 3>
.	.
.	.
.	.
.	.
N+4	<data byte N> (with EOI, if last block)**

* Data byte count is an unsigned integer which in this case equals N. It contains the number of bytes being transferred in the block. In this binary representation there is 1 data value per byte.

**EOI, if sent, must be sent with the last byte. EOI terminates the file transfer. If EOI is not sent, the 9100 will accept another block as part of the same file. The last block of a file transfer must be sent with EOI on the last byte.

FOR HEX ASCII TRANSFER:

Byte Number	Byte Value
1	# (ASCII #)
2	L (ASCII uppercase L)
3	<value count, 4th hex digit, most significant >*
4	<value count, 3rd hex digit>*
5	<value count, 2nd hex digit>*
6	<value count, 1st hex digit, least significant>*
7	<most significant hex digit of data byte 1>
8	<least significant hex digit of data byte 1>
9	<most significant hex digit of data byte 2>
10	<least significant hex digit of data byte 2>
.	.
.	.
.	.
.	.
2N+5	<msb hex digit of data byte N>
2N+6	<lsb hex digit of data byte N> (with EOI, if no last block)

* Value count is the number of data bytes you are sending over in this block. In this hex ascii representation there are 2 bytes per data value.

**EOI, if sent, must be sent with the last byte. EOI terminates the file transfer. If EOI is not sent, the 9100 will accept another block as part of the same file. The last block of a file transfer must be sent with EOI on the last byte.

NOTE: When transferring files over the RS-232 interface, the last byte must be followed by the character defined by COMM_RS_CONF as simulting EOI; see Chapter 6.

LOADING THE WAVEFORM FILES FROM RAM DISK INTO THE WAVEFORM GENERATOR CIRCUIT

The simplest type of waveform that we can generate is based on a single waveform file. To generate the waveform described by a single waveform file, simply load it and go by issuing the following commands:

LOAD filename.ext; GO;

Where ext is either WAV or WAD, if single or dual channel respectively.

NOTE: The commands shown in this screen are remote commands valid over GPIB or RS-232. All functions are also accessible from the 9100/CP. Operation with the 9100/CP is covered in Chapter 4.

If you are using only simple waveforms composed of single waveform file, skip the rest of this section of the operation procedure. The procedure for building up more complicated waveforms which utilize the linking and looping capabilities of the 9100 will now be described.

The waveform data memory length of the 9100 is 64 Kbytes. This means that if you are using only a single waveform file the upper limit on a single channel waveform is 64 Kpoints and for a dual channel waveform is 32 Kpoints per channel. The 9100 provides a way to effectively generate much longer waveforms if any parts of the waveform are repetitive in nature.

You may link together waveform files when loading into the waveform memory to define what can be thought of as a waveform program. Lets look at an example. Suppose you want to generate the waveform shown in Figure 3.2. It consists of several pieces each of which are repeated several times:

1 sine cycle
1 DC section
4 since cyles
2 DC sections
2 Gaussian pulses
6 DC sections

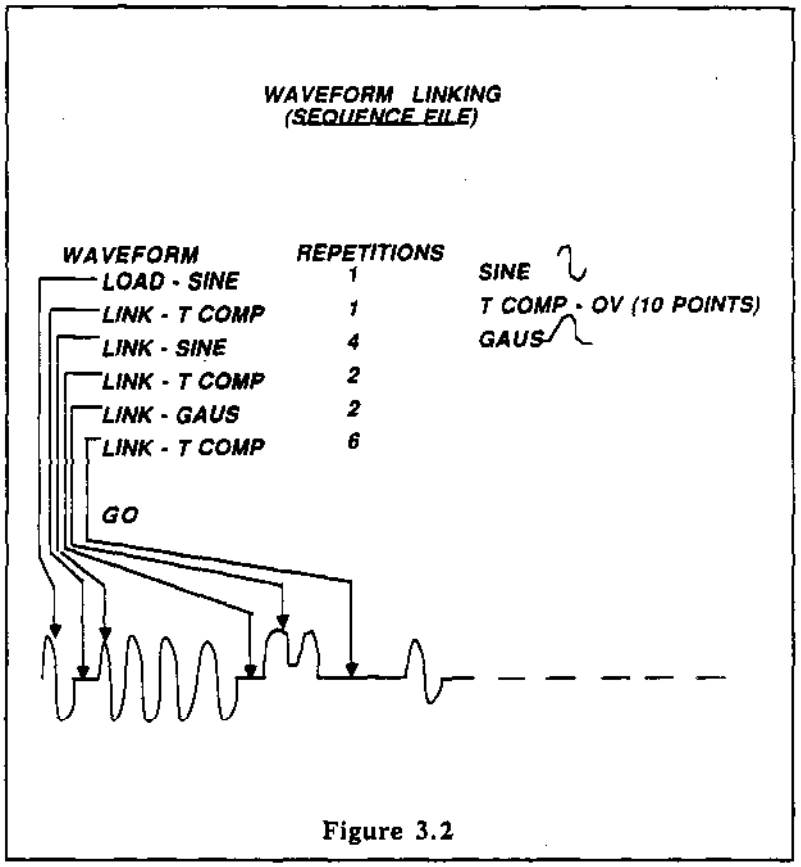


Figure 3.2

You could simply generate a single data file which contained all the data as a single array or we provide another method which will use less waveform memory. We may define three waveform files as follows:

GAUS.WAV	contains 1 Gaussian pulse
SINE.WAV	contains 1 cycle of a sine wave
T.WAV	contains a constant data array

We can then load the waveform using the following sequence of commands:

```
LOAD SINE.WAV,1;
LINK TCOMP.WAV,1;
LINK SINE.WAV,4;
LINK TCOMP.WAV,2;
LINK GAUS.WAV,2;
LINK TCOMP.WAV,6;
GO; (when you want to start it running)
```

The load command always comes first and tells the 9100 that we are loading a new waveform into the waveform memory. In this waveform the 9100 will generate one repetition of SINE.WAV, then one repetition of TCOMP.WAV, then four repetitions of SINE.WAV, then two repetitions of TCOMP.WAV, then two repetitions of GAUS.WAV, and finally six repetitions of TCOMP.WAV. When the waveform is loaded in this manner, as a multi-file waveform, the amount of waveform data memory used is conserved since each unique file has to reside in the waveform memory only once. Therefore, the amount of waveform memory used by this waveform is the sum only of the number of data values in the three files.

Main constraints in making linked waveforms:

1. Minimum size of each file must be 72 bytes, as opposed to 8 for a single file waveform.
2. A Maximum of 1 Load + 681 sequential Link commands can be used to generate a linked waveform.
3. The maximum number for the repetition argument in the load or link is 4095.

The LINK command also accepts an additional argument. The purpose of this argument is to permit each trigger cause output of different waveform segments.

The format of the command is:

LINK arg1 [arg2] [arg3];

where optional items are contained in brackets, and items to be replaced are in lower case.

arg1: filename to link, with extension, such as A.WAD.

arg2: Number between 1 and 4095, inclusive, representing the segment repetition count. Default if not present is 1.

arg3: WAIT.

The "WAIT" argument, if present, tells the 9100 Series AFG to wait for trigger before executing this segment. More precisely, it tells the AFG to act as if the entire waveform ended with the segment before this one, and this segment is the first one in the next waveform repetition. A detailed discussion of the effect of this argument will be found under "Specifying the Trigger Mode", page 3-15.

CONTROL SETTINGS SUMMARY (amplitude, clock, ...)

Specifying the 9100 control settings gives the user control over the various waveform characteristics. All attributes can be controlled from the Control Panel as well as by GPIB commands. The values of the settings determine when a particular waveform data point will be output and at what voltage level. The settings can be grouped into the following major categories shown below.

Channel Parameter Settings

Settings which control the signal conditioning applied to the Channel 1 and Channel 2 signals.

CH1_AMPLITUDE	CH2_AMPLITUDE
CH1_OFFSET	CH2_OFFSET
CH1_ZERO_REF	CH2_ZERO_REF
CH1_FILTER	CH2_FILTER
CH1_INVERT	CH2_INVERT
CH1_OUTPUT	CH2_OUTPUT
EXTERNAL_SUM	
SUM_MODE	

Timebase Settings

Settings that affect the main clock, which determines the data point period (i.e., determines rate at which the waveform is output).

CLOCK_RATE
CLOCK_PERIOD
CLOCK_SOURCE
CLOCK_REFERENCE
CLOCK_LEVEL
CLOCK_MODE
CLOCK_SLOPE

Trigger Settings

Settings that affect when and how the waveform is triggered.

TRIG_MODE
TRIG_DELAY
TRIG_SOURCE
TRIG_ARM_SOURCE
TRIG_SLOPE
TRIG_LEVEL
MARKER_DELAY
DELAY_MODE

A detailed explanation of every command is contained in the command reference in Chapter 5.

SPECIFYING HOW THE DATA VALUES ARE CONVERTED TO VOLTAGE LEVELS

AMPLITUDE, OFFSET AND ZERO_REF determine the output voltage as a function of data point value, V(n) where n is the data point value.

NOTE: All voltages are for the output terminated in 50 Ω. If the output load is a high impedance, then all voltages at the output will be 2 × higher than set.

The AMPLITUDE command sets the full scale voltage range, that is, the voltage swing obtained when the data point value changes from 0 to 255. For example the commands to set both channel amplitudes to 2.3 V would be:

```
CH1_AMPLITUDE 2.3V;
CH2_AMPLITUDE 2.3V;
```

ZERO_REF sets the data point value whose output voltage does not change when the amplitude is changed (think of it as the fixed point or baseline). This is also the data point value which when output from the AFG will correspond to the offset voltage. This value must fall between 0 and 255 but need not be constrained only to integer values (127.5 is a valid value and is the default value for this parameter). The commands to set zero_ref to 0 (for unipolar positive operation) are:

```
CH1_ZERO_REF 0;
CH2_ZERO_REF 0;
```

For unipolar positive operation zref is typically set to 0. For unipolar negative operation zref is typically set to 255.

NOTE: For an autoscaled waveform (i.e., one that is normalized so that the maximum value is 255 and minimum is 0) to be generated symmetrically about 0 V ZREF should be set to 127.5, and the offset should be set to 0 V.

OFFSET sets the output voltage obtained when the data point value is equal to zref. The following commands set the offset on channel 1 to 1 V and the offset on channel 2 to 2 V.

```
CH1_OFFSET 1V;
CH2_OFFSET 2V;
```

To summarize:

```
V(n=zref) = Voffset
V(255) - V(0) = Vamplitude
```

so for a general data point value n:

```
V(n) = Voffset + Vamplitude*(n-zref)/255
```

Where

V(n) is the voltage output for data value n. n is the waveform data value between 0 and 255. Voffset is the programmed offset voltage. Vamplitude is the selected amplitude voltage. Zref is the selected zero reference point.

SPECIFYING THE TIME PER POINT

The clock period attribute controls the amount of time each waveform point is output.

CLOCK_PERIOD < time value with optional units>;

SPECIFYING THE TRIGGER MODE

The TRIG_MODE specifies the overall running mode of the waveform. The 9100 has five different trigger modes:

1. **Continuous** – On receipt of the GO command the generator outputs the loaded waveform. When it reaches the end of the waveform it immediately starts over at the beginning with no interruption between the last point and the first point. The generator will continue to cycle the loaded waveform until receipt of an ABORT or STOP. A pulse will be output from the START output at the beginning of each cycle. The SYNC and MARKER outputs are not available in this mode.

   COMMAND: TRIG_MODE CONTINUOUS;

2. **Single (triggered)** – This is a single sweep triggered mode. In general, for each receipt of a trigger the generator will output one sweep of the loaded waveform. On receipt of a GO command the generator waits for an ARM command (if ARM_ SOURCE=BUS) before it proceeds. Usually (and by default) ARM_SOURCE=AUTO, in which case no ARM is needed. It then waits for receipt of a trigger from any one of the enabled sources. While waiting for a trigger, the first data point in the waveform is being output. Upon receipt of a trigger a pulse is output from the SYNC connector (the output is actually issued on the 2nd positive clock edge after receipt of trigger). Then the generator waits a programmed number of clock cycles called the TRIG_DELAY. At the end of the TRIG_DELAY a pulse is generated at the START output on the front panel. The generator then outputs the loaded waveform and stops output, holding the last point if ARM_SOURCE=BUS. In this case, the output will remain at the last point until an ARM command is received. After the ARM command is detected, the output changes to the first point of the waveform, and remains in that state until a trigger is

received. If, however, ARM_SOURCE=AUTO (the default condition), the last point will only be held for the rearm time, and then the output will switch back to the first point automatically, and the unit will be ready to accept a trigger.

Command: TRIG_MODE SINGLE;

3. **Burst (triggered)** – This is a multiple sweep triggered mode. It operates identically to the SINGLE mode except that it will output the programmed number of sweeps of the waveform instead of just a single sweep.

Command: TRIG_MODE BURST,<number of sweeps>;

4. **Recurrent** – This is basically a BURST mode with automatic retriggering. It is a free running mode, not a triggered mode. When the GO command is given in this mode the waveform will be cycled until an ABORT or STOP is received. Although it is free running it is identical in operation to the Burst mode with two exceptions: (1) no trigger is needed to initiate the waveform, and (2) the generator is automatically rearmed and retriggered after every BURST of waveform sweeps.

Command: TRIG_MODE RECURRENT,<sweeps/cycle>

5. **Gate** – Gate is a combination of the triggered modes and the continuous mode. The starting of the waveform is identical to the triggered modes. The waveform then cycles in a manner similar to Continuous. When the external GATE input becomes inactive the generator will complete the current sweep of the waveform, stop output, rearm and await the next transition of the Gate input to the active state. The ARM feature is not active (always set to ARM_SOURCE=AUTO).

Command: TRIG_MODE GATE

The "WAIT"argument, if appended to a LINK command, tells the 9100 Series AFG to wait for trigger before executing the segment. More precisely, it tells the AFG to act as if the entire waveform ended with the segment before this one, and this segment is the first one in the next waveform repetition. This provides interesting effects, depending on which trigger mode is selected. It is meant to be used in single trigger mode. The effects are as follows:

Trigger Mode (TMOD): Effect

Single: A new trigger is required to generate each segment (or group of segments beginning with one) which has been linked with "wait". For example, consider:

LOAD A.WAV,1; LINK B.WAV,2, WAIT;
LINK C.WAV,2,; LINK D.WAV, 3, WAIT;

The first trigger will generate only A.WAV once, because B.WAV was linked with "wait". The second trigger will generate two repetitions of B.WAV and two repetitions of C.WAV, because C.WAV was linked without "wait". The third trigger will generate three repetitions of D.WAV. Each trigger generates appropriate timing outputs: SYNC, START and MARKER, if possible. The programmed trigger delay occurs following each trigger.

Continuous: The generated waveform is not affected by links with wait, since continuous mode never waits for trigger. However, a START pulse is generated at each end-of-waveform mark, i.e., at the beginning of each segment linked with "wait" as well as at the beginning of the first (LOADed) segment. Given the example above, a START pulse would be generated at the beginning of A.WAV and at the beginning of B.WAV's first repetition and at the beginning of D.WAV's first repetition. The programmed trigger delay has no effect as usual.

Gated: In this mode, waveform generation is halted at the first end-of-waveform after the GATE signal goes false. Each link with "wait" introduces an end-of-waveform mark. Thus, to continue the example above, in gate mode generation may stop just before A.WAV (as normal), or before B.WAV's first repetition or before D.WAV's first repetition, whichever comes first after the gate goes false. When the gate goes true again, output will begin with the appropriate segment, either A.WAV or B.WAV or D.WAV, after the programmed trigger delay.

Burst: Burst is very similar to single, except single stops at every end-of-wave, while burst counts the specified number of end-of-waves and then stops. So, using the example from "single" mode once gain, in TMOD BURST, 3 each trigger would cause the 9100 to wait the programmed trigger delay and then produce A.WAV followed by two repetitions of B.WAV, two repetitions of C.WAV and three repetitions of D.WAV. The three end-of-waveform marks are just before B.WAV, just before D.WAV and just before A.WAV.

TMOD BURST,1 is exactly equivalent to single trigger mode, see above. An interesting mode is to give a burst count that is neither 1 nor the number of end-of-wave markers in the waveform. For example, TMOD BURST 2 would cause A.WAV, B.WAV and C.WAV to be produced by the first trigger (following GO); D.WAV and A.WAV to be produced by the second trigger; B.WAV, C.WAV and D.WAV to be produced by the third trigger, etc.

Recurrent: Recurrent is the same as burst, with an automatic trigger immediately occurring whenever the system waits for trigger.

In summary, in single trigger mode this feature permits the 9100 to produce a sequence of different waveforms in response to a series of asynchronous external triggers, with as little as 70 nsec delay from trigger to the next waveform. The trigger may also be supplied by the TRIG command, but the response will be slower. In either case, the response is much faster than could be achieved if a sequence of LOAD and LINK commands had to be executed to change the waveform. In other trigger modes, other possibly useful effects are obtained.

TIMING OUTPUT SIGNAL RELATIONSHIPS

The following description of timing relationships details the operation of the SYNC, START and MARKER outputs, how they relate to the waveform output(s), and how they change with the selected triggering mode. For purposes of this discussion, the unit of timing will be the waveform point (i.e., clock period), in order to provide an understanding of how the timing of these signals may vary with the clock. At high clock rates (in excess of 10 MHz), the signal timing may appear somewhat different due to asynchronous (e.g., propagation) delays. Unless otherwise noted, MARKER output timing is the same as START output timing, but is programmed using the MARKER DELAY command rather than the TRIGGER DELAY command. Timing will also vary depending on whether a single-channel or dual-channel waveform is being generated. Delay values for dual-channel operation will be given in parentheses () following the single-channel value.

Single - After the GO command is issued, the first point(s) of the waveform will be present at the analog output(s). The AFG then waits for a trigger from any enabled source. The first trigger received will be synchronized to the generator's internal clock, and a SYNC pulse will be output. The actual time from the recognition of a trigger to the SYNC output will vary from one trigger to the next because of the synchronization process. The START pulse occurs [TRIGGER DELAY - 2 (1)] points after the SYNC. The synchronization delay is also included in the TRIGGER DELAY, so that the actual time from a trigger to the START will never be longer than the programmed delay value, but may be shorter by 1 (1/2) point. In any event, the START pulse occurs 1 point before the analog output(s) makes the transition from the first point to the second. At the end of the waveform, if the auto-arm function is enabled (the default condition), the last point of the waveform is held for 10 (5 1/2)

points. If bus arming is selected, then the last point is held until 9 (4 1/2) points after the arm command is received. This is the trigger re-arm time, following which the analog output(s) returns to the first point of the waveform and the unit awaits the next trigger. Figure 3.4 shows an overview of single trigger mode timing relationships. A more detailed view is shown in Figure 3.8.

Burst - Same as for single mode. See Figure 3.5.

Continuous - The SYNC and MARKER outputs are generated once in response to the GO command. Their relationship to the waveform output(s) is the same as in single mode. The START pulse is actually generated near the end of any given waveform cycle (which, given the nature of continuous operation, roughly corresponds to the beginning of the next cycle). The absolute timing from the START output to the first waveform point will vary depending on the number of points contained in the waveform file. Since the intent of the START pulse in this mode is merely as a convenient triggering signal for an oscilloscope, the exact timing relationship is non-critical. See Figure 3.3.

Gated - In this mode, the GO command again puts the first point(s) of the waveform at the analog output(s). The SYNC and MARKER outputs are generated in response to the gate signal's transition from the "closed" state to the "open" state (as determined by the TRIGGER SLOPE and TRIGGER LEVEL settings), in the same manner as in single trigger mode. Transitions on the analog output are delayed by TRIGGER DELAY, as in single mode. The START pulses are generated near the end of each cycle within the gate signal's active interval as in continuous mode. The number of repetitions is determined by the duration of the true state of the gate input, and one START pulse will occur for each repetition. The waveform will continue to its natural completion after the gate "closes", and the analog output(s) will make the transition from the last point back to the first point after the trigger re-arm time of 9 (4 1/2) points. The AFG then waits for the next transition of the gate signal. See Figure 3.7 for an overview of timing relationships in gate mode.

Recurrent - In recurrent mode, trigger delay is defined as the time from the end of the natural duration of the last point of one occurrence of the waveform (i.e., 1 clock period after the transition to the last point) to the beginning of the natural duration of the first point of the next occurrence (i.e., 1 cycle before the transition to the second point). Our discussion of this operating mode will therefore commence with the end of a

waveform occurrence. The last point is held for its normal duration plus 9 (4 1/2)) points while the trigger re-arms. The output(s) then make makes the transition to the first point. The SYNC output occurs 15 (8) points after the transition to the last point (i.e., 14 (7) points after the last point's normal duration). The START pulse occurs TRIGGER DELAY points after the normal duration of the last point (or TRIGGER DELAY + 1 points after the transition to the last point). The first point of the waveform is held for one period after the leading edge of the START pulse. Figure 3.6 shows an overview of recurrent mode timing. More detail in shown in Figure 3.9.

CONTINUOUS MODE OPERATION

This mode is used to loop on the programmed waveform in a continuous and uninterrupted manner (i.e., the first point is generated immediately after the last point. For example, this mode would be used to generate a continuous wave sine).

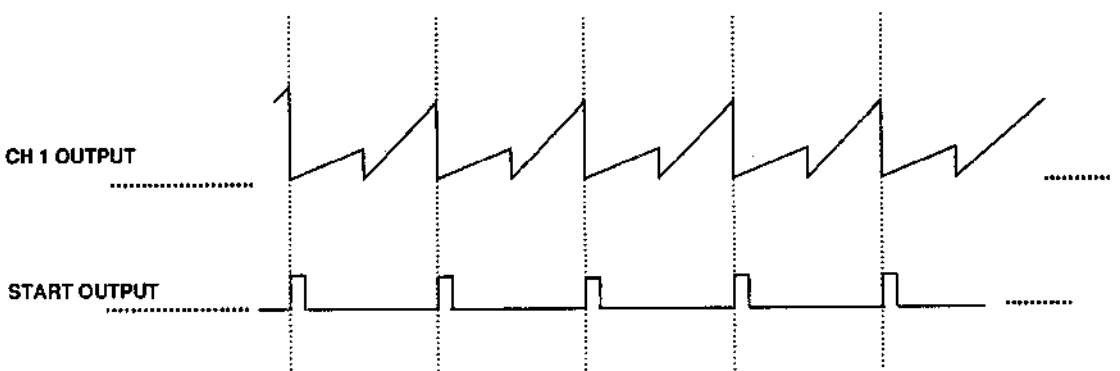


Figure 3.3

TRIGGERED SINGLE MODE OPERATION

In this mode each trigger causes a single repetition of the programmed waveform to be generated. Initial and final output levels are set by first and last points of waveform respectively.

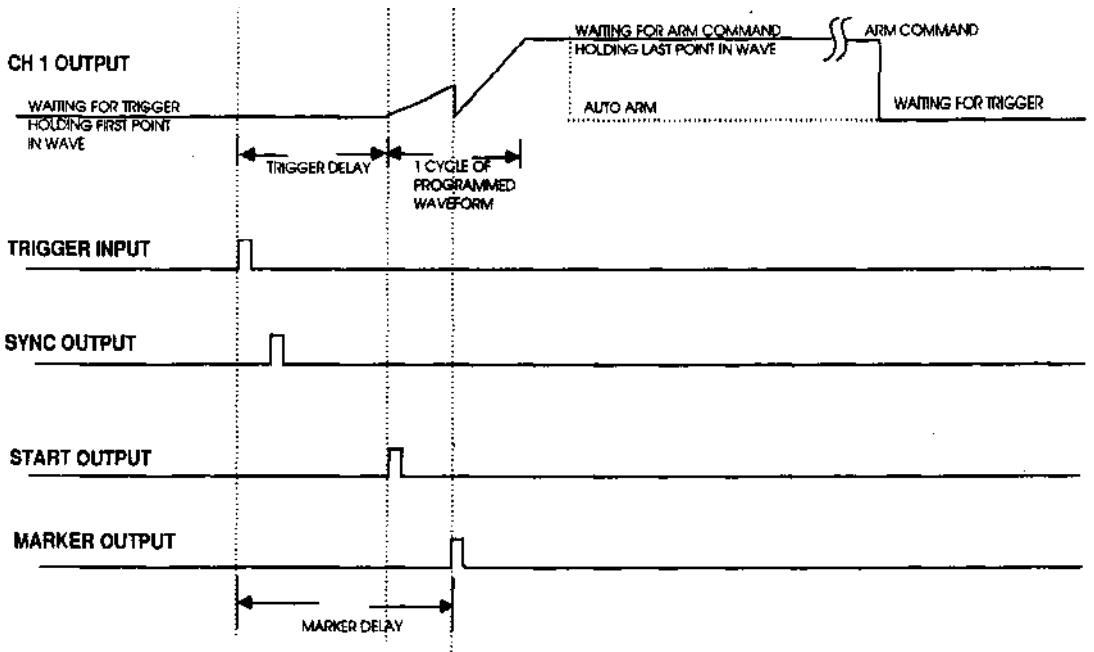


Figure 3.4

TRIGGERED BURST MODE OPERATION

In this mode each trigger causes a set number of repetitions of the programmed waveform to be generated (3 in the example below). Initial and final output levels are set by first and last points of waveform respectively.

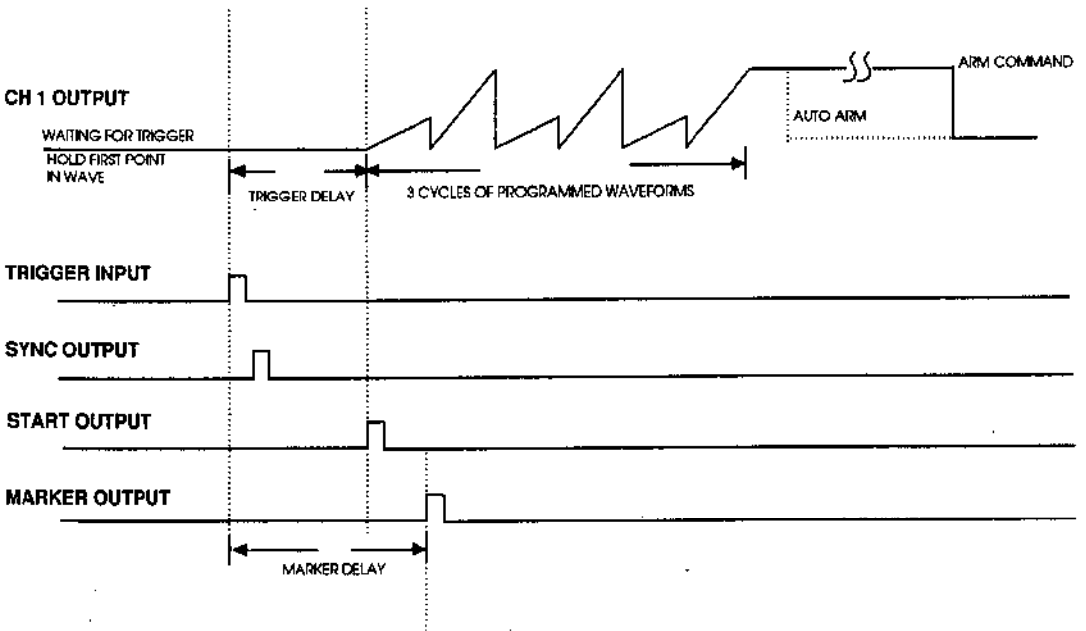


Figure 3.5

RECURRENT MODE OPERATION

A free running auto-triggered mode. The end of one cycle of the programmed waveform synchronously triggers the next cycle. In this mode, a programmable trigger delay separates the cycles. By changing the trigger delay the rep rate can be varied independent of the clock rate thus keeping the shape constant. Note that the trigger delay time includes the auto arm interval. All timing outputs are available in this mode.

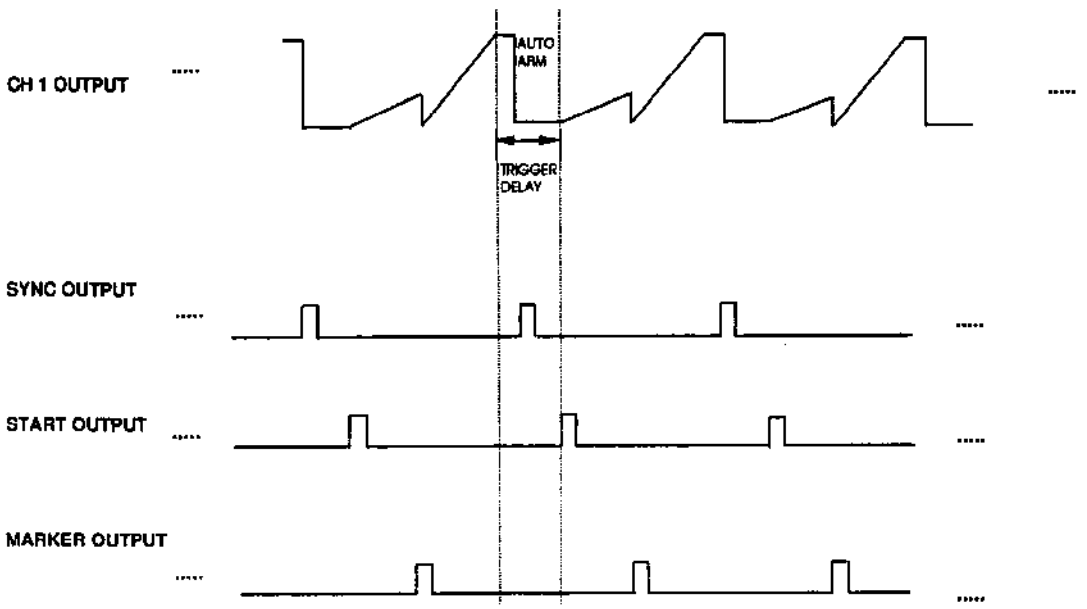


Figure 3.6

GATED MODE OPERATION

Program waveform to output continuously while the gate is active. After gate becomes inactive the current cycle of the waveform is completed and the trigger is ready to be re-armed. Typically the trigger delay should be set to minimum, but is programmable for additional flexibility.

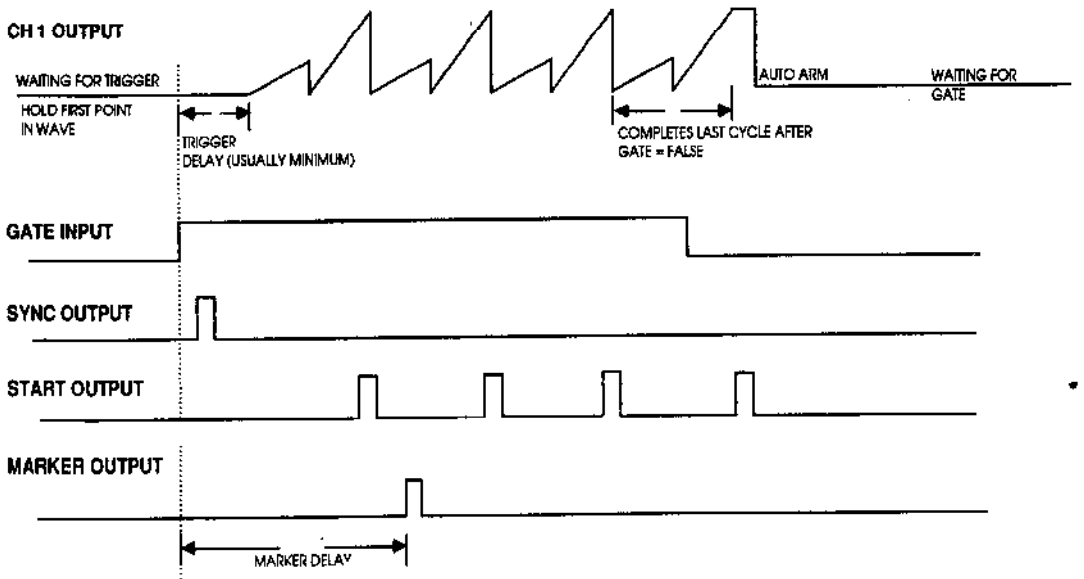


Figure 3.7

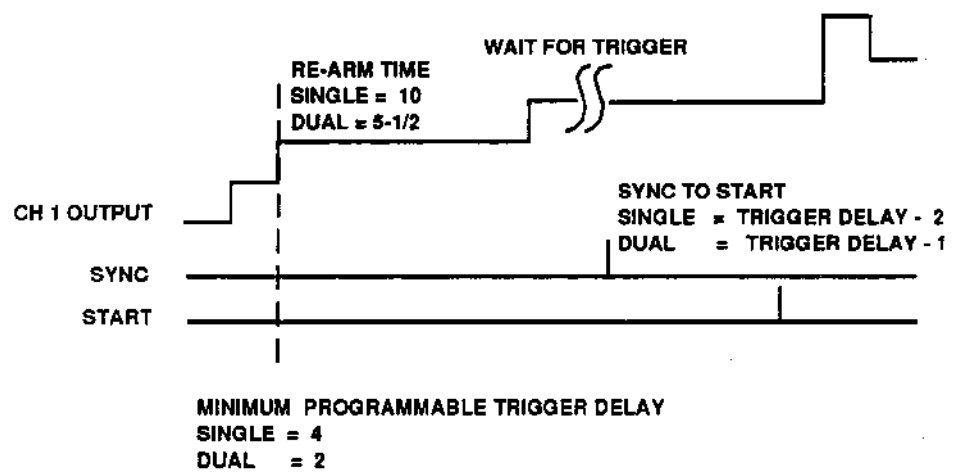

9100 SINGLE MODE TIMING
WAIT FOR TRIGGER
RE-ARM TIME
SINGLE = 10
DUAL = 5-1/2
CH 1 OUTPUT
SYNC TO START
SINGLE = TRIGGER DELAY - 2
DUAL = TRIGGER DELAY - 1
SYNC
START
MINIMUM PROGRAMMABLE TRIGGER DELAY
SINGLE = 4
DUAL = 2

Figure 3.8

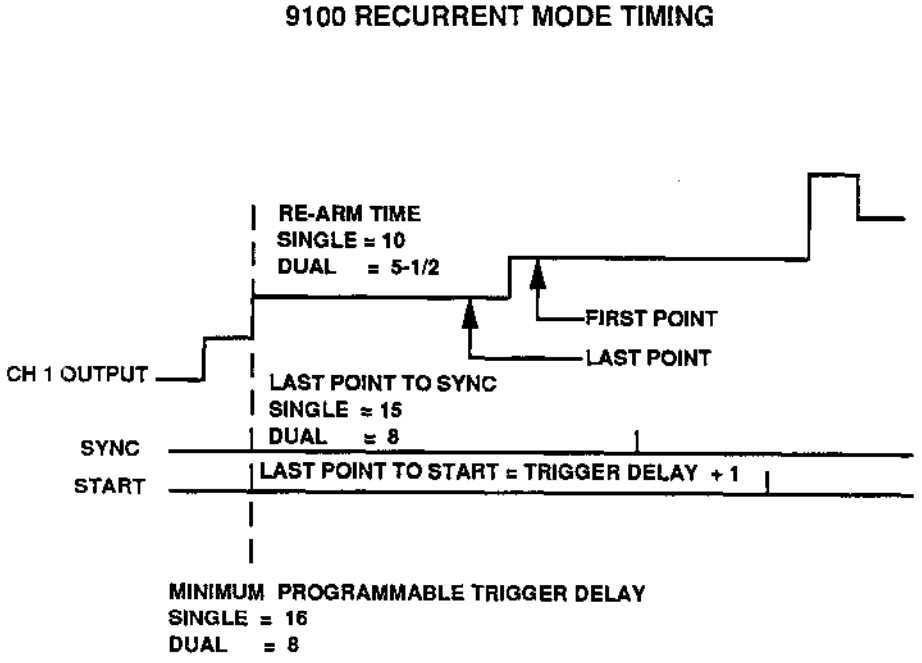

9100 RECURRENT MODE TIMING
RE-ARM TIME
SINGLE = 10
DUAL = 5-1/2
FIRST POINT
LAST POINT
CH 1 OUTPUT
LAST POINT TO SYNC
SINGLE = 15
DUAL = 8
SYNC
START
LAST POINT TO START = TRIGGER DELAY + 1
MINIMUM PROGRAMMABLE TRIGGER DELAY
SINGLE = 16
DUAL = 8

Figure 3.9

SPECIFYING THE TRIGGER DELAY

The trigger delay is used in Single, Burst and Recurrent modes. It determines the amount of delay between receipt of trigger and the start of waveform output. In Recurrent, it is the number of points between the end of the last burst of sweeps and the beginning of the next.

Command: TRIG_DELAY <desired trigger delay>

SPECIFYING EXTERNAL TRIGGERING

To trigger the 9100 on an external signal it should be input to the trigger/gate input BNC on the front panel. The input impedance is 50 Ω. The trigger source called external must be selected to be on. The TRIG_SLOPE and TRIG_LEVEL commands are used to set the point at which the 9100 will trigger on the applied signal. For most cases TRIG_ARM_SOURCE should be set to AUTO so that the trigger will be armed automatically after each waveform sweep.

The following command sequence would be used to trigger externally at a 1 V level on the positive slope with the trigger being automatically armed.

```
TRIG_SOURCE,EXTERNAL,ON;
TRIG_LEVEL,1V;
TRIG_SLOPE,POSITIVE;
TRIG_ARM_SOURCE,AUTO;
```

USING THE FILTERS TO SMOOTH THE WAVEFORM

Each output channel has six filter settings that provide additional signal conditioning capability. They are intended to help in removing the clock frequency and its harmonics. The filter you will select depends on the particular clock frequency you are using and the frequencies to which the circuit being stimulated is sensitive.

The filters are 3-pole bessel. The possible settings are NONE, 100 MHz, 30 MHz, 10 MHz, 3 MHz, and 1 MHz. For example, to set the Channel 1 filter to 1 MHz:

```
CH1_FILTER,1MHZ;
```

DISCONNECTING THE OUTPUT WHILE THE GENERATOR IS RUNNING

The output of either channel may be disconnected without interrupting waveform generation at the other output or at the timing outputs. The commands to do this are:

CH1_OUTPUT,<on or off>; CH2_OUTPUT,<on or off>;

INVERTING CHANNEL 1 OR 2

Either channel may be inverted without changing the waveform file. The waveform will be inverted about the zref point. The commands to do this are:

CH1_INVERT,<on or off>; CH2_INVERT,<on or off>;

SUMMING CHANNEL 1 AND CHANNEL 2 SIGNALS

When running a dual channel waveform the signals may be summed together and output from the Channel 1 output. Each channel's amplitude may be adjusted independently within limits. When summing channels, the respective amplitudes may differ by no more than a factor of 16. The channel sum command is:

SUM,<on or off>;

USING THE EXTERNAL SUM INPUT •

An external signal may be summed together with the signal being generated on Channel 1. It is input through the front-panel BNC labeled SUM(Ch1). The following command is used to turn the sum input on or off:

EXTERNAL_SUM,<on or off>;

NOTE: We do not recommend that the sum input be used for Channel 1 amplitudes less than .35 V. If the Channel 1 amplitude is less than .32 V then the sum signal will be attenuated by the smallest power of 2 that is greater than .625 divided by the set amplitude.

USING AN EXTERNAL CLOCK REFERENCE

An external 4 MHz reference oscillator (amplitude between 1 and 4 V) may be used as the timebase reference instead of the internal 4 MHz crystal. This is useful if the 9100 needs to be referenced to a system reference. The clock period is still controlled by the generator; only the reference is changed. The command to select the reference source is:

CLOCK_REFERENCE,<external or internal>;

When using Standard Functions, see page 3-3: STANDARD FUNCTIONS.

USING AN EXTERNAL CLOCK SOURCE

An external clock source may be used to drive the generator. When the external clock source is selected, the clock period is controlled completely by the external source and the clock period command has no effect. Note that in dual channel mode, the point output rate will be 1/2 the applied frequency, e.g., if the external clock frequency is 200 MHz, each channel will output a new point every 10 nsec. The clock source is selected with the following command:

CLOCK_SOURCE,<external or internal>;

SYNCHRONIZING WITH ANOTHER 9100 SERIES AFG

CLOCK_MODE,SLAVE is used to synchronize one 9100 Series AFG to another. The unit placed in SLAVE mode uses the signal on the CLOCK IN (EXT) rear panel BNC connector as its clock. This signal is assumed to come from the CLOCK OUT 2 rear panel BNC connector of another 9100 which is in CLOCK MODE MASTER.

NOTE: CLOCK OUT 1 provides continuous output at the clock frequency. Only CLOCK OUT 2 is suitable for MASTER/SLAVE operation.

Upon entering slave mode, CLOCK_SOURCE defaults to EXTERNAL, CLOCK_SLOPE defaults to positive, and CLOCK_LEVEL defaults to -200 mV. The previous settings are restored upon receipt of a CLOCK_MODE, MASTER command. While in slave mode, the CLOCK_SOURCE and CLOCK_SLOPE cannot be changed. CLOCK_LEVEL can be changed. Also, while a unit is in slave mode, the TRIG_MODE settings have no effect. The trigger delay is controlled by the absence of clock pulses from the master 9100. Trigger settings entered while in SLAVE mode will correctly take effect when the clock mode is changed to MASTER. Other commands that

have no effect in SLAVE mode are: CRAT, CPER, MDEL, DMOD.

To use two 9100s in master/slave operation, do the following:

1. Set one of the 9100's to clock mode slave and connect a cable from the master's CLOCK OUT 2 to slave's CLOCK IN (EXT).
2. LOAD and LINK the desired waveforms on both 9100s.
3. Issue "GO;" to the slave.
4. Issue "GO;" to the master.

NOTE: Steps 3 and 4 must be done in order. Any time the master aborts waveform generation, whether because of an ABORT command or because of a change of trigger settings, etc., both master and slave must be aborted and GO's issued in the proper order. Failure to issue GO to the slave first while the master is still stopped will result in loss of synchronization.

The START, SYNC and MARKER outputs of the master unit may be used, those of the slave unit are disabled.

Selection of the clock operating mode is accomplished with the following command:

CLOCK_MODE,<master or slave>;

STARTING AND STOPPING THE WAVEFORM

After loading an arbitrary waveform or invoking a standard waveform, the waveform is always initiated by giving the GO command.

GO;

The waveform may be stopped by giving the ABORT command.

ABORT;

When the waveform is aborted all outputs are stopped and the Channel 1 and Channel 2 output relays are opened.

AUTOMATING THE SETUP AND LOADING OF WAVEFORMS

Any valid sequence of 9100 commands, with the exception of file transfer commands or commands that require a response, may be automated by putting them into a sequence file. The sequence file is sent to the 9100 with the STORE command using the #I block format. See Chapter 5 for details. Always follow the rules below:

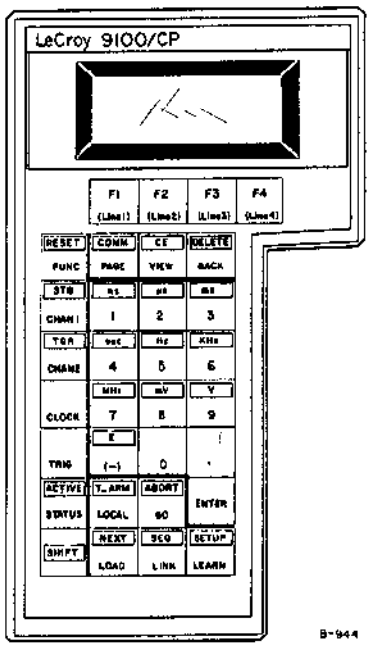
1. Make certain that all commands within a sequence file end with a semicolon.
2. Always terminate a sequence with the command: END;

4 CONTROL PANEL OPERATION

GETTING STARTED WITH THE 9100/CP

Basic Description

The 9100/CP, Figure 4.1, is an external panel that allows a user, without computer intervention, to control all aspects of the Model 9100 Series Arbitrary Function Generators, except storing (downloading) of files and recall (uploading) of files.



Model 9100/CP Control Panel

Figure 4.1

Functions that can be performed using the 9100/CP include:

- Selecting, loading, linking, and executing arbitrary (user-defined) waveforms that have been previously downloaded from a computer via the GPIB or RS-232C Interface to the Model 9100's RAM disk storage memory.
- Selecting and executing any of the six standard waveforms (sine, square, triangle, ramp, pulse, and DC) incorporated into the Model 9100.

- Implementing ON/OFF selections for Channel 1 and Channel 2 summing and output modes; and controlling the amplitude, invert, offset, zero reference, and filter parameters for each channel.
- Selecting internal or external clock source or clock reference and determining rate or period for internal clock; threshold level and slope for external clock.
- Choosing trigger mode; arming and firing the trigger via keyboard command or by selecting automatic trigger arming and alternate trigger sources.
- Learning in memory, and executing complete setup files, each consisting of a complete set of channel, timebase, and trigger commands.
- Selecting and executing setup files created via computer and previously downloaded to the Model 9100.
- Selecting and executing sequence files created via computer and previously downloaded to the Model 9100. Consisting of valid GPIB commands, a sequence file can contain nested sequence and setup files as well as additional commands to load, link, and execute waveforms.
- Returning control of the Arbitrary Function Generator from a computer (remote mode) to the 9100/CP keyboard (local mode) if local lockout has not been invoked via GPIB.

Compact and light in weight, the 9100/CP can be easily handheld while being used. Or, it comes with a bracket with which it can be mounted on a benchtop, any other convenient surface, or the Model 9100 itself.

Connected to the Arbitrary Function Generator by means of a 6-ft coiled cable that plugs into the front of the Model 9100, the control panel is readily detachable. Optional 6-ft extender cables are available, and as many as four extenders may be chained together for additional length.

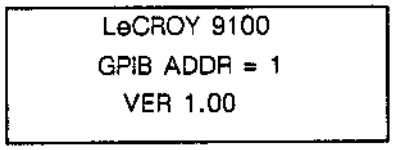
The main features of the 9100/CP are an LCD screen that displays functional menus and prompts operator instructions to the Model 9100 and a multi-function keyboard that serves as the mechanism by which those instructions are input.

Connecting the 9100/CP to the Arbitrary Function Generator

The cable attached to the 9100/CP plugs directly into the connector within the **KEYPAD** rectangle in the right corner of the Model 9100 front panel.

The Model 9100 can be under local (9100/CP) control or computer (remote) control. The default, on power-up, is local control mode.

As the instrument goes through initialization after power-up, a series of brief readouts will flash on the 9100/CP screen. Such readouts are normal and need not be interpreted for operation. Within a few seconds, however, the power-up display will be seen on the 9100/CP screen, as shown below.



Power-up display shows the software version (VER) number in use and the GPIB Address of the Model 9100

Figure 4.2

In the event that the Arbitrary Function Generator is already powered up and operating in remote mode when the 9100/CP is connected, the 9100 automatically returns to Local Mode and sends the "power up screen" to the 9100/CP.

If the Model 9100 is in local lockout mode, however, pressing the [LOCAL] key will result in the 9100/CP screen saying LOCKOUT. When that happens, the 9100/CP will be inoperative; use EASYWAVE, GPIB, or RS-232 control to exit the lockout mode, and then press **[LOCAL]** to continue.

LCD Display

The 9100/CP display shows information in pages containing as many as four lines of data or prompts. In this regard, a # sign at the bottom of the screen view indicates that the menu or information sequence you are looking at has at least one more page. Some operations require several pages.

Keyboard

The 9100/CP keyboard consists of 32 keys. To confirm that contact has been made, each key gives off an audible signal (beep) upon being pressed.

Twenty-two of the keys have dual functions. A key has two functions if it contains two sets of identification, the top set being white letters in a blue rectangle.

Four of the keys have functions that set them apart from the other keys:

[SHIFT] when pressed immediately prior to pressing any dual function key, causes the upper function (blue rectangle) on that key to be executed. If a dual function key is pressed without the **[SHIFT]** key being pressed first, the lower function is invoked, After invoking a shifted function, all keys return to the unshifted position.

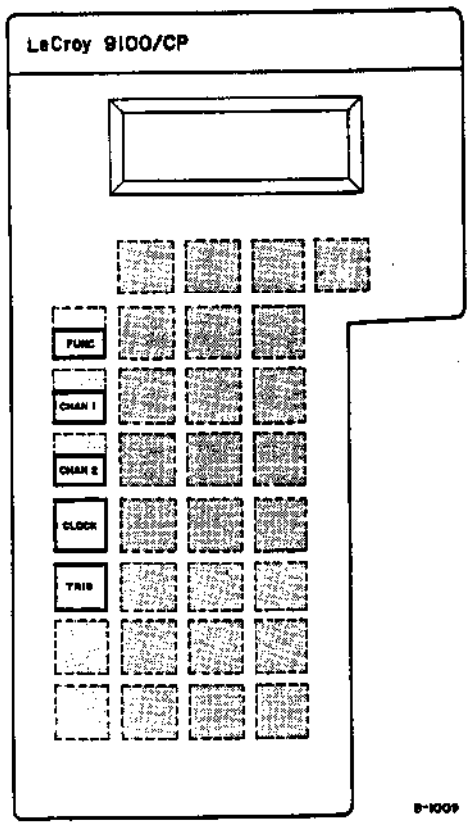
[SHIFT RESET] resets all instrument settings to the power-up defaults and results in the display shown in Figure 4.2.

[SHIFT DELETE] can remove a selected file from RAM disk memory. This may be an arbitrary waveform, setup or sequence file.

[SHIFT CE] stands for CLEAR ENTRY. Pressing this key clears numeric entries and enables a new entry to be made.

The remainder of the keyboard can be thought of as being divided into five main groupings: main menu keys, display keys, numeric/units keypad, action keys, information keys.

Main Menu Keys — Keys that call up main menus



Main Menu Keys
Figure 4.3

[FUNC] accesses menus that allow selection of arbitrary waveforms, standard waveforms, setup, and sequence files.

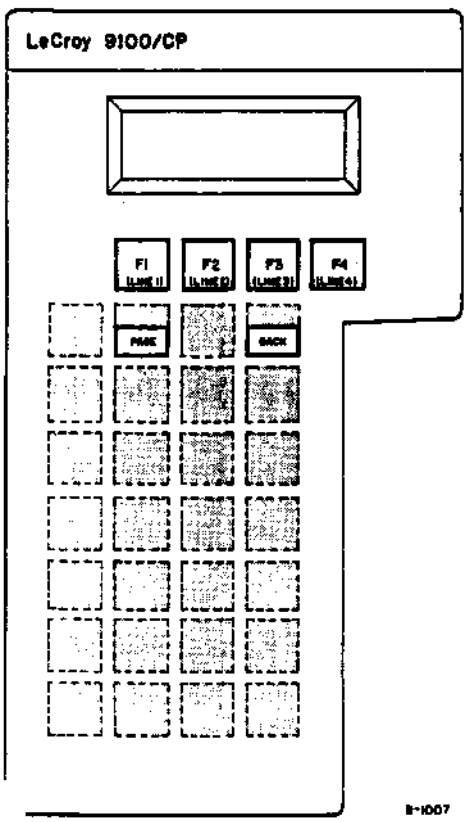
[CHAN 1] is used to set operating parameters for waveforms generated on Channel 1.

[CHAN 2] is used to set operating parameters for waveforms generated on Channel 2.

[CLOCK] is used to enter the generator clock rate and period. It also allows operator selection of internal or external clock source or reference use. If an external clock is used, threshold level and slope may be user selected.

[TRIG] allows entry of trigger parameters and modes.

Display Keys



Display Keys

Figure 4.4

Menu Manipulation and Selection:

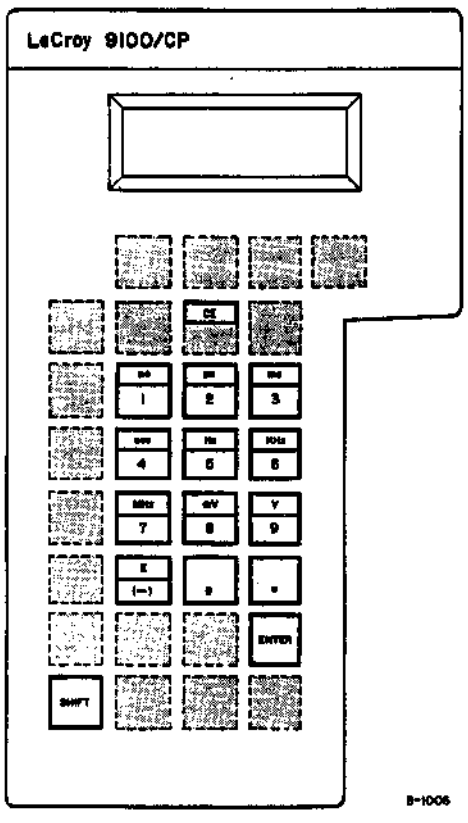
[F] KEYS: [F1], [F2], [F3] and [F4] are used to perform file selections, execute actions or access submenus for the lines on the display. F1 refers to the first line of the display and F4 to the fourth line. When used to select a file, an @ will appear after the name of the selected file.

[PAGE] When a menu contains more than one page, a # will appear at the end of the fourth line of the display. Pressing **[PAGE]** will cause the next page of information to be displayed. When the # does not appear this indicates either a single page menu or the last page of a multiple page menu. Pressing the **[PAGE]** key in this latter instance returns the menu to the first page of the multiple page menu.

[BACK] causes the display to step backwards one page in a menu. If the display is showing the first page of a menu, pressing **[BACK]** will move the screen to the upper level menu page from which that first page was selected.

Numeric/Units Keypad

Thirteen keys in the center of the keyboard that are used to enter numbers and units:



Numeric/Units Keypad
Figure 4.5

[NUMERIC] keys and **[DECIMAL POINT]** key are for those situations in which a particular menu item requires numeric entry.

[−] is for entry of negative values.

[ENTER] is used to terminate numeric entries for which units are not required, such as number of repetitions.

[SHIFT UNITS KEYS] append units to numeric entries and terminate those entries.

To terminate (complete entry of) a numeric entry that is dimensionless, key in the number and then press **[ENTER]**.

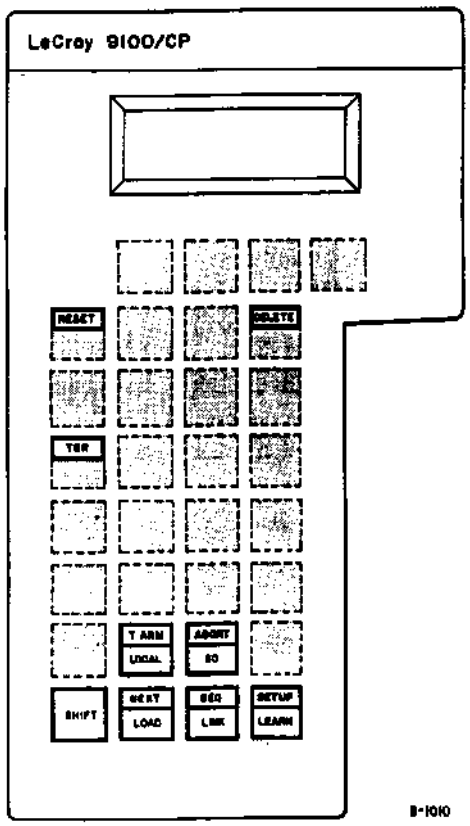
When units are added to a number, first key in the number. Next press [SHIFT], and then the appropriate units key. As soon as the units key is pressed, entry is completed and [ENTER] need not be pressed.

[SHIFT E] is used to separate the base from the exponent when numeric entries are made using scientific notation.

[SHIFT CE] is used for clearing erroneous entries from the display. This key sequence clear the entire display and returns to the entry prompt.

Action Keys

Cause the generator to take top level action:



Action Keys
Figure 4.6

[SHIFT TGR] issues single shot trigger if enabled.

[LOCAL] returns control of the 9100 to the 9100/CP if a local lockout is not invoked via GPIB.

[SHIFT T. ARM] arms the trigger when the trigger arm source is BUS. The default trigger arming mode is automatic. In order to have manual control of trigger arming, select BUS trigger arm source via the trigger menu by using the [TRIG] key.

[GO] is pressed to execute a waveform that has been selected and loaded or linked.

[SHIFT ABORT] halts waveform generation and opens the output relays. This does not change the status of any files or attributes.

[LOAD] will cause a selected arbitrary waveform to be loaded from RAM disk into the high speed memory, from where it can be generated.

[SHIFT NEXT] is pressed to continue execution of a sequence that has executed a WAIT command, suspending its execution.

[LINK] To link additional arbitrary waveforms to a **LOADed** waveform, this key is pressed instead of [LOAD] for the subsequent waveforms after file selection.

[SHIFT SEQ] executes the presently selected sequence file.

[LEARN] When this key is pressed, all existing setup parameters are saved to a file which is given the name SETXXX, where XXX is a sequential number managed by the 9100 ranging from 1 to 999.

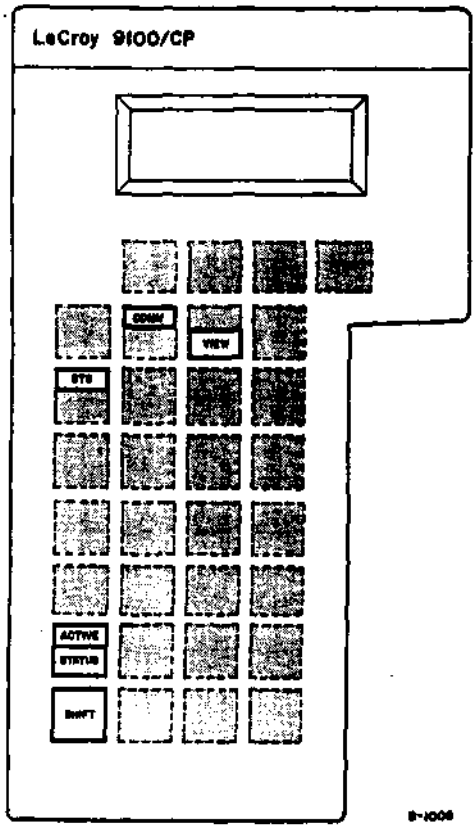
[SHIFT SETUP] executes the presently selected setup file.

[SHIFT DELETE] can remove a selected file from RAM disk memory.

[SHIFT RESET] returns the 9100 to its initial power-up state, with all settings in their default states.

Information Keys

Provide the user with the current state of the instrument:



Information Keys
Figure 4.7

[STATUS] identifies the current generator status for lockout and trigger state, if appropriate.

[SHIFT ACTIVE] performs the Active Files function which identifies which waveform, setup and sequence files are presently being executed.

[SHIFT COMM] displays the present setup of the communications port (GPIB or RS-232).

[VIEW] All instrument settings are displayed in 17 menu pages when this key is pressed. As with all other 9100/CP operations, the **[PAGE]** and **[BACK]** keys must be pressed to move forwards or backwards through the **[VIEW]** pages.

[SHIFT STB] pressing this key causes a status byte condition to be displayed in three lines on the LCD display. Eight menu pages are used to display the eight status bytes.

Terminating (completed) Numeric Entries

To terminate (complete entry of) a numeric entry that is dimensionless, key in the number and then press **[ENTER]**

When units must be changed or added to that number, first key in the number, Next, press **[SHIFT]**, and then the appropriate

units key. As soon as the units key is pressed, entry is completed and [ENTER] need not be pressed.

UNDERSTANDING THE 9100/CP MENUS

Taken together, the lines on a 9100/CP page (or series of pages) comprise a "menu" that tells an operator what information must be understood or what actions must be implemented to use each portion of the system.

In this regard, each line on a page falls into one of six categories. Specifically, a line may be:

- A filename for operator selection (currently selected file indicated by *) (Selection indicated by @).
- An information item for operator reference (values indicated by =).
- A location at which numeric information is entered or modified (indicated by □ cursor).
- A point at which direct action is initiated (indicated by <).
- An entry point for access to a submenu (indicated by : or >).
- A value which can be changed by MORE/LESS (indicated by :)

The display keys ([BACK], [PAGE], [F1], [F2], [F3], and [F4]) are used to access menus or parts of menus. The thirteen keys in the center of the keyboard ([ENTER], [E], [-], [.], the numeric keys, and the units keys) are for entering information required by use of other keys.As their name implies, the action keys ([TGR], [LOCAL], [T.ARM], [GO], [ABORT], [LOAD], [NEXT], [LINK], [SEQ], [LEARN] and [SETUP]) initiate actions, for the most part without use of menu listings.

Information Menus

Pressing the [STATUS], [ACTIVE], [COMM], [VIEW], or [STB] key has no effect on the operation of (or actions imposed on) the Arbitrary Function Generator. These keys display information menus consisting entirely of listings that can be used for reference purposes in taking other action.

Main Menu Selections

The five main menu keys ([FUNC], [CHAN 1], [CHAN 2], [CLOCK] and [TRIG]) use menus and submenus extensively. Pressing any of these keys results in a 4-line listing of different selections categories from which a choice must be made to proceed.

Each line in a main menu listing is accessed or implemented by pressing one of the [F] keys at the top of the keyboard, with [F1] accessing the first line, [F2] the second line, [F3] the

third line, and [F4] the fourth line. So when you press [F3], you access the parameter named by line 3 on the display.

Alternatively, pressing an [F] key may result in display of a submenu from which additional [F] key selection may be required.

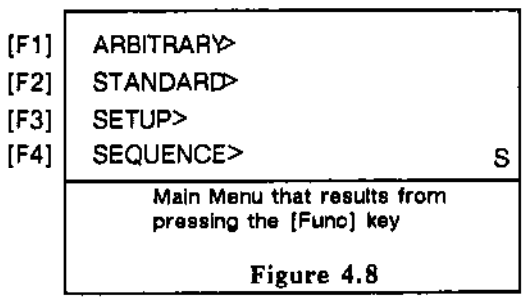


Figure 4.8

Pressing the [FUNC] key, for example, will result in a menu of file types. That menu is shown in Figure 4.8.

Line 1 is ARBITRARY, so pressing [F1] will therefore access a submenu for selection of arbitrary waveforms. Similarly, pressing [F2] will access a submenu for selection of standard waveforms, [F3] for setup files, and [F4] for sequence files.

In other instances, [F] key selections allow you to look up current parameter settings and then to change those settings as required. An example of this can be seen by pressing the [CLOCK] key, an action which produces a main menu listing in which line 1 is clock rate, line 2 is clock period, line 3 is threshold level for an external clock source, and line 4 is a selection of internal or external source.

The special symbols <, :, and □ (cursor) act as question prompts as shown in Table 4.1.

Table 4.1
Special 9100/CP Display Symbols

>	means go to next submenu for this function using appropriate [F] key
<	means use [F] key to do this function or toggle value
:	means value or parameter shown is current value which may be changed by either more/less or accessing the next menu
*	means that a particular file is currently selected
#	means that there are additional submenus or displays at this menu level
R	means running. The 9100 is active either because a waveform is being output or a sequence or setup file is in process
S	means stopped. No wave output or no sequence or setup in process
W	means wait for trigger. When this symbol appears after the name of a waveform segment in a listing of the contents of control memory, it means that the generator will wait for a trigger before outputting that segment.
□	the cursor acts as a prompt for numeric entries

NOTE: Informational messages and error messages generally do not use any special display symbols except = which is used literally.

Toggled Menu Entries

As described above, line 4 of the main menu displayed after pressing [CLOCK] is an immediate action prompt. That line can have one of only two entries: CLOCK SRC< INT (internal clock source) or CLOCK SRC< EXT (external clock source).

The clock source is listed on line 4, so repeatedly pressing the **[F4]** key will "toggle" line 4 from CLOCK SRC< INT to CLOCK SRC< EXT and back again.

Not all such prompts represent INT/EXT toggles. Others include OFF/ON, POS/NEG, and SING/DUAL. Each toggled **[F]** key operation will be described on the following pages.

Parameter/Delta Submenus

Starting with a main menu, pressing an **[F]** key will in many instances result in a parameter/delta submenu for the selection on the line number corresponding to that key. The parameter/delta submenu format is shown in Figure 4.9.

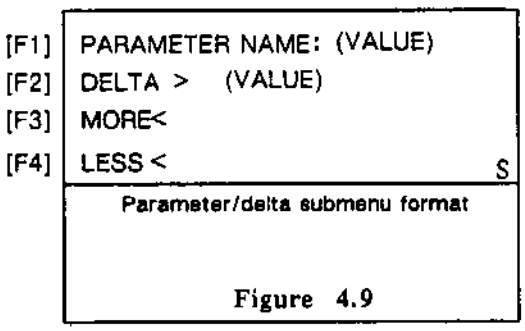
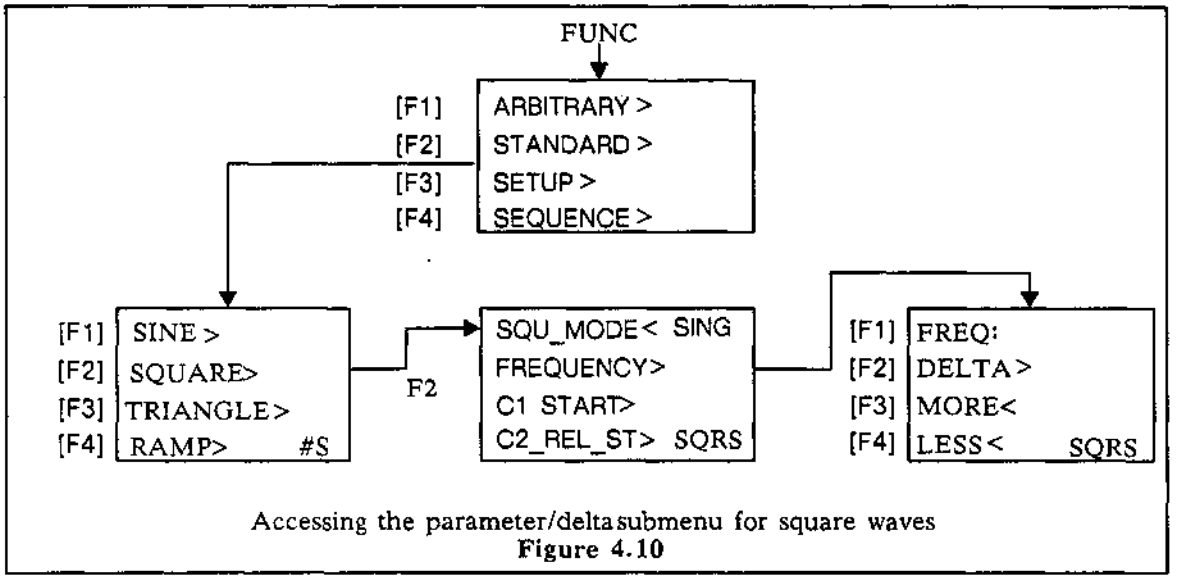


Figure 4.9

Pressing **[F2]** three times after the display in Figure 4.8 appears, for example, will produce a submenu in which the four lines are FREQ, DELTA, MORE, and LESS. The specific parameter in that instance is the frequency of square waves. This is depicted in Figure 4.10.



Accessing the parameter/delta submenu for square waves
Figure 4.10

The operations and displays pertinent to a parameter/delta submenu are summarized in Table 4.2

Table 4.2
Parameter/Delta Submenu Operations

Press	Resulting Screen Display	Explanation
[F1] (PARAMETER NAME)	2-line submenu appears, saying: (PARAMETER NAME)= NEW (PARAMETER NAME) ☐cursor	Current value* of parameter is listed on line. Enter desired new value of parameter by using numeric and units keys if required. An [F] is not necessary to use in this submenu. As you key in your entry, it will appear on line 3. Terminate entry, and parameter/delta menu will reappear showing the new parameter value.**
[F2] (DELTA)	2-line submenu appears, saying: DELTA= NEW DELTA ☐cursor	Current delta* is displayed on line 1. Enter desired new delta by using numeric keys (F key required). As you key in the new delta, it will appear on line 3. Terminate entry, and parameter/delta menu will reappear showing the new delta.**
[F3] (MORE)	Parameter/delta menu remains on screen and is updated.	Increments line 1 parameter value upwards by the absolute value of delta.
[F4] (LESS)	Parameter/delta menu remains on screen and is updated.	Increments line 1 parameter value downwards by the absolute value of delta.

NOTE: * *Present value is the value most recently entered. This will be the default value if no setup file has been initiated and if no other values have been entered.*

** *See section earlier in this chapter for instructions on Terminating Numeric Entries (page 4-10)*

To illustrate the use of Table 4.2, press **[SHIFT]** and then **[RESET]**. This will restore the instrument to its power-up state, and in the process restore all parameters to default values.

After you press **[RESET]**, the screen will prompt, "are your sure". Pressing the **[F3]** (yes) response will cause the screen to blank, after which the screen shown in Figure 4.2 will appear. Press **[CHAN 1]** when that happens, and the first page of the Channel 1 main menu will appear, Figure 4.11.

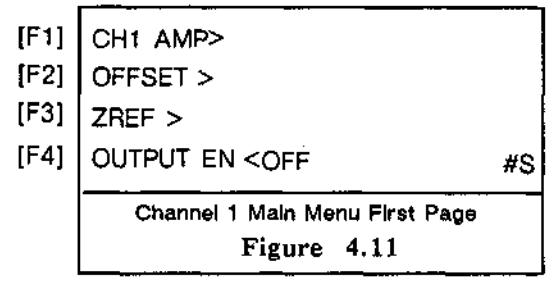


Figure 4.11

To determine the current value of amplitude settings, you have to access line 1, where C1 AMP stands for Channel 1 amplitude. Pressing **[F1]** when Figure 4.11 is displayed will result in the screen changing to the parameter/delta submenu shown in Figure 4.12.

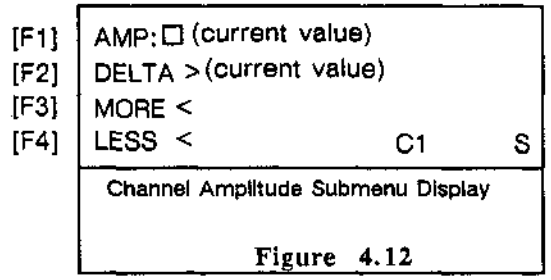


Figure 4.12

Note the cursor before the value. A new amplitude value can be entered simply by entering the new first digit. The menu of Figure 4.13 will be deployed and the rest of the new value can be entered.

In this figure, AMP is set to its default condition of 1.0 V. If that amplitude is acceptable press **[BACK]** and the first page of the Channel 1 main menu will appear as shown in Figure 4.11.

Changing Amplitude Value

Pressing **[F1]** with the screen of Figure 4.12 displayed, will change the screen to that shown in Figure 4.13. *Note that no [F] keys are used in this* menu, the cursor shows the position of number to be entered.

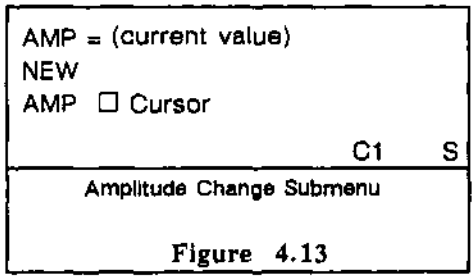


Figure 4.13

The current amplitude is shown on line 1. The default (power-up) level of amplitude is 1.000 V. To change amplitude to 2 V, press the **[2]** key. "2" appears after the "NEW AMP" header. Press **[ENTER]**, and the original AMP/DELTA/MORE/LESS menu is again displayed, this time with the top line showing an amplitude of 2.000 V.

Another way to change amplitude is to use the MORE and LESS functions.The delta (default level 100 mV) is the amount by which you can increment the amplitude up or down by pressing **[F3]** (MORE) or **[F4]** (LESS).

If amplitude is 2.0 V and delta is 0.5 V, pressing **[F3]** will increase the amplitude to 2.5 V, while pressing **[F4]** once after that would decrease the amplitude back to 2.0 V. Within the 0 to 10 V range of the instrument, **[F3]** and **[F4]** can be pressed in any sequence as many times as need be to achieve a desired C1 AMP.

If an increment of 0.1 V is unsatisfactory, however, press **[F2]** when Figure 4.12 is displayed. The screen view will then change to that shown in Figure 4.14. Note that no [F] key is used in this submenu. The numeric keys are used to enter a new value, if desired.

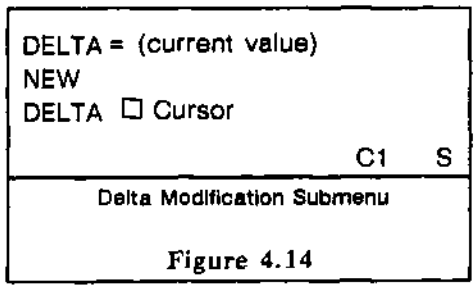


Figure 4.14

A new delta can be entered here, in the same manner as amplitude could be changed with the AMP/NEW AMP

submenu. As the revised delta is keyed in, it will appear immediately to the right of NEW DELTA. Press [ENTER] to terminate and the AMP/DELTA/MORE/LESS screen will again appear, this time showing the new delta.

By using the AMP/NEW AMP method and/or the delta method, channel amplitude can be easily changed and set. Or, progressing through the submenu layers may show that some parameters are acceptable at their current values, in which case new values need not be entered.

ENTRY CHANGES

The 9100/CP offers several means for changing entries or correcting entries that have been inadvertently made in error. Specifically,

Changes Made After Waveform Execution has Commenced

A waveform being executed can be stopped by pressing [SHIFT] and then [ABORT]. Waveform execution will cease. After that the keyboard can be used again to re-select a waveform and/or to re-enter desired parameters. Except for disconnecting the output and turning off the WAVEFORM ACTIVE LED, ABORT does not affect any attribute or files.

Changes Made Prior to Execution of a Waveform

The Model 9100 executes only waveform files that are loaded into high speed memory with currently selected waveform attributes. Waveforms may be loaded and attributes changed at any time prior to execution (i.e., "GO;"). Examples are as follows:

- The waveform can be re-selected so that a different waveform is chosen, loaded into high speed memory, and executed.
- Any individual attribute can be changed by accessing the proper main menu (CHAN 1, CHAN 2, CLOCK, or TRIG keys) and entering a new setting for that attribute.
- If a combination of attribute settings are stored as a setup file and initiated (put into effect), those settings will become the Model 9100's current settings. A new combination of settings can, however, be made current simply by initiating a different setup file.
- Alternatively, any setting made current by use of a setup file can be changed to a more current setting merely by accessing the proper menu line and changing the setting accordingly.
- If a waveform is loaded into high speed memory, another waveform can become the currently loaded waveform if the

loading process is repeated with the second waveform before the GO command is given to execute

- Additional waveforms can be linked to any currently loaded waveform as explained below.

Changes Made Prior to Completion of a Numeric Entry

If a number has been keyed in or partially keyed in, but **[ENTER]** or a units key has not yet been pressed, that number can be "erased" by pressing **[SHIFT]** and **[CE]**. Then, the number can be re-entered as desired.

Eliminating Arbitrary Waveform, Setup, and Sequence Files from RAM Disk Memory

As shown in Figure 4.8, pressing **[FUNC]** results in a main menu that enables selection of arbitrary waveform files, standard waveforms, setup files, and sequence files. Any arbitrary waveform, setup, or sequence file can be deleted from RAM disk memory by a four step process:

- Press **[FUNC]** and then the **[F]** key corresponding to the type of file to be deleted (**[F1]** for arbitrary waveforms, **[F3]** for setup files, and **[F4]** for sequence files).
- Press the **[F]** key corresponding to the line on which the file to be deleted is shown. An @ symbol will then appear to the right of that line.
- Press **[SHIFT]** and then **[DELETE]**. The menu of Figure 4.15 will appear.

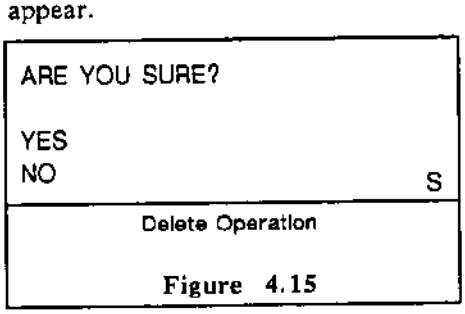


Figure 4.15

- Pressing **[F3]** will cause the selected file to disappear from the screen listing and no longer be in RAM disk memory. Pressing **[F4]** avoids the delete operation, unmarks the waveform file and returns to the previous screen.

Changing all Attribute Settings to Default Conditions

Pressing **[SHIFT]** and then **[RESET]** will cause the menu of Figure 4.15 to appear. A yes response will cause all 9100 settings to revert to default conditions.

Changes that Cannot be Made with the 9100/CP

The 9100/CP *cannot* make the following changes:

- Altering the contents of a waveform file
- Altering the contents of a sequence file
- Altering the contents of a setup file.

NOTE: The 9100/CP can, however, store new setup files in memory (LEARN). Accordingly, if a setup file needs be changed, a new setup file can be created and LEARNed. The original setup file can then be deleted, if desired, as described above.

- Change one waveform file in a linked series of waveform files without re-loading and re-linking every waveform file in the chain.

CONTROLLING THE ARBITRARY FUNCTION GENERATOR WITH THE 9100/CP

Steps to be Taken in Executing Waveforms

When controlling the Model 9100 with the 9100/CP, waveform execution is accomplished in four steps: waveform selection, loading the waveform into high speed memory, specification of waveform attributes and trigger parameters, and execution.

Selection: The 9100/CP, by means of the menus accessed by pressing its **[FUNC]** key, can select from any of six standard waveforms, or from arbitrary waveforms downloaded to the Model 9100's RAM disk memory. The 9100/CP *cannot* be used to create arbitrary waveforms. Nor can it be used to command the Model 9100 to replicate waveforms measured from other sources by LeCroy oscilloscopes. These operations can, however, be performed from a computer using EASYWAVE software.

Loading and Linking the

Waveform into High Speed Memory: Just because a waveform is selected does not mean it is executed. First, it must be loaded into high speed memory. Pressing the **[LOAD]** key loads an arbitrary waveform that has been selected. Standard waveforms are automatically loaded when they are selected.

Arbitrary waveforms can also be chained together. Pressing the **[LINK]** key will link an arbitrary waveform to arbitrary waveforms that are already loaded or linked.

NOTE: To enter a link with "wait" command from the 9100/CP hand-held control panel, press the TRIG button instead of the ENTER button after entering the number of segment repetitions for LINK. This appends the "wait" argument to the LINK command from the 9100/CP.

Specification of Waveform Attributes and Trigger Parameters: The **[CHAN 1]**, **[CHAN 2]**, **[Clock]**, and **[Trig]** keys access menus that control the waveform amplitude, timebase, and trigger commands.

The net effect of those four keys is to define what is called the waveform setup. A setup can be "learned" (stored in memory) by the **[Learn]** key on the 9100/CP and implemented by the **[Setup]** key, which can also implement setups downloaded by EASYWAVE, GPIB, or RS-232 operation.

In addition, the **[Seq]** key can be pressed to access and implement sequences; files of GPIB commands that are downloaded to the Model 9100 via computer control.

Executing Loaded and Linked Waveforms: Executing is accomplished by pressing the [GO] key. Execution can be aborted by pressing the [ABORT] key.

Details of these steps are covered below.

Selecting an Arbitrary Waveform

Pressing the [FUNC] key causes the menu shown below to be displayed.

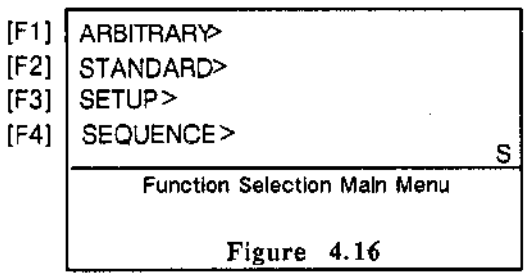


Figure 4.16

Selecting an Arbitrary (User-Designed) Waveform Stored in Memory:

If previously downloaded to RAM disk storage memory via the GPIB or RS-232 bus, an ARBITRARY waveform can be accessed by first accessing the function selection main menu shown in the above figure, and then pressing [F1]. This will cause a 4-line submenu to appear, as shown below.

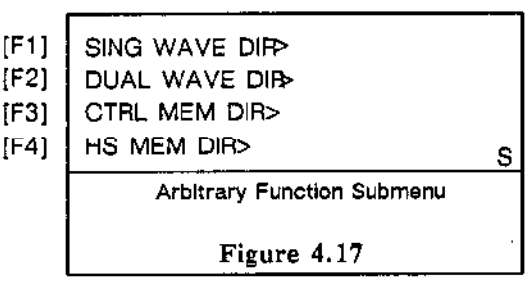


Figure 4.17

Pressing [F1] here will present a listing of the file names for all the single waveforms stored in RAM memory. If [F2] were pressed, however, the dual waveform names would be displayed. File names are a combination of as many as eight user-selected letters and numbers, followed by .WAV for single waveforms, or .WAD for dual waveforms.

If no files are stored in any of these categories, the screen will so indicate. For example, if no single arbitrary waveforms are in

memory and [F1] is pressed when Figure 4.17 is displayed, the screen will show NO .WAV FILES.

If single waveform files *are* in RAM memory, pressing [F1] when Figure 4.17 is displayed will bring up a single waveform listing similar to that shown in Figure 4.18.

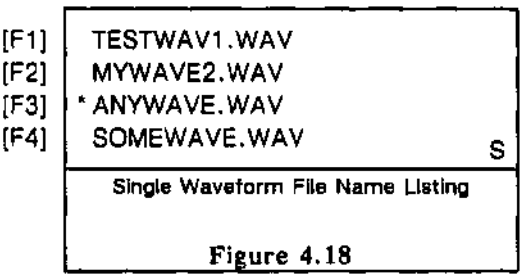


Figure 4.18

The symbol * indicates that ANYWAVE.WAV is the currently selected file.

If the MYWAVE2.WAV waveform were desired here, [F2] would be pressed and @ would appear to the right of the second line on the screen.

To select a dual waveform that has been downloaded into RAM memory, press [F2] when Figure 4.17 is displayed. Otherwise, the procedure is exactly as described above.

Finding Number of Repetitions

Pressing [F3] when Figure 4.17 is displayed will cause a display similar to Figure 4.19, where the segment names are those currently loaded and linked in the Control Memory (CM). The numbers indicate the number of repetitions for each waveform. This display is information only and no action is required.

A "W" at the end of a segment's Control Memory listing indicates that the given segment was loaded or linked with the "wait" option, and that the generator will wait until a trigger (or, in recurrent trigger mode, a re-trigger) is received before outputting the segment in question.

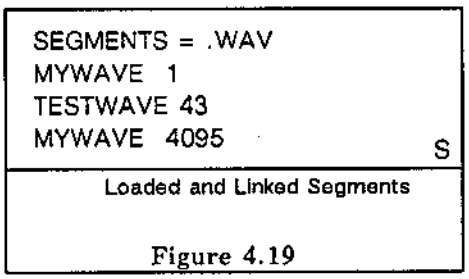


Figure 4.19

Checking Controls of HS Memory

Pressing **[F4]** when Figure 4.17 is displayed will cause a display similar to Figure 4.20 where the file names shown are those actually present in High Speed Memory (HSM). Referring to Figure 4.20, note that MYWAVE.WAV is loaded into HSM only once, even though it is referenced more than once by the Control Memory (CM). This display is information only and no action is required.

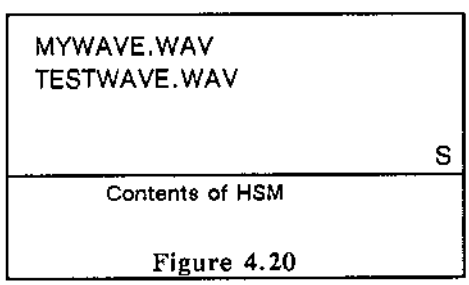


Figure 4.20

Selecting a Standard Waveform

A standard waveform is selected by first accessing the Function Selection Main Menu shown in Figure 4.16, and then pressing [F2] (STANDARD). This will cause the first of two pages in the Standard Function Sub Menu to be displayed, Figure 4.21.

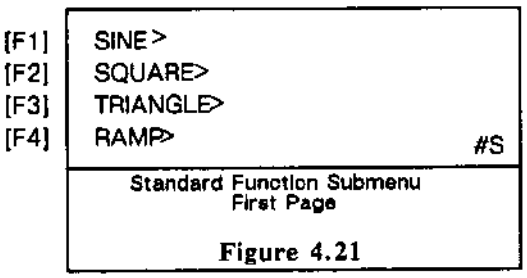


Figure 4.21

Where:

SINE> **[F1]** selects a submenu from which the attributes of the standard sine function can be selected.

SQUARE> **[F2]** selects a submenu from which the attributes of the standard square function can be selected.

TRIANGLE> **[F3]** selects a submenu from which the attributes of the standard triangle function can be selected.

RAMP> **[F4]** selects a submenu from which the attributes of the standard ramp function can be selected.

Press **[PAGE]** and the second page of the Standard Function Submenu will be displayed, Figure 4.22.

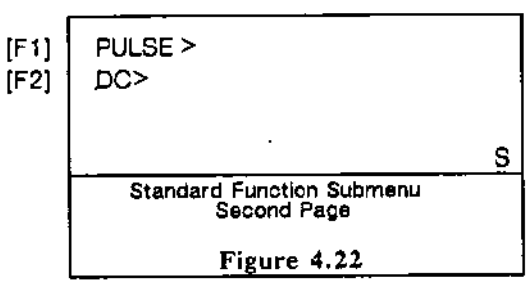


Figure 4.22

Where:

PULSE> **[F1]** selects a submenu from which the attributes of the standard pulse function can be selected.

DC> **[F2]** selects a submenu from which the attributes of the standard DC function can be selected.

NOTE: Once the submenu for a particular standard function has been selected, output of that function may be activated by pressing [GO]. Once the function is active, any change by the user in the attribute submenu for that function will be immediately reflected in the output of the 9100 AFG.

Selecting Attributes Of The Standard Sine Function

When [F1] (SINE) is selected on the Standard Function Submenu, the Standard Sine Attribute Submenu is displayed, Figure 4.23.

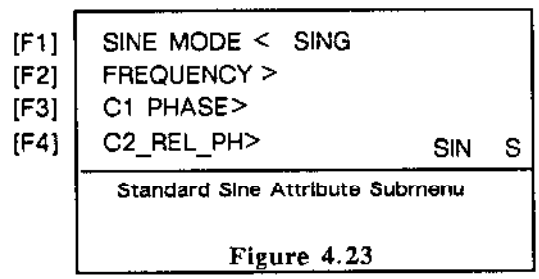


Figure 4.23

Where:

SINE_MODE< [F1] selects whether the sine function is to be output as a SINGLE (SING) or DUAL waveform. The SINGLE waveform is output on Channel 1 only, the DUAL waveform on both Channels 1 and 2.

FREQUENCY> [F2] selects a submenu from which the frequency of the generated sine wave may be set. In SINGLE mode the allowed frequency range is 0.010 – 25.0E+6 Hz; in DUAL mode the allowed range is 0.010 – 25.0E+6 Hz (both channels have the same frequency). Units can be Hz, kHz, or MHz.

C1 PHASE> [F3] selects a submenu from which the start phase of the Channel 1 sine waveform may be set in degrees from 0.0 – 360. If SINE_MODE is dual Channel 2's start phase will be identical to Channel 1's unless further action is taken.

C2 REL PH> [F4] selects a submenu from which the start phase of the Channel 2 sine waveform relative to the Channel 1 waveform may be set in degrees from 0.0 – 360. Note that Channel 2 leads Channel 1 by the number of degrees specified. C2 REL PH has no meaning in SINE_MODE SINGLE.

Selecting Attributes Of The Standard Square Function

WHEN [F2] (SQUARE) is selected on the Standard Function Submenu, the Standard Square Attribute Submenu is displayed, Figure 4.24.

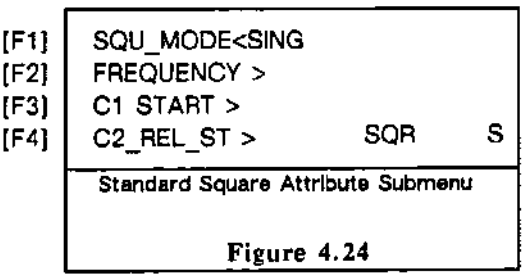


Figure 4.24

Where:

SQU_MODE< **[F1]** selects single or dual channel square wave generation.

FREQUENCY **[F2]** selects a submenu from which the frequency of the generated square wave may be set from 0.01 to 100.0E+6Hz in single mode, 0.01 to 50.0E+6Hz in dual mode. Units can be Hz, kHz, or MHz.

C1 START **[F3]** selects a submenu from which the start time of the waveform may be set. The allowed range is from 0.0 to the currently set period of the square wave.

C2_REL_ST **[F4]** selects a submenu from which the start time of the channel 2 output relative to the channel 1 output may be set.

The allowed range is from 0.0 to the currently set period. This attribute has no meaning for single channel operating mode.

Selecting Attributes Of The Standard Triangle Function

WHEN **[F3]** (TRIANGLE) is selected on the Standard Function Submenu, the Standard Triangle Attribute Submenu is displayed, Figure 4.25.

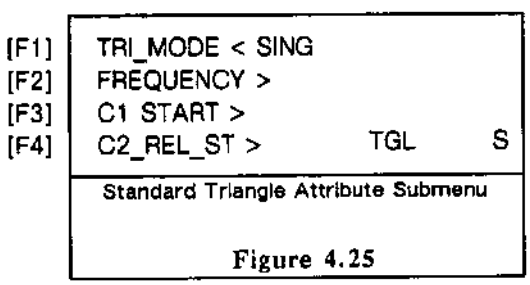


Figure 4.25

Where:

TRI_MODE [F1] selects either a single or dual triangle waveform.

FREQUENCY> [F2] selects a submenu from which the frequency of the generated triangle wave may be set from 0.010 to 25.0E+6 Hz. Units can be Hz, kHz, or MHz.

C1_START> [F3] selects a submenu from which the start time of the waveform may be set. The start time is set not in degrees but in time; the allowed range is 0.0 to the current PERIOD of the triangle wave.

C2_REL_ST> [F4] selects a submenu from which the relative start time of CH2 can be set from 0 to PERIOD for a dual wave.

Selecting Attributes Of The Standard Ramp Function

WHEN [F3] (RAMP) is selected on the Standard Function Submenu, the Standard Ramp Attribute Submenu is displayed, Figure 4.26.

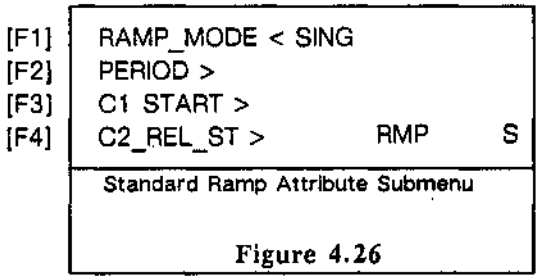


Figure 4.26

Where:

RAMP_MODE< [F1] selects either a single or dual ramp waveform.

PERIOD> [F2] selects a submenu from which the period of the generated ramp wave may be set from 40.0 nsec to 100.0 sec. Units can be nsec, µsec, msec, sec.

C1 START> [F3] selects a submenu from which the start time of the waveform may be set. The start time is set not in degrees but in time; the allowed range is 0.0 to the current PERIOD of the ramp wave.

C2_REL_ST [F4] selects a submenu from which the relative start time of CH2 in dual mode can be set to 0.0 to PERIOD.

Selecting Attributes Of The Standard Pulse Function

WHEN [F1] (PULSE) is selected on the second page of the Standard Function Submenu, the Standard Pulse Attribute Submenu is displayed, Figure 4.27.

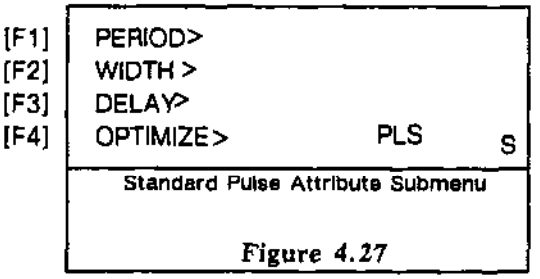


Figure 4.27

Where:

PERIOD> [F1] selects a submenu from which the period of the generated pulse wave may be set from 40.0 nsec to 10.0 sec. Units can be nsec, µsec, msec, sec.

WIDTH> [F2] selects a submenu from which the width of the generated pulse (the duration of the high part of the pulse waveform) may be set from 5.0 nsec to PERIOD. Units can be *nsec, µsec, msec, sec.*

DELAY> [F3] selects a submenu which allows the setting of the delay in time from the receipt of a trigger to the start of the pulse waveform (the first rising edge). The allowed range is 25.0 nsec to 5.0 msec in single or burst trigger mode, and 85.0 nsec to 5.0 msec in recurrent trigger mode. The DELAY has no meaning in continuous or gated trigger modes. Units can be nsec, µsec, msec, sec.

NOTE: In the standard pulse function the trigger delay must be set using this submenu and not the TRIG DELAY submenu located in the Trigger Main Menu.

OPTIMIZE> [F4] selects a submenu which allows the user to specify whether the pulse function is to be generated so as to achieve highest accuracy on the pulse WIDTH (WID), PERIOD (PER), or DELAY (DEL) attribute.

Selecting Attributes Of The Standard DC Function

When [F2] (DC) is selected on the second page of the Standard Function Submenu, the Standard DC Attribute Submenu is displayed, Figure 4.28.

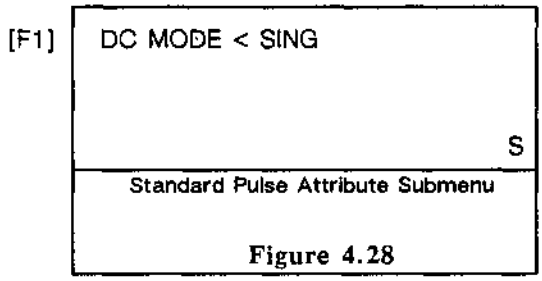


Figure 4.28

Where:

DC_MODE< **[F1]** selects whether the DC function is to be output as a SINGLE (SING) or DUAL waveform. The SINGLE waveform is output on Channel 1 only, the DUAL waveform on both Channels 1 and 2.

NOTE: The standard DC waveform is loaded with a DAC code of 128 which is centered between the 0 to 255 amplitude limits. If the channel's Zref is also 128, then the OFFSET voltage is exactly the Output voltage of the standard DC mode. If Zref is not 128 (default Zref=127.5) then the level of the DC signal will be affected by both AMPLITUDE and OFFSET changes.

Channel 1 Waveform Attribute Menus

Pressing the **[CHAN 1]** key on the 9100/CP will result in display of the first of three pages in the Channel 1 main menu, Figure 4.29.

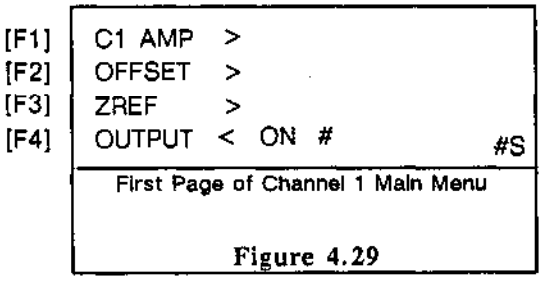


Figure 4.29

Where:

C1 AMP > **[F1]** selects the next submenu

which allows setting the amplitude of the Channel 1 waveform in units of mV or V. Range is 10 V p-p with 50 Ω termination, 20 V p-p open circuit. Minimum amplitude is 5 mV into 50 Ω, 10 mV open circuit.

OFFSET > **[F2]** selects the next submenu which allows setting the Channel 1 DC offset level from -5 V to +5 V in units of mV or V.

ZREF > **[F3]** selects the next submenu which allows specification of the zero reference in floating point values from 0 to 255.

OUTPUT < **[F4]** selects the function used to determine whether channel signal output is on or off. This is a toggle.

If **[PAGE]** is pressed when the screen shown in Figure 4.29 is displayed, the second page of the Channel 1 main menu will appear on the screen as shown in Figure 4.30.

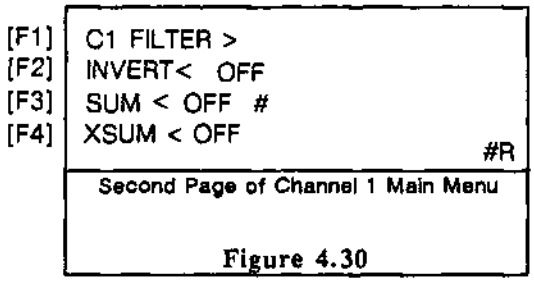


Figure 4.30

Where:

FILTER > **[F1]** selects the next submenu which allows selection of filters from 1 to 100 MHz in 1,3 steps or the filters may be selected OFF by using the **[F2]** key on the filter menu.

INVERT > **[F2]** selects the function which inverts the Channel 1 waveform. **[F2]** toggles this line from OFF to ON (inverted) and back again. The zero reference value is automatically adjusted by the invert command.

SUM > **[F3]** selects the function which sums the Channel 2 signal into the Channel 1 signal and disconnects the Channel 2 signal from its output. Repeatedly pressing **[F3]** when Figure 4.30 is displayed will cause the SUM line to switch from OFF to ON and back again. ON results in the Channel 2 waveform being summed into the Channel 1 waveform.

XSUM > **[F4]** selects the External Sum input on the front panel and enables or disables it.

With the second page of the Channel 1 main menu on display (Figure 4.30), pressing **[Page]** again will cause the third and last page of that menu to appear on the screen, Figure 4.31.

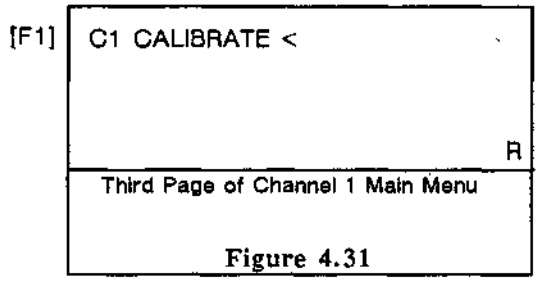


Figure 4.31

Pressing **[F1]** when this menu page is displayed results in automatic calibration of the amplitude and offset conditions in the Model 9100. The screen display will change to say CALIBRATION IN PROCESS and the 9100/CP will be locked out of operation until the calibration is complete, when the screen will again change to say CALIBRATION COMPLETE. At that point, pressing any key will cause the 9100/CP and the Model 9100 to function in accordance with the command inherent in that key.

[F2] [F3] [F4] are not used in this page of the Channel 1 main menu.

As shown above, the Channel 1 main menu has a total of nine parameters. Of those, four (OUTPUT, INVERT, SUM and XSUM) are [F] key toggled, while one (CALIBRATE) results in a direct action.

Three of the remaining four parameters (C1 AMP, OFFSET, ZREF) are controlled via parameter–delta submenus. In each case, accessing the parameter–delta submenu will display the current or default value of the parameter, and changes can be made in that value by direct entry or by use of the MORE and LESS prompts.

When Figure 4.30 is displayed, pressing **[F1]** will access the filter submenu, which is similar (but not identical) to a parameter–delta submenu.

The filter submenu has an ON/OFF toggle, allowing **[F2]** to shut the filter off. **[F3]** and **[F4]** represent prompts for MORE and LESS, but the filter control has no delta. This is because the filters in the 9100 are in fixed increments; 1 MHz to 100 MHz in 1,3 steps.

Accordingly, if the filter is set at 1 MHz, pressing [F3] (MORE) will change the setting to 3 MHz, then 10 MHz, 30 MHz, 100 MHz and (finally) off (which is displayed as O). Pressing [LESS] however, will step the filter value through the same sequence in reverse.

Any value can be entered in the screen that says FILTER NEW FILTER, but the instrument will automatically select the next higher bandwidth of the five filters between 1 MHz and 100 MHz. Entering 15 MHz, for example, will result in the 9100 acting as if 30 MHz was entered.

Channel 2 Waveform Attribute Menus

To access the Channel 2 main menu, press the [CHAN 2] key and the first page of a three page Channel 2 main menu will appear on the 9100/CP screen.

The Channel 2 main menu allows setting of amplitude, offset, filter, output, Z reference, and invert commands for Channel 2 independent of the settings for Channel 1.

The Channel 2 main menu is with one exception identical in form and use to the Channel 1 main menu described above. That exception is that there is no SUM command or XSUM (external sum command) in the Channel 2 main menu; to sum Channel 2 into Channel 1, or use XSUM, use the Channel 1 main menu.

Controlling The Timebase

When the [CLOCK] key is pressed, the first of two timebase main menu pages appears on screen, Figure 4.32.

NOTE: If standard functions have been selected then the message: "No clock control standard function in process" will appear. All clock control in standard function is via the standard function frequency or period selections.

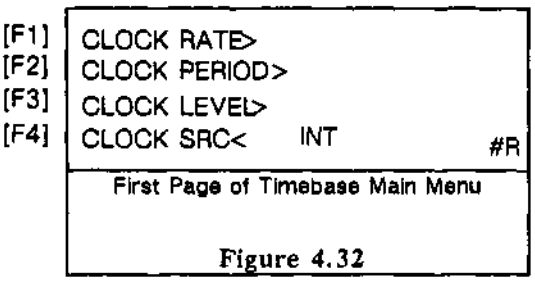


Figure 4.32

Where:

CLOCK RATE > [F1] selects the next submenu which allows setting of internal clock repetition rate from0.05 Hz to 200 MHz. Units can be Hz, kHz, or MHz.

CLOCK PERIOD > [F2] selects the next submenu which allows setting of the internal clock period from 5 nsec to 10 seconds. Units can be nsec, µsec, msec, or sec.

NOTE: Although the 9100/CP displays the above parameters with only 4 digits of precision, up to 9 digits can be entered (8 if a decimal point is used). The entire number entered is transferred to the AFG, and the timebase is adjusted to a point as close to that as is possible, even though the CP only displays the 4 most significant digits.

CLOCK LEVEL > [F3] selects the next submenu which allows setting of the threshold detection level if an external clock is used. Can be set from –2.5 V to +2.5 V with three digits of resolution.

CLOCK SRC < [F4] selects the function which toggles between an internal or external clock source.

NOTE: When the internal clock is used, the user does not have to set both clock rate and clock period. One is the inverse of the other, and changing either one will automatically adjust the other accordingly. Selection of which to use is subject solely to user preference.

Press [PAGE] when Figure 4.32 is shown, and the second page of the timebase main menu will appear, Figure 4.33.

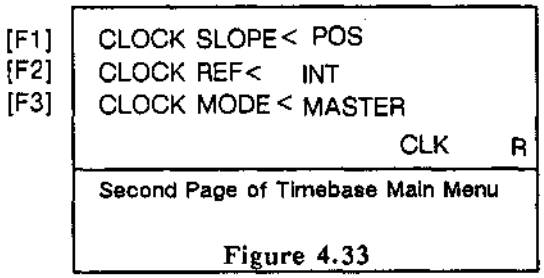


Figure 4.33

Where:

CLOCK SLOPE < [F1] is used to specify which edge of an externally applied clock signal will cause transitions of the analog output.

The default is the positive edge and the [F1] key acts as a toggle.

CLOCK REF < [F2] determines the source of the 4 MHz reference signal required by the AFG's phase-lock loop. The default is the internal 4 MHz crystal (INT). The [F2] key toggles the selected source to the rear-panel CLOCK IN REF connector (EXT).

CLOCK MODE < [F3] is used to select master or slave clock operating mode. Master mode is the default setting.

CLOCK_MODE,SLAVE is used to synchronize one 9100 Series AFG to another.The unit placed in SLAVE mode uses the signal on the CLOCK IN (EXT) rear panel BNC connector as its clock. This signal is assumed to come from the CLOCK OUT 2 rear panel BNC connector of another 9100 which is in CLOCK MODE MASTER.

NOTE: CLOCK OUT 1 provides continuous output at the clock frequency. Only CLOCK OUT 2 is suitable for MASTER/SLAVE operation.

Upon entering slave mode, CLOCK SOURCE defaults to EXTERNAL, CLOCK SLOPE defaults to positive, and CLOCK LEVEL defaults to -200 mV. The previous settings are restored upon receipt of a CLOCK MODE, MASTER command. While in slave mode, the CLOCK SOURCE and CLOCK SLOPE cannot be changed. CLOCK LEVEL can be changed. Also, while a unit is in slave mode, TRIGGER MODE settings have no effect. The trigger delay is controlled by the absence of clock pulses from the master 9100. Trigger settings entered while in SLAVE mode will correctly take effect when the clock mode is changed to MASTER. Other commands that have no effect in SLAVE mode are: CRAT, CPER, MDEL, DMOD.

To use two 9100's in master/slave operation, do the following:

1. Set one of the 9100's to clock mode slave and connect a cable from the master's CLOCK OUT 2 to the slave's CLOCK IN (EXT).
2. LOAD and LINK the desired waveforms on both 9100s.
3. Issue "GO;" to the slave.
4. Issue "GO;" to the master.

NOTE: Steps 3 and 4 must be done in that order. Any time the master aborts waveform generation, whether because of an ABORT command or because of a change of trigger settings, etc., both master and slave must be aborted and GO's issued in the proper order. Failure to issue GO to the slave first while the master is still stopped will result in loss of synchronization.

The START, SYNC and MARKER outputs of the master unit may be used, those of the slave unit are disabled.

Of the six parameters in the timebase main menu, four are toggled:

- Pressing [F4] on the first page of the menu toggles the CLOCK SRC from INT (internal) to EXT (external) and back again.
- Pressing [F1] on the second page of the menu toggles the external clock slope from POS (positive) to NEG (negative) and back again.
- Pressing [F2] on the second page of the menu toggles the clock reference from INT (internal) to EXT (external) and back again.
- Pressing [F3] on the second page of the menu toggles CLOCK MODE from MASTER to SLAVE and back again.

NOTE: When the clock source is internal, only CLOCK RATE or CLOCK PERIOD need be specified; clock level and slope have no meaning and need not be used with the internal clock.

When the clock source is external, however, only CLOCK LEVEL and CLOCK SLOPE need be specified. The rate or period of an external clock cannot be controlled from the 9100/CP, so the first two lines of Figure 4.32 can be disregarded if the clock source is set to EXT.

CLOCK RATE, CLOCK PERIOD, and CLOCK LEVEL are specified using parameter–delta submenus.

The CLOCK menu on the 9100/CP (hand–held control panel) is blocked while the 9100 is generating one of its standard functions. This is because the 9100 automatically sets the clock rate for standard functions. However, since the menu is entirely blocked, it is not possible to change CLOCK SOURCE, CLOCK SLOPE or CLOCK REFERENCE from the 9100/CP while executing a standard function. To change either of these items while a standard function is being generated, press: [FUNCTION], ARBITRARY, [CLOCK] and change the desired items (threshold level and slope selection for external clock should also be made at this time), then press [FUNCTION], [F2] (STANDARD), re–select the desired standard function, and press [GO]. Frequency information presented on the standard function submenus will be incorrect if the external clock source is selected, but requesting a lower frequency can add more points to the waveform. The point output rate will be equal to the external clock's frequency for single channel functions, half the clock rate for dual channel.

Trigger Control with the 9100/CP

Complete details on the Model 9100's triggering and trigger control capabilities are found in Chapter 2. For ease of

reference, the instrument's trigger modes, trigger sources, trigger arm modes, and trigger delays are summarized below.

Table 4.3
Trigger Modes, Arm Modes, Sources and Delay Capabilities

Trigger Mode	Description of Resultant Waveform	Trigger Source	Trigger Arm Source	User-Specified delay between trigger receipt and waveform start
CONTINUOUS	Continuous	Internal (Implicit with GO)	Automatic; Implicit with GO	No
RECURRENT	Executes N Repeats		(Does not have to be selected or implemented by user	8 clock cycles to 1 million clock cycles
SINGLE	Executes Once	Manual, Bus, or External Analog	AUTO or BUS	2 clock cycles to 1 million clock cycles (plus a minimum of 10 cycles reset time if in AUTO arm)
BURST	Execute N Repeats			
GATED	Continuous as long as trigger signal level is above user-selected threshold	External Analog	Automatic (Implicit with GO)	2 clock cycles to 1 million clock cycles from the leading edge of the Gate signal.

NOTES: 1. N max = 65,535 in RECURRENT and BURST modes
2. The difference between RECURRENT and BURST is that the former is automatically armed and fired, while the latter can be armed via computer or the 9100/CP, and fired by either an external analog signal, by pushing the trigger button on the front panel of the Model 9100 (manual), by BUS firing (host computer), or by TGR from the 9100/CP.
3. With the 9100/CP, the TRIG key accesses menus that allow choosing trigger mode, trigger source, and trigger arm source.
4. The 9100/CP's T.ARM key can always be used to arm the trigger. It is not affected by Trigger Arm Source Selection.
5. The TRG key on the 9100/CP can always be used to fire the trigger. It is not affected by Trigger Source Selection.
6. The GO key on the 9100/CP is used to execute loaded waveforms.

Trigger Main Menu Control

Press the **[TRIG]** key on the 9100/CP and the first of two trigger main menu screens will come into view, Figure 4.34.

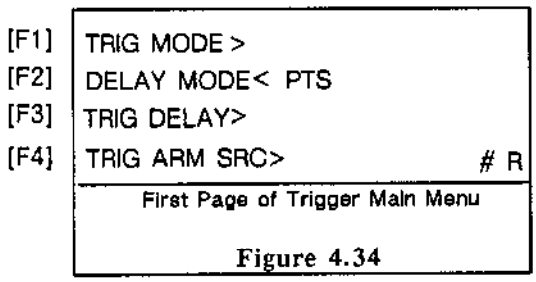


Figure 4.34

Where

TRIG MODE > **[F1]** selects a submenu from which one of the five trigger modes tabulated in Table 4.3 can be selected.

DELAY MODE < **[F2]** selects whether trigger and marker delays are to be specified in POINTS (PTS) or TIME (TIM). Note that when the CLOCK SOURCE is EXTERNAL, the AFG does not know the clock's period and is unable to calculate how many points is equivalent to how much time. Therefore, DELAY MODE, POINTS should be used when CLOCK SOURCE is EXTERNAL.

TRIG DELAY > **[F3]** selects a submenu from which the trigger delay may be entered in the selected Delay Mode (i.e., POINTS or TIME).

TRIG ARM SRC > [F4] selects a submenu which displays the trigger arm source and where it may be toggled between BUS and AUTO.

Press **[PAGE]** and the second page of the trigger main menu will appear as shown in Figure 4.35.

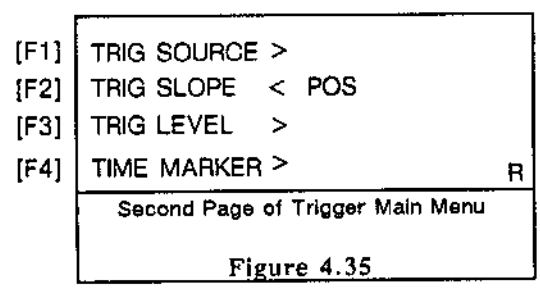


Figure 4.35

TRIG SOURCE > **[F1]** selects a submenu which displays the current trigger source or sources selected

and allows for toggling their condition between ON/OFF. The sources are EXTERNAL, BUS and MANUAL.

TRIG SLOPE < [F2] selects whether the external trigger will fire on the rising (positive) or falling (negative) edge. This command is used only if the trigger mode is SINGLE, BURST, or GATED.

TRIG LEVEL > [F3] selects a submenu which allows setting the threshold level at which an external signal will cause the waveform to start. It can be –2.5 V to +2.5 V with 3 digits of resolution.

TIME MARKER > [F4] controls the time position of the Marker output pulse by setting a delay of up to a million clock cycles (points) between the trigger and the Marker output pulse. Note that if the Marker delay is programmed for a number greater than the sum of the trigger delay and the total number of points that will be output (including segment repetitions, links, and waveform repetitions), no Marker pulse will be generated. Also, at clock rates greater than 10 MHz, the width of the Marker pulse (nominally 75 nsec) may be reduced if it is positioned with 75 nsec of the last point generated.

Arming and Firing the Trigger with the 9100/CP

If the Continuous or Recurrent mode is chosen, a selected waveform that has been LOADed or LINKed will be executed by pressing [GO].

If Gated mode is selected, pressing [GO] will result in execution as long as the external analog trigger signal level is above a user-designated threshold.

In Single or Burst modes with Bus source and Bus Arm mode, trigger firing is user-implemented and occurs after [GO] is pressed. Execution will therefore *not* occur until the trigger is fired.

When Single or Burst mode is selected the 9100/CP can also be used to arm the trigger. This is accomplished by pressing [SHIFT] and the [T.ARM]. Pressing [SHIFT] and [TGR] will cause the trigger to be fired, the screen to say TRIGGERED and the waveform to be executed.

The trigger will be automatically armed when Single or Burst mode is selected with AUTO arming.

WORKING WITH SETUP FILES

A setup file is one that contains all waveform attributes and trigger parameters accessed by the [CHAN 1], [CHAN 2], [CLOCK], and [TRIG] keys of the 9100/CP.

When the **[FUNC]** key is pressed, the function selection main menu appears as shown in Figure 4.36.

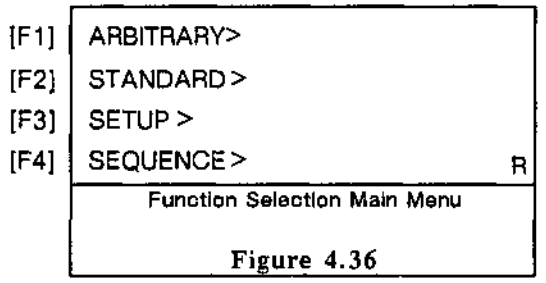


Figure 4.36

Pressing **[F3]** when Figure 4.36 is displayed will cause the 9100/CP's LCD screen to display a listing of all setup files in memory.

If no setup files are stored, the screen will say NO .SET FILES.When setup files are stored, however, each such file is named with up to 8 characters followed by .SET. Any setup file shown in the list can then be selected by pressing the **[F]** key corresponding to the line on which that file is listed. An @ sign will appear to the right of that file as soon as that **[F]** key is pressed.

If **[SHIFT]** and then **[SETUP]** are pressed, the screen view will change to that shown in Figure 4.37.

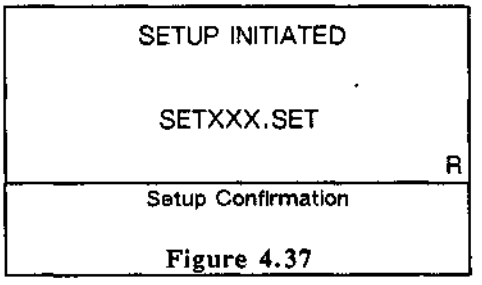


Figure 4.37

Where SETXXX.SET is the name of the selected file.

When Figure 4.37 appears, all commands in the selected file become the current (active) channel, timebase, and trigger commands controlling the Arbitrary Function Generator. Press any key when Figure 4.37 is displayed, and the instrument operation will continue in accordance with the command inherent in that key.

In addition to recalling setup files, the 9100/CP can be used to create them. Whenever the **[LEARN]** key is pressed, the

instrument creates and stores a setup file of all current channel, timebase, and [TRIG] key parameters. Such a file is automatically given the file name SETXXX.SET, where XXX is a number assigned by the AFG.

The [LEARN] key can be pressed at any time, after which the screen on the 9100/CP will change from whatever it was showing to the display in Figure 4.38.

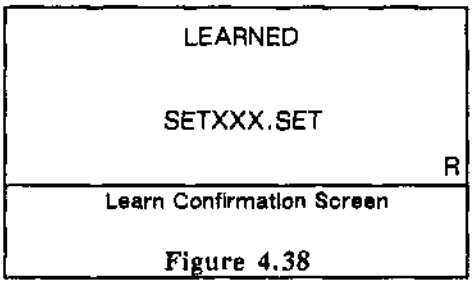


Figure 4.38

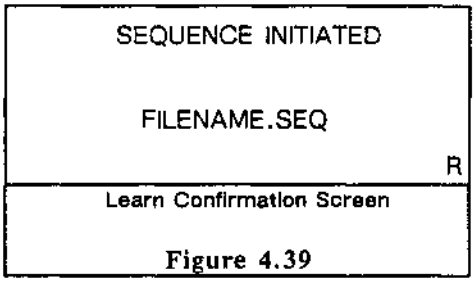
Press any key to continue using the 9100/CP after a LEARN operation. If you press [FUNC], for example, the screen in Figure 4.36 will reappear, and you can then press [F3] to access a list containing the new setup file.

WORKING WITH SEQUENCE FILES

The 9100/CP cannot be used to create or store sequence files. If [F4] is pressed when the function selection main menu (reference Figure 4.36) is displayed, however, the screen will list any sequence files created and stored in the AFG via computer operation. If no sequence files are in memory, the screen will say NO .SEQ FILES.

When one or more sequence files are in memory, however, they will be listed. Any listed sequence file can then be selected by pressing the [F] key corresponding to the line on which that file appears.

To execute a selected sequence file, press [SHIFT] and then [SEQ]. This will result in the screen view shown in Figure 4.39.



Learn Confirmation Screen

Figure 4.39

Where FILENAME.SEQ is the name of the selected file. Pressing any key will enable continued use of the 9100/CP after the screen in Figure 4.39 appears.

The 9100/CP's screen will say WAITING FOR NEXT at any point at which a WAIT is incorporated into a sequence that has been selected and initiated. To continue the sequence, press **[SHIFT]** and then **[NEXT]**. The screen will then say SEQUENCE CONTINUED as the sequence does in fact continue.

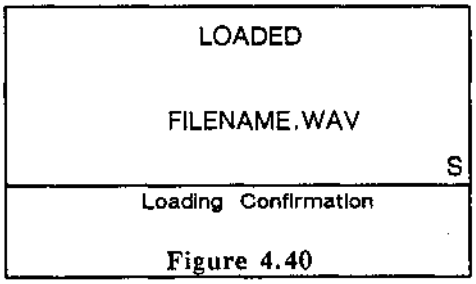
LOADING AND LINKING WAVEFORMS

Arbitrary Waveforms

Once an arbitrary waveform (single or dual) has been selected, it can be loaded into fast memory by pressing the **[LOAD]** key. A prompt on the LCD display will then ask how many repetitions of that waveform are to be loaded. You can respond with any whole number up to 4095.

If you just press **[ENTER]**, the number of repetitions defaults to one. Or, you can press the number keys corresponding to the desired number of repetitions and then press **[ENTER]**.

Once **[ENTER]** is pressed, the 9100/CP's screen will change to the display shown in Figure 4.40.



Loading Confirmation

Figure 4.40

Where "FILENAME" represents whatever name the selected file has, and .WAV indicates that file to be a single arbitrary

waveform. If a dual arbitrary waveform is selected, .WAD would appear instead of .WAV. To continue using the 9100/CP after Figure 4.37 appears, press any key.

After an arbitrary function is loaded into fast memory, another arbitrary waveform may be linked to it. If desired, yet another arbitrary waveform may be linked to that one. Linking can continue until all points in the high speed memory are used up, or the total number of loaded and linked wave segments is 682.

Single arbitrary waveforms, however, can be linked only to other single arbitrary waveforms. Similarly, dual arbitrary waveforms can be linked only to other dual arbitrary waveforms.

To link a selected waveform to waveform(s) already loaded or linked, press **[LINK]**. The LCD screen will ask how many repetitions are desired. As with LOAD, you can default to one repetition and terminate by pressing **[ENTER]**. Also as with LOAD, LINK is confirmed with a screen that names the linked file and tells you that it has been LINKED. Press any other key to continue after that.

The link command accepts an additional argument, WAIT. The purpose of this argument is to permit each trigger to cause output of different waveform segments (in single trigger mode). To enter a link with "wait" command from the 9100/CP hand-held control panel, press the TRIG button instead of the ENTER button after entering the number of segment repetitions for LINK.

The "wait" argument, if present, tells the 9100 Series AFG to wait for trigger before executing this segment. More precisely, it tells the AFG to act as if the entire waveform ended with the segment before this one, and this segment is the first one in the next waveform repetition. See Chapter 3 for details.

NOTE:

1. *Neither loading or linking will occur unless a waveform has first been selected.*
2. *The number of repetitions is the number of times the waveform will be executed.*
3. *The number of repetitions for LOADed or LINKed waveforms if CONTINUOUS or GATED triggering is used controls how many reps occur between START pulses.*
4. *Whenever a waveform is loaded, any waveform that had previously been loaded or linked is cleared from high speed memory.*

Standard Waveforms

Parameters for standard waveforms are automatically loaded as they are entered. Standard waveforms cannot, however, be linked to other standard waveforms or to arbitrary waveforms.

In the event that standard waveform linking is desirable, the AFG must be returned to remote mode where the waveform to be linked can be created as an "arbitrary" waveform. Once created, such a waveform can be linked as described above.

EXECUTING WAVEFORMS

The 9100/CP executes loaded and linked waveforms when the [GO] key is pressed. At that time, the 9100/CP screen will say "R" in the last position of the 4th line to indicate that the waveform has been executed. If a waveform has not been loaded, execution will not occur and the screen will say NO WAVEFORM LOADED. Press the [BACK] key to return to previous screen. Press any other key to continue after execution commences.

ABORTING WAVEFORMS

To stop execution, press [SHIFT] and [ABORT]. The screen will say "S" in the last position of the 4th line and the execution will cease. You can then press any 9100/CP key to continue. Aborting a waveform does not effect any attributes or files, except outputs are disconnected and waveform active LED will extinguish. The waveform can be reinitiated by simply pressing [GO]

ACCESSING THE STATE OF THE ARBITRARY FUNCTION GENERATOR

Identifying Which Files Are Active

If the 9100 Series AFG is executing a single or dual waveform of unknown specifications, the 9100/CP can be used to identify those specifications.

Start by pressing the [VIEW] key. If the first line of the screen that comes into view says FUNC: ARBITRARY, the AFG is executing a single arbitrary waveform, a series of single arbitrary waveforms linked together, or a dual arbitrary waveform.

In the event that FUNC is followed by STANDARD, however, the AFG is in standard waveform mode and no particular standard function has been selected. If a standard function has been selected the first line of the first page of VIEW will show func=SINE, SQUARE, TRIANGLE, RAMP, PULSE or DC.

Determination of arbitrary or standard waveform activity is critical to waveform identification, since the generator cannot execute both waveform types simultaneously.

Identifying Active Arbitrary Waveforms

To identify which arbitrary waveforms are loaded and linked, and to determine which setup files and sequence files are active, press [**SHIFT**] and then [ACTIVE].

The top line will include the name of the first waveform loaded, the next line the name of the first waveform linked (if any are linked), with the next lines naming any other linked waveforms. After waveforms are listed, the subsequent lines will name setup (.SET) and sequence (.SEQ) files that are active.

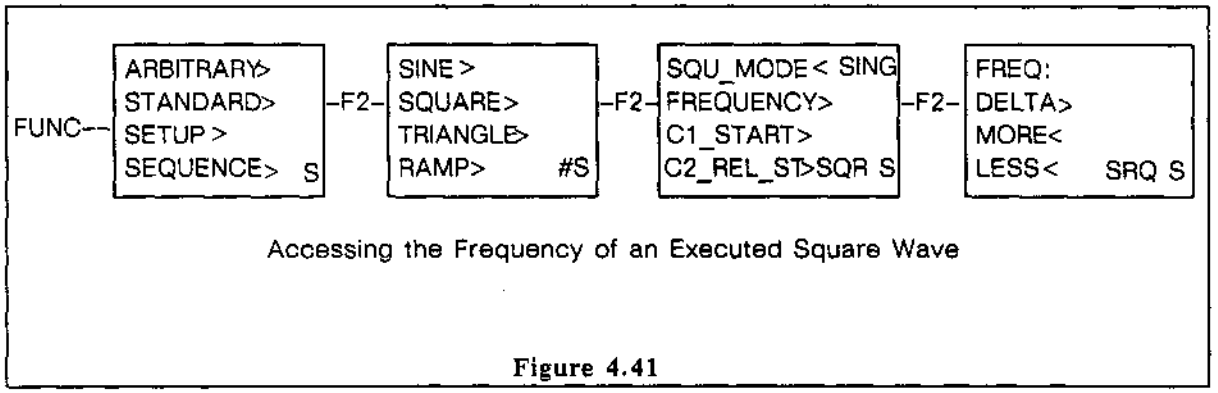
If no arbitrary waveforms have been loaded or linked, the screen will say NO .WAV ACTIVE or NO .WAD ACTIVE. Similarly, NO .SET ACTIVE and/or NO .SEQ ACTIVE will appear when no setup files or sequence files have been implemented.

Another way of identifying active arbitrary waveforms is to press [**FUNC**] and then [**F1**]. Press [**F1**] again to access single arbitrary waveform files, or [**F2**] for dual arbitrary waveform files. As the files are listed on screen in each case, an asterisk* will appear beside an arbitrary waveform file that is loaded or linked.

Identifying Active Standard Waveforms

As mentioned above, the first line of VIEW shows an active standard function. To access or select standard functions press [**FUNC**] and [**F2**]. This will result in a 2-page display of standard waveforms, with SINE, SQUARE, TRIANGLE, and RAMP on the first page, while PULSE and DC are on the second page. Use [**PAGE**] and/or [**BACK**] to display the page containing the standard waveform type identified by VIEW as being active. Then, press the [F] key corresponding to the line on which that waveform type is shown.

Pressing [**F2**] on the first standard waveform menu page for example, will result in the submenu for square waves, and pressing [**F2**] again will show the current frequency of that wave. The process is shown graphically by the flow chart shown in Figure 4.41.



Accessing the Frequency of an Executed Square Wave

Figure 4.41

Identifying Active Setup and Sequence Files

As stated on the previous page active setup and sequence files can be identified by pressing **[SHIFT]** and then **[ACTIVE]**.

Another approach is to press **[FUNC]** and then **[F3]** to list setup files stored in memory. An asterisk is to the left of any setup file that is active. FUNC and **[F4]** will identify active sequence files.

Keep in mind, however, that waveforms may be executed without selecting a setup file. If such a waveform has been loaded and the **[GO]** key is pressed, the Model 9100 will execute the waveform based on current setup conditions. In that instance, or to identify the details of a named setup file, pressing the **[VIEW]** key will lead you to a 17-page menu that will identify current setup conditions.

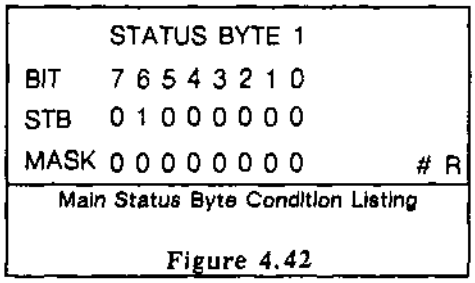
Reviewing Instrument Settings

Pressing the **[VIEW]** key will cause the 9100/CP screen to display the first page of a multiple page information menu that shows the current value of all settings.

Moving from one page to another through the 17 VIEW pages is accomplished by using the **[PAGE]** and **[BACK]** keys.

Accessing the Main Status Byte Condition

Pressing **[SHIFT]** and then **[STB]** will result in the 9100/CP displaying a three-line informational menu as shown in Figure 4.42.



Main Status Byte Condition Listing

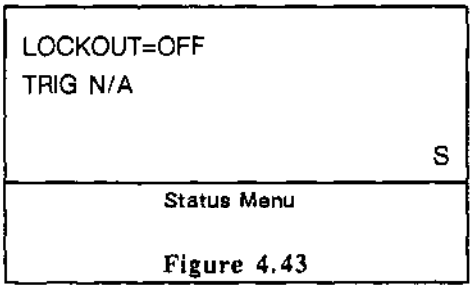
Figure 4.42

Where each of the bits in the STB line (with the exception of bit 6, which is the Require Service bit) represents the status of a group of instrument conditions. The MASK line indicates which, if any, STB values are masked so as to not cause a Service Request (SRQ) to be generated.

See Chapter 5 for a detailed description of the hierarchical structure of the status bytes. All status bytes and masks are displayable, executing the STB command which does not affect the status byte or mask.

Determining the Current Status Mode

When the **[STATUS]** key is pressed, Figure 4.43 will appear on the screen of the 9100/CP.



Status Menu

Figure 4.43

Looking at the two lines in Figures 4.43:

LOCKOUT indicates whether lockout is invoked, ON meaning that the Model 9100 is set to be controlled only by computer command and that the 9100/CP is "locked out" from control. OFF, on the other hand, means that the 9100/CP is in control or can regain control.

TRIG identifies the status of trigger arming in the Single and Burst trigger modes. ARMED, UNARMED, and N/A are the possible readouts on this line, with N/A indicating that the instrument is set to trigger in neither the Single mode nor the Burst mode.

Displaying the Present Bus Communications Commands

Pressing [SHIFT] and [COMM] will result in display of the first page of a two page informational menu that identifies current communications commands, as in Figure 4.44.

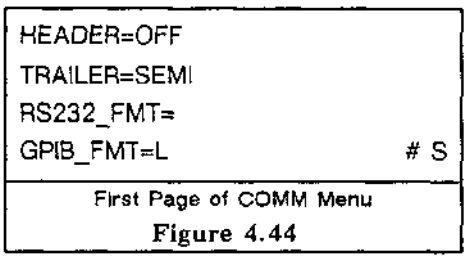


Figure 4.44

If [**Page**] is pressed while Figure 4.44 is displayed, the second page of the COMM menu will be shown, Figure 4.45.

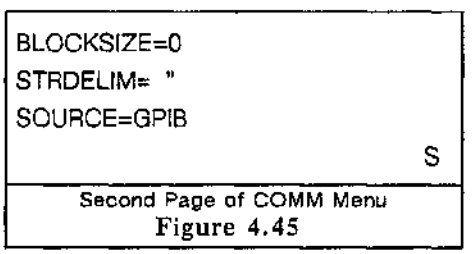


Figure 4.45

Where:

HEADER defines the header format being used in bus communications. OFF presents no header with the data, SHORT presents the short form of the header, and LONG presents the long form of the header.

TRAILER defines the trailer format used in bus communications when the generator transmits to external equipment. Possibilities are CRLF (carriage return/line feed); CR (carriage return); LF (line feed); SEMI (semi-colon); or OFF (no trailer).

RS232_FMT is the data format for RS-232 block transfers, L, I or OFF.

GPIB_FMT is the data format for the GPIB block transfers, L, A, I, or OFF.

BLOCKSIZE sets the blocksize for block transfers over the bus, 0 to 65,536 in 8-byte increments.

STRDELIM defines the ASCII character that the Model 9100 recognizes as a string delimiter.

SOURCE: designates the bus over which the Model 9100 is set to communicate: RS-232 or GPIB.

NOTE: See Chapter 5 for additional details on Model 9100 communications commands.

5 OPERATING OVER THE GPIB

INTRODUCTION

The generator can be operated over the General Purpose Interface Bus (GPIB). GPIB is the standard implementation of the IEEE 488-1978 standard and the identical ANSI standard MC1.1. The following interface functions have been implemented on the LeCroy 9100 Series Arbitrary Function Generators: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, and C0. Except for the line switch, all generator operations are fully programmable over the GPIB.

In this manual, program codes are shown as characters, which should be transmitted in ASCII code.

REMOTE MODE

The generator always powers up in the Local Mode (the Local LED in the "KEYPAD" box should be lit). It switches to remote operation (the LOCAL LED goes out) upon receipt of the remote message. The remote message has two parts:

1. Remote Enable (REN) bus control line is set true, and,
2. Device Listen Address is received once (while REN is true).

In remote, the generator can be addressed to talk or listen. When addressed to listen, it responds to device-dependent commands and standard GPIB bus commands (device-independent commands). When addressed to talk, the generator can send responses to queries. Whether addressed or not the generator responds to the Clear (DCL), Local Lockout (LLO), Clear Lockout/Set Local (GTL), and Interface Clear (IFC) messages. In remote only the LOCAL button on the 9100/CP is active, all other controls are disabled. In remote with lockout, all controls including the LOCAL button are disabled.

LOCAL MODE

In Local, the two buttons on the front panel and the detachable control panel are fully operable. In this mode the generator responds only to the Remote message from the GPIB.

ADDRESSING

The generator's address is set by a DIP switch located on the rear panel of the instrument. The address is set to 1 at the factory. Any address between 1 and 30 can be assigned to the generator. The procedure to set the address switch is described in Chapter 3 under GPIB Address Selection. The address switch is read only once when the power is turned on. Therefore, if the unit is already on and the address switch is changed, the power must be cycled to complete the address change.

The generator interprets the byte on the eight GPIB data lines (DIO-1 to DIO-8) as an IEEE-488 bus command rather than a device-dependent message if it receives the data while the Attention (ATN) control line is true and the Interface Clear

(IFC) control line is false. The most common bus commands are Talk <address> and Listen <address>.

Each time the generator is addressed, either the Talk or Listen LED on the front panel will flash.

MESSAGES

The generator communicates on the bus primarily with "device-dependent" command, or file messages. These messages consist of one or more bytes sent over the bus' eight data lines while the ATN bus control line is false.

In this section "message" means an IEEE-488 standard message command or "device-dependent message". The generator responds to commands when it is enabled to Remote (REN bus control line is true) and it is addressed to listen. The instrument remains addressed to listen until it receives a talk address, an IFC message, or a universal unlisten command.

DEVICE DEPENDENT MESSAGES

Message Input Format

Input messages program instrument functions. These messages contain a string of device-dependent commands. Program commands within a message must be separated with the proper delimiter (separator) and are executed when a message unit terminator (Trailer or <END>) is received. There are two levels of delimiters:

Message Unit Separators: Different commands within a message unit must be separated with a <;>. The separator between a command Header and the first argument can be any of the following: Space<SP>, Equal sign<=>, or a Comma<,>. Each additional argument must be separated with a <,>. For example:

```
C1A 3V,REL;C1Z 100;C1O 0V
```

C1A 3V,REL; C1Z 100; and C1O 0V are all commands and, if sent together in one message unit, must be separated by <;>. The 3V; 100; and 0V are the first arguments of each of the commands and must be separated from the command header with a space <SP>, equal sign <=> or comma<,>. Multiple arguments have to be separated by <,> (as REL is for the C1A command). At the end of the string, a message terminator is required. If each command was sent separately, each would require a message terminator.

Message Terminator: An <END> message must be sent to terminate the message string. An <END> message may take one

of two forms. It may be the EOI bus line asserted true with the last data byte (character), or it can be a "Trailer" (End Of String) character along with the EOI. The generator will always accept the byte sent with EOI. Trailer must be semicolon if used.

Command Format

Program commands consist of a "Header", which in most cases is followed by parameters (arguments) and/or data (as in waveform files).

Headers may take either of two forms: Long Form or Short Form. Long Form Headers are alpha characters and may be more than one word with underscores separating them. For example:

CLOCK_SOURCE
CH1_AMPLITUDE

Long Form Headers are useful if it is desirable to keep the source program as near to English language as possible.

Short Form Headers are three-or-four letter acronyms for the Long

Form Commands. For example:

CSOU for CLOCK_SOURCE
C1A for CH1_AMPLITUDE

Some Headers qualify as either Long or Short Form. They are Headers which are not more than four letters long. For example:

GO
STOP
ARM

Either Long or Short Form Headers will be accepted by the generator, and they may be inter-mixed.

Command Parameters (arguments) can be letters, words, numbers or a combination of those. For example:

LOAD ANYWAVE.WAV,1000

LOAD is the header while ANYWAVE.WAV and 1000 are parameters (arguments).

Command Parameters

Command parameters can be one of two types:

Decimal Numeric – Any integer, floating point, or exponential value. Valid characters are 0 through 9, E, <+>, <–> and the decimal point <.>. Spaces are allowed between the +, – or E

and the digits. This means the 9100 will accept numbers in NR1, NR2, or NR3 representations, as defined by IEEE–728.

Character – Some commands require alpha arguments, such as "ON", "OFF" or file names. These arguments are ASCII strings that start with an alpha character and are followed by alphanumeric characters A through Z and 0 through 9. All other characters are not allowed: such as: Space<SP>, <;>, <,>, <#>, underscore <_> or delete <DEL>.

General Rules:

The general rules of command format are as follows:

The generator sends and receives command messages in standard ASCII code, unless otherwise noted. It sends and receives block transfers in any of the forms A, I or L. All file transfers are block transfers.

The generator is not case sensitive. It responds equally to upper and lower case alpha characters.

A delimiter is required between a command header and its parameter, and between parameters. Delimiters are: space, comma, equals and backslash. The 9100 converts "=" to space, and then converts groups of one or more spaces to a single comma, and converts comma followed by a group of spaces to a single comma. For readability, this manual uses underscore between the words of a multi-word command header and comma between parameters.

Semicolon is treated as an end of command delimiter; question mark is an end of command delimiter for queries.

NOTE: Over GPIB, EOI may be sent with the last character of a command instead of sending a semicolon. In effect, the EOI causes a semicolon to be appended to the command if the last character is not semicolon.

Some examples of the use of delimiters are:

clock_rate,10MHz;	OK
clock_rate, 10MHz;	OK
clock_rate=10MHz;	OK
clock rate 10MHz;	OK
clock rate 10MHz;	OK
clock_rate?	OK (query)
clock_rate , 10MHz;	wrong: space before comma
clock_rate 10 MHz;	wrong: space inside the parameter
clock_rate;	wrong: no parameter but not a query

Errors in message syntax are trapped and can be reported via the GPIB.

Refer to the section on Error Reporting for details.GPIB <END> must be received for a command to be processed.

IEEE-488 STANDARD MESSAGES

Receiving the Device Clear Message

The generator responds to the Device Clear Message by clearing any incomplete entries or messages. When addressed to listen, it responds equally to the Selected Device Clear (SDC) message or the device-dependent messages CLEAR or (<ESC>C). It responds to the Device Clear (DCL) message whether addressed or not.

Receiving the Trigger Message

If addressed to listen, the generator responds equally to the device specific TRIGGER command or to the Group Execute Trigger message (GET). In either case it causes the generator (if in the Single or Burst mode, the trigger is Armed, and the Bus Trigger Source is ON) to execute the programmed waveform.

Receiving the Remote Message

The remote message has two parts. First the Remote Enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the generator in the Remote mode. The generator must be addressed as a listener before it can start accepting remote messages. No instrument settings are changed by the transition from Local to Remote.

Receiving the Local Message

If the generator is addressed to listen, the Go To Local (GTL) message is used to return it to the Local Mode. Also, if the instrument is not in the Remote With Lock Out State, pressing the LOCAL button on the Optional Control Panel will return it to Local Mode.

Receiving the Local Lockout and Clear Local Lockout/Set Local Messages

Receiving Local Lockout – If the instrument is in remote and has been addressed as a listener, it will enter the Remote With Lock Out State when it receives the Local Lock Out (LLO) message with ATN true.

Clearing Local Lock Out – The generator will exit the Remote With Lock Out State and enter: 1) the Local State if the REN

line is made false, or 2) the Local With Lock Out State if the GTL message is made true and the generator has been addressed as a listener.

SENDING MESSAGES

The generator may send device-dependent messages when addressed to talk. The instrument remains configured to talk until it is unaddressed to talk by the controller. To unaddress the generator, the controller must send the generator's listen address, a new talk address, an IFC message, or a universal untalk command.

Before the instrument is addressed to talk, the desired output data must be specified with an appropriate input message or a query. Otherwise the instrument will not send anything. The DIRECTORY or MEMORY commands are examples.

Queries are program commands that end with a question mark (?). The generator responds to the query by outputting a message containing the value or state of the associated parameter.

Queries, when executed, cause their replies to be placed in the output buffer. Multiple queries without reading replies will result in the last reply being written over the previous one.

All output messages are ended with the EOI going true with the last character sent. Block transfers are formatted according to the format selected with the COMM_FORMAT command.

Require Service Message

The generator sends the Require Service message by setting the Service Request (SRQ) bus control line true when a previously programmed condition occurs. The Require Service message is cleared when a Serial Poll is executed by the system controller. During Serial Poll, the SRQ control line is reset as soon as the instrument places the Main Status Byte message on the bus. If all bits on the Main Status Byte are masked "off", the Require Service message is effectively disabled.

When the generator is sending the Require Service message, the front-panel SRQ LED lights. The LED is turned off during the serial poll when the SRQ control line is reset.

Serial Poll Status Byte Message

After receiving a Serial Poll Enable (SPE) bus command and when addressed to talk, the generator sends the Main Status Byte Message. The Main Status Byte message consists of one 8-bit byte in which the bits are set according to the conditions that caused the SRQ.

Bits in the Main Status Byte are set by events (such as error,trigger, etc.). If an event occurs that causes one of the bits in the Main Status Byte to be set and if that bit is enabled by the mask, the RQS (require service) bit is set and the SRQ line set true.

If the RQS bit is set, indicating that the instrument sent the SRQ message, and a serial poll is executed, the RQS bit will be cleared. All other bits in the Main Status Byte remain unchanged.

Secondary Status Bytes

Each of the bits in the Main Status Byte (STB 1), except for bit 7 which is the RQS bit, is a summary bit for a group of instrument events. If more detail is desired about a particular group of conditions, there is a Secondary Status Byte for each bit of the Main Status Byte. These Secondary Status Bytes are numbered STB 2–8. By addressing the generator to listen and sending the query (STB (2 to 8) <?>), and addressing the generator to talk, a single byte of 8 bits will be sent. Each bit (or combination of bits) of that byte will represent a certain instrument event.

An "event" is the transition from one state to another state. Bits in the above status bytes are set true by a specified event. No change in the 9100 condition can clear these bits, thus guaranteeing that no events are missed by an application. Only the STB command, which reads these bytes, can clear them.

MAV (message available, STB 6) is a condition bit. It is set true and false based on the state of the GPIB output buffer.

In addition to the status bytes described above, one additional byte is a 'condition register'. Bits in this byte are set true and false by transitions into and out of 9100 states. There is no way to write to or clear this byte; it always reflects current conditions. This byte is readable by the command "TSTB,0". Details of the status bytes follow.

OPERATION OF THE STATUS BYTES

Each Status Byte has a MASK associated with it. An event is first latched in a secondary status byte. If the MASK for that status byte has been set to 1, then the summary bit in the serial poll status byte is also set. If the MASK for that summary bit is set to 1, then the master status summary bit (shown as bit 6 in Figure 5.1) is also set. If the MASK bit for the master status summary bit is set to 1, then an SRQ is generated.

An example will make this clear. If we wish to receive an SRQ only when a remote/local transition occurs, we would send the

commands MASK 1,65; MASK 2,2. Pressing the local key will cause the following things to happen:

a. Bit 1 of STB 2 will be turned on.

b. Because STB 2 AND'd with MASK 2 is non-zero, bit 0 of STB 1 is turned on.

c. Because STB 1 AND'd with MASK 1 is non-zero, bit 6 of STB 1 is turned on.

d. Because bit 6 of STB 1 and MASK 1 are both on, an SRQ is generated.

A Serial Poll at this point reads the Serial Poll Status Byte and turns off SRQ. Only Serial Poll can turn off SRQ. It does not affect the contents of STB 1. Only the STB command can clear the event status bytes. TSTB may be used to read the status bytes without clearing them.

NOTE TO ADVANCED USERS: The above example is actually more complex than indicated above, because if REMOTE is asserted (which it typically is) then when the 9100 is addressed to listen so it can receive the STB command, it goes back into REMOTE! The application program might then do the following:

1. *Send REMOTE false.*
2. *Address the 9100 to listen (there is no need to actually send anything). This puts the 9100 into local, as the operator requested.*
3. *Wait for SRQ, then serial poll to clear it. Do not send STB.*

This returns the 9100 to local and leaves it there. The program can put the 9100 back into REMOTE by turning on REMOTE and addressing the 9100 to lsiten.

There are other ways to accomplish the above. The method shown is used by EASYWAVE.

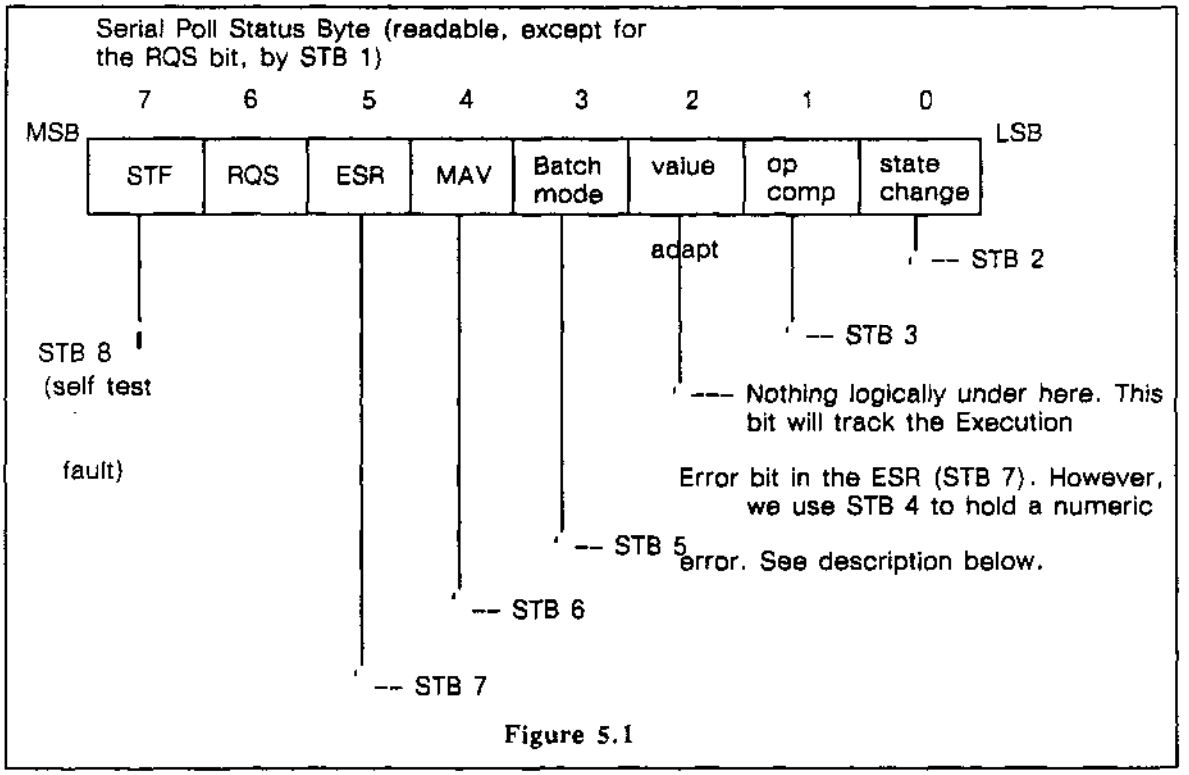


Figure 5.1

command string	action or response
STB? or STB	responds with 8 status bytes (1 to 8) and clears all 8 status bytes
STB n? or STB n	responds with STB n,xx (n=1 to 8) where xx is the value of the status byte and clears STB n. (except INTERNAL STATE)
MASK n? or MASK n,xx	responds with MASK n,xx (n=1 to 8) where xx is the value of the status byte mask sets MASK n (n=1 to 8) to the given value xx
TSTB n? or TSTB	responds as for STB n<cr> but does not clear the status byte
MASK? or MASK	responds with 8 mask bytes (1 to 8) unused mask bytes show as 0 values are returned in ASCII (default decimal) separated by commas

Table 5.1
Status Bytes Bit Assignments

EVENT REGISTERS

STB 2: readable by STB 2?
- bit 0 = No files found at power on, file system reinitialized
- bit 1 = remote to local or local to remote transition occurred
- bit 2 = Channel 1 overload occurred
- bit 3 = Channel 2 overload occurred
- bit 4 = Triggered (in a triggered mode only)
- bit 5 = External sum overload occurred
- bit 6 = unused
- bit 7 = unused

STB 3: readable by STB 3?
- bit 0 = operation complete
- bits 7-1 = unused

STB 5: readable by STB 5?
- bit 0 = batch (sequence or setup) file execution initiated
- bit 1 = unused
- bit 2 = batch execution ended normally, i.e., at END statement
- bit 3 = WAITing for NEXT
- bit 4 = batch execution terminated before END
- bit 5 = batch single step
- bits 7, 6 = spare, always 0

STB 7: readable by STB 7?
- This is the standard Event Status Register
- bit 0 = Operation Complete
- bit 1 = unused
- bit 2 = unused
- bit 3 = unused
- bit 4 = Execution error (Warning)
- bit 5 = Command error (unrecognized command, etc.)
- bit 6 = unused
- bit 7 = Power on

STB 8: readable by STB 8?
- bit 0 = analog board problem, see CALERR file
- bit 1 = high speed memory problem
- bit 2 = control memory problem
- bit 3 = Nonvolatile memory problem
- bit 4 = transfer from high speed memory to analog board failed
- bits 7,6,5 = unused

CONDITION REGISTERS

STB 0: readable by TSTB 0? This is not an event register, but a condition register. It does not generate SRQs.
- bits 0, 2, 3, 4, 5 = unused
- bit 1 = batch execution in progress
- bit 6 = waveform active
- bit 7 = armed

STB 4: readable by STB 4?
- bits 7-0 = error code (Table 5.2)
- The MASK 4 command will parse but has no effect
- The appropriate bits of STB 7 are always set on error

STB 6: readable by STB 6?
- bit 0 = message available
- bits 7-1 = unused

Table 5.2
Error Codes

/* command parse errors */		
10	too many parameters	Example: Ch1_Ampl 1V, 2V;
11	invalid header	
12	invalid number format	Example: Ch1_Ampl, 1.2.3V;
13	invalid keyword	An alpha argument was not recognized
14	invalid block	Not #A, #L or #I
15	two strings in cmd	
16	invalid symbol	
17	invalid trailer	
18	invalid acronym	Short form command not recognized
19	syntax error	General problem parsing command
20	command permission error	(No way to get this error)
30	option not installed	(No way to get this error)
40	semantic error	
41	command not found	
/* environment errors - requested action not possible in current state */		
50	environment error	
51	received trigger command in nontriggered mode	
52	received arm in nontriggered mode	
53	received go with no trigger source enabled in a triggered mode	
54	segment less than 72 points in triggered mode (can only run in CONTINUOUS trigger mode)	
55	received trigger and not armed	
56	received trigger arm when not ready	
70	communications error	
71	unrecognized gpib bus cmd	
72	unrecognized escape sequence	
73	received file of count error. (data < count)	
80	function error	
90	batch mode error	
100	cmd not implemented	

110 unclassified error
120 file accounting error

121 Cannot add another directory entry to file memory

122 Cannot add another directory entry to system memory

123 Cannot add another directory entry to high speed memory

124 Cannot add another line to control memory

125 file memory space exceeded

126 system memory space exceeded

127 high speed memory space exceeded

128 Control memory space exceeded

129 file nesting level exceeded (for sequence, setup files)
130 file specification error

131 invalid device

132 invalid extension

133 Invalid filename

134 reserved filename

135 address out of range

136 missing filename

137 missing extension

138 missing device

139 file field delimiter
140 file handling error

141 no waveform loaded

142 failed to find segment

143 file already exists

144 no file found

145 file does not exist

146 cannot close file

147 missing end of file

148 incompatible wav wad files – tried to link wav, wad files

149 short segments not linkable – tried to link seg < 72 points

150 standard function command error – error unique to standard functions

160 self test error

/* Calibration errors */

170 calibration aborted – measurement system or signal DAC non-functional. Your 9100 will be either significantly out of calibration or nonfunctional.

171 amplitude not achelvable – Not actually a calibration error. Using the current calibration constants, the requested amplitude cannot be achelved.

172 offset not achelvable – similar to 171, but for offset. Note: if offset is set to more than 16 times amplitude, this error may result. If offset > 32x amplitude, this error will result.

173 cal completed with errors – something was out of specification. Note: Thoroughly unreasonable measurements are replaced with default values, so as not to "hide" problems, or disable a unit with a bad measurement circuit.

181 dual waveform of less than 72 points.

182 dual waveform not loaded.

NOTE: Error numbers greater than 200 are warnings

200 warning default units – specifying a value for Hertz, Volts, or seconds without any extension. The base unit (ie, Hertz, Volts, or seconds) is used. For example: CRAT,10; gives a 10 Hertz clock.

201 warning adjusted wave file – File padded to multiple of 8 bytes to meet restrictions of 9100 hardware.

202 Warning: signal beyond 5 V.

203 Warning: no trigger delay control allowed in standard mode pulse

204 Warning: no clock control in Standard Function Mode.

205 Warning: no clock rate control while Clock Source is External.

255 unclassified warning – a warning for which no more specific error code has been created yet.

ACRONYM GUIDELINES

Single Words: Long form words of four letters or less: The word is used in its entirety.

If the word is over four letters, the first three or four letters are used. Where conflicts arise between words, exceptions are made.

For example, ID, SING, RCL, TGR, CM, STR.

Two Words: Generally, the first letter of the first word, plus the first three letters of the second word. Exceptions are made for clarity and to prevent conflicts. There are four categories of exceptions:

a. The first two letters of the first word and the first two letters of the second word are used when there are conflicts.

b. CH1 and CH2 acronyms are shortened for clarity.

c. COMM acronyms are kept consistent with LeCroy Digital Oscilloscopes.

d. DELE, DELT use the first four letters.

Three Words: The first letter of each word is used, for instance HSM, RAM.

Table 5.3
9100 GPIB Acronyms

ACRONYM	MEANING
AFUN	ARBITRARY FUNCTION
ARB	ARBITRARY
ABO	ABORT
AFIL	ACTIVE FILES
ALT	ALTERNATE
ARM	ARM
AUTO	AUTO
BOTH	BOTH
BUR	BURST
BUS	BUS
C1A	CH1_AMPLITUDE
C1F	CH1_FILTER
C1I	CH1_INVERT
C1O	CH1_OFFSET
C1P	CH1_OUTPUT
C1Z	CH1_ZERO_REF
C2A	CH2_AMPLITUDE
C2F	CH2_FILTER
C2I	CH2_INVERT
C2O	CH2_OFFSET
C2P	CH2_OUTPUT
C2Z	CH2_ZERO_REF.
CAL	CALIBRATE
CFMT	COMM_FORMAT
CHDR	COMM_HEADER
CLE	CLEAR
CLEV	CLOCK_LEVEL
CM	CONTROL_MEMORY
CMOD	CLOCK_MODE
CPER	CLOCK_PERIOD
CPRM	COMM_PROMPT
CRAT	CLOCK_RATE
CREF	CLOCK_REFERENCE
CSLO	CLOCK_SLOPE
CSOU	CLOCK_SOURCE
CON	CONTINUOUS
CONC	CONCATENATE
CSDE	COMM_STRDELIM
CTRL	COMM_TRAILER
DC	D.C.
DCL	DEVICE_CLEAR
DCMD	D.C. MODE
DEC	DECREMENT
DELE	DELETE
DELT	DELTA
DIR	DIRECTORY
DMOD	DELAY_MODE
DUAL	DUAL
END	END
EXIS	EXIST
EXT	EXTERNAL
FUNC	FUNCTION QUERY
GATE	GATE
GO	GO
GPIB	GPIB
HSM	HIGH SPEED MEM
ID	IDENTIFY
IFC	INTERFACE CLEAR
INC	INCREMENT
INT	INTERNAL
INTL	INTERLEAVE
LEARN	LEARN_SETUP
LINK	LINK
LLO	LOCAL_LOCKOUT
LOAD	LOAD
LOC	LOCAL
LONG	LONG
MAN	MANUAL
MASK	MASK
MDEL	MARKER_DELAY
MEM	MEMORY
MODE	MODE
NEG	NEGATIVE
NEXT	NEXT
OFF	OFF
ON	ON
POS	POSITIVE
PPER	PULSE_PERIOD
PTS	POINTS
PDEL	PULSE_DELAY
POPT	PULSE_OPTIMIZE
PUL	PULSE
PWID	PULSE_WIDTH
RAM	RAM DISK MEMORY
RAMP	RAMP
RCEI	RECEIVE
RCL	RECALL
REC	RECURRENT
REL	RELATIVE
REM	REMOTE
REP	REPEAT
RMOD	RAMP_MODE
RMPP	RAMP_PHASE
RPRP	RAMP_REL.PHASE
RPER	RAMP_PERIOD
RPOL	RAMP_POLARITY
RS23	RS-232_PORT
SC1P	SINE_CH1_PHASE
SC2P	SINE_CH2_PHASE
SDC	SELECTIVE DEV CLR
SEQ	SEQUENCE
SEND	SEND
SET	SETUP
SFR	SINE_FREQ
SINE	SINE
SMOD	SINE_MODE
SING	SINGLE
SHORT	SHORT
SQFR	SQUARE_FREQ.
SQMD	SQUARE_MODE
SQUP	SQUARE_PHASE
SQRP	SQUARE_REL.PHASE
SQU	SQUARE
SEL	SELFTEST
STAN	STANDARD FUNC.
STAT	STATUS
STB	STATUS_BYTE
STOP	STOP
STR	STORE
SUM	SUM_MODE
TAS	TRIG_ARM_SOURCE
TDEL	TRIG_DELAY
TGR	TRIGGER
TLEV	TRIG_LEVEL
TMOD	TRIG_MODE
TRFR	TRIANGLE_FREQ.
TRI	TRIANGLE
TRIM	TRIANGLE_MODE
TRIP	TRIANGLE_PHASE
TRRP	TRIANGLE_REL_PHASE
TSLO	TRIG_SLOPE
TSOU	TRIG_SOURCE
TSTB	TEST_STATUS_BYTE
UFIX	UNSIGNED_FIXED
USHO	UNSIGNED_SHORT
VIEW	VIEW_SETTINGS
WAIT	WAIT
[ESC]A	ABORT
[ESC]C	DEV. CLEAR
[ESC]L	LOCAL
[ESC]N	NEXT
[ESC]R	REMOTE
[ESC]S	STB?
[ESC]T	TRIGGER
[ESC](	DISABLE RS-232 XON/XOFF HANDSHAKE
[ESC])	ENABLE RS-232 XON/XOFF HANDSHAKE
[ESC][	RS-232 ECHO OFF
[ESC]]	RS-232 ECHO ON
[ESC][1-7]	SUBSTB?
[ESC][CNTL]C	CLEAR
[CNTL]R	REPEAT LAST CMD
WAV	WAVE SINGLE CH
WAD	WAVE DUAL CH
XSUM	EXTERNAL SUM

PROGRAMMING COMMANDS SECTION

The following is a description of each of the programming commands for the LeCroy 9100 Series Arbitrary Function Generators.

The command set is divided into eight main categories. They are:

1. File Handling Commands
2. Action Commands
3. Channel Parameter Commands
4. Timebase Commands
5. Trigger Commands
6. Standard Function Commands
7. Query Type Commands
8. Communication Commands

LeCROY 9100 SERIES COMMAND SET

Section 1 FILE HANDLING COMMANDS

DELETE (DELE)
END (END)
EXIST (see Query Type) (no short form - EXIS recognized)
LEARN_SETUP (LEARN)
LINK (LINK)
LOAD (LOAD)
NEXT (NEXT)
RECALL (RCL)
SETUP (SET)
SEQUENCE (SEQ)
STORE (STR)
WAIT (WAIT) (see Action Type)

see also
ACTIVE_FILES (AFIL) (see Query Type)
DIRECTORY (DIR) (see Query Type)
MEMORY (MEM) (see Query Type)

Section 2 ACTION COMMANDS

ABORT (ABO)
ARBITRARY (ARB)
ARM (ARM)
CALIBRATE (CAL)
CLEAR (CLE)
GO (GO)
NEXT (NEXT)
SELFTEST (SEL)
STOP (STOP)
TRIGGER (TGR)

Section 3 CHANNEL PARAMETER COMMANDS

CH1_AMPLITUDE (C1A) CH2_AMPLITUDE (C2A)
CH1_FILTER (C1F) CH2_FILTER (C2F)
CH1_INVERT (C1I) CH2_INVERT (C2I)
CH1_OFFSET (C1O) CH2_OFFSET (C2O)
CH1_OUTPUT (C1P) CH2_OUTPUT (C2P)
CH1_ZERO_REF (C1Z) CH2_ZERO_REF (C2Z)
EXTERNAL_SUM (XSUM)
SUM_MODE (SUM)

Section 4 TIMEBASE COMMANDS

CLOCK_LEVEL (CLEV)
CLOCK_MODE (CMOD)
CLOCK_PERIOD (CPER)
CLOCK_RATE (CRAT)
CLOCK_REFERENCE (CREF)
CLOCK_SLOPE (CSLO)
CLOCK_SOURCE (CSOU)

Section 5 TRIGGER COMMANDS

DELAY_MODE (DMOD)
MARKER_DELAY (MDEL)
TRIG_ARM_SOURCE (TAS)
TRIG_DELAY (TDEL)
TRIG_LEVEL (TLEV)
TRIG_SLOPE (TSLO)
TRIG_MODE (TMOD)
TRIG_SOURCE (TSOU)

Section 6 STANDARD FUNCTION COMMANDS

STANDARD (STAN)
SINE (SINE)
SINE_MODE (SMOD)
SINE_FREQUENCY (SIFR)
SINE_CH1_PHASE (SC1P)
SINE_CH2_PHASE (SC2P)
SQUARE (SQU)
SQUARE_MODE (SQMD)
SQUARE_FREQUENCY (SQFR)
SQUARE_PHASE (SQUP)
SQUARE_RELATIVE_PHASE (SQRP)
TRIANGLE (TRI)
TRIANGLE_FREQUENCY (TRFR)
TRIANGLE_MODE (TRIM)
TRIANGLE_PHASE (TRIP)
TRIANGLE_RELATIVE_PHASE (TRRP)
RAMP (RAMP)

RAMP_MODE (RMOD)
RAMP_PERIOD (RPER)
RAMP_PHASE (RMPP)
RAMP_RELATIVE_PHASE (RPRP)
PULSE (PUL)
PULSE_WIDTH (PWID)
PULSE_PERIOD (PPER)
PULSE_DELAY (PDEL)
PULSE_OPTIMIZE (POPT)
DC (DC)
DC_MODE (DCMD)

Section 7 QUERY TYPE COMMANDS

ACTIVE_FILES (AFIL)
DIRECTORY (DIR)
EXIST (EXIS)
FUNCTION (FUNC)
IDENTIFY (ID)
MEMORY (MEM)
VIEW (VIEW)

Section 8 COMMUNICATION COMMANDS

COMM_FORMAT (CFMT)
COMM_HEADER (CHDR)
MASK
STB
TSTB

FILE HANDLING COMMANDS

File Structures

There are four types of files which the generator accepts. They are Setup and Sequence, Single Waveform, and Dual Waveform. The structures for these files are described below. All files are transmitted over the bus in block format; waveforms use #A or #L formats, setup and sequence files use #I format.

BLOCKS - Blocks are used to transfer waveform files, setup files or sequence files to and from the 9100. Block formats (except for #L) are described in the IEEE Std. 488.2-1987. Three block formats can be received:

NOTE: For all formats, the count and data must be of the same form.

BLOCK FORMAT A - GPIB only, binary only, no checksum

For Binary Transfer:

Byte Number	Byte Value
1	# (ASCII #)
2	A (ASCII uppercase A)
3	<data byte count, most significant byte>*
4	<data byte count, least significant byte>*
5	<data byte 1>
6	<data byte 2>
7	<data byte 3>
•	•
•	•
•	•
•	•
N+4	<data byte N> with EOI, if last block)**

* Data byte count is an unsigned integer which in this case equals N. It contains the number of bytes being transferred in the block. In this binary representation there is 1 data value per byte.

**The EOI, if sent, must be sent with the last byte. EOI terminates the file tansfer. If EOI is not sent, the 9100 will accept another block as part of the same file. The last block of a file transfer must be sent with EOI on the last byte.

BLOCK FORMAT I - The "#I" format begins with the characters "#I", followed by any number of ASCII characters, the last of which must be sent with EOI asserted (the standard GPIB END message).

BLOCK FORMAT L - GPIB or RS-232, ASCII text only.

For HEX ASCII Transfer:

Byte Number	Byte Value
1	# (ASCII#)
2	L (ASCII)
3	<byte count, 4th hex digit, most significant >*
4	<byte count, 3rd hex digit>*
5	<byte count, 2nd hex digit>*
6	<byte count, 1st hex digit, least significant>*
7	<most significant hex digit of data byte 1>
8	<least significant hex digit of data byte 1>
9	<most significant hex digit of data byte 2>
10	<least significant hex digit of data byte 2>
"	"
"	"
"	"
"	"
2N+5	<ms hex digit of data byte N>
2N+6	<ls hex digit of data byteN>(with EOI, if last block)**

*Byte count is number of bytes you are sending over in this block. In this hex ASCII representation there are 2 bytes per data value.

**The EOI, if sent, must be sent with the last byte of the block. EOI terminates the file transfer. If EOI is not sent, the 9100 will accept another block as part of the same file. The last block of a file transfer must be sent with EOI on the last byte. Over RS-232, the termination sequence set up by COMM_RS_CONF must follow the last data byte. Please see COMM_RS_CONF in Section 6 for details.

Setup and Sequence Files

The generator will accept both Setup and Sequence files in the "#I" block transfer format. These files may be thought of as "batch" files. The only difference between the files, is the kind of instructions they contain.

Setup Files

The Setup file should never contain any instructions other than valid instrument setup commands. These are the commands which setup the instrument parameters such as Amplitude, Clock and Trigger. An example of a Setup file, as the generator would receive it from the bus, is shown below:

```
160         'FOR THIS EXAMPLE, THE NAME OF THE FILE IS
             "TESTPROG.SET"; A SETUP FILE
170         '
180         NAM$="TESTPROG.SET"
.
.
.
310         'THE FIRST 2 BYTES OF ALL SETUP AND SEQUENCE
             FILES ARE "#I"
320         '
330         INIT$="#I"
340         '
350         'THE FOLLOWING COMMANDS ARE A SETUP FILE
            THAT CHANGES THE AMPLITUDE OF
360         'CHANNEL ONE TO 5 VOLTS, CHANNEL TWO TO 2
             VOLTS, TURNS OFF SUMMING MODE,
370         'TURNS OFF THE CHANNEL 1 AND CHANNEL
             2 FILTERS AND MAKES THE CLOCK PERIOD
380         'EQUAL TO 100 nsec PER POINT(10 MHz)
390         '
400         COMMAND$="C1A,5V; C2A,2V;SUM_MODE,OFF;
             C1F,OFF; C2F,OFF;CPER,1.00E-007;"
410         COMM$=INIT$+COMMAND$
420         '
430         ' WE WILL NOW SEND THE FILENAME AND DATA TO
             THE 9100
440         '
450         HEAD$="STORE "+NAM$
460         CALL IBWRT(AFG%,HEAD$) 'write string HEAD$ to the
             AFG
470         CALL IBWRT(AFG%,COMM$) 'write string COMM$ to the
             AFG
480         ENDSample BASICA program for transferring a setup file.
```

The STORE is the command that will cause the setup file to be stored in the generator's file storage area (RAM Disk). The TESTPROG.SET is the file name, with the .SET identifying it as a setup file. The #I identifies the type of block transfer that is to occur. Note that none of these items are a part of the Setup file. It is the rest of the data that is the Setup file.

NOTE: The end shown is not GPIB END, it is the end required to close the file.

Executing Setup File

The setup file above, once in the 9100 RAM memory, would be executed with the command SETUP TESTPROG.SET;.

Sequence Files

A Sequence File, like a Setup File, can be executed by the LeCroy 9100 simply by invoking the filename. However, unlike a Setup file, a Sequence file can contain Setup files nested within the Sequence file itself. In this respect, a Sequence is really a more global file type than a Setup file. The Sequence file can contain any valid 9100 GPIB command, also a WAIT

statement. It can even include Setup files. An example of a Sequence file follows:

```
160         'FOR THIS EXAMPLE, THE NAME OF THE FILE IS
             "TESTPROG.SEQ"; A SEQUENCE FILE
170         '
180         NAM$="TESTPROG.SEQ"
190         '
.
.
.
.
310         'THE FIRST 2 BYTES OF ALL SETUP AND SEQUENCE
             FILES ARE "#I"
320         '
330         INIT$="#I"
340         '
350         'THE FOLLOWING COMMANDS ARE A SEQUENCE
             FILE THAT ABORTS THE WAVEFORM BEING
            GENERATED, IF ANY, CHANGES CHANNEL 1
            AMPLITUDE
360         'TO 5 VOLTS, TURNS OFF SUMMING MODE, LOADS A
             NEW WAVEFORM, REPEATS IT ONCE ON
370         'EVERY TRIGGER, AND OUTPUTS THAT WAVEFORM
             FROM THE 9100.
380         '
390         COMMAND$="ABORT; C1A,5V; SUM_MODE,OFF;
             LOAD,SIN100.WAV,1; TMOD,SING;GO; END;"
400         COMM$=INIT$+COMMAND$
410         '
420         ' WE WILL NOW SEND THE FILENAME AND DATA TO
             THE 9100
430         '
440         HEAD$="STORE "+NAM$
450         CALL IBWRT(AFG%,HEAD$)  ' writes string HEAD$ to the
             AFG
460         CALL IBWRT(AFG%,COMM$)  ' writes string COMM$ to
             the AFG
470         ENDSample BASICA program for transferring a sequence file.
```

The STORE command causes this sequence file to be stored into the generator's RAM Disk. The .SEQ extension identifies it as a Sequence file. The #I sets the block transfer format. The rest is the actual Sequence file. This program example includes setup commands combined with a load operation. The command LOAD SIN100.WAV,1 causes a waveform to be loaded from the RAM Disk to the high speed memory. The number 1 specifies the number of times the waveform is to be repeated. The TMOD, SING sets the Trigger Mode to single.

The GO causes the generator to execute the waveform SIN100.WAV.

The END closes the file and leaves the instrument in the last setup state with the waveform active, awaiting a trigger.

Executing of Sequence File

The sequence file above, once resident in 9100 RAM can be executed with the command, SEQUENCE TESTPROG.SEQ;.

Single Waveform Files

A Single Waveform File is one that will run only on Channel 1. It is received over the bus in the #A or #L block format. An example of the Single Waveform File format sent by an IBM BASICA program is below:

```
800 HEADER$="STORE "+NAME$+".WAV"
810 '
820 '
830 REM THE NEXT LINE PUTS THE DATA INTO A
FORMAT THE 9100 CAN UNDERSTAND. IT FIRST SEES
"#A", THEN 2 BYTES WHICH DEFINE THE LENGTH OF
THE WAVE IN BYTES, AND THEN THE WAVEFORM
DATA WITH AN EOI.
840 '
850 '
860 OUTWAVE$="#A"+CHR$(0)+STR$(LEN(WAVE$))
+WAVE$
870 CALL IBWRT(ARB%,HEADER$)
880 CALL IBWRT(ARB%,OUTWAVE$)
890 PRINT "WAVEFORM TRANSFER COMPLETED"
```

where: the 2 bytes following the "#A" encode the file length.

WAVE$ contains binary data bytes.

STORE is the command to save the file to the 9100 RAM Memory.

NAME$ contains the file name The .WAV extension must always used to signify a Single Waveform File.

#A specifies the block format. THE #A and the size bytes are not part of the file. The file contains only the binary data. The file can be up to 65,536 bytes long.

Dual Waveform Files

A Dual Waveform File is composed of waveform data for Channel 1 and Channel 2. The 9100 stores these files internally with .WAD extensions to the filename in order to delineate between Single and Dual Waveforms.

The 9100 accepts only interleaved dual waveform data files. This is due to the internal memory accessing architecture of the instrument.

An example of an interleaved Dual Channel Waveform, as it is received over the bus, follows:

```
STORE
TESTWAVE.WAD;#AS1S2|A1A2|B1B2|A3A4|B3B4|.....
..An-1An|Bn-1Bn | EOI
```

S1 and S2 are binary block size bytes. A1 to An are Channel 1 binary data bytes. B1 to Bn are Channel 2 binary data bytes. STORE is the command which causes the file to be stored into the 9100 RAM Memory.

TESTWAVE.WAD is the filename. The .WAD extension must always used to indicate a Dual Channel Waveform.

#A specifies the block transfer format and is not part of the file, nor are the 2 subsequent size bytes. Only the binary data bytes are a part of the file. The file may be 65,536 bytes long.

Observe that the data bytes are interleaved two bytes at a time. A1A2 for Channel 1, then B1B2 for Channel 2, then A3A4 for Channel 1, then B3B4 for Channel 2, etc. There must be an equal number of bytes for Channel 1 (A) and for Channel 2 (B).

Dual Waveform Files are received over the bus in the #A or #L block format.

NOTE: A waveform file may be sent as more than one physical block. If the last character of an #A block is not sent with EOI (the GPIB END message), then another block may be sent.

Executing Waveform Files

Both dual and single waveform files are executed by using LOAD THISWAV.WAV; or LOAD TESTWAV.WAD; followed by a GO; command. Optionally, additional WAV files may be LINKED to WAV files or WAD files to WAD files.

FILE HANDLING COMMANDS

File Handling **DELETE**

(DELE)

Causes the named file to be deleted from the RAM Disk.

FORMAT:

DELETE arg
DELE arg

VALID ARGUMENTS:

Any valid Setup, Sequence, or Waveform filename (with extension).

EXAMPLE:	**COMMAND**	**COMMENTS**
	DELETE MYFILE.SEQ; DELE MYFILE.SEQ;	The file named MYFILE.SEQ will be deleted from the RAM Disk.

NOTES: No query form of this command.

File Handling **END**

The command END must be included at the end of a sequence or setup batch file. While END is not a valid GPIB command, its query form, "END?", is. END? is used to debug batch file execution problems. This query returns either "NOT BATCH END STATUS AVAILABLE" if no setup or sequence file has been run, or a list of the following form.

LEVEL	FILENAME.EXT	LINE<CR><LF>
0	SET1 .SET	53<CR><LF>

Levels are in the range of 0 to 5. Line numbers start at 1. If line number shows 0, then batch execution ended before the first command from that file was executed. Line number increases by one with each command fetched.

The last file in the list is the one which was running when batch execution was terminated. Normally, there will only be one file shown in the list (level 0); batch execution is ended by the "END;" command at the end of that file. Batch execution is terminated on any error, or on remote/local change. In these cases, if batch files were nested (i.e., A.SEQ contained the command "SEQUENCE B.SEQ;"), then the list would contain more than one file name.

FORMAT:

END?

EXAMPLE:	**COMMAND**	**COMMENTS**
	END?	issued at power-up response: LEVEL FILENAME.EXT LINE<CR><LF> 0 CLEARCMD.SYS 87<CR><LF>

File Handling

LEARN_SETUP

(LEARN)

When this command is received, all the present instrument settings (parameters) are saved to a filename specified (the extension of which must always be .SET).

FORMAT:

LEARN_SETUP filename.SET

VALID FILENAMES:

Any combination of alphanumeric characters. (no symbols)

DEFAULTS:

Unspecified Argument: if no filename is specified, then a universal filename will automatically be supplied. It will be of the form: SETXXX.SET, where XXX is a sequential number managed by the generator.

EXAMPLE:	COMMAND	COMMENTS
	LEARN_SETUP ANYWAVE.SET; LEARN ANYWAVE.SET;	The present generator settings are saved into a file named ANYWAVE.SET
	LEARN_SETUP;	Since no filename is specified, the settings will be saved to a file named SET1.SET.
	LEARN;	

NOTES: No query form of this command.

File Handling **LINK**

This command causes the specified waveform to be added to the high speed memory, starting at the end of the last waveform previously LOADED or LINKED. The LINK command may not be used unless one waveform has been previously LOADED. Single waveforms (.WAV) cannot be linked to dual waveforms (.WAD) or visa versa. In the event a waveform is linked a multiple number of times it is not duplicated in high speed memory (HSM). This allows extremely complex waveforms to be made up of much simpler individual waveforms which can be used multiple times. Additionally, this feature can be used to gain even larger apparent HSM by specifying a repetition count for each linked waveform.

The "WAIT" argument, if present, tells the 9100 Series AFG to wait for trigger before executing this segment. More precisely, it tells the AFG to act as if the entire waveform ended with the segment before this one, and this segment is the first one in the next waveform repetition. See "Specifying the Trigger Mode" in Chapter 3 for details on the effect of "WAIT" in each trigger mode.

FORMAT:

LINK arg1 [arg2] [arg3]
where optional items are contained in brackets, and items to be replaced are in lower case.

VALID ARGUMENTS:

arg1: filename to link, with extension, such as A.WAD

arg2: number between 1 and 4095 inclusive representing the segment repetition count. Default if not present is 1.

arg3: WAIT. The presence of this argument indicates a pause or wait state before the waveform described by the filename in arg 1 will be output. The default, if "WAIT" is not present, is not to wait. Only the "W" is required. The presence of an argument in this position not beginning with "W" generates error code 16, invalid symbol

DEFAULT: Number of repetitions:1, no wait

EXAMPLE:

COMMAND	COMMENTS
LINK NEWWAVE.WAV, 300;	Requires "LOADED" waveform see LOAD. 9100 links NEWWAVE.WAV at next data point after end of present file contained in high speed memory. It also sets up this individual waveform to be repeated 300 times. Thus, the

composite wave created from LOAD ANYFILE.WAV (illustrated at LOAD) and NEWWAVE.WAV repeats the first wave segment 100 times and the second wave segment 300 times for each single repetition of the composite waveform.

NOTES:

1. *No query form of this command.*
2. *Minimum size of a wave that will be linked to other waveforms (or to have other waveforms linked to it is) is 72 bytes. This is 72 points of a single waveform or 36 points of a dual waveform.*

File Handling **LOAD**

Causes a specified waveform to be moved from the storage memory (RAM Disk) to the high speed memory (HSM). It is used for both Single and Dual Waveforms. The number of times the waveform must be repeated should be specified (not to exceed 4,095). If no specification is given, the generator will default to one.

This command must be issued *at least once* before issuing a GO command to execute the waveform.

FORMAT:

LOAD arg1, arg2

VALID ARGUMENTS:

arg1: Any waveform filename (.WAV or .WAD)

arg2: The number of repetitions for the waveform

DEFAULT:

Number of repetitions: 1

EXAMPLE:	COMMAND	COMMENTS
	LOAD ANYFILE.WAV, 100;	Moves the file named ANYFILE.WAV from the RAM memory to the High Speed Memory. It also sets up the Control Memory to repeat the waveform 100 times.

NOTES:

1. *No query form of this command.*
2. *Minimum size of a waveform that will have waveforms linked to it is 72 bytes. This is 72 points of a single waveform or 36 points of a dual waveform.*

File Handling **RECALL**

(RCL)

Causes the generator to send the contents of the specified file. The format will depend on the type of file being sent. If it is a Waveform file (.WAV or .WAD) it will be format #A, and will always be interleaved when a dual waveform file. If it is a Setup or Sequence file the format will be #I (see the section on file structures).

FORMAT:

RECALL arg

VALID ARGUMENTS:

Any valid Setup, Sequence, or Waveform filename (with extension).

EXAMPLE	COMMAND	COMMENTS
	RECALL MYFILE.WAD	Sends the entire contents of the waveform file named "MYFILE.WAD". It will be in format #A, and the data will be interleaved (see the File Structure section).

NOTES:

1. No query form of this command.

2. Over RS-232, waveform files are sent in #L format.

File Handling **SEQUENCE**

(SEQ)

This command causes the named Sequence file to execute. A Sequence file can contain most valid 9100 specific GPIB commands including the Setup and Sequence, but not NEXT or any query. Setup/Sequence files can be nested to a depth of five. The last command in a sequence file must be "END";. All commands within a sequence file should be terminated with a semicolon <;>.

FORMAT:

SEQUENCE arg

VALID ARGUMENTS:

Any 8 character or less file name with the .SEQ extension

EXAMPLE:	COMMAND	COMMENTS
	SEQUENCE ANYFILE.SEQ;	Initiates a sequence file in the 9100.
	SEQ ANYFILE.SEQ;	

NOTES:

1. *After execution of a sequence or setup file, the query command "END?" can be used to determine which line (starting at 1) was the last fetched from (each of the possibly up to five levels of nested) sequence file when execution ended.*
2. *The individual commands in a sequence file do not generate op complete status.*
3. *The NEXT command, from GPIB, does generate op complete status. While the 9100 is executing a sequence file it will not parse other GPIB commands; the immediate action command <ESC S> may be used instead of "STB?" to read the status bytes while a sequence is in progress. (See Table 5.3).*
4. *The immediate action command <ESC-A> will abort sequence/setup file execution if any; if none it will abort generation of the current waveform.*
5. *No query form of this command.*

File Handling **SETUP**

(SET)

Causes the named setup file to be executed. This configures the LeCroy 9100 as defined by the Setup file. The setup file must be resident in the 9100 RAM Disk Memory. The last command in a setup file must be "END;".

FORMAT:

SETUP arg

VALID ARGUMENTS:

Any filename with the extension .SET, resident in the RAM Disk Memory.

EXAMPLE:	COMMAND	COMMENTS
	SETUP FILENAME.SET; SET FILENAME.SET;	Sends a file from RAM to the 9100 hardware containing all of the instrument settings as defined in a file named FILENAME.SET.

NOTES:

1. *After execution of a sequence or setup file, the query command "END?" can be used to determine which line (starting at 1) was the last fetched from (each of the possibly up to five levels of nested) sequence file when execution ended.*
2. *The first line in a setup file automatically learned by the 9100 is the response to the query "FUNCTION?". This is for information only.*
3. *LEARN creates setup files containing the current setup. See LEARN.*
4. *No query form of this command.*

File Handling **STORE**

(STR)

Causes Waveform, Setup, or Sequence files to be moved from the GPIB to the generator's internal RAM Disk (storage memory). This step must precede executing a file. Setup or Sequence files may be executed only after being stored. Likewise, waveform files may be loaded into high speed memory only after having been stored. All file transfers are block format.

FORMAT:

STORE arg

VALID ARGUMENTS:

filename.SET (for Setups) or
filename.SEQ (for Sequence) or
filename.WAV (for Single Waveforms) or
filename.WAD (for Dual Waveforms)

VALID DATA BLOCKS:

1. #A or #L for both types of waveform files
2. #I for Setup and Sequence files (see the beginning of this section on file structures)

NOTE: For information on how to configure #A, #L and #I formats see Section 5.1.

EXAMPLE:	COMMAND	COMMENTS
	STORE MYFILE.WAD;	Stores MYFILE.WAD, which is two waveforms interleaved together, into file storage space (RAM memory). EOI must be asserted with the semicolon. The block of data must follow immediately.

NOTES: No query form of this command.

ACTION COMMANDS

Action Command **ABORT**

(ABO)

Stops the waveform currently being generated immediately without waiting for completion of the current repetition.

FORMAT:

ABORT

EXAMPLE:	COMMAND	COMMENTS
	ABORT; ABO; or <ESC> A;	Stops the generation of waveform file(s) in the high speed memory.

NOTES:

1. *<ESC>A aborts sequence/setup file execution if any; if none it aborts waveform generation.*

2. *No query form of this command.*

Action Command **ARBITRARY**

(ARB)

Selects arbitrary function mode. If a standard function was being generated it is aborted. In arbitrary mode you have explicit control over the 9100's clock. In this mode you can LOAD and LINK files from the 9100's file system into its high speed operating memory for generation.

FORMAT:

ARBITRARY

ARB

EXAMPLE:	**COMMAND**	**COMMENTS**
	ARB;	Select arbitrary function mode.

NOTES:

1. *The LOAD command forces ARBITRARY mode.*
2. *Query will respond with an argument of "ON" or "OFF".*

Action Command **ARM**

Used in conjunction with the TRIGGER_ARM_SOURCE BUS command to arm the trigger from the bus. If TAS BUS is already active, invoking the ARM command causes the trigger circuits to be enabled to accept the next trigger.

FORMAT:

ARM

EXAMPLE:	COMMAND	COMMENTS
	ARM;	If the generator TAS was BUS, then the trigger circuits would be enabled for the next trigger signal.

NOTES: To Query the state of ARM use TSTB 0. See Table 5.1.

Action Command **CALIBRATE**

(CAL)

Causes the generator to initiate a calibration cycle. A CAL cycle occurs automatically at power–up and whenever requested using this command. It is also executed as part of a SELFTEST command cycle. Calibrate writes a file into the 9100 file memory, CALERR.SEQ. This file contains plain text documenting any errors (or the lack of errors) in the last CALIBRATE. This file may be recalled at any time.

FORMAT:

CALIBRATE

EXAMPLE:	**COMMAND**	**COMMENTS**
	CAL;	The next time the waveform is stopped or aborted, the generator will initiate the self–calibration routine.

NOTES:

1. *CALERR.SEQ is not actually a SEQUENCE file. It is plain text, like a sequence file. Attempting to run it as a sequence file has no effect.*

2. *No Query form of this command.*

Action Command **CLEAR**

(CLE)

Resets all instrument settings to the power-up defaults. (See the section on power-up settings.)

FORMAT:

CLEAR

EXAMPLE:	**COMMAND**	**COMMENTS**
	CLEAR; CLE;	Causes the generator to reset all its settings to the power-up defaults.

NOTES:

1. *The [SHIFT] RESET key on the 9100/CP executes this command.*
2. *No Query form of this command.*
3. *"CLEAR FM" will clear file memory. All files of all types are deleted by this command. This is a completely different function than "CLEAR" without an argument and was originally for internal use only. However, enough people are using this command that we are now supporting it. For compatibility with earlier 9100 Series models "CLEAR FM" does not cause OPERATION COMPLETE status.*

Action Command GO

Causes generation of the waveform(s) loaded into the high speed memory to begin.

FORMAT:

GO

EXAMPLE:	COMMAND	COMMENTS
	GO;	The waveform(s) resident in the high speed memory at that moment from the previous LOAD and LINK commands will be generated after arm and trigger conditions are met. (See Trigger modes command)

NOTES:

1. *In the event that the following commands are requested during the execution of a waveform (i.e., while GO is executing) an ABORT and GO sequence is executed automatically by the generator, thus re-establishing the new conditions.*
   CH1/CH2 INVERT
   TRIGGER_MODE (in DELAY_MODE of POINTS or TIME)
   TRIGGER_DELAY

   Additionally, a change in amplitude will result in a momentary disconnect/reconnect of output. A change in CLOCK RATE will also result in a momentary stop and restart of the time base.

2. *A LOAD command terminates a GO, (i.e., ABORTS the waveform running).*

3. *No Query form of this command.*

Action Command **NEXT**

This command is sent over the bus when it is desired to cause a Sequence file, which is holding at a WAIT, to resume execution. An <ESC>N will accomplish the same result.

FORMAT: NEXT

EXAMPLES:	COMMAND	COMMENTS
	NEXT or <ESC>N;	Causes the resumption of the Sequence file which had previously been paused by an internal WAIT statement.

NOTES:

1. *The NEXT command from GPIB does generate 'Op complete' status. While the 9100 is executing a sequence file it will not parse other GPIB commands. The immediate action command <ESC> S may be used instead of "STB?" to read the status bytes while a sequence is in progress. (See Table 5.3).*

2. *No Query form of this command.*

Action Command **SELFTEST**

(SEL)

SELFTEST causes the following tests to be run:

1) CALIBRATION – Tests internal measurement paths (except for reference voltages), DAC's, attenuators and filters. Tests normal and sum path. See CALIBRATE for more information.

2) HIGH SPEED MEMORY – RAM test of high speed memory capable of detecting all stuck data bits or address lines, any coupled address lines, and coupling of adjacent data bits.

3) CONTROL MEMORY – RAM test similar to above.

4) NON-VOLATILE MEMORY – Non-destructive RAM test capable of detecting all the errors of the previous tests except for errors in the higher address lines, since the test is done in blocks (and the data from that block is saved elsewhere). Note that errors addressing non-volatile (file) memory would be obvious in operation.

5) HIGH SPEED MEMORY TO ANALOG BOARD TRANSFER – Tests the capability to transfer data from the high speed memory to the analog board along the path used during waveform generation.

The results of selftest appear only in status byte 8, readable by "STB 8". See table 5.1. Selftest takes over one minute to complete.

FORMAT:

SELFTEST

EXAMPLES:	**COMMAND**	**COMMENTS**
	SELFTEST;	The tests described above are run. The front panel SELFTEST LED is illuminated while the tests are in progress.

FRONT PANEL CONTROL/INDICATORS:

If the SELFTEST button is pressed until the SELFTEST LED lights, SELFTEST is initiated. The SELFTEST LED remains on during the duration of the tests.

NOTES:

1. *No Query form of this command.*
2. *The front panel Selftest button is only active in the LOCAL state, like all other local controls. See "IEEE-488 STANDARD MESSAGES" earlier in this chapter.*

Action Command **STOP**

Same as ABORT.

FORMAT:

STOP

EXAMPLE:	COMMAND	COMMENTS
	STOP;	Will cause a presently active waveform to stop running from the 9100 high speed memory.

NOTES: No Query form of this command.

Action Command **TRIGGER (TGR)**

If TRIGGER_SOURCE BUS=ON, this command will fire the trigger from the bus. Using the GPIB Device Trigger (GET) will achieve the same result.

FORMAT:

TRIGGER

EXAMPLE:	COMMAND	COMMENTS
	TRIGGER; TGR;	If the TRIGGER_SOURCE BUS is ON, it will initiate the trigger and cause the waveform to begin generation.

CHANNEL PARAMETER COMMANDS

Channel Parameter Command **CH1_AMPLITUDE**
CH2_AMPLITUDE
(C1A) (C2A)

Sets the peak-to-peak amplitude of the waveform being output on Channel 1 or Channel 2. The amplitude must be from 0 to 10 V. If it is desired to increase or decrease the amplitude from its current setting, the RELATIVE argument may be used. In this case the sign on the number designates the direction to increment: (+) for up and (–) for down.

FORMAT:

CH1_AMPLITUDE arg1, arg2
C1A arg1, arg2

VALID ARGUMENTS:

arg1:	A number from 0 to 10, with units designator mV or V. When used with RELATIVE (REL) command as arg2 this is a signed number, otherwise this is an unsigned number.
arg2:	The word RELATIVE (REL), (optional)

DEFAULTS:

Power–up: 1 V p–p; unspecified unit defaults to V.

EXAMPLES:

COMMAND	COMMENTS
CH1_AMPLITUDE +.1V, REL; C1A=+.1V, REL; C1A=.1,RELATIVE;	These commands increment current amplitude + .1 V

IMPORTANT: The following set of channel parameter commands for the 9100 are applicable to both Channel 1 and Channel 2. For instance, to change the amplitude of Channel 1 use C1A or CH1_AMPLITUDE. Similarly, to change the amplitude of Channel 2 use the command C2A or CH2_AMPLITUDE. Only the channel number is changed.

NOTES: Query responses are always sent as plain ASCII strings, not as a #I block.

Channel Parameter Command **CH1_FILTER**
CH2_FILTER
(C1F) (C2F)

This command selects one of five CH1 or CH2 Bessel filters. The generator will select the filter of the specified frequency, or the filter with the nearest wider bandwidth if the frequency does not correspond to the cutoff of an available filter. The filter can be disabled by using the OFF argument or by an input of 0 MHz. The filter frequencies go from 1 MHz to 100 MHz in a 1,3 sequence. (1 MHz, 3 MHz, 10 MHz, 30 MHz, 100 MHz).

FORMAT:

CH1_FILTER arg
C1F arg

VALID ARGUMENTS:

An unsigned number from 0 to 9999 with a maximum of 4 digit resolution,and unit designators (Hz, KHz, MHz).

OR

The word OFF may be used.

DEFAULTS: Power-up: OFF

EXAMPLE:	COMMAND	COMMENTS
	CH1_FILTER=10MHz; C1F=10MHz; C1F=OFF;	These commands will cause the CH1 filter to be set to 10 MHz. This command turns the filter off.

NOTES: Query responses are always sent as plain ASCII strings.

Channel Parameter Command **CH1_INVERT**
CH2_INVERT
(C1I) (C2I)

This command inverts the waveform in Channel 1 or Channel 2 and resets the ZERO_REFERENCE to the complement value about a center value of 127.5.

COMMANDS

FORMAT: CH1_INVERT
C1I

VALID ARGUMENTS:

ON	turns invert on if it is not currently on on
OFF	turns invert off if it is not currently off

DEFAULTS:

Power up: OFF

EXAMPLES:	COMMAND	COMMENTS
	C1I,ON;	This command inverts the waveform on channel 1.

FRONT PANEL CONTROL/INDICATORS: LEDs indicate invert state for each channel.

NOTES:

1. *The generator automatically handles changes of ZERO_REFERENCE, SINGLE TO DUAL WAVEFORM and DUAL TO SINGLE, if CH1, CH2 or both channels have INVERT on.*

2. *Query responses are always sent as plain ASCII strings.*

Channel Parameter Command

CH1_OFFSET
CH2_OFFSET
(C1O) (C2O)

Sets the Channel 1 or Channel 2 DC offset levels. If it is desired to increase or decrease from the present value, the REL argument may be used.

FORMAT:

CH1_OFFSET arg1, arg2
C1O arg1, arg2

VALID ARGUMENTS:

arg1: a signed number from 0 and 5 V with a unit designator (mV or V).
In RELATIVE (REL) mode, a signed number from 0 to 10 V.

arg2: The word RELATIVE (REL) (Optional).

DEFAULTS:

Power-up: 0 V

EXAMPLES:	**COMMANDS**	**COMMENT**
	CH1_OFFSET +1.05V;	The CH1 offset will be set to +1.05 V by these commands.
	CH1_OFFSET=+1.05 V; C1O=1.05;	

NOTES: Query responses are always sent as plain ASCII strings.

Channel Parameter Command **CH1_OUTPUT**
CH2_OUTPUT
(C1P) (C2P)

Controls the requested state of the CH1 or CH2 output relays and acts as an enable to the output control. The output will be connected when the output enable is on and the mode of the AFG allows the channel to be on.Channel 1 output will be on whenever a waveform is active and CH1_OUTPUT = ON.

NOTE: Turning SUM = ON forces CH1_OUTPUT = ON and CH2_OUTPUT = OFF.

CH1_OUTPUT may be controlled while SUM is ON, CH2_OUTPUT may not. When SUM is turned off, the state of CH1_OUTPUT and CH2_OUTPUT are restored to what they were when SUM was turned ON.

Channel 2 output will be on whenever a dual waveform is active and

CH2_OUTPUT = ON and SUM = OFF.

FORMAT:

C1P arg
CH1_OUTPUT arg

VALID ARGUMENTS:

The words ON, OFF, ALT

DEFAULTS:

Power-up: ON

EXAMPLE:	**COMMAND**	**COMMENTS**
	CH1_OUTPUT ON;	The output enable for CH1 is turned on. If waveform is active, the output relay for CH1 will be turned on.
	C1P=OFF;	The enable for CH1 is turned off. If the output relay for CH1 was on, it will be turned off.

NOTES: Query responses are always sent as plain strings.

Channel Parameter Command **CH1_ZERO_REF**
CH2_ZERO_REF
(C1Z) (C2Z)

This command specifies the point on the vertical axis of the CH1 or CH2 waveforms that represents the DC Offset level of the output. If the DC Offset is zero, then this command specifies the zero volt reference point for the waveform. Since there are 256 levels in the amplitude of the waveform (8 bits), the C1Z or C2Z can be set anywhere from 0 to 255. If it is desired to increase or decrease present value, then REL may be used as an argument.

FORMAT:

CH1_ZERO_REF arg1, arg2
C1Z, arg1, arg2

VALID ARGUMENTS:

arg1: a floating point number from 0 to 255. When used with RELATIVE command this is a signed number otherwise this is an unsigned number.

arg2: the word RELATIVE (REL).

DEFAULTS:

Power-up: 127.5

EXAMPLE:	COMMANDS	COMMENTS
	CH2_ZERO_REF=0 C1Z=0;	These commands set zero reference to 0, bottom of waveform then corresponds to DC offset level.
	C2Z=255;	Set zero reference to 255, top of waveform then corresponds to DC offset level.

NOTES:

1. *Query responses are always sent as plain ASCII strings.*

2. *Query respones will be of the form CH1_ZERO_REFERENCE, which will also parse correctly as a command, if COMM_HDR=LONG.*

Channel Parameter Command **EXTERNAL_SUM (XSUM)**

This command, when turned on, causes the signal present on the SUM (CH1) connector to be summed into CH1. The output is present on the CH1 output connector.

FORMAT:

EXTERNAL_SUM arg
XSUM arg

VALID ARGUMENTS:

The words ON, OFF.

DEFAULTS:

Power-up: OFF

EXAMPLE:

COMMANDS	COMMENTS
XSUM ON;	
XSUM OFF;	

Channel Parameter Command **SUM_MODE (SUM)**

This command, when turned on, causes the output relay of CH2 to be turned OFF and CH1 to be turned on. The CH2 waveform is diverted to CH1 where it is summed into the CH1 waveform. This command can be executed only if a dual (.WAD) waveform has been loaded into HSM. Otherwise an error will be generated. When turned off, the summing connection is broken and CH1 and CH2 are restored to the state they were in when SUM was turned on.

FORMAT:

SUM_MODE arg
SUM arg

VALID ARGUMENTS:

The words ON, OFF

DEFAULTS:

Power-up: OFF

EXAMPLE:	COMMAND	COMMENTS
	SUM_MODE ON; SUM=ON; SUM_MODE=OFF;	The CH2 waveform is summed into the CH1 waveform. Summing connection to CH1 from CH2 is broken. The waveforms are not summed together.

FRONT PANEL CONTROL/INDICATORS: SUM 1+2 INDICATOR = ON, if SUM = ON.

NOTES:

1. *Query responses are always sent as plain ASCII strings.*
2. *SUM mode does not preclude the use of EXTERNAL SUM as well.*

TIME BASE COMMANDS

Time Base Command — **CLOCK_SOURCE (CSOU)**

Selects the source of the generator clock: either internal or external.

FORMAT:

CSOU arg
CLOCK_SOURCE arg

VALID ARGUMENTS:

The words INTERNAL (INT), EXTERNAL (EXT)

DEFAULTS:

Power–up: INTERNAL

EXAMPLE:	COMMAND	COMMENT
	CSOU=INTERNAL;	The generator will use the internal clock source.
	CLOCK_SOURCE EXTERNAL; CSOU=EXT;	The generator derives clock from the rear panel BNC.

REAR PANEL CONTROL: External Input must be provided.

NOTES: Query responses are always sent as plain ASCII strings.

Time Base Command — CLOCK_LEVEL (CLEV)

Sets the threshold detection level for the EXTERNAL CLOCK input. The range is ±2.5 V, with 8 bits resolution. If it is desired to increase or decrease the level from its present value, the REL argument may be used.

FORMAT:

CLOCK_LEVEL arg1, arg2
CLEV arg1, arg2

VALID ARGUMENTS:

arg1: A signed number from 0 to 2.5, with an optional units designator. In RELATIVE (REL) mode a signed number (+/–) from 0 to 5 V with 3 digits resolution.

arg2: The word RELATIVE (REL); (optional).

DEFAULTS:

Power–up: +2V
Unspecified Command: sign: +
units: V
Not RELATIVE

EXAMPLE:	COMMAND	COMMENTS
	CLOCK_LEVEL +200mV;	This sets the EXTERNAL CLOCK threshold to +200 mV.
	CLEV=–2V;	This sets the EXTERNAL CLOCK threshold to –2 V.

REAR PANEL CONTROL: Applies only to external input.

NOTES: Query responses are always sent as plain strings.

Time Base Command **CLOCK_MODE (CMOD)**

CLOCK_MODE,SLAVE is used to synchronize one 9100 Series AFG to another. The unit placed in SLAVE mode uses the signal on the CLOCK IN (EXT) rear panel BNC connector as its clock. This signal is assumed to come from the CLOCK OUT 2 rear panel BNC connector of another 9100 which is in CLOCK MODE MASTER.

NOTE: CLOCK OUT 1 provides continuous output at the timebase frequency. Only CLOCK OUT 2 is suitable for MASTER/SLAVE operation.

Upon entering slave mode, CLOCK SOURCE defaults to EXTERNAL, CLOCK SLOPE defaults to positive, and CLOCK LEVEL defaults to -200 mV. The previous settings are restored upon receipt of a CLOCK MODE, MASTER command. While in slave mode, the CLOCK SOURCE and CLOCK SLOPE cannot be changed. CLOCK LEVEL can be changed. Also, while a unit is in slave mode, TRIG_MODE settings have no effect. The trigger delay is controlled by the absence of clock pulses from the master 9100. Trigger settings entered while in SLAVE mode will correctly take effect when the clock mode is changed to MASTER. Other commands that have no effect in SLAVE mode are: CRAT, CPER, MDEL, DMOD. Please see "Synchronizing with another 9100 Series AFG" in Chapter 3 for more information.

FORMAT:

CLOCK_MODE arg1

VALID ARGUMENTS:

MASTER
SLAVE

DEFAULT:

MASTER

EXAMPLE:

COMMAND	COMMENTS
CLOCK_MODE,SLAVE;	
CMOD,SLAVE;	
CLOCK_MODE,MASTER;	
CMOD,MASTER;	

QUERY RESPONSE:

CHDR off:	MASTER; or SLAVE;
CHDR short:	CMOD=MASTER; or CMOD=SLAVE;
CHDR long;	CLOCK_MODE=MASTER; or CLOCK_MODE=SLAVE;

REAR PANEL CONTROL:

The MASTER's CLOCK OUT 2 must be connected to the slave's CLOCK IN (EXT).

Time Base Command **CLOCK_RATE (CRAT)**

Sets the internal clock repetition rate in a frequency range from .05 Hz to 200 MHz. The new setting can be made relative to the current setting by using the RELATIVE (REL) argument. In that case, the number can be preceded by a sign to indicate whether the increment is up (+) or down (-).

FORMAT:

CLOCK_RATE arg1, arg2
CRAT arg1, arg2

VALID ARGUMENTS:

arg1: a number from .05 Hz to 200 MHz with 9 digits of resolution, with optional units designator (Hz, kHz, or MHz).

arg2: the words RELATIVE (REL) (optional).

DEFAULTS:

Power-up = 200 MHz
Unspecified command: Units: Hz, not RELATIVE

EXAMPLES:	COMMAND	COMMENTS
	CLOCK_RATE=100.1MHz; CRAT=100.1MHz;	Sets clock to 100.1 MHz

NOTES:

1. *Query responses are always sent as plain ASCII strings. Only 4 digits are returned.*
2. *CLOCK_PERIOD may be entered if preferred.*
3. *CLOCK_RATE not applicable if CLOCK_SOURCE is external.*

Time Base Command — **CLOCK_SLOPE (CSLO)**

Selects which edge of the external clock will be used as the reference for all external timing. Only applicable if CLOCK_SOURCE is set to external.

FORMAT:

CLOCK_SLOPE arg1
CSLO arg1

VALID ARGUMENTS:

The words POSITIVE (POS) or the word NEGATIVE (NEG) or ALTERNATE (ALT).

DEFAULTS:

Power-up: POSITIVE (POS)

EXAMPLE:	**COMMAND**	**COMMENTS**
	CLOCK_SLOPE=NEGATIVE; CSLO=NEG;	Causes transitions on the analog outputs to occur in response to negative going edges of the external clock signal.

REAR PANEL CONTROL: Only applicable to external input.

NOTES: Query responses are always sent as plain ASCII strings.

Time Base Command — **CLOCK_PERIOD (CPER)**

Sets the internal clock period in a range from 5 nsec to 20 sec The new setting can be made relative to the current setting by using the RELATIVE argument. In that case, a sign must precede the number to indicate whether the increment is up (+) or down (-).

FORMAT:

CLOCK_PERIOD arg1, arg2
CPER arg1, arg2

VALID ARGUMENTS:

arg1: a number from 5 nsec to 20 sec with optional units (sec, msec, μsec, nsec). In RELATIVE (REL) mode, can be a signed number from 5 nsec to 20 sec.

arg2: The words RELATIVE (REL). (optional)

DEFAULTS:

Power-up: 5 nsec
Unspecified Command: Units: sec, Not RELATIVE

EXAMPLES:	COMMAND	COMMENTS
	CLOCK_PERIOD=+5nsec,REL;	Increments the INTERNAL CLOCK period by 5 nsec.
	CPER=9.012msec;	Sets the INTERNAL CLOCK period to 9.012 msec.

NOTES:

1. *Query responses are always sent as plain ASCII strings. Only 4 digits are returned.*
2. *CLOCK_RATE may be entered, if preferred.*
3. *CLOCK_PERIOD not applicable if CLOCK_SOURCE is external.*

Timebase Commands **CLOCK_REFERENCE (CREF)**

This command selects internal or external 4 MHz phase lock loop reference for the 9100's internal clock generation circuitry. This permits multiple 9100s to run at different clock frequencies and still be phase locked.

NOTE: Do not set CREF EXT unless a 4 MHz signal is present at the reference input, or improper operation will result.

This command can be used as a query to find the current setting.

FORMAT:

CLOCK_REFERENCE arg
CREF arg
CLOCK_REFERENCE?
CREF?

VALID ARGUMENTS:

INT
INTERNAL
EXT
EXTERNAL

DEFAULT:

INTERNAL

EXAMPLE:	COMMAND	COMMENTS
	CREF INT;	Select internal clock reference.

REAR PANEL CONTROL: External reference must be supplied, if selected.

NOTES:

1. *Query responses are always sent as plain ASCII strings.*
2. *WARNING - Setting CLOCK_REFERENCE, EXTERNAL and failure to supply EXTERNAL REFERENCE will result in erroneous values for CLOCK_RATE and CLOCK_PERIOD.*

TRIGGER COMMANDS

Trigger Commands **DELAY_MODE (DMOD)**

This commands determines whether TRIGGER_DELAY and MARKER_DELAY will be set in either POINTS or TIME. In Standard Function mode, the delays should be set in time only, since the clock is not under explicit user control. See STANDARD for more information.If DMOD=TIME and the clock rate is changed, the 9100 attempts to maintain the specified delay in time. (This is likely to produce 'value adapted' status.)

Note that when CLOCK_SOURCE is EXTERNAL, the 9100 does not know the clock's period and is unable to calculate how many points is equivalent to how much time. Therefore, DELAY_MODE, POINTS should be used when CLOCK_SOURCE is EXTERNAL.

This command can be used as a query to find the current setting (see below).

FORMAT:

DELAY_MODE arg
DMOD arg
DELAY_MODE?
DMOD?

VALID ARGUMENTS:

POINTS
PTS
TIME
TIM

DEFAULT:

points (in Arbitrary Function mode).

EXAMPLE:	COMMAND	COMMENTS
	DMOD TIME;	Make TDEL and MDEL settable in time.

Trigger Command **MARKER_DELAY (MDEL)**

Controls the time position Marker synchronizing output pulse. This pulse is available at the Marker Output BNC. Its timing is relative to the trigger input, and it is only available in the RECURRENT, SINGLE or BURST Trigger Modes. The MARKER_DELAY command sets the delay in clock cycles (points) or time from the trigger point to the output pulse. See DELAY_MODE for more information. If the RELATIVE (REL) argument is used the delay will increase by the value in arg1.

Note that if the Marker delay is programmed for a number of greater than the sum of the trigger delay and the total number of points that will be output (including segment repetitions, links, and waveform repetitions), no Marker pulse will be generated. Also, at clock rates greater than 10 MHz, the width of the Marker pulse (nominally 75 nsec) may be reduced if it is positioned with 75 nsec of the last point generated.

FORMAT:

MARKER_DELAY arg1, arg2
MDEL arg1, arg2

VALID ARGUMENTS:

arg1: Any integer number from 4 to 1+E6. In RELATIVE mode arg1 is a signed number in the range (+/-) 1+E6.

arg2: The word RELATIVE (REL). (Optional)

DEFAULTS:

Power-up: 4 Unspecified Command: Not Relative

EXAMPLE:

COMMAND	COMMENTS
MARKER_DELAY 4000; MDEL=4000;	The marker pulse will be delayed 4000 clock cycles from the trigger point.

FRONT PANEL CONTROL/INDICATORS: Available at front panel connector

NOTES:

1. *In the RECURRENT trigger mode the minimum delay is 16 clock cycles.*
2. *The valid arguments listed above assume that DELAY_MODE is POINTS. For DELAY_MODE, TIME, the range of valid arguments is dependent upon the CLOCK_RATE, and extends from 20 nsec to 10,000,000 sec.*
3. *Query responses are always sent as plain ASCII strings.*

Trigger Command — **TRIG_ARM_SOURCE (TAS)**

Selects the source for arming the trigger. There are two options: the bus or automatic re-arming. The bus argument is useful if it is desirable to have the trigger disabled until just before the event. The auto argument is useful when a repetitive signal is present on the Ext. Trigger input and it is desired that the waveform be re-triggered as fast as possible.

FORMAT:

TRIG_ARM_SOURCE arg

TAS arg

VALID ARGUMENTS:

BUS: receives its arming command from the GPIB, RS-232, or the Optional Control Panel.

AUTO: automatically re-arms itself as soon as the waveform has completed one cycle.

DEFAULTS:

Power-up: AUTO

EXAMPLE:	COMMAND	COMMENTS
	TRIG_ARM_SOURCE=BUS; TAS=BUS;	Receives its arming signal from a bus or the optional control panel.
	TAS=AUTO;	Re-arms after each waveform cycle.
	TAS?	Query.

Trigger Command **TRIG_DELAY (TDEL)**

Causes a specified delay, in clock cycles (points) or time, from the time of receipt of a trigger to the start of a waveform. Can be any value from two to one million points or the equivalent in time. If it is desired to increase the value from the present value the RELATIVE argument can be used. If the REL argument is used the TRIG_DELAY will be increased or decreased (+/–) by the specified value. See DELAY_MODE for more information.

FORMAT:

TRIG_DELAY arg1, arg2

TDEL arg1, arg2

VALID ARGUMENTS:

arg1: An integer value between 2 and 1+E6. In RELATIVE (REL) mode it can be a number (+/–) 1+E6.

arg2: The word RELATIVE (REL) (optional).

DEFAULTS:

Power-up: 4
Unspecified Command: not relative

EXAMPLE:	**COMMAND**	**COMMENTS**
	TDEL=+10,REL;	Increases the trigger delay in clock cycles (points) by a count of ten.
	TRIG_DELAY = +10,REL;	

NOTES:

1. *In RECURRENT TRIG_MODE the minimum delay is 16 clock cycles.*
2. *The valid arguments listed above assume that DELAY_MODE is POINTS. For DELAY_MODE, TIME, the range of valid arguments is dependent upon the CLOCK_RATE, and extends from 20 nsec to 10,000,000 sec.*
3. *Query responses are always sent as plain ASCII strings.*

Trigger Command — **TRIG_LEVEL (TLEV)**

Sets the threshold voltage level for an external trigger signal where the trigger will cause the waveform to start. It is settable in the range from ±2.5 V with three digits of resolution. If the optional RELATIVE (REL) argument is used, the value expressed in arg1 becomes the value for increasing the present level.

FORMAT:

TRIG_LEVEL arg1, arg2

TLEV arg1, arg2

VALID ARGUMENTS:

arg1: Any signed number in the range (+/-) 2.5 with up to three digits of resolution and an optional units designator (mV or V). In RELATIVE (REL) Mode, can be a signed number (+/-) 5 V.

arg2: The word RELATIVE (REL) (optional).

DEFAULTS:

Power-up: +2V
Unspecified Command: Sign: plus(+) Units: Volts (V)

EXAMPLE:	COMMAND	COMMENTS
	TRIG_LEVEL +1.05V; TLEV=1.05 V;	Sets the trigger level to +1.05V.

FRONT PANEL CONTROL/INDICATORS: Command only applicable to front panel external TRIGGER/GATE input.

NOTES: Query responses are always sent as plain ASCII strings.

Trigger Command **TRIG_MODE (TMOD)**

This command determines how the waveform is generated. It can be generated in one of five ways: CONTINUOUS – where the waveform starts again with the very next clock cycle after its last programmed point; RECURRENT – after completing its last programmed point, the waveform starts again, but with a programmable delay (TRIG_DELAY command); SINGLE – where the waveform runs only once after receiving an external or manual trigger; BURST – where the waveform runs a programmed number of repetitions upon receipt of an internal or external trigger, then stops; GATE – where the waveform runs continuously after a gate signal is detected above threshold at the Trigger/Gate input. The gated signal stops after the gate signal drops below threshold. (See also TRIG_ARM_SOURCE and TRIGGER_SOURCE commands.)

FORMAT:

TRIG_MODE arg1, arg2

TMOD arg1 arg2

VALID ARGUMENTS:

arg1:
1. CONTINUOUS (CON)
2. RECURRENT (REC)
3. SINGLE (SING)
4. BURST (BUR)
5. GATE

arg2: Any integer number from 0 to 65,535. It specifies the number of waveform cycles to be repeated. NOTE: arg2 is valid only when used with either the RECURRENT or BURST arguments.

DEFAULTS:

Power–up: CONTINUOUS
Unspecified Command: Current Setting

EXAMPLE:	COMMAND	COMMENTS
	TRIG_MODE BURST,100;	The waveform will not start until it receives a manual or external trigger signal. Then it will repeat 100 times and stop.
	TMOD = SING;	After receiving an external or manual trigger signal, the waveform runs one time only.

NOTES: Query responses are always sent as plain ASCII strings.

Trigger Command **TRIG_SLOPE**
(TSLO)

Selects which slope of an external trigger signal will be used to start the waveform. This command is only used when the TRIG_MODE is SINGLE, BURST or GATED.

FORMAT:

TRIG_SLOPE arg
TSLO arg

VALID ARGUMENTS:

The word POSITIVE (POS), or the word NEGATIVE (NEG)

DEFAULTS:

Power-up: POSITIVE (POS)

EXAMPLE:	COMMAND	COMMENTS
	TRIG_SLOPE NEGATIVE; TSLO = NEG;	Causes the waveform to start on the negative edge of an external trigger signal.

FRONT PANEL CONTROL/INDICATORS: Command only applicable to front panel TRIGGER/GATE input.

NOTES: Query responses are always sent as plain ASCII strings.

Trigger Command **TRIG_SOURCE (TSOU)**

This command selects the source for the trigger signal. The options are: MANUAL (front-panel button or control panel key), EXTERNAL (an analog signal from the External Trigger input BNC), or BUS (from either the GPIB or the RS-232 bus). Any one, all, or any combination of these may be active at the same time, they are logically OR'd together.

FORMAT:

TSOU arg1, arg2
TRIG_SOURCE arg1, arg2

VALID ARGUMENTS:

arg1: 1. MANUAL (MAN)
2. EXTERNAL (EXT)
3. BUS

arg2: ON or OFF

DEFAULTS:

Power-up: MAN and BUS ON and EXT OFF
Unspecified Command: current settings

QUERY RESPONSE:

All three sources and their state (ON or OFF)

EXAMPLE:

COMMAND	COMMENTS
TRIG_SOURCE MANUAL, ON;	This turns on the MANUAL trigger source.
TSOU MAN, OFF;	Turns off the MANUAL trigger source.

QUERY RESPONSES: Queries are individually requested by source (i.e., TSOU MAN?)

COMM_HEADER	= OFF:	ON/OFF;
	= SHORT:	TSOU (MAN/EXT/BUS) OFF/ON;
	= LONG	TRIG_SOURCE (MANUAL/EXTERNAL/BUS) (OFF/ON);

NOTES:

1. *If all trigger sources are "ON" a trigger will occur on a first-come, first-serve basis if trigger arm source is bus and the generator is armed in a triggerable mode (i.e., single or burst). In TRIG_ARM_SOURCE = AUTO, under these circumstances trigger is strictly first-come, first-served.*

2. *Query responses are always sent as plain ASCII strings.*
3. *If no trigger source is enabled in a triggered mode, issuing the 'GO' command produces error status.*

STANDARD FUNCTION COMMANDS

Standard Function **STANDARD (STAN)**

Selects standard function generation mode. If an arbitrary waveform was being generated it is aborted. In this mode you cannot LOAD and LINK files, you simply specify the desired function and GO.

In standard mode the 9100's clock is automatically set to achieve the characteristics of the function which you requested. Since you do not have explicit control over the 9100's clock, i.e., the time per point, you should set DELAY_MODE to TIME.

FORMAT:

STANDARD
STAN

EXAMPLE:	**COMMAND**	**COMMENTS**
	STAN;	Select standard function mode.

NOTE: Use FUNCTION to determine the current function.

NOTES:

1. *It is not necessary to send this command. For example, sending SINE; GO; is sufficient to enter standard function SINE and generate a sine waveform.*
2. *If FUNC was ARBITRARY, after issuing the STANDARD command, the query "FUNC?;" will return FUNC = STANDARD. In this state the 9100 waits for you to select a function (e.g., SINE). If a standard function was already running, STANDARD has no effect.*

Standard Function **SINE**
(SINE)

This command forces Standard Function mode. It selects sine wave as the current standard function. If some other standard function was being generated it is aborted. After issuing this command, issuing GO will cause a sine wave to be generated using the current settings.

FORMAT:

SINE

EXAMPLE:	**COMMAND**	**COMMENTS**
	SINE;	Select SINE as the current standard function.

QUERY RESPONSES:
Use FUNCTION? to determine the current function.

NOTES: If the 9100 is already generating a STANDARD function SINE, this command has no effect and output continues.

Standard Function — **SINE_MODE (SMOD)**

Select single or dual channel sine wave generation.This command can be used as a query to find the current setting.

FORMAT:

SINE_MODE arg
SMOD arg
SINE_MODE?
SMOD?

VALID ARGUMENTS:

SINGLE
SING
DUAL

DEFAULT: Power-up: SINGLE

EXAMPLE:	COMMAND	COMMENTS
	SMOD SING;	Select single channel output for standard function sine wave.
	SMOD?;	Would return either SINGLE (or SING) or DUAL, reflecting the current setting.

NOTES: If the 9100 is already generating a standard SINE wave, output continues in the new mode.

Standard Function **SINE_FREQUENCY (SIFR)**

Sets the frequency of the sine wave generated by the SINE standard function.

This command can be used as a query to find the current setting.

FORMAT:

SINE_FREQUENCY arg1,arg2
SIFR arg1,arg2
SINE_FREQUENCY?
SIFR?

VALID ARGUMENTS:

arg1: A number representing the frequency in Hz, from 0.010 to 25.0E+6 or INC or DEC.

arg2: Optional. Relative. If this argument is omitted, arg1 becomes the sine wave frequency.

DEFAULT: Power-up: 1 MHz

EXAMPLE:	COMMAND	COMMENTS
	SIFR 10MHZ;	Sets sine frequency to 10 MHz. If a standard function sine wave is being output, this takes effect immediately.
	SIFR?;	Returns the current setting.

NOTES: If the 9100 is already generating a standard SINE wave, output continues at the new frequency.

Standard Function **SINE_CH1_PHASE (SC1P)**

Sets standard function sinewave Channel 1 starting phase in degrees.

NOTE: If SINE_MODE is dual, this will effect the starting phase of Channel 2 also; see SC2P for more information.

This command can be used as a query to find the current setting.

FORMAT:

SINE_CH1_PHASE arg1,arg2
SC1P arg1,arg2
SINE_CH1_PHASE?
SC1P?

VALID ARGUMENTS:

arg1: A number from 0 to 360, or INC or DEC

arg2: Optional. REL

DEFAULT: Power-up: 0

EXAMPLE:	COMMAND	COMMENTS
	SC1P 45;	The first point in the generated sine wave will be at 45 degrees. If a standard function sine wave is being output, this takes effect immediately.
	SC1P 10,REL;	SC1P is increased by 10 degrees.
SC1P?;	The current setting is returned.	

NOTES: If the 9100 is already generating a standard sine wave, output continues at the new phase.

Standard Function **SINE_CH2_PHASE (SC2P)**

Sets standard function sine wave Channel 2 phase in degrees relative to Channel 1 phase.

NOTE: Channel 2 leads Channel 1 by the number of degrees specified.

This command can be used as a query to find the current setting.

FORMAT:

```
SINE_CH2_PHASE arg1,arg2
SC2P arg1,arg2
SINE_CH2_PHASE?
SC2P?
```

VALID ARGUMENTS:

arg1: A number from 0 to 360

arg2: Optional. REL

EXAMPLE:	**COMMAND**	**COMMENTS**
DEFAULT: Power-up: 0		
	SC2P 45;	The first point in channel 2's generated sine wave will be 45 degrees ahead of channel 1's sine wave. If a standard function sine wave is being output, this takes effect immediately.
	SC2P 10,REL;	SC2P is increased by 10 degrees.
SC2P?;	The current setting is returned.	

NOTES: If the 9100 is already generating a standard sine wave, this command causes the new wave to be calculated and output continues.

Standard Function **SQUARE**
(SQU)

This command forces Standard Function Mode. It selects square wave as the current standard function. If some other standard function was being generated it is aborted.

After issuing this command, issuing GO will cause a square wave to be generated at the current settings.

FORMAT:

SQUARE

EXAMPLE:	COMMAND	COMMENTS
	SQUARE;	Select SQUARE as the current standard function.

QUERY RESPONSES: Use FUNCTION? to determine the current function.

Standard Function

SQUARE_MODE (SQMD)

Select single or dual channel square wave generation.

This command can be used as a query to find the current setting.

FORMAT:

SQUARE_MODE arg
SQUARE_MODE?
SQMD?

VALID ARGUMENTS:

SINGLE
SING
DUAL

DEFAULT: Power-up: Single

EXAMPLE:	COMMAND	COMMENTS
	SQMD SING;	Select single channel output for standard function square wave.
	SQMD?;	Would return either SINGLE (or SING) or DUAL, reflecting the current setting.

Standard Function **SQUARE_FREQUENCY (SQFR)**

Sets the frequency of the square wave generated by the SQUARE standard function. This command can be used as a query to find the current setting.

FORMAT:

```
SQUARE_FREQUENCY arg1,arg2
SQFR arg1,arg2
SQUARE_FREQUENCY?
SQFR?
```

VALID ARGUMENTS:

arg1: A number representing the frequency in Hz, from 0.010 to 100.0E+6.

arg2: Optional. REL. If this argument is omitted, arg1 becomes the squarewave frequency.

DEFAULT: Power-up: 1 MHz

EXAMPLE:	COMMAND	COMMENTS
	SQFR 10MHZ;	Sets squarewave frequency to 10 MHz. If a standard function square wave is being output, this takes effect immediately.
	SQFR 100,REL; SQFR?;	SQFR is increased by 100 Hz. Returns the current setting.

Standard Function **SQUARE_PHASE (SQUP)**

Sets standard function square wave Channel 1 starting phase in time.

Note that if SQUARE_MODE is dual, this will effect the starting phase of Channel 2 also; see SQRP for more information.

This command can be used as a query to find the current setting.

FORMAT:

SQUARE_PHASE arg1,arg2
SQUP arg1,arg2
SQUARE_PHASE?
SQUP?

VALID ARGUMENTS:

arg1: A time which is a fraction of the selected period. Times in excess of period will be ignored.

arg2: Optional. REL.

DEFAULT: Power-up: 0

EXAMPLE:	**COMMAND**	**COMMENTS**
	SQUP 100ns	The first point in the generated square wave will be at 100 nsec after the transition to the lowest value. If a standard function square wave is being output, this takes effect immediately.
	SQUP 10ns,REL;	SQUP is increased by 10 nsec.
	SQUP?;	The current setting is returned.

Standard Function **SQUARE_RELATIVE_PHASE (SQRP)**

Sets standard function square wave Channel 2 phase in time relative to Channel 1 phase.

NOTE: Channel 2 leads Channel 1 by the time specified.

This command can be used as a query to find the current setting.

FORMAT:

SQUARE_RELATIVE_PHASE arg1,arg2
SQRP arg1,arg2
SQUARE_RELATIVE_PHASE?
SQRP?

VALID ARGUMENTS:

arg1: A time which is a fraction of the selected period, i.e., 0 to period.

arg2: Optional. REL

DEFAULT: Power-up: 0

EXAMPLE:	COMMAND	COMMENTS
	SQRP 100ns;	Channel 2's square wave will be 100 nsec ahead of channel 1's square wave. If a standard function square wave is being output, this takes effect immediately.
	SQRP 10,REL;	SQRP is increased by 10 nsec.
	SQRP?;	The current setting is returned.

NOTES: If COMM_HDR=LONG, query responses will be of the form SQ_REL_PHASE, which will also parse correctly as a command

Standard Function **TRIANGLE (TRI)**

This command forces Standard Function mode. It selects triangle wave as the current standard function. If some other standard function was being generated it is aborted.

After issuing this command, issuing GO will cause a triangle wave to be generated using the current settings.

FORMAT:

TRIANGLE
TRI

EXAMPLE:	**COMMAND**	**COMMENTS**
	TRI;	Select TRIANGLE as the current standard function.

QUERY RESPONSES: Use FUNCTION? to determine the current function

Standard Function TRIANGLE_MODE (TRIM)

Select single or dual channel triangle wave generation.This command can be used as a query to find the current setting.

FORMAT:

TRIANGLE_MODE arg
TRIM arg
TRIANGLE_MODE?
TRIM?

VALID ARGUMENTS:

SINGLE
SING
DUAL

DEFAULT: Power-up: SINGLE

EXAMPLE:	COMMAND	COMMENTS
	TRIM SING;	Select single channel output for standard function triangle wave.
	TRIM?	Would return either SINGLE (or SING) or DUAL, reflecting the current setting.

Standard Function **TRIANGLE_FREQUENCY (TRFR)**

Sets the frequency of the triangle wave generated by the TRIANGLE standard function.

This command can be used as a query to find the current setting.

FORMAT:

```
TRIANGLE_FREQUENCY arg1,arg2
TRFR arg1,arg2
TRIANGLE_FREQUENCY?
TRFR?
```

VALID ARGUMENTS:

arg1: A number representing the frequency in Hz, from 0.010 to 25.0E+6.

arg2: Optional. REL. If this argument is omitted, arg1 becomes the triangle frequency.

DEFAULT: Power-up: 1 MHz

EXAMPLE:	COMMAND	COMMENTS
	TRFR 10MHZ;	Sets triangle frequency to 10 MHz. If a standard function triangle wave is being output, this takes effect immediately.
	TRFR 100,REL; TRFR?	TRFR is increased by 100 Hz. Returns the current setting.

Standard Function **TRIANGLE_PHASE (TRIP)**

This command sets the starting point of the Channel 1 triangle wave. Unlike SINE_CH1_PHASE but like RAMP_PHASE and SQUARE_PHASE, this command's first argument is not in degrees but is in time, from 0 to period.

NOTE: If TMOD is DUAL, this will affect the starting phase of Channel 2 also; see TRRP for more information.

This command can be used as a query to find the current setting.

FORMAT:

TRIANGLE_PHASE arg1,arg2
TRIP arg1,arg2
TRIANGLE_PHASE?
TRIP?

VALID ARGUMENTS:

arg1: A number representing the time offset into the wave, from 0 to the period, or INC or DEC.

arg2: Optional. REL.

DEFAULT: Power-up: 0

EXAMPLE:

COMMAND	COMMENTS
TRIP 40ns;	Sets triangle "phase" to 40 nsec, which means the wave begins at the point which is 40 nsec after the lowest value. If a standard function triangle wave is being output, this takes effect immediately.
TRIP 10E-9,REL;	TRIP is increased by 10 nsec.
TRIP?	Returns the current setting.

Standard Function **TRIANGLE_RELATIVE_PHASE (TRRP)**

Sets standard function triangle wave Channel 2 starting phase in time, relative to Channel 1. This command can be used as a query to find the current setting.

FORMAT:

TRIANGLE_RELATIVE_PHASE arg1,arg2
TRRP arg1,arg2
TRIANGLE_RELATIVE_PHASE?
TRRP?

VALID ARGUMENTS:

arg1: A number from 0 to period, or INC or DEC.

arg2: Optional. REL

DEFAULT: Power-up: 0

EXAMPLE:	COMMAND	COMMENTS
	TRRP 100nsec;	All points in Channel 2's triangle wave will precede the corresponding points in Channel 1 by 100 nsec. If a standard function triangle wave is being output, this takes effect immediately.
	TRRP 10nsec,REL; TRRP?	TRRP is increased by 10 nsec. The current setting is returned.

NOTES: If COMM_HDR=LONG, query responses will be of the form TRI_REL_PHASE, which will also parse correctly as a command

Standard Function **RAMP**
(RAMP)

This command forces Standard Function mode. It selects RAMP as the current standard function. If some other standard function was being generated it is aborted.

After issuing this command, issuing GO will cause a ramp to be generated using the current settings.

FORMAT:

RAMP

EXAMPLE:	COMMAND	COMMENTS
		Select RAMP as the currrent standard function.

QUERY RESPONSES: Use FUNCTION? to determine the current function.

Standard Function **RAMP_MODE (RMOD)**

Select single or dual channel ramp wave generation.

This command can be used as a query to find the current setting.

FORMAT:

RAMP_MODE arg
RMOD arg
RAMP_MODE?
RMOD?

VALID ARGUMENTS:

SINGLE
SING
DUAL

DEFAULT: Power-up: SINGLE

EXAMPLE:	COMMAND	COMMENTS
	RMOD SING;	Select single channel output for standard function ramp wave.
	RMOD?	Would return either SINGLE (or SING) or DUAL, reflecting the current setting.

Standard Function — **RAMP_PERIOD (RPER)**

Sets the period of the ramp generated by the RAMP standard function.

This command can be used as a query to find the current setting.

FORMAT:

```
RAMP_PERIOD arg1,arg2
RPER arg1,arg2
RAMP_PERIOD?
RPER?
```

VALID ARGUMENTS:

arg1: A number representing the time duration of the ramp in seconds, from 40 nsec to 100.0 sec.

arg2: Optional. REL.

DEFAULT: Power-up: 1 µsec

EXAMPLE:

COMMAND	COMMENTS
RPER 10us;	Sets ramp period to 10 µsec. If a standard function ramp is being output, this takes effect immediately.
RPER 1E-6,REL; RPER?;	RPER is increased by 1 µsec. Returns the current setting.

Standard Function **RAMP_PHASE (RMPP)**

This command sets the starting point of the standard function ramp.

Unlike SINE_CH1_PHASE but like TRIANGLE_PHASE and SQUARE_PHASE this command's first argument is not in degrees but is in time, from 0 to period.

This command can be used as a query to find the current setting.

FORMAT:

RAMP_PHASE arg1,arg2
RMPP arg1,arg2
RAMP_PHASE?
RMPP?

VALID ARGUMENTS:

arg1: A number representing the time offset into the wave, from 0 to the period, or INC or DEC.

arg2: Optional. REL.

DEFAULT: Power-up: 0

EXAMPLE:	**COMMAND**	**COMMENTS**
	RMPP 40ns;	Sets ramp "phase" to 40 nsec, which means the wave begins at the point which is 40 nsec after the lowest value. If a standard function ramp is being output, this takes effect immediately.
	RMPP 10E-9,REL; RMPP?	RMPP is increased by 10 nsec. Returns the current setting.

Standard Function **RAMP_RELATIVE_PHASE (RPRP)**

Sets standard function ramp wave Channel 2 phase in time relative to Channel 1 phase.

NOTE: Channel 2 leads Channel 1 by the time specified.

This command can be used as a query to find the current setting.

FORMAT:

RAMP_RELATIVE_PHASE arg1,arg2
RPRP arg1,arg2
RAMP_RELATIVE_PHASE?
RPRP?

VALID ARGUMENTS:

arg1: A number from 0 to period, or INC or DEC

arg2: Optional. REL.

DEFAULT: Power-up: 0

EXAMPLE:	COMMAND	COMMENTS
	RPRP 45ns;	All points in channel 2's generated ramp wave precede the corresponding points in channel 1's by 45 nsec. If a standard function ramp wave is being output, this takes effect immediately.
	RPRP 10ns,REL;	RPRP is increased by 10 nsec.
RPRP?	The current setting is returned.	

NOTES: If COMM_HDR=LONG, query responses will be of the form RAMP_REL_PHASE, which will also parse correctly as a command

Standard Function **PULSE**
(PUL)

This command is only available in Standard Function Mode. It selects PULSE as the current standard function. If some other standard function was being generated it is aborted.

After issuing this command, issuing GO will cause a pulse to be generated using the current settings.

NOTE: Pulse functions are not available for CH2 (i.e., DUAL mode).

FORMAT:

PULSE

EXAMPLE:	**COMMAND**	**COMMENTS**
	PULSE;	Select PULSE as the current standard function.

Standard Function **PULSE_WIDTH (PWID)**

This command sets the duration of the high part of the standard function pulse waveform. This command can be used as a query to find the current setting.

FORMAT:

PULSE_WIDTH arg1,arg2
PWID arg1,arg2
PULSE_WIDTH?
PWID?

VALID ARGUMENTS:

arg1: A number from 5 nsec to almost 10 sec.

arg2: Optional. REL.

DEFAULT: Power-up: 200 nsec.

EXAMPLE:	COMMAND	COMMENTS
	PWID 27.3nsec; PWID?	Sets pulse width to 27.3 nsec. Returns current setting.

Standard Function **PULSE_PERIOD (PPER)**

Select the repetition rate of the standard function pulse.

This command can be used as a query to find the current setting.

FORMAT:

PULSE_PERIOD arg1,arg2
PPER arg1,arg2
PULSE_PERIOD?
PPER?

VALID ARGUMENTS:

arg1: A number from 40 nsec to 10 sec, or INC or DEC.

arg2: Optional. REL.

DEFAULT: Power-up: 2 µsec.

EXAMPLE:	COMMAND	COMMENTS
	PPER 1.234msec; PPER?;	Sets pulse period to 1.234 msec. Returns current setting.

Standard Function **PULSE_DELAY (PDEL)**

This command sets a specified delay in time from receipt of a trigger to the start of the standard function Pulse waveform. This command has no meaning in Continuous or Gated Trigger Modes. The mimimum setting is dependent on the trigger mode.

This command is exactly analagous to TRIGGER_DELAY in time mode. PULSE_DELAY is used in standard function Pulse instead of TRIGGER_DELAY.

This command can be used as a query to find the current setting.

FORMAT:

PULSE_DELAY arg1,arg2
PDEL arg1,arg2
PULSE_DELAY?
PDEL?

VALID ARGUMENTS:

arg1: Any value from 25.0 nsec to 5.0 msec in single or burst trigger modes. 85.0 nsec to 5.0 msec in recurrent trigger mode.

arg2: Optional. REL.

DEFAULTS:

Power-up: 100 nsec.

EXAMPLE:	COMMAND	COMMENTS
	PDEL 1 us;	Sets pulse delay to 1 μsec. If a standard function pulse is being generated, this command takes effect immediately.
	PDEL REL;	Invalid. Missing arg1.

Standard Function **PULSE_OPTIMIZE (POPT)**

This command asks the 9100 to achieve highest accuracy on pulse width, pulse period or pulse delay.To consider why this is necessary, consider asking the 9100 to produce a 20 nsec pulse at a 53.7 nsec period, and have a trigger delay of 61 nsec. Since the 9100's minimum clock period is 5 nsec, it cannot attain accurate timing of more than one of these settings in this case. The PULSE_OPTIMIZE command instructs the 9100 to attempt to get one of the parameters exactly, at the expense of the others.

This command can be used as a query to find the current setting.

FORMAT:

PULSE_OPTIMIZE arg
POPT arg
PULSE_OPTIMIZE?
POPT?

VALID ARGUMENTS:

WIDTH
PERIOD
DELAY

EXAMPLE:	COMMAND	COMMENTS
	POPT WIDTH;	Ask the 9100 to get the pulse width as close as possible to PULSE_WIDTH setting. If a standard function pulse is being generated, this takes effect immediately.
	POPT?	Returns current setting.

Standard Function **DC**

(DC)

This command forces Standard Function Mode. It selects DC as the current standard function. If some other standard function was being generated it is aborted.

After issuing this command, issuing GO will cause a DC level to be generated. The value generated is determined by the OFFSET command. (See Channel/Parameter Commands). ZERO_REFERENCE should be set to 128.

FORMAT:

DC

EXAMPLE:	COMMAND	COMMENTS
	DC;	Cause DC level to be generated corresponding to the OFFSET and AMP setting.

QUERY RESPONSES: Use FUNCTION? to determine the current function.

Standard Function **DC_MODE (DCMD)**

Select single or dual channel DC level generation.

This command can be used as a query to find the current setting.

FORMAT:

DC_MODE arg
DCMD arg
DC_MODE?
DCMD?

VALID ARGUMENTS:

SINGLE
SING
DUAL

DEFAULT: Power-up: SINGLE

EXAMPLE:	COMMAND	COMMENTS
	DCMD SING;	Select single channel output for standard function DC level.
	DCMD?;	Would return either SINGLE (or SING) or DUAL, reflecting the current setting.

QUERY TYPE (Informational) COMMANDS

File Handling (also Query Type Command) **ACTIVE_FILES (AFIL)**

This command is a query command which causes the names of all the currently active files to be returned over the GPIB. These would include the active SETUP file, SEQUENCE file, and all the WAVEFORM (.WAV or .WAD) files currently active in the high speed memory. These messages are sent in an ASCII format string. As in the directory listing, the names of active files are preceded by '*'.

FORMAT: ACTIVE_FILES
AFIL

EXAMPLES	COMMAND	COMMENTS
	ACTIVE_FILES; AFIL;	Returns to controller the names of all active files in the LeCroy 9100. *NOTE: If there is a series of files linked, it will return their names also.*

NOTES: The same formatted string as seen on a 9100/CP is returned. It is variable length with CRLF each 16 bytes. Unused lines are padded with spaces. It is terminated with the semicolon and is suitable for direct viewing.

Standard Function **FUNCTION**
(FUNC)

This command is a query which causes the LeCroy 9100 to return a string, either "ARBITRARY" or SINE, TRIANGLE, RAMP, SQUARE, DC_SING, DC_DUAL, PULSE, or STANDARD. This indicates whether the 9100 is currently in Arbitrary Waveform or Standard Function Mode. "STANDARD" is only returned after the STANDARD command is received, before a function is selected. See the commands ARBITRARY and STANDARD for more information.

FORMAT:

FUNCTION
FUNC
FUNCTION?
FUNC?

EXAMPLE:	COMMAND	COMMENTS
	FUNCTION;	9100 returns either ARBITRARY, STANDARD, or the selected standard function, if any.

File Handling (also Query Type Command) **EXIST (EXIS)**

This command is a query which causes the LeCroy 9100 to return a message indicating the presence of the named file. The answer will include the file length.

FORMAT:

EXIST arg
EXIS arg

VALID ARGUMENTS:

Any filename ending with the extensions: .WAV, .WAD, .SET, .SEQ

EXAMPLE:	COMMAND	COMMENTS
	EXIST ANYFILE.WAV;	Returns either FILE IN FILEMEM (length); or NOFILE IN MEMORY.

File Handling (also Query Type Command) **DIRECTORY**

(DIR)

This command is a query which causes the LeCroy 9100 to return a directory of all the files (waveform, setup and sequence) stored in the RAM memory. If one of the arguments is used, only that file category will be returned. If no argument is presented, a directory of all files will be returned.

FORMAT:

DIRECTORY arg
DIR arg

VALID ARGUMENTS:

WAV (single waveforms), WAD (dual waveforms),
SET (setup), SEQ (i.e., sequence)
CM (control memory), HSM (high speed memory)

DEFAULT:

Unspecified Argument: DIR of all files will be sent by extension, i.e., .WAV, .WAD, .SET and .SEQ.

EXAMPLE:	COMMAND	COMMENTS
	DIRECTORY WAD; DIR WAD;	This query returns a directory of the dual waveform files contained in the RAM Memory space.
	DIRECTORY CM; DIR CM;	This query returns a directory of control memory, showing the order of segment output, and number of repetitions for each wave file loaded and linked in high speed memory.
	DIRECTORY HSM; DIR HSM;	This query returns a directory of waveform files currently loaded and linked in high-speed memory.

QUERY RESPONSES: The same formatted string as seen on a 9100/CP is returned. It is of variable length depending on number of files. For details of format see ACTIVE_FILES. A string

NO.WAD FILES; <CRLF>
NO.WAV FILES; <CRLF>
NO.SET FILES; <CRLF>
NO.SEQ FILES; <CRLF> or <END> is returned if no argument is supplied and no files are present.
The individual strings are returned for the applicable arguments if no file of a particular type is present.

Action Command (also a Query Type Command) **IDENTIFY (ID)**

This query causes the generator to return its bus address, model number and version number of firmware. This information is returned as four 16-character lines (the first of which is all blank), each followed by <CRLF> for a total of 72 characters.

FORMAT:

IDENTIFY

EXAMPLE:	**COMMAND**	**COMMENTS**
	IDENTIFY; ID;	Returns the information given above.

QUERY RESPONSES: The same ASCII string is returned regardless of COMM_HEADER setting.

File Handling (also Query Type Command) **MEMORY**

(MEM)

This command is a query which causes the LeCroy 9100 to return an ASCII string. Hence, the number is in ASCII decimal notation. The meaning of the string depends on the argument used with the command. If the argument is HSM (for high speed memory) or the RAM (for RAM Disk), the string represents the number of bytes (points) available in that memory. If the CM (for control memory) argument is used, the string represents the number of line entries which are still available; one line is used per loaded/linked file.

FORMAT:

MEMORY arg
MEM arg

VALID ARGUMENTS:

HSM (high speed memory)
RAM (RAM memory)
CM (control buffer)

DEFAULTS:

Unspecified Argument: HSM

EXAMPLE:	COMMAND	COMMENTS
	MEMORY CM; MEM CM;	This command will result in representing the number of entries available in the Control Memory. An ASCII decimal number of 0 to 682 would be returned.

QUERY RESPONSES: The same ASCII string is returned regardless of COMM_HEADER setting.

Action Command (also Query Type Command) **VIEW**
(VIEW)

This is a query command which returns all current 9100 settings in a form which may be returned to the 9100 as program messages, or sent back to the 9100 as a Setup file. The format of the output is the short form header naming a parameter, an "=" sign, and the current setting, followed by a semicolon. The length of the output is less than 1200 bytes. "Modes" which are necessary to interpret certain settings are always output before those settings.

FORMAT:

VIEW

EXAMPLES:	COMMAND	COMMENTS
	VIEW;	Returns all settings.

QUERY RESPONSES: The same formatted string as seen on a 9100/CP is returned. It is variable length with CRLF each 16 bytes. Unused lines are padded with spaces. It is terminated with semicolon and is suitable for direct viewing.

Communications Command — **COMM_FORMAT (CFMT)**

Determines the data format for block transfers of waveform data over the GPIB. See File Handling Commands. Only two formats are supported.

FORMAT:

COMM_FORMAT A, BYTE, BINARY

and

COMM_FORMAT L, BYTE HEX

VALID ARGUMENTS:

HEX results in 2 characters for each 8 bits of data.

BIN (BINARY) implies simple binary format, 1 byte for 1 byte.

DEFAULTS:

A, BYTE, BINARY

EXAMPLE:	COMMAND	COMMENTS
	COMM_FORMAT L, BYTE, HEX; CFMT L, BYTE, HEX;	Format is L with 8 bits of data and 2 HEX characters each.

NOTES: COMM_FORMAT I, ASCII only; (all letters and numbers are interpreted as characters) is always used for SETUP and SEQUENCE files.

Communications Command — **COMM_HEADER (CHDR)**

Defines the header format used by the 9100 in response to queries.

FORMAT:

CHDR arg
COMM_HEADER arg

VALID ARGUMENTS:

OFF, SHORT, LONG

arg: OFF presents no header with the data

SHORT presents the short form of the header

LONG presents the long form of the header

EXAMPLE:	**COMMAND**	**COMMENTS**
	COMM_HEADER OFF; CHDR OFF;	Data file will be sent with no header information.

Communications Commands **MASK**

This command causes a value of a particular STB to be masked (0) or unmasked (1). See Operation of Status Bytes at the beginning of Chapter 5.

FORMAT:

MASK arg1, arg2

VALID ARGUMENTS:

arg1: defines which STB is to be masked and can be any decimalASCII number 1 through 8.

arg2: decimal ASCII representation of a byte value where each bit equal to 1 unmasks the corresponding bit in the STB.

EXAMPLE:	COMMAND	COMMENTS
	MASK 2, 128;	This would stop the value 128 on STB 2 from causing a SRQ to be generated.

Communications Command **STB**

STB is the command used to query the 9100 regarding SRQ's on the GPIB.If no argument is presented, the values of all 8 status bytes are eturned, separated by commas. If a number (1 through 8) is used as an argument, a status byte will be returned which represents more detailed information about the condition represented by that particular bit of the main status byte. When a STB command is received the respective byte is cleared. The values sent back are ASCII decimal (NR1 format).

FORMAT:

STB arg

VALID ARGUMENTS:

the numbers 1 through 8

EXAMPLE:	COMMAND	COMMENTS
	STB 2;	This would cause the 9100 to send status byte 2, which would contain a value indicating that a self test fault condition exists. (Self-test fault is the second bit of the main status byte.)

NOTES: See "Operation of the Status Bytes" at the beginning of Chapter 5.

Communications Command **TSTB**

This command operates exactly like the STB command, except that the byte is not cleared. In addition, TSTB,0; reads a byte which cannot be cleared (and is therefore not readable by STB,0). Please see Table 5.1.

NOTES: See Operation of the Status Bytes at the beginning of Chapter 5.

Table 5.6
GPIB COMMAND SUMMARY

FILE HANDLING COMMANDS	
DELETE (DELE)	Causes the named file to be deleted from the RAM Disk.
END	Used as the last command in a Setup or Sequence file.
LEARN_SETUP (LEARN)	Causes all existing instrument settings (parameters) to be saved into a specified file name (or default name).
LINK	Causes the named waveform to be added to the high speed memory, beginning at the end of the last waveform previously LOADED or LINKED.
LOAD	Causes a specified waveform to be moved from the RAM memory to the operating memory.
NEXT	Used to cause a Sequence file to resume execution.
RECALL (RCL)	Causes the generator to send the contents of the specified file.
STORE (STR)	Causes Waveform, Setup or Sequence files to be moved from the GPIB to the generator's internal RAM memory. STORE must be used to transfer files to RAM memory before a LOAD command can be used to transfer them to High Speed Memory.
ACTION COMMANDS	
ABORT (ABO)	Immediately stops the waveform being generated without waiting for its end point.
ARBITRARY (ARB)	Selects Arbitrary Function Mode.
ARM	Arms the trigger from the bus.
CALIBRATE (CAL)	Initiates a self calibration cycle.
CLEAR (CLE)	Resets all instrument settings to the power-up defaults.

GO	Causes the waveform(s) loaded into High Speed Memory to be executed (generated).
NEXT	Used to continue a sequence file after WAIT.
SELFTEST (SEL)	Performs SELFTEST.
SETUP (SET)	Causes the named setup file to be executed.
SEQUENCE (SEQ)	Causes the named sequence file to execute.
STOP	Same as Abort.
TRIGGER (TGR)	Used to trigger from the bus.

CHANNEL PARAMETER COMMANDS

CH1_AMPLITUDE (C1A)	Sets the amplitude of the waveform being generated on Channel 1.
CH1_FILTER (C1F)	Selects one of the CH1 low pass filters.
CH1_INVERT (C1I)	Inverts the waveform in Channel 1.
CH1_OFFSET (C1O)	Sets the CH1 DC offset level.
CH1_OUTPUT (C1P)	Turns on and off the CH1 output relay.
CH1_ZERO_REF (C1Z)	Sets the amplitude point which represents the DC offset voltage for CH1.
CH2_AMPLITUDE (C2A)	Sets the amplitude of the waveform being generated on Channel 2.
CH2_FILTER (C2F)	Selects one of the CH2 low pass filters.
CH2_INVERT (C2I)	Inverts the waveform in Channel 2.
CH2_OFFSET (C2O)	Sets the CH2 DC offset level.
CH2_OUTPUT (C2P)	Turns on and off the CH2 output relay.
CH2_ZERO_REF (C2Z)	Sets the amplitude point which represents the DC offset voltage for CH2.

SUM_MODE (SUM)	Sums the Channel 2 waveform into the Channel 1 waveform.
EXTERNAL_SUM (XSUM)	Sums an external signal into the Channel 1 waveform.

TIMEBASE COMMANDS

CLOCK_LEVEL (CLEV)	Sets the threshold level for the external clock.
CLOCK_MODE (CMOD)	Selects master or slave operating mode.
CLOCK_PERIOD (CPER)	Sets the internal clock period.
CLOCK_RATE (CRAT)	Sets the internal clock repetition frequency.
CLOCK_REFERENCE (CREF)	Select internal or external 4 MHz reference for the 9100's internal clock generation circuitry.
CLOCK_SLOPE (CSLO)	Selects the edge of the external clock that the generator will respond to.
CLOCK_SOURCE (CSOU)	Sets the source for the generator clock to Internal or External.

TRIGGER COMMANDS

TRIG_ARM_SOURCE (TAS)	Selects the source for arming the trigger.
TRIG_DELAY (TDEL)	Sets the delay from the trigger point to start
of waveform.	
TRIG_LEVEL (TLEV)	Sets the threshold for an external trigger.
TRIG_MODE (TMOD)	Sets the mode in which the waveform is generated: Continuous, Recurrent, Single, Burst or Gated.
TRIG_SLOPE (TSLO)	Sets the triggering slope of an external signal.
TRIG_SOURCE (TSOU)	Selects the source of the trigger signal.
MARKER_DELAY (MDEL)	Sets the delay of the marker pulse.
DELAY_MODE (DMOD)	Set whether TRIGGER_DELAY and MARKER_DELAY will be set in either POINTS or TIME.

COMMUNICATIONS COMMANDS

COMM_FORMAT (CFMT)	Determines the data format for block transfers over the bus.
COMM_HEADER (CHDR)	Defines the header format (LONG, SHORT or OFF) used in bus communications.
STB	Causes the AFG to send its status byte. Clears the byte.
TSTB	Same as STB but the byte is not cleared.
MASK	Masks bits of the specified status byte.

STANDARD FUNCTION COMMANDS

STANDARD (STAN)	Selects Standard Function Generation Mode.
SINE	Select sine wave as the current standard function.
SINE_MODE (SMOD)	Select single or dual channel sine wave generation.
SINE_FREQUENCY (SIFR)	Sets the frequency of the sine standard function.
SINE_CH1_PHASE (SC1P)	Sine Channel 1 starting phase.
SINE_CH2_PHASE (SC2P)	Sine Channel 2 relative phase.
SQUARE (SQU)	Select square wave as the current standard function.
SQUARE_MODE (SQMD)	Selects single or dual channel square wave generation.
SQUARE_FREQUENCY(SQFR)	Sets the frequency of the square standard function.
SQUARE_PHASE (SQUP)	Square Channel 1 starting phase.
SQUARE_RELATIVE_PHASE (SQRP)	Square Channel 2 relative phase.
TRIANGLE (TRI)	Select triangle wave as the current standard function.
TRIANGLE_MODE (TRIM)	Selects single or dual channel triangle wave generation.

TRIANGLE_FREQUENCY (TRFR)	Sets the frequency of the triangle standard function.
TRIANGLE_PHASE (TRIP)	Set start time of the triangle.
TRIANGLE-RELATIVE_PHASE (TRRP)	Set start time of Channel 2 triangle wave relative to Channel 1.
RAMP	Select ramp as the current standard function.
RAMP_MODE (RMOD)	Selects single or dual channel ramp generation.
RAMP_PERIOD (RPER)	Select the duration of standard function ramp.
RAMP_PHASE (RMPP)	Set start time of the ramp.
RAMP_RELATIVE_PHASE (RPRP)	Set Channel 2 start time relative to Channel 1.
PULSE (PUL)	Select pulse as the current standard function.
PULSE_WIDTH (PWID)	Select the duration of the high part of the standard function pulse waveform.
PULSE_PERIOD (PPER)	Select the period of the standard function pulse (not meaningful in single trigger mode).
PULSE_DELAY (PDEL)	Set the portion of the period preceding the high part of the pulse.
PULSE_OPTIMIZE (POPT)	Ask the 9100 to achieve highest accuracy on pulse WIDTH, pulse PERIOD or pulse DELAY.
DC	Select DC as the current standard function.
DC_MODE (DCMD)	Select single or dual channel DC level generation.

QUERY COMMANDS

ACTIVE_FILES (AFIL)	A query command which causes the names of all the currently active files to be returned.
DIRECTORY (DIR)	A query command which causes the names of all files to be returned.
EXIST (EXIS)	A query command which causes the AFG to indicate whether a file exists, and if so, the file length.
FUNCTION (FUNC)	A query command which returns either ARBITRARY or STANDARD, or the current standard function.
MEMORY (MEM)	A query command, causes the AFG to return a number indicating the amount of free memory.
IDENTIFY (ID)	Causes the generator to return its bus address, model number and SW version.
VIEW	Returns all current 9100 settings in exactly the same form displayed on the 9100/CP hand-held control panel. The messages are in a form which may be returned to the 9100 as program messages.

6 RS-232-INTERFACE

OPERATING OVER THE RS-232C INTERFACE

Selecting the RS-232C Interface

The 9100 responds to one interface at a time. The currently active interface is also called the "communications source" or COMM_SOURCE. Switch 3 on the GPIB switch block determines which interface is the default COMM_SOURCE. This switch is read only at power up. (All rear panel switches are read only at power up.)

If switch 3 on the GPIB switch block is up (1), the default COMM_SOURCE is GPIB. The RS-232 port will not be active until the command "COMM_SOURCE,RS232;" is received from GPIB.

If switch 3 on the GPIB switch block is down (0), the default COMM_SOURCE is RS-232C. The RS-232 port will be active (and the GPIB port inactive) until the command "COMM_SOURCE,GPIB;" is received from RS-232.

Configuring the RS-232C Interface

The eight switches on the RS-232 switch block configure the RS-232 interface as follows:

Stop Bits		Parity			Data Bits		-- Baud --				<--Switch
1		2	3		4		5	6	7	8	
0	one	0	0	None	0	eight	0	1	1	0	300 baud
1	two	0	1	None	1	seven	0	1	1	1	600 baud
		1	0	Even			1	0	0	0	1200 baud
		1	1	Odd			1	0	1	1	2400 baud
							1	1	0	1	4800 baud
							1	1	1	1	9600 baud
							--other--				9600 baud

The RS-232 switch block is read only at power up. These switches are the only way to configure the RS-232 interface. The selected RS-232 configuration must match the user's terminal configuration.

The 25 pin RS-232 (type DB 25S) connector on the rear panel of the LeCroy 9100 is wired as Data Communications Equipment (DCE). An appropriate cable should be used to connect the user's terminal or computer serial port to the 9100.

RS-232C COMMANDS

All commands available over GPIB are available over RS-232C (see Chapter 5 of this manual). The commands at the end of this chapter apply only to RS-232C.

Using RS-232

Major differences between GPIB and RS-232 operation are as follows:

1. There is no "EOI" wire on RS-232 to mark the end of a logical group of characters, such as a command. Therefore, all commands *must* end with semicolon (;). File transfers must end with the character (sequence) defined by COMM_RS_CONFIG, see below.
2. If the COMM_SOURCE is RS-232, any unmasked event or condition which would cause a Service Request over GPIB causes a BEL character (control-G, binary 7) to be sent over RS-232. This makes most terminals beep. The service request character(s) can be user selected by the command COMM_RS_SRQ,abc;, where the "abc" argument represents up to 3 bytes to be sent to signify a service request. The query command COMM_RS_SRQ? returns the current equivalent SRQ character(s).
3. The 9100 produces a prompt (by default "AFG\>") over RS-232 when it is ready for a command. This corresponds to the "Operation Complete" condition. This prompt will first be issued about 20 seconds after powering on the 9100, after self-calibration and initialization. The prompt may be changed, as shown in the example below.

   NOTE: The STB and TSTB commands do not generate Operation Complete so as not to change the status information they read out. Over RS-232, this means that a new prompt is not generated after the response to STB or TSTB.
4. The 9100 will not transfer binary data over RS-232, since it is not possible to do so if "seven data bits" has been selected. Instead of the "#A" binary format used over GPIB the "#L" format is used over RS-232. This format is similar to the "#A" format described in Section 5 of this manual, except that each byte which would follow the #A is represented by two ASCII characters each representing a base 16 (or "hex") digit. The digits 0-9, and A-F where A-F stand for 10, 11, 12... 15 respectively. Two hex digits can be recombined to make a byte as follows:

   byte = ((value of hex digit 1) *16) + value of hex digit 2)
5. The Local LED on the 9100 will remain lit even while remote operations via RS-232 are in process.

6. The RS-232 equivalent of the GPIB "three wire handshake" is the XON/XOFF (Ctrl Q/ Ctrl S) software handshake. This handshake is enabled by sending the escape sequence "Esc)". This is the default state. Once enabled, sending a Ctrl S command will stop RS-232 data transfer. The Ctrl Q command will resume transfer. The handshake is disabled by the command "Esc(". See Table 5.3 for Escape commands which control this and other RS-232 related features.

A Typical RS-232C Dialog

A transcript of RS-232 communication with a 9100 follows.

Prompt, Command & Response as displayed on terminal	Comments (not displayed)
AFG\>**dir; CALERR .SEQ** NO .SET FILES NO .WAV FILES NO .WAD FILES ;	"AFG\>" = prompt at power on "dir;" = our first command the rest is the answer
AFG\>**sine;**	prompt and command
AFG\>**go;**	
AFG\>**mem,hsm;**65336 AFG\>**sifr?;**+1.000E+06;	prompt, command and response
AFG\>**sifr,100KHz;**	
AFG\>**sifr?;**+100.0E+03;	
AFG\>**mem,hsm;**64512	
AFG\>**recall,calerr.seq;** AFG\>#ICalibration completed successfully! Internal temperature is approximately 38.10°C	Recall a file from file memory
	Note the prompts.
AFG\>**comm_prompt,9100>;** 9100>**abort;** 9100>**csrc,gpib;**	Change the prompt. Stop generating a waveform. Change the COMM_SOURCE. *Note: There is no prompt after* this.

RS-232C COMMAND

RS-232C Command **COMM_RS_CONF**

This command is used to define the file terminating sequence over RS232, which is equivalent to receiving a byte with EOI via GPIB.

FORMAT:

COMM_RS_CONF,byte1,byte2;

VALID ARGUMENTS:

byte1; byte2: Any valid hex digit or alpha character used in commands.

DEFAULTS:

26 (Control Z)

EXAMPLE:	**COMMAND**	**COMMENTS**
	COMM_RS_CONF,42;	Sets up a one character termination sequence, with "*" as the one terminating character.
	COMM_RS_CONF,40,41;	Sets up a two-character termination sequence, with "()" as the two-character termination sequence.

QUERY RESPONSE: COMM_RS_CONF ? returns current terminating sequence.

NOTES:

1. *This sequence is sent after the last data byte of a block, to tell the 9100 to close the file – no more blocks are coming.*
2. *There is no restriction on the value of the one or two bytes making up the termination sequence. However, it is advisable that the values NOT be*
   a) *any valid hex digit or alpha character used in commands*
   b) *"#", the beginning of a block delimiter.*

Careful use of the terminating sequence will enable the user to transfer multiple file blocks sequentially via RS-232C. The 9100 behavior when receiving a file in #L format from RS232 can be summarized as follows:

At the end of a block:

If the next two characters are "#L", another block is accepted.

If the next one (or two) characters are the defined terminating sequence, the file is closed normally.

If the next character is "#" but the subsequent character is not "L", an error code is generated. The file is not saved.

If the next character is the first of a two-character termination sequence but the subsequent character is not the second character of the termination sequence, an error code is generated. The file is not saved.

In the middle of a block:

If the next one (or two) characters are the defined termination sequence, the file is closed normally. An error code is generated indicating that the block was shorter than expected.

If the next character is the first character of a two-character termination sequence, but the subsequent character is not the second character of the termination sequence, an error code is generated. The file is not saved.

If the next character is not part of the termination sequence and is not a valid hex digit ("0" through "9" and "A" through "F"), an error code is generated. The file is not saved.

RS-232C COMMAND COMM_PROMPT

This command is used to define the prompt returned by the 9100 over RS232.

FORMAT:

COMM_PROMPT,prompt string;

VALID ARGUMENTS:

prompt string: An ASCII character string with a maximum of eight characters.

DEFAULTS:

AFG\>

EXAMPLE:	COMMAND	COMMENTS
	COMM_PROMPT,9100>;	Changes RS-232C prompt to "9100>".

RS-232C Command **COMM_RS_SRQ**

This command is used to define the service request response sent over RS232, which is equivalent to receiving a service request (SRQ) via GPIB.

FORMAT:

COMM_RS_SRQ,byte1,byte2,byte3;

VALID ARGUMENTS:

byte1,byte2, byte3: Valid decimal ASCII characters or control codes

DEFAULTS:

ASCII 7 (Control-G, Bel)

EXAMPLE:	**COMMAND**	**COMMENTS**
	COMM_RS_SRQ,61;	Sets SRQ response on RS- 232C to "="
	COMM_RS_SRQ,83,82,81;	Sets SRQ response on RS- 232C to "SRQ"

QUERY RESPONSE: COMM_RS_SRQ ? returns current SRQ response termination sequence.

NOTES:

1. *This sequence is sent by the 9100 over the RS-232C interface to indicate a condition requiring an operator's attention. A summary of required service conditions, status bytes, and status byte masks are included in the GPIB programming section, Chapter 5, of the operating manual.*
2. *The default condition is Control-G or BEL which will cause the RS-232C terminal or terminal emulator to emit its bell tone.*
3. *The service request condition in RS-232C is cleared by issuing the STB ? query command and reading the response from the 9100.*

7 MODEL 9109

The Model 9109 is a member of the LeCroy 9100 Family of AFGs. This section provides information specific to the Model 9109.

GENERAL DESCRIPTION

The LeCroy 9109 Arbitrary Function Generator with Digital Outputs provides dual 8-bit TTL or ECL digital outputs and expanded (128 Kbyte) waveform memory. Each channel outputs latched digital data, equivalent to the corresponding analog channel output. Digital data can be output from channel 1 at a maximum data rate of 200 Mbytes/sec (5 nsec/per point) in single channel mode. In dual channel mode data can be output from both channels at up to 100 Mbytes/sec (10 nsec/point). Each output channel is independently configurable as either TTL or ECL by internal jumper selection. All ECL data and clock lines are provided as differential pairs while the TTL outputs are separated by ground lines. The TTL output configuration includes a complementary clock output.

Digital data and clock signals are available via two 20 pin connectors mounted on the front panel. Data is available continuously with no internal masking or blanking provided. TTL outputs will drive up to two TTL loads and have an internal 75 Ω resistor in series with each data and clock line to reduce reflections. ECL outputs have 470 Ω internal pulldown resistors to protect the outputs from electro-static discharge.

HIGH SPEED MEMORY

The 9109 offers 128K of High Speed Memory, twice the memory available in the 9100 configuration. This allows longer waveforms to be executed. All the descriptions on **LOAD** or **LINK** operations are unchanged from the way they are presented in Chapter 5.

The maximum segment size that is allowed is 64K. In order to execute a waveform of greater than 65536 bytes the additional bytes must be in a different waveform segment (file). This additional segment(s) must then be **LINK**ed to the composite waveform being created. There is no additional restriction as to how the waveform files cross over the 65536 byte boundary. To summarize, no segment may be greater than 64K in length but any number of segments (each less than 64K) may be **LINK**ed together up to a maximum waveform size of 128K.

DIGITAL OUTPUT SPECIFICATIONS

Output Channels: 2 channels with Channel 1 data corresponding to the channel 1 analog output. Channel 2 digital data corresponds to the channel 2 analog output. Digital data is

normalized so that a data value of $255(FF_{16})$ corresponds to maximum analog amplitude and a data value of $0(00_{16})$ corresponds to the minimum analog output.

Maximum Digital pattern length: Single channel mode, non repeating, 128 Kbytes. Dual channel, non repeating 64 Kbytes/channel.

Digital Outputs per Channel: TTL mode; 8 data lines, clock, clock*, 10 grounds. ECL mode; 8 differential data lines, differential clock output, 2 grounds.

Digital output mode selection: Each channel individually configurable as TTL or ECL output by internal jumper selection.

Maximum Data Output Rates: (Identical to 9100 clock rate)
Single channel (channel 1 only): 200 Mbytes/sec (5 nsec per byte)

Dual channel (channel 1 and channel 2): 100 Mbytes/sec (10 nsec per byte)

Timing, ECL Mode: (All outputs terminated into the equivalent of 56 Ω to -2 V)
Digital Clock to Analog Output: Clock precedes the Analog output by 1 clock period +4 nsec ± 2 nsec
Digital Clock to Digital Data: 2 nsec typical
Hold Time Provided: 1.0 nsec min
Setup Time Provided: 1.5 nsec min at 200 Mbytes/sec typically.
setup time = (sample period)–(hold time)–(transition time)

Data to Data Skew Time: ± 0.5 nsec max within each channel's data byte

Complementary Output Skew: <0.5 nsec
Channel to Channel Skew:
Clock: <1 nsec
Data to Data Skew Time: ±1.3 nsec for any data line to data line (Channel 2 precedes Channel 1 typically)
Rise and Falltimes: 3 nsec typical. 4 nsec max, measured 20%–80% after 3 ft of Twist 'N Flat cable terminated by 56 Ω to -2 V

Logic Levels, ECL Mode: V(high) min = -1.0 Volts
V(low) max = -1.55 Volts
Absolute max externally applied voltages: +0.5 V, -2.0 V

Timing, TTL Mode: (All outputs unloaded)
Digital Clock to Analog Output: Clock precedes the Analog output by 1 clock period +3 nsec ±3 nsec
Digital Clock to Digital Data: 3.5 nsec typical

Hold Time Provided: 2.0 nsec min
Setup Time Provided: 3.0 nsec min at 80 Megabytes/second typically.

Setup time = (sample period)−(hold time)−(transition time)

Data to Data Skew Time: ±0.8 nsec max within each channel's data byte

Clock to Clock* Skew: <1.5 nsec
Channel to Channel Skew:
Clock: <1.6 nsec
Data to Data Skew Time: ±1.6 nsec for any data line to data line (Channel 2 precedes Channel 1 typically)
Risetime: 5 nsec max 20%–80%
Falltime: 3.5 nsec max 20%–80%

Both risetime and falltime measured 20%–80% after 3 ft of Twist 'N Flat cable. Loading at termination is two LSTTL data inputs plus a probe loading of 5 KΩ in parallel with 2pF.

Logic Levels, TTL Mode:
V(high) min: +2.7 Volts at +1 mA
V(low) max: +0.75 Volts at −3.2 mA
Absolute max externally applied voltages: + 5.5 V, −0.5V

Timing, Mixed Mode TTL to ECL:
Clock TTL to Clock ECL: 1 nsec ±1.5 nsec (ECL precedes TTL)
Data TTL to Data ECL: 2 nsec ±2.2 nsec (ECL precedes TTL)

Maximum Data Rates:
ECL mode: 200 Msample/sec (NRZ) with ≤3 feet Twist N' Flat cable, differentially terminated with 56 Ω to − 2 V on each leg of differential signal, clock received differentially.

TTL Mode: > 80 M/sample per second (NRZ) with ≤3 feet of Twist N' Flat cable, no termination with 1 TTL LS (or equivalent) load, single ended clock.

TTL Output Connector configuration:
Same pattern for channel 1 and channel 2
All TTL outputs are single ended, back terminated in 75 Ω
The Clock outputs are available in both polarities.

Signal	Pin #		Signal
Clock	1	2	Ground
Clock*	3	4	Ground
(LSB) D0	5	6	Ground
D1	7	8	Ground
D2	9	10	Ground
D3	11	12	Ground
D4	13	14	Ground
D5	15	16	Ground
D6	17	18	Ground
(MSB) D7	19	20	Ground

ECL Output Connector Configuration:
Same pattern for channel 1 and channel 2
All lines of the ECL outputs are differential.

Signal	Pin #		Signal
Clock	1	2	Clock*
Ground	3	4	Ground
(LSB) D0	5	6	D0*
D1	7	8	D1*
D2	9	10	D2*
D3	11	12	D3*
D4	13	14	D4*
D5	15	16	D5*
D6	17	18	D6*
(MSB) D7	19	20	D7*

NOTES:

*1: * Indicates active low signal. Complementary to signal with same name but without *.*

2: Suggested connector type 3-M Part No. 3421-7020 or equivalent (20 pin .1"x.1" flat cable socket connector with strain relief). One required for each channel's output.

3: Normal Flat cables are not recommended. Best performance may be achieved with Twisted Pair Flat cable such as Spectra Strip # 455-248-20 (10 pair Twist & Flat, 28 AWG)

RECONFIGURING THE DIGITAL OUTPUT

The Model 9109 is delivered from the factory with the Digital Outputs configured for TTL output levels on both channels.

NOTE: The current configuration is indicated via front panel LED's unique to each channel's Digital Output.

Either or both Digital Outputs can be user configured to ECL levels.

To change the logic level of either or both channel's Digital Output the 9109 front panel must be removed and some cable assemblies must be moved. The procedure follows:

1) Remove top cover by removing two Pan Head screws on each side of the instrument.
2) Remove upper front panel retaining screws. These are #1 Phillips screws which are accessible from the top of the front panel bezel.
3) Remove lower front panel retaining screws. These are similar to the upper front panel retaining screws as detailed above except that the bottom panel does not need to be removed to access them.
4) With the 9109 sitting on a tabletop, carefully remove front panel from bezel and drop it down to the tabletop without detaching any cables. A cabling drawing specific to the 9109 is shown attached to the inside of the front panel of the 9109.
5) The Digital Outputs are derived from the 9100-22 printed circuit board. It is the second board from the top in the card cage. The following five steps detail the method of gaining access to the top of that board in order to change the logic type of the outputs.
6) Remove the two 34 pin flat cables (cable numbers 15 and 16) which connect the upper three printed circuit boards.
7) Remove the two very short coax cables with SMB connectors (cable numbers 25 and 26) between the upper two printed circuit boards.
8) Remove coax cables 13 and 14 from the 9100-22 printed circuit board (the second PC board from the top)
9) On both the left and right sides of the printed circuit board cage there are locking plates secured with Phillips head screws. Slightly loosen both locking plates and slide them outward.
10) The 9100-22 printed circuit board (the second from the top) can now be removed from the printed circuit board cage.
11) At the left side of the 9100-22 PC board two 24 conductor flat cables go off to the front panel. The location of the 24 pin DIP connector on the 9100-22 determines the logic type of the Digital Output. The location nearer the front panel

(J3 or J4) will produce TTL outputs while the more rearward (J1 or J2) sockets will provide ECL outputs. Move/verify the DIP connector position for channel 1 and then for channel 2.

12) Insert the 9100-22 PC board fully into the card cage. Give the open cage a quick examination for any hanging cable ends which would could cause a short, and then for a quick test turn on the AC power switch of the 9109. Carefully check which LED's are lit within the Digital Output area of the front panel. Turn the AC power off. If the LED's correctly indicated the configuration that was desired go to step 13. Otherwise recheck the position of the flat cables on the 9100-22 PC board.

    NOTE: If none of the four LED's was lit it is likely that the cables for channel 1 and channel 2 are reversed.

13) The 9109 can be reassembled by reversing the disassembly sequence starting from step 10.

INTERCONNECTION INFORMATION

Recommended TTL interconnection configuration:

The 9109 is delivered with 75 Ω back terminations on all of the TTL output lines. In this fashion, no termination resistor is required or desired. These 75 Ω resistors are on three socketed DIP resistor arrays (U23, U24 and U25 on the 9100-22 Board). This resistor is used to match the transmission line impedance taking into account the additional source impedance of the TTL driver. The 75 Ω resistors match the 100 Ω impedance of flat cable fairly well. The most important consideration to this scheme is that the load should be as close to an open circuit as possible. One or at most two TTL loads should be placed at the termination of the line. LS or FAST type TTL gates are recommended, with FAST being preferred do to increased low state noise immunity. Capacitance at the termination will have a detrimental effect on the rise time of the received signals. Every effort should be made to limit parasitic capacitance at the termination of the cable to under 10 pF. All grounds should be tied together at the load side of the cable. See Figure 7-1.

Alternate TTL interconnection techniques:

If the Digital outputs are terminated with 100 Ω to ground the output logic high level will be reduced by nearly 50%. This will not produce a guaranteed TTL logic high and would require the use of a line receiver or comparator to receive the Digital output

signal. If it is desirable to terminate the flat cable with 100 Ω (110 Ω preferred) resistors to ground in order to be able to drive larger capacitive loads, or to increase fanout, the back terminations inside the 9109 should be removed. The 75 Ω resistors (U23, U24 and U25 on the 9100-22 Board) may be replaced with 0 Ω jumpers. The TTL high state in this mode will be greater than 2.4 V guaranteed and will typically reach around 3.5 V. With this configuration drive capability is greatly increased, risetimes are optimized and noise immunity is increased. Use of FAST logic at the receiving end would be advantageous. There are two reasons that the 9109 is not delivered with this output configuration. First the outputs are not protected in this method; the 75 Ω internal back terminations provide a high degree of protection against shorting and Electro-Static Discharge. Secondly, when the outputs are not terminated with 100 Ω, reflections will be generated which exceed the normal TTL supply voltages. These may detrimentally affect the TTL output drivers.

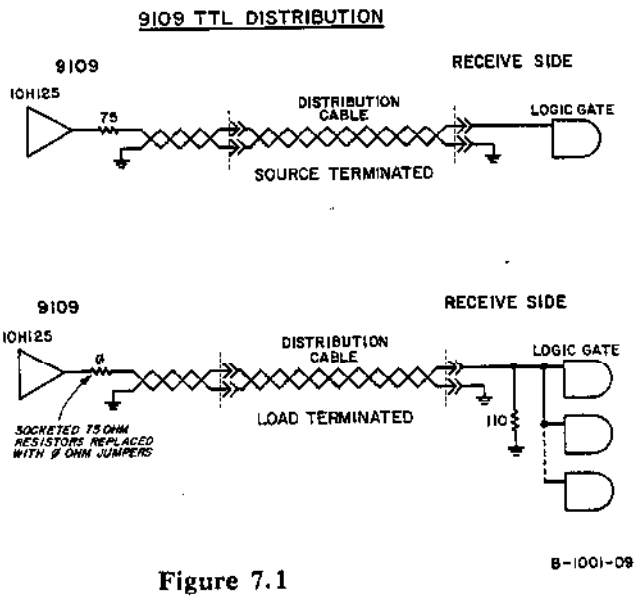


Figure 7.1

ECL Termination and Interconnection:

The 9109 provides 470 Ω internal pulldown resistors at the ECL output drivers. The ECL outputs need to be terminated at the load side of the cable. Use of Twist 'N Flat cable is required; normal flat cables will cause excessive crosstalk and reflections.

The most optimum interconnection would be to utilize ECL line receivers at the receiver end of the twisted pair cable. Termination is easily done with a 100 Ω resistor across the differential outputs at the receive end. See Figure 7.2. The necessary pull down current will be supplied by the internal 470 Ω pulldown resistors. This scheme provides the best common mode rejection between the 9109 and the receiving system. Even without differential line receivers it is practical to differentially terminate the twisted pair with a 100 Ω resistor across the twisted pairs and to use one of the two differential signals single-endedly. (Figure 7.2). Use caution with single-ended receipt of the signal since there will be reduced noise immunity; only short cable runs where it is certain that there are not ground loop problems should be tried single-endedly.

Another method of termination would be to provide 51 Ω or 56 Ω resistors to -2 V on both sides of the differential cable. (Figure 7.2). Note that both sides of the twisted pair should be terminated even if only one is to be used. If -2 V is not available a Thevenin equivalent made by a 82 Ω resistor to ground and 130 Ω (1/4 W recommended) resistor to -5.2 V may be substituted. (Figure 7.2). The junction of the resistors appears as a 50 Ω resistance to -2 V.

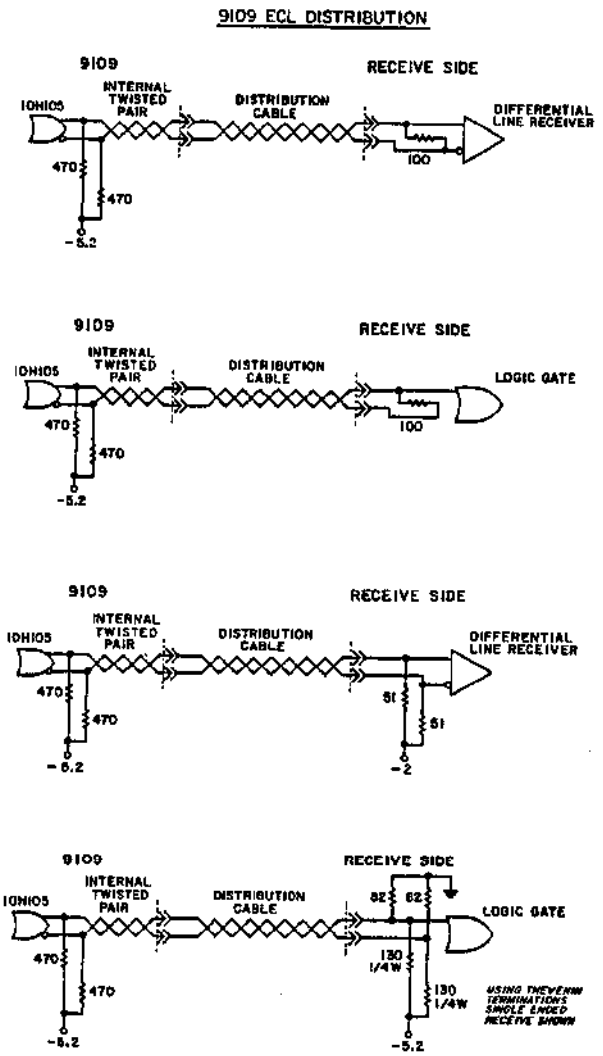

9109 ECL DISTRIBUTION
9109
RECEIVE SIDE
10H105
INTERNAL TWISTED PAIR
DISTRIBUTION CABLE
DIFFERENTIAL LINE RECEIVER
100
470
470
-5.2
9109
RECEIVE SIDE
10H105
INTERNAL TWISTED PAIR
DISTRIBUTION CABLE
LOGIC GATE
100
470
470
-5.2
9109
RECEIVE SIDE
10H105
INTERNAL TWISTED PAIR
DISTRIBUTION CABLE
DIFFERENTIAL LINE RECEIVER
51
51
470
470
-5.2
-2
9109
RECEIVE SIDE
10H105
INTERNAL TWISTED PAIR
DISTRIBUTION CABLE
82
82
LOGIC GATE
130 1/4W
130 1/4W
470
470
-5.2
-5.2
USING THEVENIN TERMINATIONS SINGLE ENDED RECEIVE SHOWN

Figure 7.2

APPLICATION INFORMATION

Digital Output produces the Digital Data one sample period in advance of the Analog Output. For critical timing applications this enables you to remove any data skew added by the distribution cabling. This can be done by latching the data at the termination of the cable. This requires you to provide appropriate logic latches but will reduce the data skew to that inherent in the latches themselves. When this technique is utilized, latched Digital Data concurrent with the Analog Output can be realized with great precision.

The Digital Output data can be used directly. Since the Digital Output data is output one sample period in advance of the Analog output there are some points to be aware of. When a waveform is loaded and waiting for a trigger such as in single trigger mode, the Analog output will be at the first point of the waveform while the Digital Outputs will represent the second point of the waveform file. In a similar way, when the 9109 has completed executing a waveform and is waiting for a trigger arm, the Analog output will be at the last point of the waveform file while the Digital Outputs will be at the first point of the waveform file.

The user should be aware of the fact that the clock delivered to the front-panel Digital Outputs is derived directly from the internal clocks to the Analog Card. While the Analog Card has an output connect relay which can mask much of the procedures for initialization, the Digital Output card does not mask these initialization sequences. As a result there are two pulses on the clock lines of the Digital Output between the GO command and the actual start of the waveform. The first pulse has a duration of about 20 msec and the second pulse has a duration of about 50 µsec. After the second pulse there is a duration of about 40 msec until the waveform actually starts.

The clock delivered by the Digital Output will vary as the 9109 changes from single to dual channel mode. In single channel mode the clock will be quite symmetrical and should appear as a square wave. When the mode is changed to dual channel mode and a *.WAD waveform is being executed, the appearance of the clock changes. The dual channel clock changes to a duty cycle of 3/4 high and 1/4 low in both TTL and ECL modes. It is similar to having every other low going clock suppressed.

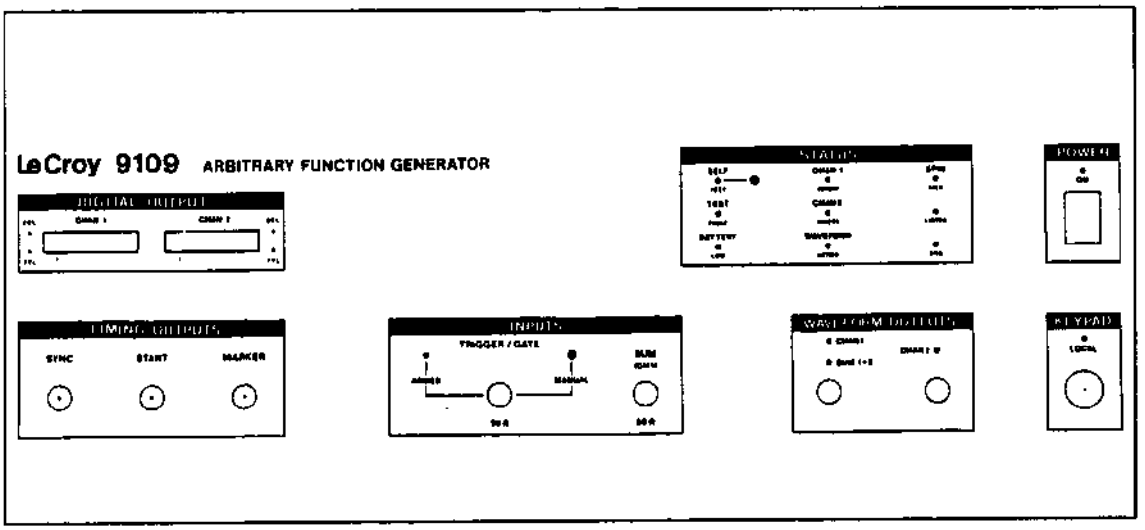
The clock low time for TTL is intentionally stretched somewhat as compared to the ECL mode. This provides increased clocking bandwidth in dual channel mode and allows the 9109 Digital Output Clock to operate reliably above 50 Msample/sec while

in dual channel mode and utilizing the TTL Digital Outputs.

In both TTL and ECL modes the rising edge of the normal clock output is the active edge. In the case of the ECL Outputs the clock and all data outputs are truly differential and are ideally suited to be received by differential line drivers at the termination of the Digital Output cable. In the TTL mode the Clock and Clock* drivers have some skew and are not truly balanced due to the asymmetry of the TTL drivers. The Clock* output is primarily provided due to the fact that the negative going edge is certain to be faster and more noise immune than the positive going clock output that is more conventional in the TTL environment. Typically, the Clock* and Clock outputs will not be utilized simultaneously.

NOTE: The TTL clock and Clock outputs are not on adjacent pairs of the output cable. In higher noise or more stringent timing situations it may be preferable to use the Clock* output rather than the clock output.*

The Digital Outputs are never turned off or tristated and always are active. When the 9109 is not actively executing a waveform the Digital Output state is not necessarily initialized and is at an arbitrary value. The clock however, will generally go quiescent in the high state while the Clock* will go into the low state. The front-panel SYNC output may be used to indicate to external circuits that waveform execution has begun. If the 9109 is executing a single channel waveform, the Channel 2 Digital Outputs contain non valid data, but the clock is still running.


LeCroy 9109 ARBITRARY FUNCTION GENERATOR
DIGITAL OUTPUT
STATUS
POWER
TIMING OUTPUTS
SYNC
START
MARKER
INPUTS
TRIGGER / GATE
KEYPAD

8 MODEL 9101

INTRODUCTION

The LeCroy 9101 is a single channel version of the LeCroy 9100 Arbitrary Function Generator. The 9101 is intended to be as compatible as possible with the 9100. This means that dual channel waveform files may be stored in a 9101 and run, even though only channel 1 will be generated. Similarly, setup files containing channel 2 setup may be run (see below).

Therefore, the 9101 is supplied with a 9100 Series manual. This chapter specifies differences between the LeCroy 9101 and the LeCroy 9100.

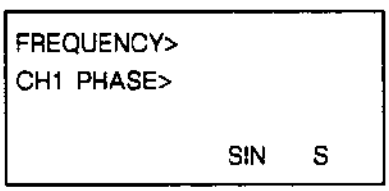
All the changes may be summarized as follows:

1) The front panel of the 9101 does not contain a "CHAN 2" waveform output BNC, "CHAN 2" LED and "SUM 1+2" LED. Internally, the 9101 does not contain analog hardware for a second channel.
2) All commands that affect channel 2 (including SUM and all standard function single/dual mode commands) return warning code 210 in status byte 4, but have no other effect.
3) On the 9100/CP, the "CH 2" button generates an error message.
4) Because the "SUM 1+2" LED is not present, overload on either the external sum input or the channel 1 output cause the "CHAN 1" LED to flash.

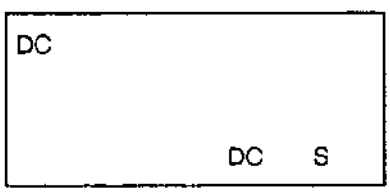
Differences Between 9101 and 9100

Page	Section	Change
2-4	Figure 2.2	the "CH2 OUT" connector is not present on a 9101.
2-9	Figure 2.4	the "CH2 SIGNAL DAC" through "CH2 OUTPUT" path is not present in a 9101.
2-10	Front Panel Controls and Indicators (Figure 2.5)	the front panel of the 9101 does not contain a "CHAN 2" waveform output BNC (11), "CHAN 2" LED and "SUM 1+2" LED (12).
2-15	Waveform Outputs:	Channels: 1 Crosstalk between channels: not applicable.
2-20	Indicators	There is no CHAN 1+2 or CHAN 2 LED.
3-4		The example shown (dual channel standard sine) cannot be performed on a 9101. Eliminate the commands SINE_MODE DUAL; and SINE_CH2_PHASE 20; from the example, they only produce a warning. The example will produce a single channel 1MHZ sine wave on a 9101.

3-13	Channel Parameter Settings:	The SUM_MODE command, and all commands starting "CH2_" only produce a warning in the 9101.
4-5		Control Panel: [CHAN 2] has no effect except to produce a warning message on the 9100/CP screen, with a 9101.
4-10		Control Panel: [VIEW] is 13 pages for a 9101 instead of 17 pages. This is because there are no channel 2 settings.
4-27		Control Panel: Selecting Attributes of a Standard Function: All of the standard function attribute menus have two lines on a 9101, instead of four lines as shown. The "MODE" and channel 2 relative phase or start time lines are missing. For example, the Standard Sine attribute menu, Figure 4.17, is:

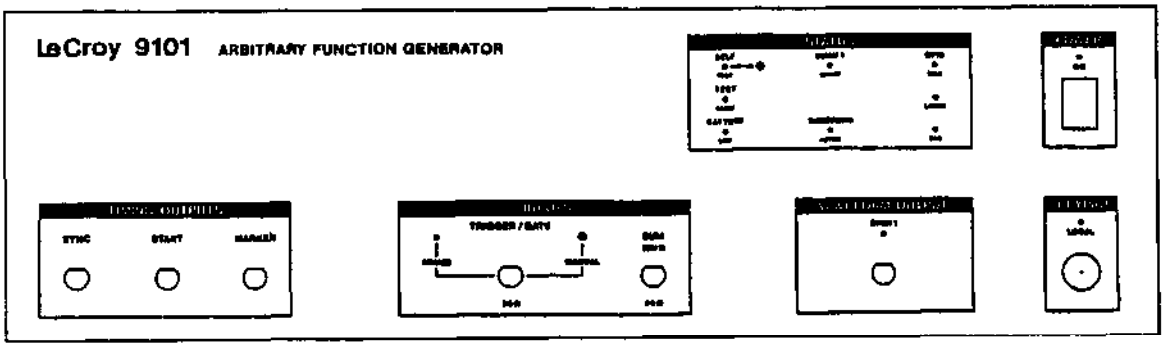


The Standard DC function has no selectable items on its attribute menu in a 9101. The standard DC attribute menu is simply:



4-47	Figure 4.41	The third screen should not have the SQU_MODE or C2_REL_ST lines.
5-14	Table 5.2	Add "210 Warning: channel 2 command to 9101".
5-18	Section 3	All commands beginning "CH2_" or "C2" and the "SUM_MODE" or "SUM" command are not applicable to the 9101.
5-18, 5-19	Section 6	The commands SINE_MODE, SINE_CH2_PHASE, SQUARE_MODE, SQUARE_RELATIVE_PHASE, TRIANGLE_MODE, TRIANGLE_RELATIVE_PHASE, RAMP_MODE, RAMP_RELATIVE_PHASE and DC_MODE are not applicable to the 9101.
5-53	SUM	This page is not applicable to the 9101.
5-72	SMOD	This page is not applicable to the 9101.

5-75	SC2P	This page is not applicable to the 9101.
5-77	SQMD	This page is not applicable to the 9101.
5-80	SQRP	This page is not applicable to the 9101.
5-82	TRIM	This page is not applicable to the 9101.
5-85	TRRP	This page is not applicable to the 9101.
5-87	RMOD	This page is not applicable to the 9101.
5-90	RPRP	This page is not applicable to the 9101.
5-97	DCMD	This page is not applicable to the 9101.
5-111	Table 5-6	All commands beginning "CH2_" (or "C2") and the "SUM_MODE" (or "SUM") command are not applicable to the 9101. The commands SINE_MODE, SINE_CH2_PHASE, SQUARE_MODE, SQUARE_RELATIVE_PHASE, TRIANGLE_MODE, TRIANGLE_RELATIVE_PHASE, RAMP_MODE, RAMP_RELATIVE_PHASE and DC_MODE are not applicable to the 9101.


LeCroy 9101 ARBITRARY FUNCTION GENERATOR
SYNC
START
MARKER
TRIGGER / GATE

9 9100/MM, /MM1, /MM2

9100/MM, /MM1 and /MM2 WAVEFORM MEMORY EXPANSION OPTION

Description

The built-in memory expansion option increases the capacity of the arbitrary function generators high speed waveform memory. Three option configurations offer incremental expansion of the waveform memory to a maximum capacities shown below:

Option	Maximum Memory Capacity
9100/MM	524,288 bytes (512K)
9100/MM1	1,048,576 bytes (1 M)
9100/MM2	2,097,152 bytes (2 M)

The expanded memory option is compatible with all models of the LeCroy 9100 Series Arbitrary Function Generators.

NOTE: The 9112 High Resolution AFG uses two memory bytes per data point resulting in a maximum waveform capacity which is 1/2 the available memory size.

The expanded memory options are implemented in non-volatile,battery backed-up, static random access memory (SRAM). Backup power is supplied by non-rechargeable "C" size lithium batteries contained in battery holders mounted on the rear panel. AFG's without the expanded memory options and those with 9100/MM will have only a single battery installed. Units with 9100/MM1 or /MM2 will have both batteries installed. When any of the memory expansion options are added to existing AFG's the battery configuration and location will vary, depending upon the serial number of the unit.

The addition of the memory expansion options alters the internal memory architecture of the 9100 Series Arbitrary Function Generators. Waveform data is downloaded directly into the high speed waveform memory rather than through the non-volatile storage memory. Data transfer using GPIB occurs at >200 Kbytes/sec. The maximum data block size is unchanged and is limited to 64 Kbytes. The existing non-volatile storage memory is used for storing setup and sequence files as well as for miscellaneous system storage requirements. All of these changes occur automatically and are transparent to the user.

Expanded memory increases length of waveforms that can be generated. The maximum length of any individual waveform file that can be transferred to an AFG is limited to 64 Kbytes. This requires that longer waveforms be be composites of several smaller waveforms. Composite waveforms are constructed by loading an initial waveform segment and linking additional segments to it, in what is called a linked sequence, until the total

waveform is complete. The expanded memory options supports longer waveforms by increasing the number of waveform segments that can be linked from 682, in the standard 9100, to 2048, file directory capacity is also increased to 1024 entries.

The AFG stores a description of the linked waveform in its control memory. The memory expansion option includes the ability to learn and recall the control memory image of desired waveforms. Recalling a control memory image eliminates the need to re–enter the linked sequence description of a waveform in order to generate it. The use of control memory images requires that all the waveform segments used in the original linked sequence, describing the waveform, be present in the high speed memory.

Using The Memory Expansion Option

The operation of the 9100/MM, /MM1, or /MM2 Memory Expansion option is, in general, completely transparent to the user. Waveforms can be stored, selected and generated using the same operations described in the earlier sections of this manual covering the standard AFG configuration.

The existence of the memory expansion option can be verified on the 9100/CP Hand–held Control Panel or via the EASYWAVE waveform creation software. The following procedure applies to the hand–held control panel:

a. Press the FUNC button
b. Press the PAGE button. The LCD display should include the lines "CTRL MEM IMAGE >" and "OPTIONS >"
c. Select OPTIONS by pressing the F2 button. The installed options will be listed the format shown below:

HS /MM 512K
CM ENTRIES XXXX
RT OPTION XXX"

The first line describes the installed memory options and maximum installed memory capacity, possible entries are:

Displayed		Option Installed
HS /MM	512K	9100/MM
HS /MM1	1024K	9100/MM1
HS /MM2	2048K	9100/MM2
HS NO /MM	64K	NONE
HS NO /MM	128K	NONE (9109 and 9112) or 9100/EM (9100 and 9101)

The amount of high speed memory available can be determined by using the VIEW menu on the hand held control panel. The available memory is reported on the last page (page 16) of the VIEW menu. This page should appear similar to this:

RAM 372987 BYTES"
HS 1048064 BYTES"
CTRL 2048 BYTES"

The second line lists the available high speed memory in bytes. This same information is available using the VIEW query via either the GPIB or RS–232 interfaces. EASYWAVE reports all the installed options, the total memory capacity, and the available memory whenever the user enters the Operate Arbitrary mode.

The remote command, MEMORY HSM;, is a query command which returns an ASCII string which reports the available high speed waveform memory via the GPIB or the RS–232 interface.

Using The Control Memory Image Functions

The expanded memory options include the ability to learn and recall control memory image, CMI, files. These files contain all the information necessary to re–generate a multi–segment waveform, originally described by the operator entered linked sequence . Since AFG's with expanded memory can use up to 2048 linked segments, the ability to recall such a complex waveform with a single command represents a considerable productivity savings.

The use of CMI files requires that all waveform files, originally specified in the linked sequence, exist in the waveform memory. In general, if only store operations have occurred in the AFG since the CMI file was learned, then restoring the CMI will work without problem. Deletion of any waveform file included in a control memory image will cause the recalled CMI file to be inoperative.

Learning A CMI File

The first step in using the CMI files is to enter a linked sequence, describing a waveform, into the AFG. This is done in the course of normal operation using GPIB/RS232 commands, sequence files, or by direct manual entry via EASYWAVE software or by means of the hand–held control panel.

For example, the user enters the linked sequence by running the following sequence file:

```
LOAD A.WAV,1;
LINK B.WAV,3;
LINK C.WAV,1;
LINK A.WAV,1;
GO;
END;
```

The CMI file can be learned using the GPIB/RS232 command, LEARN_CMI, via learN .cmi in EASYWAVE, or by using the

LEARN key on the hand-held control panel. An example of learning a CMI file using the hand-held control panel follows:

Press the FUNC key
Press the PAGE key, this will show the following menu:

CTRL MEM IMAGE>
OPTIONS>

Pressing the F1 key from this page will display a directory of existing CMI files or a message indicating that no .CMI files exist. Press the LEARN key. A .CMI file, corresponding to the current linked sequence will be stored in a .CMI file format. The AFG will assign a sequential filename in the form CMIX.CMI, where X is a numeric index. The message LEARNED CMIX.CMI will be displayed. The numeric index, with a maximum value of 1023, is assigned automatically and incremented by each learn operation. After 1023 learn operations the index is reset and begins again at 1.

In a similar manner, issuing the remote command LEARN_CMI via RS-232 or GPIB, will cause the AFG to learn and store a .CMI file with a numerically indexed file name.

In EASYWAVE the learN .cmi menu selection is in the Operate Arbitrary menu in the Operate mode. To access it:

Type F4 to get to the System Menu.

Type O for Operate, then A, for Arbitrary generator.

The Operate Arbitrary menu contains the learN .cmi selection.

Typing N, will bring up a directory of existing .CMI files from the AFG.

The prompt, " Learn .cmi file in AFG-Name ( ): ", will appear on the menu line.

Select an existing filename from the AFG .CMI directory using the keyboard cursor keys to highlight the desired filename and the Enter key to select it. Alternatively, a new filename can be added by typing in the filename and pressing the Enter key.

After the CMI file has been learned the message, "AFG Learned XXXXXXX.CMI", will appear. If an attempt is made to overwrite an existing named file then EASYWAVE will request confirmation with the prompt,"XXXXX.CMI Already exists in AFG Overwrite old AFG file (Y/N)?". Confirm replacement by typing Y, abort by typing N.

Restoring A Control Memory Image

The control memory image can be restored using the SEQ and SETUP keys on the hand–held control panel, or by issuing the SETUP CMIX.CMI or SEQ CMIX.CMI remote commands via GPIB or RS–232. The following procedure illustrates restoring a control memory image using the hand–held control panel:

Press the FUNC key
Press the PAGE key, this will show the following menu

CTRL MEM IMAGE>
OPTIONS>

Press the F1 key to display the directory of CMI files similar to the example shown below:

CMI1.CMI
CMI2.CMI
CMI3.CMI
CMI4.CMI

Select the desired CMI file by pressing the function key corresponding to the desired file's line number. For instance, pressing F3 will select CMI3.CMI. The selected file will be indicated by an @ sign next to the filename on the hand–held control panel display.

Restore the control memory image by pressing the SHIFT key followed by either the SETUP or SEQ keys. The following message will indicate a successful restoration of the control memory image.

CMI RESTORED
CMI3.CMI

If the AFG cannot find the necessary waveform files it will display the message: LOAD/LINK DO NOT MATCH WAVE FILES. This message indicates that one or more of the waveform files contained in the original linked sequence have been deleted. If this occurs, it is best to re–enter the waveform linked sequence using the hand–held terminal or by running a sequence file.

Generate the waveform described by the control memory image by issuing the GO command either from the hand– held control panel, via the remote command, or using EASYWAVE.

Deleting A CMI File

A CMI file can be deleted using the remote command, DELETE, via either GPIB or RS–232. For example:

DELETE CMI56.CMI;

These files can also be deleted using the hand–held control panel as is illustrated below: Press the FUNC key

Press the PAGE key, this will show the following menu:

CTRL MEM IMAGE>
OPTIONS>

Press the F1 key to display the directory of CMI files similar to the example shown below:

CMI27.CMI
CMI28.CMI
CMI30.CMI
CMI31.CMI

Select the CMI file you wish to delete by pressing the function key corresponding to the line number of the desired file. For instance, pressing F3 will select CMI30.CMI. The selected file will be indicated by an @ sign next to the filename on the hand–held control panel display.

Press the SHIFT key then press the DELETE key. The AFG will confirm your request by displaying the message:

ARE YOU SURE?
YES
NO

Press F3 to delete the selected file or F4 to abort the delete operation.

Reviewing The Contents Of A CMI File

The contents of the control memory image can be viewed by restoring it in the AFG as described earlier and then viewing the linked sequence using EASYWAVE as follows:

Starting at the EASYWAVE System Menu, Press the F key to select File transfer mode.

Press the M key for More to see the second page of the file transfer menu. Press R to read the AFG file directories (diR afg).

At the AFG Directory menu select Load/link by pressing the L key. EASYWAVE will list the linked sequence corresponding to the active control memory image similar to the example below:

A.WAV	1W
B.WAV	3
C.WAV	1
A.WAV	1

The contents of a restored .CMI file can also be reviewed on the 9100/CP in the following manner:

a. Press the FUNC button
b. Press the F1 button (ARBITRARY)
c. Press the F3 button (CTRL MEM DIR)

This will bring up a directory of the currently active linked sequence the first line of the display will be SEGMENTS = .WAV if single channel wave segments are active, or .WAD if dual channel segments have been LOADed and LINKed. The following lines will list the active segments in their linked sequence. A # sign in the lower right of the display indicates that additional segments are listed on the following pages.

10 9100/RT

Introduction

This option combines the fast switching capabilities of a frequency synthesizer with the waveshape programmability of the arbitrary function generator. The LeCroy 9100/RT is an internal option for the LeCroy 91XX Series Arbitrary Function Generators (AFG's) intended for applications that require fast, random access selection of output waveforms. Waveform selection does not interrupt the current output waveform, but rather queues the next waveform. When the current waveform is complete, the change to the next waveform occurs seamlessly with no disruption or discontinuity in the output.

Waveform selection can be controlled via a high speed parallel port or via GPIB or RS–232 programming. Selection commands are pipelined via a 1024 word first–in, first–out (FIFO) memory, simplifying control timing. The minimum time overhead required to set up a change in the output waveform is 72 clock periods (360 nsec at 200 MHz clock) using the parallel port. Switching between waveforms occurs at end of the current waveform, without loss of data.

The 9100/RT Real–Time Waveform Sequencing option is intended for applications such as radar, data communications, electronic countermeasures, and data storage where fast, random access, selection of application specific waveforms is essential. Typical uses include the creation of random data patterns for error rate testing, generating spread spectrum modulation, frequency hopping, and simulating random amplitude, frequency, or phase variations.

Verifying Installation

The existence of the RT option can be verified on the 9100/CP Hand–held Control Panel or via the EASYWAVE ® waveform creation software. The following procedure applies to the hand–held control panel:

a. Press the FUNC button

b. Press the PAGE button. The LCD display should include the lines "CTRL MEM IMAGE >" and "OPTIONS>"

c. Select OPTIONS by pressing the F2 button. The installed options will be listed in the format shown below:

HS/MM	512K
CM ENTRIES	XXXX
RT OPTION	YES

The first line describes the installed memory options and maximum installed memory capacity. The second line tells how many Control Memory Entries (i.e., waveform segment LINKs) are available. The third line confirms the installation of the real

time option. If the option is not installed the third line would read "RT OPTION NO"..

NOTE: It is very important that there be no activity on the WRITE input of the external Real –Time port during the time that the AFG is performing its power–up calibration routine. If WRITEs occur during this time period, the AFG may not find what it expects when it looks at the FIFO, and will therefore assume that the option is NOT installed.

Functional Description

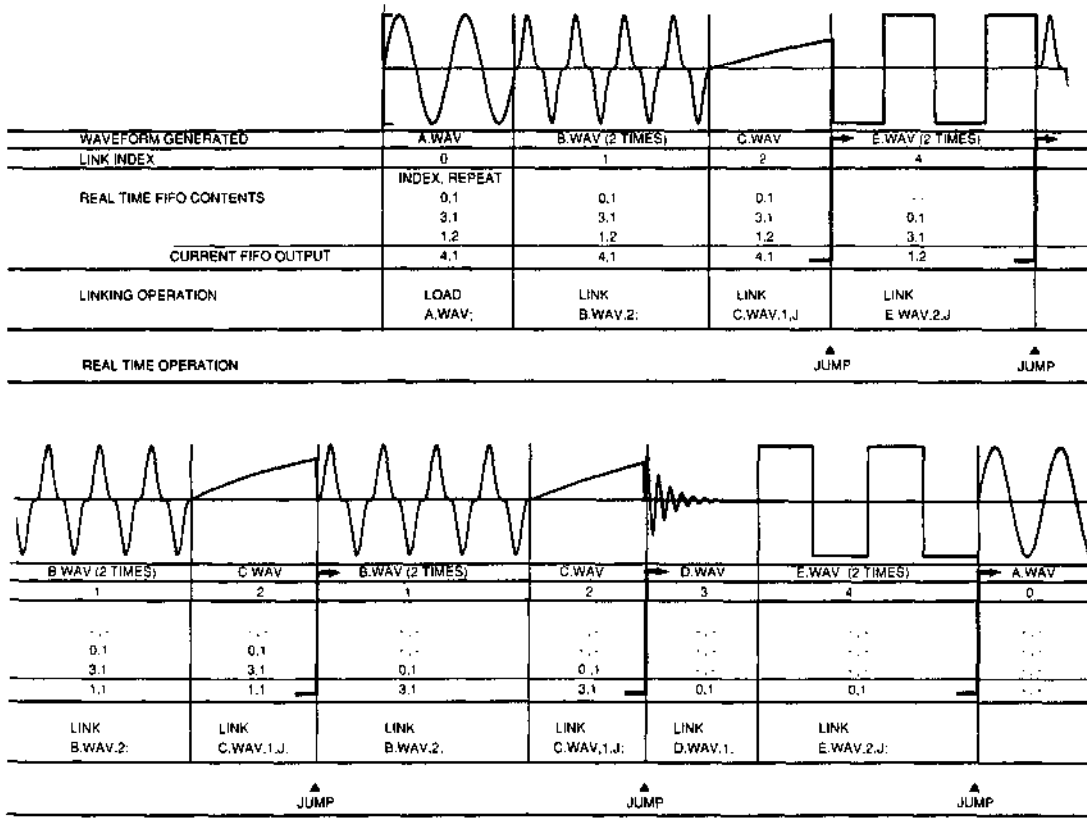
The 9100/RT, Real–Time Waveform Selection option, provides the ability to jump to any waveform segment contained in the high speed waveform memory. Waveform segments are loaded into high speed memory using a link sequence consisting of the LOAD and LINK commands described in earlier sections of this manual. When the 9100/RT is installed these commands can include added parameters to enable random access selection. Real time waveform selection is implemented by modifying the LOAD and LINK commands with the addition of a JUMP flag. Whenever a LOAD or LINK command with the JUMP flag set is encountered the address of the next segment to be output is obtained from a first–in, first–out (FIFO) memory. The 16–bit by 1024 word FIFO can be loaded from GPIB, from RS–232, or from a high speed parallel input portion the rear panel, called the Real–Time Port. The FIFO input contains both the LINK Index, which is simply the line number of the waveform segment in the link sequence, and a Repetition Count, which controls the number of times that the waveform segment, specified by the LINK Index, will be used as a jump destination. When the FIFO memory is empty, the generator can either cycle on the last waveform segment specified, or jump to the first waveform segment. The desired action is selected by means of a user specified parameter with the JUMP Flag.

Here's an example of how the 9100/RT operates (refer to accompanying figure).

The following Link Sequence is entered by the operator via GPIB, RS–232, or by execution of a sequence file.

Operator Entered Link Sequence	Internally Assigned Link Index
LOAD A.WAV,1;	0
LINK B.WAV, 2;	1
LINK C.WAV,1,J;	2
LINK D.WAV,1;	3
LINK E.WAV,2,J;	4

Signal generation will begin following a GO command. The waveform segments are generated in the order given in the operator entered Link Sequence until a link command with the Jump Flag, J, set is encountered. In this example, the first jump is encountered after executing the waveform segment C.WAV. At this point the next waveform to be selected will be determined by the current output of the FIFO memory.



9100/RT Example

The FIFO identifies the next waveform by supplying its link index. The FIFO also supplies a repetition count which controls the number of times that the specified jump will be executed.

As shown in this example, after executing C.WAV, the next waveform segment selected will be E.WAV, which has a Link

Index of 4. E.WAV also was linked with its jump flag set so that this process will be continued after it is output.

After E.WAV is output twice (because it was linked with a segment repetition count of 2), the next jump is indexed to B.WAV (Link Index of 1). The repetition count associated with this index is 2. This will cause the FIFO index to be held while the repeat count is decremented.

B.WAV is output twice, and since it does not have its jump flag set the waveform selection is determined by the natural order of the Link Sequence, in this case C.WAV is selected. The next jump causes the B.WAV, B.WAV, C.WAV sequence to be output a second time. This illustrates the use of the repetition counters to build nested sub–sequences within a complex waveform.

When the FIFO is empty the last index is latched and subsequent jumps will be directed to the last referenced index. For this example, when the FIFO is empty, the index 0 is latched and the AFG will continue to output the waveform sequence A.WAV, B.WAV, B.WAV, C.WAV, A.WAV ....

9100/RT LOAD And LINK Commands

The 9100/RT firmware includes modified LOAD and LINK commands as well as four new commands, associated with the FIFO memory. The formats for the modified LOAD and LINK commands are:

LOAD
<wavename>.{WAV|WAD}[,<nrep>[,WAIT]
[,JUMP|JUMP_REEAT|JUMP_ZERO]];

LINK
<wavename>.{WAV|WAD}[,<nrep>[,WAIT]
[,JUMP|JUMP_REPEAT|JUMP_ZERO]];

WAIT, JUMP, JUMP_REPEAT, and JUMP_ZERO have short forms, namely W, J, JR, and JZ.

JUMP_REPEAT and JUMP_ZERO specify the jump destination in the event that the FIFO is empty. JUMP_ZERO causes a jump to the waveform segment with a Link Index of 0 (i.e. the LOADed segment).

JUMP_REPEAT causes the waveform segment(s) currently being output to be repeated. The JUMP command, with no secondary parameters defaults to the same operation as JUMP_REPEAT.

NOTE: The LOAD and LINK commands, with the jump parameter, cannot be entered using the 9100/CP Hand–held Control Panel. They must be entered using EASYWAVE, a sequence file, or via GPIB or RS–232 command input.

Examples of new LOAD and LINK commands (where WAD could be used in place of WAV) are:

LOAD A.WAV,1,JUMP;

LINK B.WAV,3,WAIT,JUMP;

LINK C.WAV,1,W,JZ;

LINK D.WAV,1,JUMP_REPEAT;

LINK E.WAV,1,W,JR;

NOTE: The RLINK command is not accepted if the real–time option is installed, as the operation RLINK performs is achievable using /RT commands.

FIFO Memory Commands

Internal FIFO programming:

With the 9100/RT option the AFG firmware includes four new commands, none of which are valid if the option is not present.The new FIFO commands are: FIFO_MODE, FIFO_LOAD, FIFO_CLEAR, and FIFO_SOURCE. More detail about these commands will be provided below.

1. Clear the FIFO

   Command: FIFO_CLEAR;

   Short form: FIC;

   The FIFO is cleared at power–up, by the FIFO_MODE command, the FIFO_SOURCE command, and whenever the ABORT command is issued as well as by the FIFO_CLEAR command. The LOAD command, which includes an implicit ABORT operation, will also clear the FIFO.

2. Enable or Disable FIFO operations and reset the FIFO

   Command: FIFO_MODE {ON|OFF};

   Short form: FIM {ON|OFF};

   Default is FIFO mode off. This command also clears the FIFO.

3. Select the FIFO source

   Command: FIFO_SOURCE {INTERNAL|EXTERNAL};

   Short form: FIS {INT|EXT};

   Ignored unless FIFO_MODE is on. Default is internal. When the FIFO source is internal, the external port is ignored.

   Similarly, when the FIFO source is external, the FIFO_LOAD command is ignored. This command will clear the FIFO regardless of the argument.

4. Load the FIFO

   Command: FIFO_LOAD {index} <,repeats>;

   Short form: FIL {index} <,repeats>;

   Ignored unless FIFO_MODE is on and FIFO_SOURCE is internal.

   Repetition count defaults to 1 if unspecified.

   Example:

   FIFO_LOAD 5,4;

   When this FIFO entry is encountered, the next segment generated will be the one whose link index is 5 (link indexing starts with the LOADed segment as 0) and this segment will be repeated 4 times.

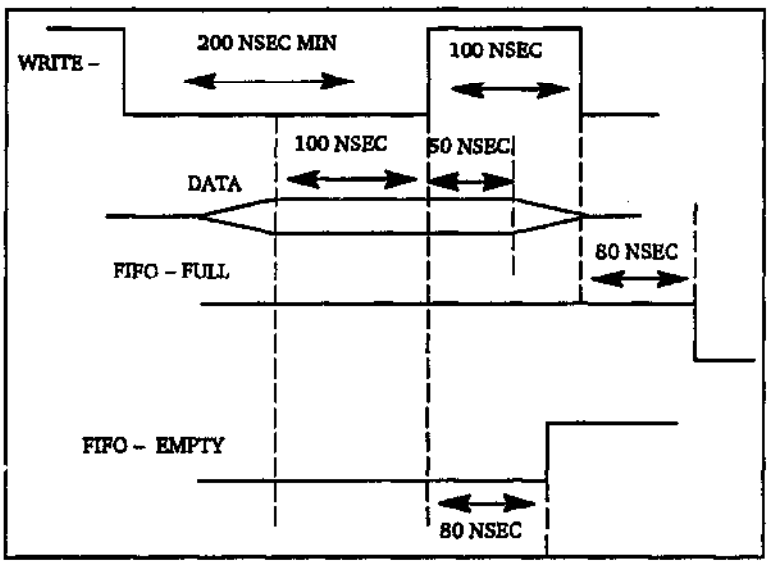
NOTE: The LOAD command will clear the contents of the real time FIFO. It, therefore, should precede any FIFO_LOAD operations.

External FIFO Loading:

The 1024 x 16-bit FIFO structure utilized has an access time of 120 nsec. To allow for possible differences in propagation delay between the WRITE* and data signals, we recommend holding the WRITE* signal in its active low state for 200 nsec. Data should remain valid for 50 nsec after WRITE* goes false (high), resulting in a 250 nsec write cycle time. The minimum time for a linked wave segment to complete is 360 nsec (72 points @ 5 nsec/point), so new records can be written to the FIFO faster than the existing ones can be read out. To load the FIFO from an external source, write to the real time port on the rear panel of the AFG. The information on the data input lines is latched into the next available FIFO location on the rising edge of the WRITE* input.

Timing requirements, allowing for differing propagation delays between the data and WRITE* signals, are as follows:

1. The WRITE* line must be held low for at least 200 nsec.
2. Data at the connector must be valid for at least 100 nsec before the WRITE* line goes high.
3. Valid data at the connector must be held for at least an additional 50 nsec after the WRITE* line goes high.
4. Allow at least 100 nsec from the rising edge of WRITE* until the next falling edge on this line.



For pin locations of the WRITE*, data and the other FIFO related signals, see the External Port definition below. FIFO contents: Each segment command is loaded into the FIFO as one 16–bit word formatted as follows:

(D15, msb) x rrrr iii iiii iiii (D0, lsb) where (each character stands for 1 bit):

x (D15) is unused;

rrrr (D11 to D14) is the repetition count (actually 1 less than the number of times the segment is to be output, see table below);

iii iiii iiii (D0 to D10) is the control index (0 to 2047).

Repeat_count	Representation	Decimal
1	0000	0
2	0001	1
3	0010	2
4	0011	3
5	0100	4
6	0101	5
7	0110	6
8	0111	7
9	1000	8
10	1001	9
11	1010	10
12	1011	11
13	1100	12
14	1101	13
15	1110	14
16	1111	15

NOTE: Subtraction of 1 from the desired repetition count applies ONLY to FIFO_MODE, EXTERNAL. When writing to FIFO in INTERNAL mode (with FIFO_LOAD), the repetition count argument is the actual, unmodified number of desired repetitions.

An example of how waveforms will be generated by interaction of control memory and FIFO contents is given later in this chapter.

NOTE: It is very important that there be no activity on the WRITE input of the external Real –Time port during the time that the AFG is performing its power–up calibration routine. If WRITEs occur during this time period, the AFG may not find what it expects when it looks at the FIFO, and will therefore assume that the option is NOT installed.

FIFO Reading:

When the waveform is started (by the GO command), the start address in the FIFO (if any) is latched into a register. When a segment linked with the jump option is encountered, the memory location pointed to by this register is "jumped" to, and then the next FIFO word is latched into the register. If the FIFO is empty, the register either remains unchanged (if the link used the REPEAT parameter), or latches the address of the LOADed segment (if the link used the ZERO parameter). When a new

record is put into the FIFO, it will be transferred to the register after its current contents are used at the end of the segment being generated, and actually used when the next JUMP is encountered.

Examples of Operation

1. Program the wave via individual commands, or with a sequence file. The sequence file may be built and sent via EASYWAVE or other GPIB or RS–232 methods.

Index	Command	Meaning
0	LOAD A.WAV;	Generate A.WAV once then advance to next linked segment
1	LINK B.WAV,2;	Generate B.WAV twice then advance to next linked segment
2	LINK C.WAV, JUMP;	Generate C>WAV once then jump as indicated by FIFO
3	LINK D.WAV;	Generate D.WAV once then advance to next link segment by FIFO
4	LINK E.WAV,10,JUMP;	Generate E.WAV 10 times then jump as indicated by FIFO
5	LINK F.WAV,JUMP;	Generate F.WAV once then jump as indicated by FIFO
6	LINK G.WAV,5,JUMP;	Generate G.WAV 5 times then jump as indicated by FIFO
7	LINK H.WAV,JUMP;	Generate H.WAV once then jump as indicated by FIFO

2. FIFO contents (meaning depends on the link sequence entered as shown above):

Index	Repeat	Command
0	1	Jump to the waveform with link index 0 (A.WAV), generate it then continue with B.WAV twice, C.WAV, then jump.
6	1	Jump to the waveform with link index 6 (G.WAV), generate G.WAV 5 times, then jump.

4	1	Jump to the waveform with link index 4 (E.WAV), generate E.WAV 10 times, then jump.
3	1	Jump to the waveform with link index 3 (D.WAV), generate D.WAV once, E.WAV 10 times, then jump.
6	2	Jump to the waveform with link index 6 (G.WAV), generate G.WAV 10 times, i.e. execute the link command twice, then jump.
5	4	Jump to the waveform with link index 5 (F.WAV), generate F.WAV 4 times, then jump.
1	3	Jump to the waveform with link index 1 (B.WAV), generate B.WAV twice, C.WAV, B.WAV twice, C.WAV, B.WAV twice, C.WAV, then jump.
4	1	Jump to the waveform with link index 4 (E.WAV), generate E.WAV 10 times, then jump.
empty		generate E.WAV 10 times over and over until FIFO has an entry, generate E.WAV once more, then jump.

3. The actual binary representation of the FIFO contents

index	repeat	binary code	hex code
		x rrrr iii iiii iiii	
0	1	0 0000 000 0000 0000	0000
6	1	0 0000 000 0000 0110	0006
4	1	0 0000 000 0000 0100	0004
3	1	0 0000 000 0000 0011	0003
6	2	0 0001 000 0000 0110	0806
5	4	0 0011 000 0000 0101	1805
1	3	0 0010 000 0000 0001	1001
4	1	0 0000 000 0000 0100	0004
empty			

External Real-Time Port

Connector type – 26 pin male header –3M part # 4626–7000, LeCroy part # 453–211–026.

Mating Connector – 26 pin female header –3M part # 3394–6026, LeCroy part # 403–220–026.

Recommended external cable – 26 conductor flat cable –3M part # 3365/26, LeCroy part # 592–211–026.

Maximum recommended length – 10 ft.

Connector wiring –

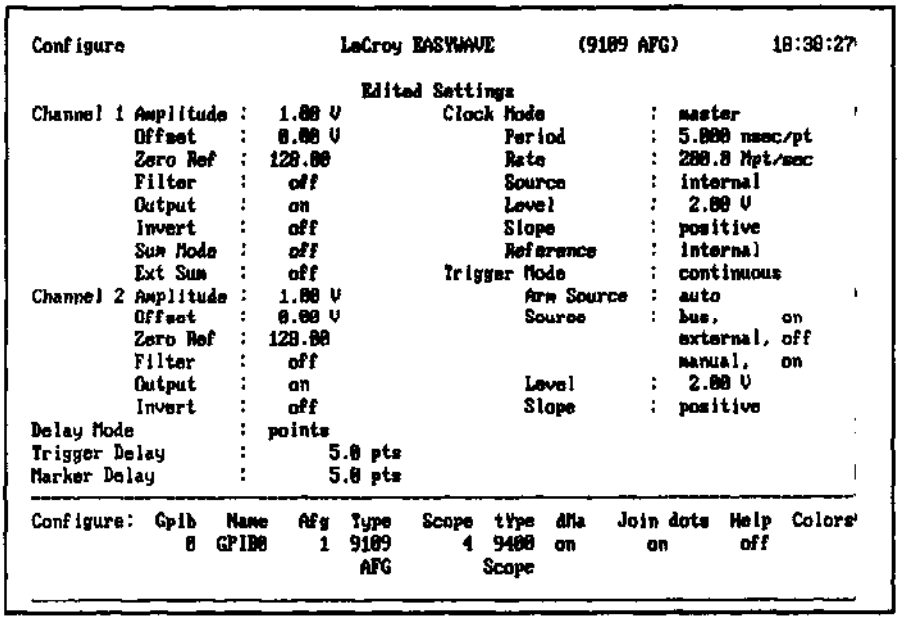
Pin	Signal	Type	Pin	Signal	Type
1	FIFO FULL*	Output	2	FIFO EMPTY*	Output
3	Ground	Return	4	DATA 0	Input
5	DATA 1	Input	6	DATA 2	Input
7	DATA 3	Input	8	Ground	Return
9	DATA 4	Input	10	DATA 5	Input
11	DATA 6	Input	12	DATA 7	Input
13	Ground	Return	14	DATA 8	Input
15	DATA 9	Input	16	DATA 10	Input
17	DATA 11	Input	18	Ground	Return
19	DATA 12	Input	20	DATA 13	Input
21	DATA 14	Input	22	Ground	Return
23	CLEAR*	Input	24	Ground	Return
25	WRITE*	Input	26	Ground	Return

* – indicates an active low signal. All signals are TTL logic levels

Using The 9100/RT Option

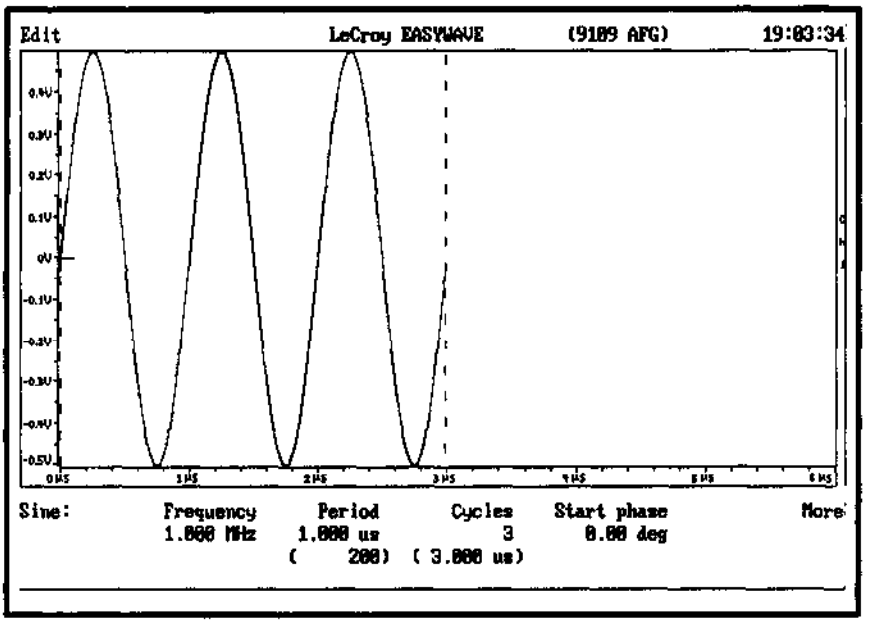
This section is intended as a tutorial in 9100/RT operation. The examples are presented in a step by step format so that a first time user can duplicate the application. It assumes that the users has EASYWAVE software and is familiar with its operation. It further assumes that the user can supply the necessary digital inputs to the external real time port.

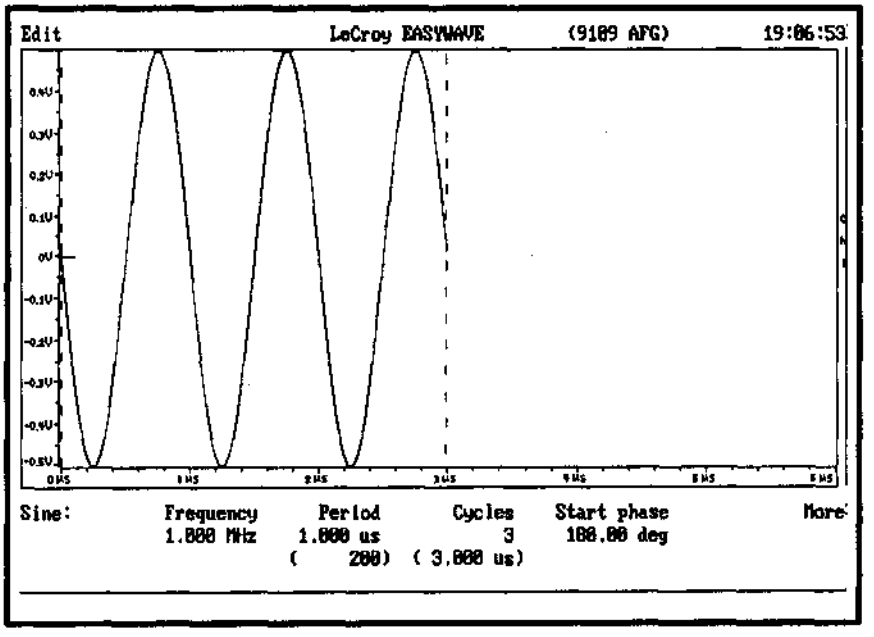
The first example is to generate a phase shift keyed (PSK) waveform and randomly generate "1" and "0" data waveforms. EASYWAVE's edit settings menu is used to select the necessary AFG settings.

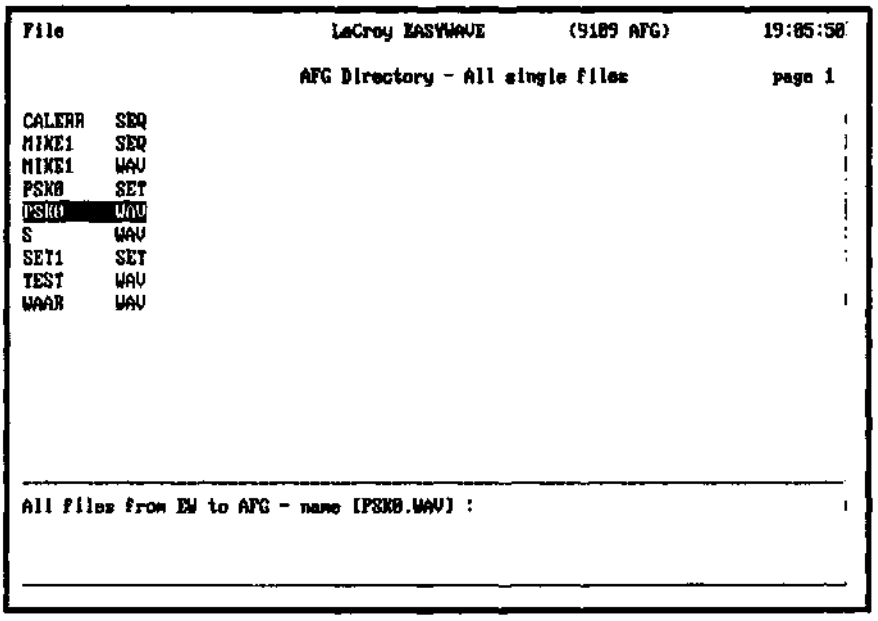


The next step is to create the two waveform segments which will represent the "0" and "1" digital data. The waveforms consist of 8 cycles of a 1 MHz sinewave. A "0" is represented by a 0° initial phase while a "1" has a 180° initial phase. These waveform segments were created using EASYWAVE's simple elements function.

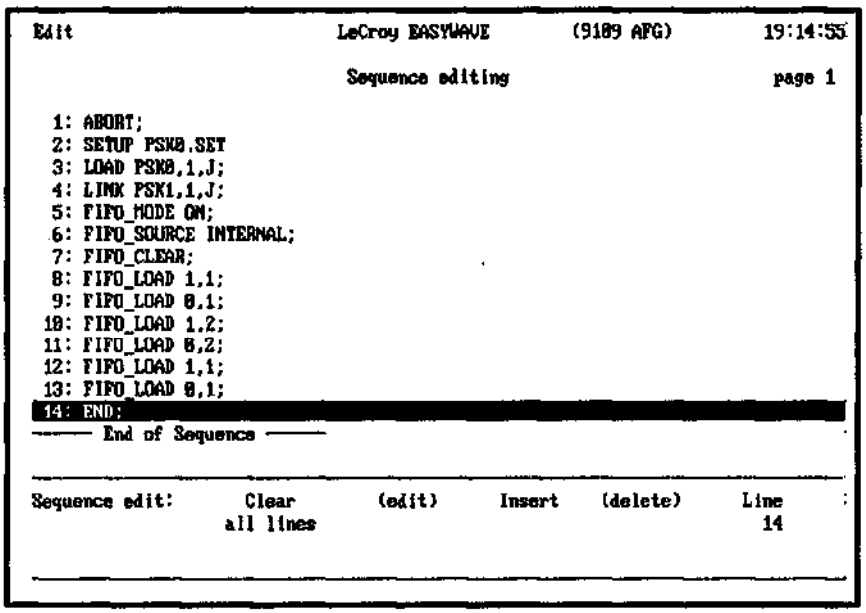
The waveform segment and the settings are transferred to the AFG. The "0" waveform segment is stored as PSK0.WAV and the "1" waveform segment is stored under the filename PSK1.WAV. The settings file was stored as PSK0.SET.


Edit
LeCroy EASYWAVE
(9109 AFG)
19:03:34
Sine:
Frequency
1.000 MHz
Period
1.000 us
(200)
Cycles
3
(3.000 us)
Start phase
0.00 deg
More


Edit
LeCroy EASYWAVE
(9109 AFG)
19:06:53
Sine:
Frequency
1.000 MHz
Period
1.000 us
(200)
Cycles
3
(3.000 us)
Start phase
180.00 deg
More



The next step is to use a sequence file to setup and load the real time FIFO memory. The sequence file is created in the EASYWAVE sequence editor.



The sequence file performs several functions. First, it calls the settings file to setup all the AFG control settings. It loads the two waveform segments, PSK0.WAV and PSK1.WAV, which have the link index 0 and 1, respectively.

NOTE: The LOAD and LINK commands MUST precede the FIFO load operations. This is required because the LOAD command includes an implicit ABORT operation which will clear the FIFO contents.

The next series of commands in the sequence file setup the FIFO operating mode and pre-load it with 6 jump instructions. The GO command starts the generation of the waveforms producing a 1,0,1,1,0,0,1,0 encoded data pattern.

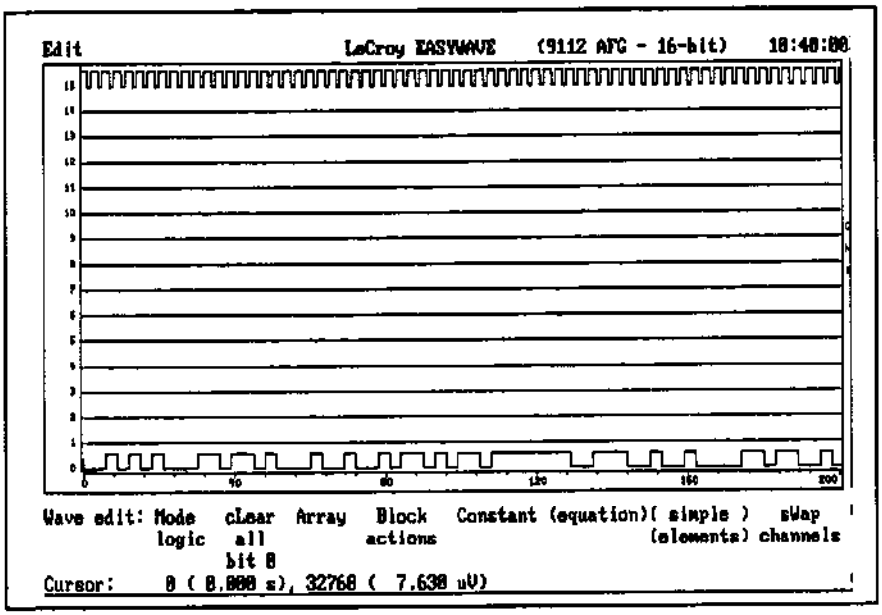
Using The External Real–Time Port

The external real time port permits waveform selection at rates up to 2.77 MHz. The following example uses the waveform segments from the previous example but selection is controlled by the external Real–Time Port. The following sequence file was created in the EASYWAVE sequence editor:

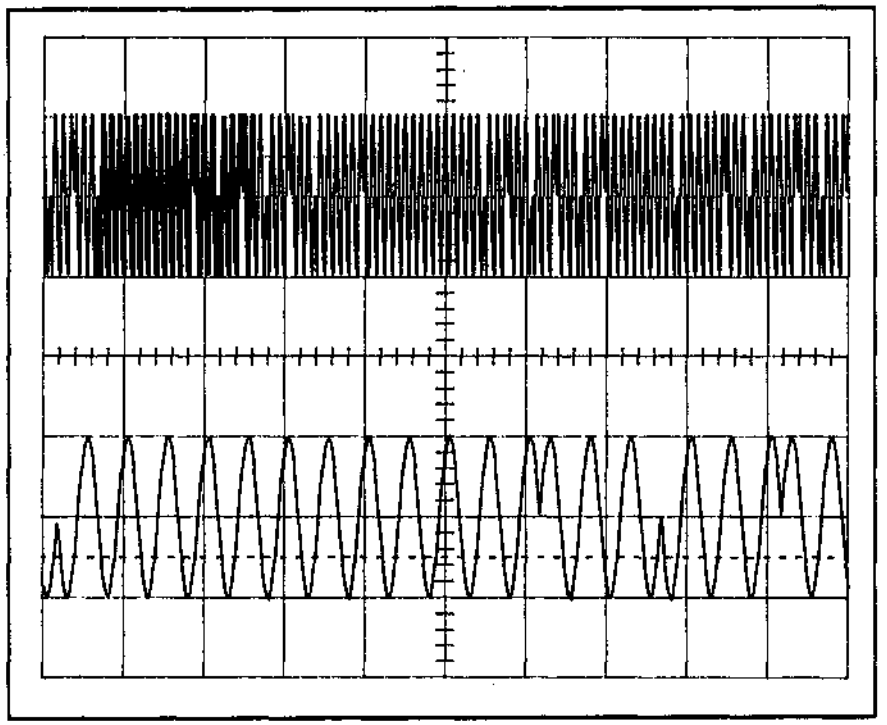
```
ABORT;
SETUP PSK0.SET;
LOAD PSK0.WAV,1,J;
LINK PSK1.WAV,1,J;
```

```
FIFO_MODE ON;
FIFO_SOURCE EXTERNAL;
FIFO_CLEAR;
GO;
END;
```

This file is transferred to the AFG and executed. In the absence of a FIFO input the AFG output waveform will consist of PSK0.WAV followed by PSK1.WAV. Data was supplied to the Real-Time Port from the digital outputs of a 9112 AFG. The Data consisted of a random 1 bit data pattern applied to the least significant bit (D0) of the Real Time Port. The write clock (D15) was also supplied by the 9112 as shown below:



The resultant AFG output consisted of random PSK data segments shown in the oscilloscope plot below:



Waveform Selection Using BASICA

The final example uses the same waveform segments but this time the selection of the desired segment is made by pressing a key on a computer keyboard. This example was implemented by using direct GPIB commands to the AFG from BASICA instead of using a sequence file. The program for accomplishing this is shown below:

```
5 '————————————————LOAD GPIB DRIVERS
10   CLEAR ,60000! : IBINIT1=60000! :
     IBINIT2=IBINIT1+3 : BLOAD "bib.m",IBINIT1
20   CALL
     IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,
     IBPPC,IBBNA, IBONL,IBRSC, IBSRE,IBRSV,IBPAD,
     IBSAD,IBIST,IBDMA,IBEOS, IBTMO,IBEOT,,IBRDF,
     IBWRTF,IBTRAP)
30   CALL
     IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,
     IBWRTA,IBCMD, IBCMDA,IBRD,IBRDA,IBSTOP,
     IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,
```

```
      IBRDIA,IBWRTIA,IB STA%,IBERR%,
      IBCNT%)
 40   '————————————DEFINE DEVICE
 50   BDNAME$="DEV1"
 60   CALL IBFIND (BDNAME$,AFG%)
 70   IF IBSTA%<0 THEN STOP
 75   '————————————ENTER AFG LINK SEQUENCE
 80   C$="SETUP PSK0.SET; LOAD NULL.WAV,1,JZ;
      LINK PSK0.WAV,1,JZ;LINK PSK1.WAV,1,JZ;"
 90   CALL IBWRT (AFG%,C$)
 100  IF IBSTA%<0 THEN STOP
 105  '————————————SETUP RT FIFO
 110  C$="FIFO_MODE ON; FIFO_SOURCE
      INTERNAL;GO;"
 120  CALL IBWRT (AFG%,C$)
 130  IF IBSTA%<0 THEN STOP
 140  '————————————LOAD FIFO BASED ON
      OPERATOR ENTERED DATA_
 160  CLS
 170   PRINT "TYPE 1 OR 0 ON THE KEYBOARD; Q TO
      EXIT PROGRAM"
 180  K$=INPUT$(1)
 190  IF K$="1" THEN C$="FIFO_LOAD 2,1;"
 200  IF K$="0" THEN C$="FIFO_LOAD 1,1;"
 210  IF K$="Q" OR K$="q" THEN GOTO 260
 220  IF K$<>"1" AND K$<>"0" THEN GOTO 160
 230  CALL IBWRT (AFG%,C$)
 240  IF IBSTA%<0 THEN STOP
 250  GOTO 160
 260  END
```

The program uses the National Instruments software drivers for the GPIB, which are loaded in program steps 5 through 20. GPIB commands for the AFG are contained in the string variable C$. These are output to the AFG via the GPIB by the IBWRT instructions.

The AFG is loaded with 3 waveform segments NULL.WAV, PSK0.WAV, and PSK1.WAV. NULL.WAV is a 72 point, 0 volt DC level which serves as a quiescent output until a keyboard entry is made. Note that all waveform segments were loaded or linked with the JZ parameter. This selects the waveform segment with link index 0, NULL.WAV, whenever the FIFO is empty. Thus in the absence of any keyboard input the AFG defaults to outputting NULL.WAV which produces a 0 volt output.

The program scans the keyboard until the Q, 1, or 0 key is pressed. A 1 or 0 input causes the FIFO to be loaded with a link index of 2 (PSK1.WAV) or 1 (PSK0.WAV) respectively. The AFG outputs the selected waveform and then returns to NULL.WAV. Entering a Q terminates the program.

Specifications

The 9100/RT Real–Time Waveform Selection Option allows fast, random access selection of any waveform stored to the AFG waveform memory. It is a fully self contained in any LeCroy 91XX Series Arbitrary Function Generator.

Compatibility: AFG's – 9100, 9101, 9109, 9112

Upgrades: Can be added to any LeCroy 91XX Series AFG. Consult factory for details.

External Real–Time Port Data Format

| D14 D13 D12 D11 | D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0 |

Repeat Count – 1 Waveform Link Address

Repeat Count is a binary value equal to one less than number of repetitions desired.

Waveform Link Index is a binary value corresponding to the desired segment's line number in the operator entered link sequence, starting with the value 0.

FIFO Memory width – 15 bits.

FIFO Memory length – 1024 words

Maximum Real–Time Rate (for waveform selection) – 2.77 MHz for 72 point single channel waveform @200 MHz clock (910X) or for 18 point dual channel @50 MHz clock (9112).

FIFO Read (Fetch) Time – 72 clock periods.

Throughput Delay (write, rising edge, to output change) – 121 clock periods + 120 nsec relative to the end of the current waveform being output.

GPIB Commands:

LOAD <wavename>,[wav|wad]{,<repeat count>[,WAIT][,J|JR|JZ]};

LINK <wavename>,[wav|wad]{,<repeat count>[,WAIT][,J|JR|JZ]};

The JUMP flag option, J, has been added to the LOAD and LINK commands. When J is encountered in a linked waveform segment it is output as specified; however, the following segment is output as specified by the link address and repetition count read from the FIFO memory.

The secondary parameters R or Z set the default jump destination in the event the FIFO memory is empty. J and JR – cause the last waveform segment to be repeated. JZ – forces a jump to the waveform at index 0.

FIFO_MODE {ON|OFF}; or the short form FIM{ON|OFF};

The FIFO_MODE command enables the real–time mode when it is set ON. When it is set to OFF it disables the real–time mode. The default is FIFO_MODE OFF.

FIFO_SOURCE {EXTERNAL|INTERNAL}; or the short form FIS{EXT|INT};

FIFO_SOURCE select the source of the FIFO. The default is INTernal which allows the FIFO to be loaded from the GPIB using the FIFO_LOAD command. If the source is internal then the External Real–time Port is disabled. If the EXTernal source is selected the FIFO is loaded from the External Real–time Port and the FIFO_LOAD command is disabled .

FIFO_CLEAR; or the short form FIC;

This command resets the FIFO pointers effectively clearing FIFO contents. The FIFO is also cleared, at power–up, by the FIFO_MODE, FIFO_SOURCE, and the ABORT commands.

FIFO_LOAD<link address>,<repeat count>; or the short form FIL<link address>,<repeat count>;

Load the FIFO with the specified link address and repeat count from the GPIB. This command is ignored if FIFO_SOURCE is set to External, or if FIFO_MODE is off.

Appendix 1

SEQUENCE FILE COMMANDS

The four commands usable only in Sequence files are PAUSE, START, LOOP and NOTE. All are described below.

PAUSE

format: PAUSE arg 1

arg 1: number between 2 and 24000 (NR3 format acceptable)

possible errors: 91 = command only valid in batch
90 = batch mode error (i.e., arg1 out of limits)

This command causes the AFG to do absolutely nothing until the specified number of tics of the 10 msec internal clock have occurred. Only hardware controlled functions, such as waveform generation, continue during a pause. Examples of things that don't continue are accepting characters from GPIB and reacting to the 9100/CP. After the pause, sequence execution continues.

Example: PAUSE 100; Causes the 9100 to do nothing for 1 second.

START

format: START

possible errors: 91 = command only valid in batch

This command begins a loop in a batch file. The LOOP command marks the end of the loop. Loops can not be nested in one sequence file. However, sequence files are nestable and each level may have a loop.

A START without a LOOP does not generate an error.

EXAMPLES:
C1A,0.1V,DELTA; START; C1A,INCREMENT; PAUSE 100; LOOP 10;

The above segment of a sequence file would cause the amplitude of channel one to increase in 10 steps of 0.1 V per step. After each amplitude change, the sequence file pauses for one second.

START; SEQUENCE,LEVEL2.SEQ; LOOP 10;

This segment of a sequence file runs a second sequence file ten times. The second sequence file may also have a loop, etc.

LOOP

format: LOOP arg1

arg1: a number from 1 to 32767 (NR3 format acceptable)

possible errors: 91 = command only valid in batch
90 = batch mode error (i.e., not preceded by START)

For a description of this command, see START.

Attempts to nest loops will cause an error on the second LOOP command. For example:

--- bad ---		--- good ---	
START;	ignored	START;	start of loop
START;	start of loop	SEQ,B.SEQ;	contains a loop
LOOP,10;	end of loop	LOOP,20;	end of loop
LOOP,20;	causes error 90		

NOTE

format: NOTE arg1[,arg2[,...]]
arg1 - argn: any ASCII characters except semicolon.
possible errors: 91 = command only valid in batch

NOTE: The 9100 will replace any characters it regards as delimiters with a comma.

This command prints out its arguments (all upper case) to the currently active COMM_SOURCE, separated by commas, and followed by carriage return and line feed.If the current COMM_SOURCE IS RS-232, then the message is sent in its entirety before sequence execution continues.

If the COMM_SOURCE is GPIB, the message is queued for output and sequence execution continues immediately; if you do not take this message before the next NOTE command it will be lost.

The total length of a NOTE command (from the first character to the semicolon) must be less than 80 characters for the command to be processed.

EXAMPLE:

NOTE reached point#1; prints "REACHED,POINT#1"<cr><lf>
NOTE This is a test; prints "THIS,IS,A,TEST"<cr><lf>

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LeCroy

Innovators in Instrumentation

Corporate Headquarters
700 Chestnut Ridge Road
Chestnut Ridge, NY 10977-6499
Tel: (914) 578-6020
Fax: (914) 578-5981

European Headquarters
2, chemin Pre-de-la-Fontaine
P.O Box 341
CH-1217 Meyrin 1 Geneva, Switzerland
Tel: (022) 719.2111
Fax: (022) 782.3915

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