WAVETEK

HMS 1213

OPERATOR'S MANUAL

Model 91

20 MHz Synthesized Pulse/Function Generator

1-7-92

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Model 91

20 MHz Synthesized Pulse/Function Generator

WAVETEK®

WAVETEK SAN DIEGO, INC.
9045 Balboa Ave., San Diego, CA 92123
P. O. Box 85265, San Diego, CA 92138
Tel 619/279-2200 FAX 619-565-9558

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Instrument Part Number: 1000-00-0649

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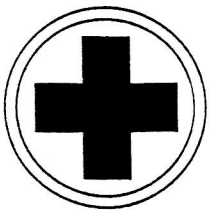
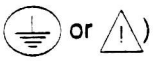
SAFETY FIRST



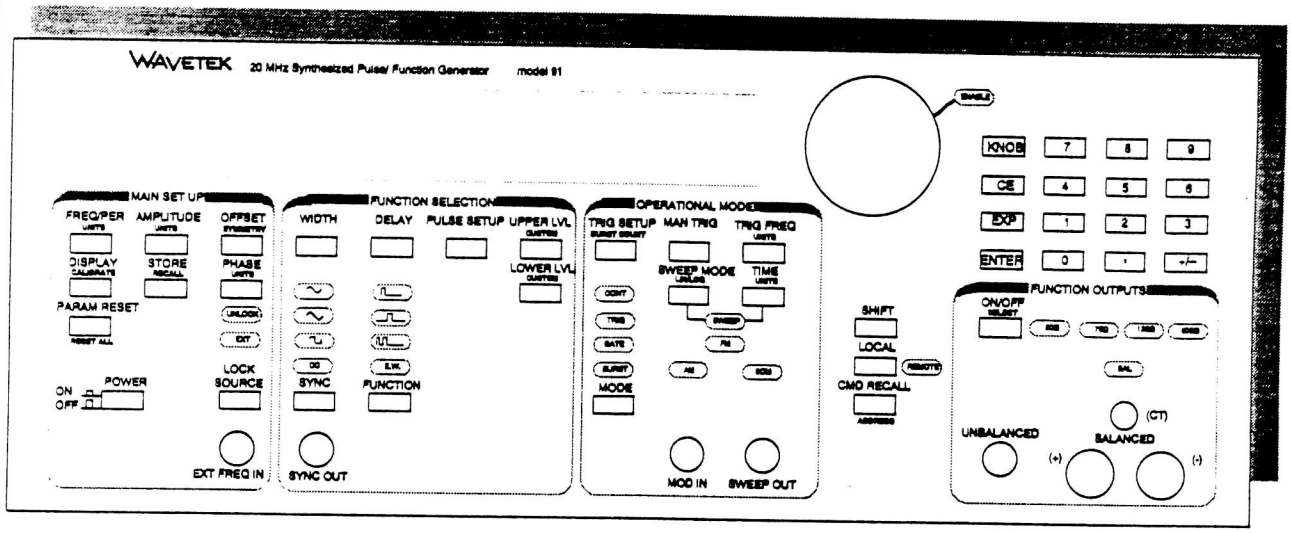
Protect yourself. Follow these precautions:

- Don't touch the outputs of the instrument or any exposed test wire carrying the output signals. This instrument can generate hazardous voltages and currents
- Don't bypass the power cord's ground lead with two-wire extension cords or plug adapters.
- Don't disconnect the green and yellow safety-earth-ground wire that connects the ground lug of the power receptacle to the chassis ground terminal (marked with  or)
- Don't hold your eyes extremely close to an RF output for a long time. The normally nonhazardous low-power RF energy generated by the instrument could possibly cause eye injury.
- Don't plug in the power cord until directed to by the installation instructions.
- Don't repair the instrument unless you are a qualified electronics technician and know how to work with hazardous voltages.
- Pay attention to the **WARNING** statements. They point out situations that can cause injury or death.
- Pay attention to the CAUTION statements. They point out situations that can cause equipment damage.

WARNING

This instrument normally contains a lithium battery. Where lithium is prohibited, such as aboard U.S. Navy ships, verify that the lithium battery has been removed.

Do not recharge, short circuit, disassemble, or apply heat to the lithium battery. Violating this rule could release potentially harmful lithium. Observe polarity when you replace the battery.



Model 91 20 MHz Synthesized Pulse/Function Generator

SECTION 1
GENERAL

1.1 ABOUT THIS MANUAL

The Model 91 20 MHz Synthesized Pulse/Function Generator Operator's Manual provides information on how to setup and use the Model 91.

Section 1 General describes and lists the Model 91 specifications.

Section 2 Preparation describes instrument receiving and inspection, return for repair, initial checkout including fuse and voltage selection and turn on, error messages, and functional check.

Section 3 Operation describes instrument operation - local (front panel) and remote (GPIB).

1.2 THE MODEL 91

The Model 91, 1mHz to 20 MHz programmable, Synthesized Pulse/Function Generator, produces sine, triangle, square, and pulse functions, plus dc. Functions can be continuous, triggered, gated, burst, AM (amplitude modulation), SCM (suppressed carrier modulation), FM (frequency modulation) or sweep. Balanced or unbalanced output is programmable from 1mV to 30 Vpp (into an open circuit) with selectable output impedances.

As a pulse generator, the Model 91 produces single, double, and delayed pulses to 50 MHz. In addition, the Model 91 produces external width outputs as well as square waves at 50% duty cycle to 100 MHz.

At frequencies above 20 Hz (all functions - Continuous, AM, and SCM modes), the Model 91 phase locks its function generator to its internal frequency synthesizer (internal phase lock) improving the frequency accuracy to ±(10 ppm). An optional frequency reference (Option 001) improves the frequency accuracy to better than 1ppm. Also, the Model 91 can phase lock to an external source (same conditions as internal phase lock). When locked to an external source, the phase of the Model 91 output can be varied ±180°. In addition, the internal frequency synthesizer acts as an accurate internal trigger source for the trigger, gate, or burst modes.

1.3 FUNCTION GENERATOR SPECIFICATIONS

1.3.1 Non-Synthesized/Synthesized Frequency

Non- Synthesized Operation
1mHz to 19.99 Hz Continuous;
0.1 Hz to 19.99 Hz, AM and SCM;
1mHz to 20 MHz, Triggered, Gated, Burst, Sweep, or FM.

Synthesized operation
20 Hz to 20 MHz, Continuous, AM, and SCM.

1.3.2 Frequency

1.3.2.1 Frequency Range

1mHz to 20 MHz;
20 Hz to 20 MHz, Synthesized;
1 mHz to 1MHz, 600Ω Output Impedance (Balanced and Unbalanced Outputs).

1.3.2.2 Frequency Modulation and Sweep Ranges

Internally, the Model 91 operates using ten frequency ranges. In the FM and Sweep modes, the frequency limits must be kept within one of these ranges. The following table lists the ten ranges and the maximum frequency deviation (1000:1 or three decades) allowed for that range.

FM/SWEEP RANGE

Normal Range	Minimum Frequency
20 - 2.001 MHz	20k
2 - 0.2001 MHz	2kHz
200 - 20.01 kHz	200 Hz
20 - 2.001 kHz	20 Hz
2 - 0.2001 kHz	2Hz
200 - 20.01 Hz	0.2 Hz
20 - 2.001 Hz	0.02 Hz
2 - 0.2001 Hz	0.002 Hz
200 - 20mHz [1]	2mHz
20 - 2mHz [2]	2mHz

[1] *100:1 or two decades only.*
[2] *10:1 or one decade only.*

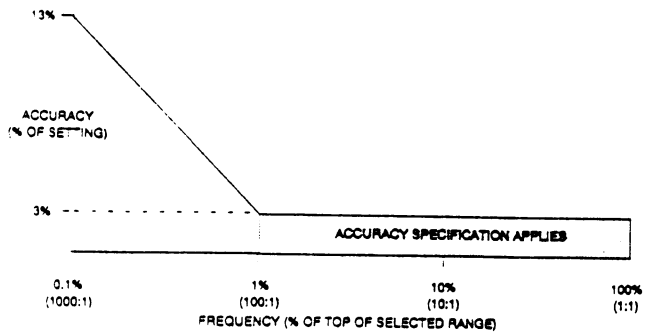
1.3.2.3 Frequency Resolution

5 digits, 20 Hz to 20 MHz;
4 digits, 1mHz to <19.99 Hz.

1.3.2.4 Frequency Accuracy

±10 ppm synthesized;
±1ppm Option 001.

Nonsynthesized frequency accuracy



1.3.2.5 Stability

VS temperature:

±2 ppm/°C for synthesized 15°C to 25°C;
±1ppm Option 001: 0°C to 50°C;
<100 ppm/°C for non-synthesized.

VS time:

±10 ppm/year for synthesized;
±1ppm/year Option 001;
±0.1% for non-synthesized within 10 minutes;
±0.5% for non-synthesized within 24 hours.

1.3.2.6 Synthesizer/Internal Lock

The Model 91 can be phase locked at frequencies ≥20 Hz (continuous, AM or SCM mode) to an internal crystal referenced frequency synthesizer which improves the generator's frequency accuracy and stability. A front panel annunciator (UNLOCK) indicates phase lock conditions.

1.3.2.7 External Lock

The Model 91 can be phase locked at frequencies ≥20 Hz (continuous, AM or SCM mode) to an external phase lock signal. Model 91 measures the external signal, sets the generator's frequency, and locks the generator to the source. When external phase locked, the external source controls the generator's frequency, stability and purity.

Also, external phase lock permits programing the phase angle relative to the positive-going zero crossing of the external sine wave. Phase angle may be set from ±180° (± π radians) with 1° resolution and, in the range of 50 Hz to 10 MHz, ±(4°+20 ns) accuracy. If the external signal has dc offset, the Model 91 ignores the offset and phase locks reference to the "0°" point on the external sine wave.

1.3.3 Functions

1.3.3.1 Time Symmetry

When time symmetry is fixed at 50%, symmetry accuracy is <±(0.2%+5 ns).

Time symmetry is variable from 5% to 95% in 1% steps to 2 MHz. Variable symmetry linearly decreases to a fixed 50% at 20 MHz. Accuracy is <±(1% + 5 ns).

1.3.3.2 Sine

Sine Distortion at 10 Vpp into 50Ω:

All outputs
<1% (-40 dB) THD 1mHz to 20 Hz;
<0.5% (-46 dB) THD 20 Hz to 100 kHz.

Unbalanced Output 50Ω and 75Ω, no harmonics above:
-40 dBc, 100 kHz to 2MHz,
-30 dBc, 2MHz to 6MHz,
-25 dBc, 6MHz to 20 MHz.

1.3.3.3 Triangle

Triangle Linearity:

10% to 90% nonlinearity:
±1%, 1mHz to 100 kHz;
±2%, 100 kHz to 2MHz;
±10%, 2MHz to 5MHz.

1.3.3.4 Square

Square Transition Time:

The transition time (rise/fall) is <9ns, 10% to 90%, Unbalanced Output into 50 Ω impedance.

Aberrations:

Overshoot and ringing are <(5%+20 mV) of the peak to peak amplitude.

1.3.3.5 dc Function

The dc function provides a variable dc voltage (±15V) at the Unbalanced Output.

Range

±1mV to ±7.5V terminated;
±2mV to ±15V open circuit.

Resolution

4 digits; may be reduced if both offset and waveform amplitude are programmed.

Accuracy

±(2%+1mV) to 9.99 mV terminated;
±(2%+2mV) to 999 mV terminated;
±(2%+10 mV) to 7.5V terminated.

1.3.4 Modes

1.3.4.1 Continuous

In this mode, the Model 91 supplies a continuous waveform at the selected frequency. The unit automatically selects its internal synthesizer at frequencies at or above 20 Hz. Display shows internal or external locking source selection and current frequency (programmed frequency if internal is selected, or external frequency if external lock is selected).

1.3.4.2 Triggered

In this mode, the Model 91 remains quiescent at trigger baseline of selected function until a trigger event occurs (positive-going transition at the rear panel Trig In connector, Manual Trigger, GPIB trigger command, or internal trigger rate generator). This initiates a single waveform or pulse period at the programmed frequency and, after completing the waveform, returns the generator to the quiescent baseline value ready for another triggering cycle. When square waves ≤20 MHz are selected, there will be a 1/4 cycle delay between the trigger input and the square wave output. Internal or external phase lock is disabled in the triggered mode. The external trigger frequency will be displayed each time the TRIG FREQ key is pressed. The generator can also be triggered using the internal trigger synthesizer. Accuracy of triggered waveform period is <±3%.

1.3.4.3 Gated

In this mode, the Model 91 functions the same as the Triggered mode, except the generator runs continuously as long as the triggering signal is true. The generator starts and stops in the quiescent state, and the Model 91 always completes its last cycle. The maximum generator frequency is limited to 20 MHz. The minimum gating frequency is half the generator's frequency. Internally gated waveforms have an approximate 1:1 on/off cycle. The display shows the internal or external trigger source selection and, if internal gated, the programmed internal triggering frequency.

1.3.4.4 Burst

In this mode, the Model 91 functions the same as the Triggered mode, except that the number of cycles generated, when triggered, is programmable from 1 to 1,000,000. The generator starts and stops in the quiescent state. The display shows internal or external trigger source selection and the programmed burst count. The maximum generator frequency in the Burst mode is limited to 20 MHz. In external trigger, the Model 91 displays the trigger frequency each time the TRIG FREQ key is pressed.

1.3.4.5 Amplitude Modulation

In this mode, the Model 91 functions the same as the continuous mode except an external signal at the MOD IN connector modulates the instantaneous amplitude of the selected carrier. The output can be modulated from 0 to 100%. Average amplitude is as programmed except signal level with no modulation is less than 7.5 Vpp. The display shows the internal or locking source as well as the programmed frequency. Minimum generator frequency for the AM mode is 0.1 Hz.

1.3.4.6 Suppressed Carrier (SCM)

In this mode, the Model 91 functions the same as the AM mode, except the selected function (carrier) is zero amplitude until an external signal is applied. Minimum generator frequency for the SCM mode is 0.1 Hz. Three selectable scale factors (Vout/Vin) determine the output/input signal ratio. SCM can only be selected when the Continuous signal level is less than 7.5 Vpp.

1.3.4.7 Frequency Modulation

In the FM mode, an instantaneous signal at the MOD IN connector controls the frequency of the generator. Connecting a dc level to the MOD IN connector shifts the generator to a frequency based on the magnitude of the level. Connecting an ac signal to the MOD IN deviates the frequency of the generator about its programmed frequency. The Model 91 only can be frequency modulated a maximum of three decades (1000:1) on any of the ten ranges (see paragraph 1.3.2.2). Internal or external phase lock is not selectable in this mode. The display shows the scale factor (Hz/V) for the selected frequency range.

1.3.4.8 Sweep

In this mode, the Model 91 frequency can be swept between programmable start and stop frequencies. The Model 91 sweeps up to three decades (1000:1) on any of the ten ranges (see paragraph 1.3.2.2). The Model 91 provides three sweep modes: continuous sweep, triggered sweep, or manual sweep. In addition, there are two sweep types: linear and logarithmic. Sweep time can be programmed from 100 ms to 100s. Start/Stop frequency accuracies are <±3% within the top decades, and on the lowest decade, the accuracy varies linearly from ±3% at 100:1 to ±13% at 1000:1. Plus, sweep start and stop frequencies can be selected to allow sweep up and down of frequencies. All 50% symmetrical waveforms can be swept. In addition, pulses (≤20 MHz) can be swept.

1.3.5 Amplitude

1.3.5.1 Range

1mVpp to 15 Vpp terminated into selected output impedance; 2mVpp to 30 Vpp into an open circuit. The peak amplitude + offset must not exceed 7.5 Vp.

1.3.5.2 Resolution

4 Digits (1mV min):
2mVpp to 20 Vpp Open Circuit,
1mVpp to 10 Vpp Terminated;
4-1/2 Digits:
20 Vpp to 30 Vpp Open Circuit,
10 Vpp to 15 Vpp Terminated.

10 mV when using the Upper and Lover Level keys. Resolution may be reduced when the waveform is offset.

1.3.5.3 Accuracy

All functions at 1kHz, % of setting:
±(2%+1mV) to 100 mVpp terminated;
±(2% + 2mV) to 1Vpp terminated;
±(2% + 10 mV) to 15 Vpp terminated.

1.3.5.4 Flatness

Relative to 1kHz:
Unbalanced 50Ω
<2MHz
±0.3 dB, sine and square;
±0.5 dB, triangle.
2MHz to 20 MHz
±0.75 dB, sine and square;
±1.5 dB, triangle.
Balanced at 135Ω (≤3 feet of RG-58)
<100 kHz
±0.3 dB, sine.
100 kHz to 1MHz
±0.75 dB, sine.

1.3.6 Offset

Offset permits the selected waveform at the Unbalanced output to be dc offset relative to the 0V baseline or dc output of the dc function.

1.3.6.1 Range

±7.5V terminated;
±15V open circuit.
The peak amplitude + offset must not exceed 7.5 Vp.

1.3.6.2 Resolution

4 digits; may be reduced if both offset and waveform amplitude are programmed.

1.3.6.3 Accuracy

±(2% +1mV) to 9.99 mV terminated;
±(2%+2mV) to 999 mV terminated;
±(2%+10 mV) to 7.5V terminated.

1.3.7 Outputs

1.3.7.1 Sync Out

Sync Out is a female BNC connector which supplies a TTL compatible pulse output at programmed frequency and symmetry in phase with the square function. Output level is 0 to <2V into 50Ω termination. The 10% to 90% transition times are less than 6ns (≤3 feet RG-58). To minimize sync delay, always select Front Sync while using the function generator. This output must be terminated with 50Ω.

1.3.7.2 Sweep Out

Sweep Out is a female BNC connector, which supplies a 0 to +6V (approximate) ramp to indicate sweep position. Source impedance is 600Ω (±10%). Inactive when not in Sweep Mode.

1.3.7.3 Unbalanced Out

The unbalanced output, a female BNC connector, provides the single-ended source of programmed function at selected frequency, amplitude, symmetry, and offset. Source impedance is 600Ω ± 1% to 1MHz; 50Ω or 75Ω ± 1% to 20 MHz. Unbalanced output is unavailable when the balanced output is selected. The Model 91 limits the Unbalanced Output frequency to 20 MHz. This output is protected from over voltages.

1.3.7.4 Balanced

Balanced outputs, dual "banana jack" connectors, provide differential zero offset outputs of the selected function at programmed frequency, amplitude and symmetry. A universal binding post is provided for signal common "center tap" connection. Source impedance is programmable as 135Ω ± 1% or 600Ω ± 1% to 1MHz. Output unbalance is <1% to 100 kHz. Balanced output is unavailable when the unbalanced output is selected. This output is protected from short circuits and over voltages.

1.3.8 Inputs

1.3.8.1 External Frequency Input

In phase lock, EXT FREQ IN accepts the signal that phase locks the Model 91 to the external source. The Model 91 measures the frequency, sets the unit to match the source frequency, and phase locks the generator to the source. This external frequency may be read by pressing the TRIG FREQ key. Model 91 phase lock range is 20 Hz to 20 MHz in the Continuous, AM or SCM modes. The input signal may be a bipolar sine wave (600 mVpp to 30 Vpp into 10 kΩ) or TTL signal which is selected by an internal jumper (paragraph 2.4.6). Input impedance is 10 kΩ ±2%. This input is protected by it high impedance input.

1.3.8.2 Modulation Input

MOD IN, a female BNC connector, serves as the modulation input for FM (VCG), AM, and SCM. Input impedance is 10 kΩ ±2%. Bandwidth is dc to 1MHz. Maximum input level is ±20 Vpp (into 10 kΩ).

FM

In FM, an external signal provides linear control of waveform frequency around the programmed fre-

quency. A ±10V input signal causes a 1000:1 frequency change (selected frequency range is the top decade in a possible three decade frequency span). An ac signal varies the frequency around the programmed frequency. A dc level sets the generator to a single frequency. VCG bandwidth is dc to 100 kHz limited by 0.06 V/μs maximum slew rate. FM bandwidth is dc to 100 kHz deviation rate; with maximum envelope distortion of 1.78% (-35 dB) taken with 10 MHz carrier frequency, 1kHz modulation frequency and 1MHz (10%) depth (sine wave modulation).

AM

In the AM mode, an external signal provides linear control of waveform amplitude around the programmed amplitude value. Displayed amplitude dependent scale factor specifies approximate Vpp (into 10 kΩ) required for 100% modulation. AM bandwidth is dc to 1MHz; with a maximum envelope distortion of 2% taken with 1MHz carrier frequency, 1kHz modulation frequency and 70% AM (sine wave modulation).

SCM

In the SCM mode, an external signal linearly controls the waveform's amplitude about the zero carrier level. The Model 91 displays a scale factor (2.4V/V, 0.24 V/V, or 0.024 V/V) which defines the amount of Mod In signal level to produce a SCM output level. SCM bandwidth is dc to 1MHz. Maximum envelope distortion is 2% (1MHz carrier and 1kHz modulation).

1.3.8.3 Trigger Input

Trig In, a rear panel BNC connector, serves as the external trigger input for both the function and pulse generator. The generator triggers from greater than 500 mVpp bipolar or TTL signal. Input impedance is 1kΩ shunted by <10 pF. The input is protected up to ±15 Vdc. The Model 91 triggers on either the positive or negative slope (selectable) of the input signal. Also, it permits the triggering level to be within ±5 Vdc (100 mV resolution). Trigger level accuracy is ±(5%+250 mV).

1.4 PULSE GENERATOR

1.4.1 Period/Frequency

1mHz to 50 MHz for pulses, 1mHz to 100 MHz (1000s to 10 ns) for square pulses at the rear panel Pulse Outputs. 20 Hz to 100 MHz synthesized. Above 20 MHz continuous and triggered modes only.

1.4.1.1 Resolution

5 digits, 1mHz to 50.000 MHz;
4-1/2 digits, 50.002 to 100 MHz (2kHz minimum resolution).

1.4.1.2 Accuracy

Same as Function Generator: Accuracy; see paragraph 1.3.2.3.

1.4.1.3 Stability

Same as Function Generator: Stability; see paragraph 1.3.2.4.

1.4.1.4 Synthesizer/Internal Phase Lock

Same as Function Generator: Synthesizer/Internal Phase Lock; see paragraph 1.3.2.5.

1.4.1.5 External Phase Lock

Same as Function Generator: External Phase Lock; see paragraph 1.3.2.6.

1.4.2 Functions

1.4.2.1 Single Pulse

In this mode, the Model 91 produces one pulse each pulse period with variable pulse width. The single pulse is coincident with the pulse sync output. Pulse repetition rate up to 50 MHz at rear panel pulse outputs and 20 MHz at front panel outputs.

1.4.2.2 Delayed Pulse

In this mode, the Model 91 produces one pulse each pulse period delayed (variable) relative to the pulse sync output. Like the single pulse, the delayed pulse has variable pulse width. Pulse repetition rate up to 50 MHz at rear panel pulse outputs and 20 MHz at front panel outputs.

1.4.2.3 Double Pulse

In this mode, the Model 91 produces one pair of pulses each pulse period. Both pulses have the same variable pulse width. The position of the second pulse is set by using delay. The first pulse is coincident with the pulse sync output. Pulse repetition rate up to 25 MHz at rear panel pulse outputs and 20 MHz at front panel outputs.

1.4.2.4 External Width

Output pulse period and width determined by the external trigger signal. The setup of trigger level and slope determines the shape of the external width pulse. When using the front panel outputs, the external width frequency range is dc to 20 MHz. When using the rear panel output, the external width frequency range is dc to 50 MHz.

1.4.3 Pulse Width

1.4.3.1 Range

10 ns to 2000s.

1.4.3.2 Resolution

4 digits, limited to 100 ps.

1.4.3.3 Accuracy

±(1.0%+5ns).

1.4.3.4 Jitter

±(0.050%+100 ps).

1.4.3.5 Duty Cycle

Maximum duty cycle is 70% of periods down to 50 ns, decreasing to 25% at 20 ns period.

1.4.4 Pulse Delay

1.4.4.1 Range

0 ns to 2000 s.

1.4.4.2 Resolution

4 digits, limited to 100 ps.

1.4.4.3 Accuracy

±(1.0%+5ns).

1.4.4.4 Jitter

±(0.05%+100 ps).

1.4.4.5 Duty Cycle

Maximum duty cycle is 70% of periods down to 50 ns, decreasing to 25% at 20 ns period.

1.4.5 Pulse Timing Definitions

t0 = Trigger Input
t1 = Sync Output
t2 = Pulse Output
(t1-t0) = <45 ns for the rear sync output; <90 ns for front sync output.
(t2-t1) = Programmable Delay

1.4.6 Modes

Continuous, Triggered, Gated, Burst, Amplitude Modulation, Suppressed Carrier (SCM), Frequency Modulation, and Sweep are the same as Function Generator Modes except continuous which operates up to 100 MHz, and triggered which operates to 50 MHz.

1.4.7 Amplitude

Amplitude specifications are the same as Function Generator: Amplitude. When front panel outputs, varying the amplitude affects the pulse's programmed upper and lower levels.

1.4.8 Offset

Offset specifications are the same as Function Generator: Offset. Varying the offset affects the pulse's programmed upper and lower level.

1.4.9 Upper and Lower Levels

1.4.9.1 Unbalanced/Balanced Outputs

When using pulse functions, the output levels can be set using upper and lower level. Upper level range is -6.499 to +7.5V and must be more positive than the lower level. Lower level range is -7.5 to +6.499V and must be more negative than the upper level. Varying the upper and lower levels affects the programmed amplitude and offset.

1.4.9.2 Pulse Outputs

See Pulse /Pulse Complement Outputs. The Model 91 permits the setting of custom upper and lower levels:

Upper Level	-1.4 to +4.2V
Lower Level	-1.8 to +3.8V

The upper level must be more positive (>0.4V) than the lower level. Custom level resolution is 100 mV.

1.4.10 Outputs

1.4.10.1 Sync Out

The Sync Out signal for the pulse generator occurs at the 50% point on the lead edge of the internal sync signal (t1). In external width, the Sync Out signal is a TTL representation of the external width trigger signal. Sync Out amplitude is 0 to >2V in to 50Ω termination. Transition time is <6 ns (≤3 feet of RG 58). This connector must be terminated with 50Ω. Use the SYNC key to select either SYNC FRONT or SYNC REAR depending on the output used.

1.4.10.2 Sweep Out

Same as Function Generator: Sweep Out; see paragraph 1.3.7.2.

1.4.10.3 Unbalanced Out

Same as Function Generator: Unbalanced Out; see paragraph 1.3.7.3.

1.4.10.4 Balanced

Same as Function Generator: Balanced Out; see paragraph 1.3.7.4.

1.4.10.5 Pulse/Pulse Complement Out

These rear panel pulse output BNC connectors provide the selected pulse outputs at four fixed levels and one custom level. Pulses Outputs can be either TTL, CMOS, +ECL, -ECL, or Custom. Pulse and Pulse Out source impedance is 50Ω. The Pulse Complement Output

supplies the inverse of the Pulse Output pulse. Between 50 and 100 MHz, the Model 91 limits the pulse outputs to 2.5 Vpp. Following is a list of programmable levels (specified into 50Ω termination).

Logic Selection	Upper Level	Lower Level
TTL	+2.5V	0V
CMOS	+4V	0V
+ECL[1]	+4.1V	+3.2V
-ECL[2]	-0.9V	-1.8V
Custom[3]	-1.4 to +4.2V	-1.8 to +3.8V

[1] Vcc = +5V, Vee = 0V.
[2] Vcc = 0V, Vee = -5.2V.
[3] Upper Level <0.4V<Lower Level.

Termination

50Ω termination

Source Impedance

25Ω

Protection

These outputs are momentarily protected to ±15 Vdc.

Accuracy

±(2%+50 mV)

Perturbations

TTL	0.25V
CMOS	0.19V
+ECL	0.36V
-ECL	0.36V

Rise/Fall Time

TTL	3.75 ns
CMOS	5ns
+ECL	3.5 ns
-ECL	3.5 ns
Custom	2.5 ns+1.75 ns/V (>1V output)

Skew

<1.5 ns.

1.4.11 Inputs

1.4.11.1 External Frequency Input

External Frequency Input function the same as described in Function Generator: External Frequency Input.

1.4.11.2 Modulation Input

Modulation Input functions the same as described in Function Generator: Modulation Input.

1.4.11.3 Trigger Input

Trigger Input functions the same as described in Function Generator: Trigger Input. In the External Width function, the trigger signal duration and rate set the pulse width and repetition rate.

1.5 USER INTERFACE

1.5.1 Display

The Model 91 contains a 16 digit, Vacuum Florescent Display (VFD). Display intensity is adjustable between 1 and 31 (relative units) with 25 being the default intensity. All selectable parameters display the parameter name, the numeric value and the unit. In addition, the display shows GPIB messages, various utilities, maintenance and diagnostic information.

1.5.2 GPIB Programming

1.5.2.1 Address

Valid GPIB addresses for the Model 91 are 0-30 (default address is 9), front panel selectable and battery backed-up.

1.5.2.2 Subsets

SH1, AH1, SR1, RL1, PP0, DC1, DT0, C0, T6, L4, TE0, LE0, and E1.

1.6 STORED SETTINGS

The Model 91 permits up to five complete setups to be stored in its internal memory. These settings can be recalled and used at any time.

1.7 OPTIONS

1.7.1 001: Frequency Reference

This option improves the reference frequency from an adjustable crystal to an adjustable TCXO with a ±1 ppm performance over the operating temperature range. A rear panel EXT REF IN connector accepts TTL or Bipolar sine wave (>500 mVpp at 10 MHz) reference input. The REF OUT connector provides TTL compatible 10 MHz pulses capable of driving a 50Ω termination.

1.7.2 003: Handles and Rack Adapter

This option consists of a pair of handles and rack adapters that attach to the left and right sides of the Model 91. The rack adapters allow the instrument to be mounted in a standard 19 inch rack. Also included are a pair of handles which may be installed in place of the existing front panel corner pieces.

1.7.3 004: Service Kit

This option supplies a set of extender cards which provide access to the plug-in boards during maintenance. This option also includes a teperature-stablizing calibration cover.

1.8 GENERAL

1.8.1 Physical Specifications

1.8.1.1 Dimensions

35.6 cm (14 in.) wide, 13.3 cm (5.219 in.) high and 43.2 cm (17 in.) deep.

1.8.1.2 Weight

Approximately 10.0 kg (22 lb.) net; 14.1 kg (31 lb.) shipping.

1.8.1.3 Power

90 to 108, 108 to 126, 198 to 231, or 216 to 252 Vrms; 48 to 440 Hz; 1 phase; <130 VA.

1.8.2 Environmental Specifications

The Model 91 conforms to MIL-T-28800C, class 5.

1.8.2.1 Temperature Range

0°C to +50°C for operation;
-40°C to +70°C for storage.

1.8.2.2 Warm Up Time

Allow 20 minutes for specified operation at ambient temperature of last Auto Cal ± 10°C. Auto Cal should be performed when the ambient temperature has changed >± 10°C.

1.8.2.3 Operational Humidity

11°C to 30°C at 95% relative humidity;
31°C to 40°C at 75% relative humidity;
41°C to 50°C at 45% relative humidity.

1.8.2.4 Altitude

To 10,000 ft. (3050m.) for operation;
To 15,000 ft. (4570m.) for non-operating.

1.8.2.5 Vibration (Operating)

Vibration level of 0.013 in. from 5 to 55 Hz (2g acceleration at 55 Hz.).

1.8.2.6 Shock (Non-operating)

40g, 9ms half-sine wave.

1.8.2.7 Bench Handling (Operating)

4 in. or point of balance drop, any face, solid wooden surface.

1.8.2.8 Electromagnetic Compatibility

The Model 91 has been tested to MIL-STD-461A Notice 4 (EL) and meets the emission and susceptibility requirements of CE02, CE04, CS02, CS06, RE02, RE02.1, and RS03. Excluding REO1 line and related harmonics up to 7th harmonics.

SECTION 2
PREPARATION

This section contains the following topics:

2.1 RECEIVING AND INSPECTING SHIPMENTS

Use the following steps to inspect a shipment of Wavetek equipment.

1. *Inspect the shipment.* Before unpacking the instrument, the receiving clerk should check the shipment for missing boxes, inspect each box for damage, and if necessary, have the driver describe the box damage and list shortages on the delivery bill. If you find unreported shortages or damage, notify the shipper before further unpacking.

2. *After unpacking the boxes.* Save all of the packing material.

3. *Inspect the equipment for damage.* Inspect it carefully, regardless of the condition of the shipping boxes.

4. *If necessary, file a damage claim.* If any damage is found, call the shipper immediately (within 10 days) and start the claim process.

5. *Call Wavetek.* Call Wavetek's Customer Service department (619-279-2200) and tell them that the equipment arrived damaged.

2.2 RETURNING EQUIPMENT FOR REPAIR

Use the following steps when returning Wavetek equipment to Wavetek for repair.

1. *Save the packing material.* Always return the equipment to Wavetek in its original packing material and boxes. If you use inadequate packing material, you will have to pay to repair any shipping damage as carriers will not pay claims on incorrectly packed equipment.

2. *Call Wavetek for a Return Authorization.* Wavetek's customer service representative will ask for the name of the person returning the equipment, telephone number, company name, equipment type and serial number, and a description of the problem.

2.3 PREPARATION FOR STORAGE OR SHIPMENT

2.3.1 Packaging

If possible, always use the original shipping container. However, when using packing materials other than the original, use the following guidelines:

Wrap the Model 91 in plastic packing material. Use a double-walled cardboard shipping container.

Protect all sides with shock absorbing material (minimum of 2 inch thick material) to prevent movement of the Model 91 within the container. Seal the shipping container with approved sealing tape.

Mark "FRAGILE" on all sides, top, and bottom of the shipping container.

2.3.2 Storage

The Model 91 should be stored in a clean, dry environment. In high humidity environments, protect the Model 91 from temperature variations that could cause internal condensation. The following environmental conditions apply to both shipping and storage:

Temperature	–40°C to +70°C
Relative Humidity	(sea level) Less than 95% at +25°C.
Altitude	Less 15,000 feet (4570 meters).
Vibration	Less than 2g.
Shock	Less than 40g.

2.4 PREPARATION FOR USE

Paragraph 2.4 covers the following topics
- Power and Fuse Selection
- Installation
- Initial turn
- Power ON,
- Maintenance and Error codes,
- AutoCal and Calibration Procedure.

2.4.1 Power and Fuse Selection

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on 108 to 126 Vac line with a 1.5 amp fuse.

Conversion to other input voltage requires a change in rear panel fuse holder voltage card position and fuse (figure 2-1) according to the following procedure.

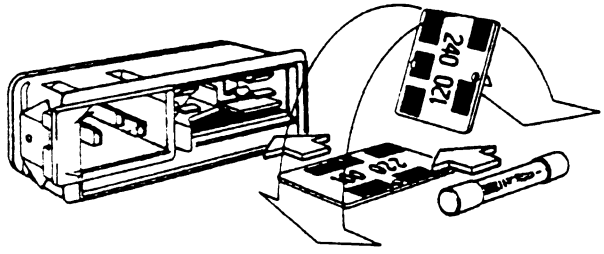


Figure 2-1 . Voltage Selector and Fuse

1. Disconnect the power cord at the instrument, open the fuse holder cover door and rotate the fuse-pull to the left to remove the fuse.
2. Read the voltage on the voltage selection printed circuit card inside the power/fuse case. Leave the card installed if the number matches the voltage needed (see the table below). To change to a different voltage, pull the card and reinsert it as shown in figure 2-1.

Card Position	Input Vac	Fuse
100	90 to 105	1.5A, 250 Vac, Slo Blo
120	108 to 126	1.5A, 250 Vac, Slo Blo
220	198 to 231	3/4A, 250 Vac, Slo Blo
240	216 to 252	3/4A, 250 Vac, Slo Blo

3. Compare the ampere rating on the fuse to the ampere ratings given in the previous table for the range of input voltages. If the fuse has the right rating, keep it. If the fuse has the wrong rating, replace it.
4. Rotate the fuse pull lever back into the normal position, insert the correct fuse, and close the cover door.
5. Connect the ac line cord to the mating connector at the rear of the unit and power source.

2.4.2 Installation

The Model 91 is primarily for bench use. For operating convenience, the Model 91 has a bail that can be adjusted to elevated the instrument.

Also, the Model 91 can be rack mounted using the two mounting ears which are available as accessories. To install the mounting ears, remove the two handle screws (each side) install the ears along with the handles using the longer screws supplied with the ears.

2.4.3 Initial Turn On

WARNING

The Model 91 is equipped with a three-wire power cable. When connected to a grounded AC power receptacle, this cable grounds the instrument front panel and cabinet. Do not use extension cords or AC adapters without a ground.

WARNING

This instrument uses internal batteries that contain more than 0.2 grams of Lithium. Do not charge or short this battery. A hazard of explosion and or contamination exists.

NOTE

The numbers in parenthesis used in the following paragraphs refer to those items described in table 3-1 and illustrated in figure 3-1.

1. Verify that only the power cable is connected to the Model 91. All other cables should be disconnected.
2. Set the "POWER" On/Off switch (*1*) from Off to On.

   When power is first applied, the Model 91 performs a Self-Test which checks the internal battery, Motherboard memory and storage memory.

Table 2-1. Maintenance Messages and Error Codes.

Display	Probable Cause	Corrective Action
Err xxxxxxxxx	Improper self-check/unit	Press "POWER" switch OFF and then ON. If identical failure error is displayed, refer to section 6 (Maintenance) of the *Model 91 Maintenance Manual*. If a different error is displayed, press the Calibrate key again. If "WAVETEK Model 91" is displayed, the unit is operational.
Low batt x.xxx v	Internal battery voltage low.	Unit is available for immediate operation. Refer to section 6 for battery replacement.
Cal Required	Internal battery dead.	Unit has lost its calibration data but can be used temporarily after performing and passing AutoCal. Instrument may not meet all specifications.

If there are Self-test errors they will be displayed; see table 2-1. If the unit passes Self-test, it will display the words "WAVETEK MODEL 91".

3. Press the SHIFT key and then the RESET ALL key (*2*). Verify the following front panel conditions exist by pressing the key and viewing the display or annunciator:

AMPLITUDE	5Vpp
SHIFT - BURST COUNT	5
DELAY	1µs
DISPLAY	25
FREQ/PER	1kHz
FUNCTION	Sine Indicator Lit
KNOB	ENABLE indicator on
PULSE SETUP	
Logic	Normal
Pulse	TTL
Rear Outputs	Off
LIN/LOG	Linear Sweep
LOCK SOURCE	Internal Lock
LOWER LVL	-5V
SHIFT - LOWER LVL	CUSTOM: 0V
MODE	Continuous (Indicator Lit)
OFFSET	0V
ON/OFF	Output Off (50Ω indicator flashes)
PHASE	0°
SHIFT - RECALL	Last stored setting
SHIFT - SELECT	50Ω, Unbalanced
SHIFT - STORE	Last stored setting
SWEEP MODE	Continuous Sweep
Sweep Start	1kHz
Sweep Stop	10 kHz
SYNC	SYNC REAR
TIME	1s Sweep time
SHIFT - SYMMETRY	50%
TRIG FREQ	100 Hz
TRIG SETUP	
Trigger Level	0V
Trigger Slope	Positive
Trigger Source	Internal Trigger
UPPER LVL	5V
SHIFT - UPPER LVL	Custom 1V
WIDTH	500 ns

4. If all above conditions are correct, the signal generator is ready for operation. If a condition is incorrect, notify your maintenance department or return the instrument to Wavetek for repair.

2.4.4 AutoCal and Calibration Procedure

The Model 91 provides two levels of calibration: AutoCal and Calibration Procedure.

AutoCal (automatic calibration) provides a quick method of calibrating the Model 91 without using external test equipment. AutoCal automatically sets up the instrument and takes internal measurements using internal standards. The Model 91 calculates correction values based on the measurements and stores those values in memory. These correction values are recalled from memory when the unit is powered up. Use AutoCal when Model 91 accuracy is critical, after long term instrument storage, following drastic changes in the environment, or when the operator believes AutoCal is necessary.

CAUTION

Remove all cables from the Model 91 during AutoCal otherwise the AutoCal circuitry could significantly alter the calibration of the instrument.

After the Model 91 has warmed up for at least 20 minutes, perform the following steps:

1. Press the "SHIFT" and then the "CALIBRATE" keys. The display shows the words CALIBRATING. If the CALIBRATE key is pressed before the 20 minute warm up time has elapsed, the display shows the time until the AutoCal starts.

2. At the end of the AutoCal cycle the display will show "AUTOCALIBRATED" if the cycle if successful. If there are errors the display will show them. See section 6 of the *Model 91 Maintenance Manual* for a listing of those errors.

The Calibration Procedure provides a more extensive method of calibrating the Model 91 using external test equipment. The Calibration Procedure requires opening the instrument and making adjustments. Use the Calibration Procedure when the Model 91 displays "CAL REQUIRED" or "ERR XXXXXXXX", when the Model 91 has been repaired, or when routine calibration is scheduled. Typically, the Model 91 calibration cycle is one year; section 5 of the *Model 91 Maintenance Manual* describes the Calibration Procedure.

2.4.5 Maintenance Messages and Error Codes

Some internal circuit failures cause maintenance messages or error codes to appear in the display. See table 2-1 for a list of possible maintenance messages/error codes and probable cause.

2.4.6 Lock Source Selection

The Model 91 allows the selection of either a TTL or bipolar external lock source. Wavetek ships the Model 91 configured for Bipolar, external lock source.

To reconfigure the lock source,

1. Disconnect the power from the Model 91.

2. Turn the Model 91 bottom side up.

3. Remove bottom cover by removing the three screws. Slide the cover back.

4. Change the jumper as shown in figure 2-2.

5. Replace the bottom cover, and secure it using the three screws.

Note

Changing the trigger selection jumper does not affect the unit's calibration.

2.5 FUNCTIONAL CHECKOUT

The functional checkout provides a quick method of verifying the operation of the Model 91. The only test equipment required to perform this checkout will be a signal source (Wavetek Model 90 or equivalent), an oscilloscope (Tektronix 2445 - dual channel or equivalent), and the appropriate cables and loads. The (*numbers*) in the checkout refer to items in figure 3-1 (located at the end of section 3) and table 3-1; for more

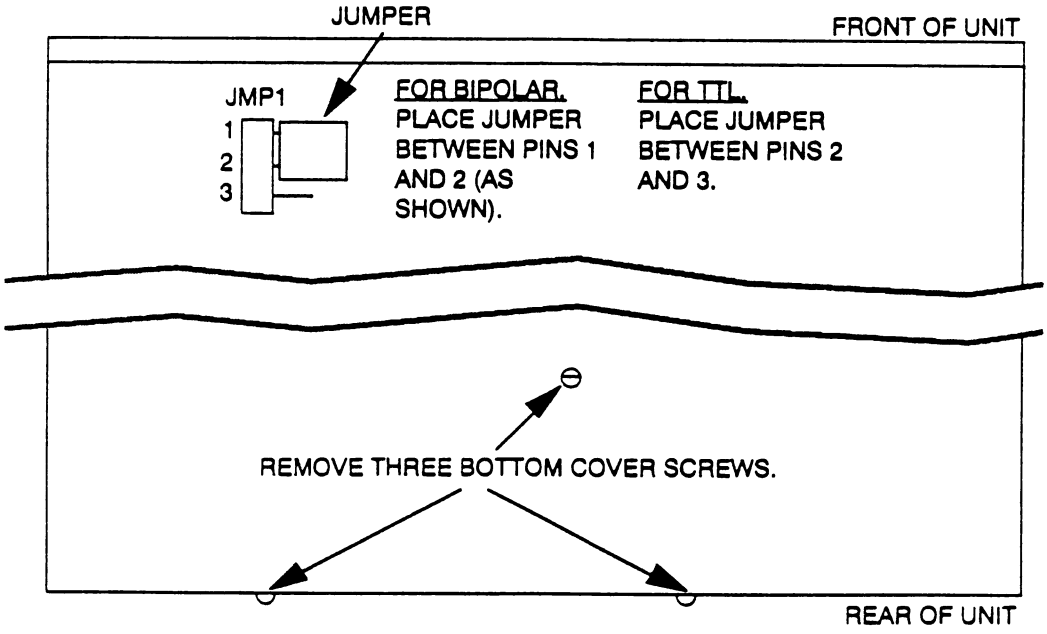


Figure 2-2. Trigger Source Selection

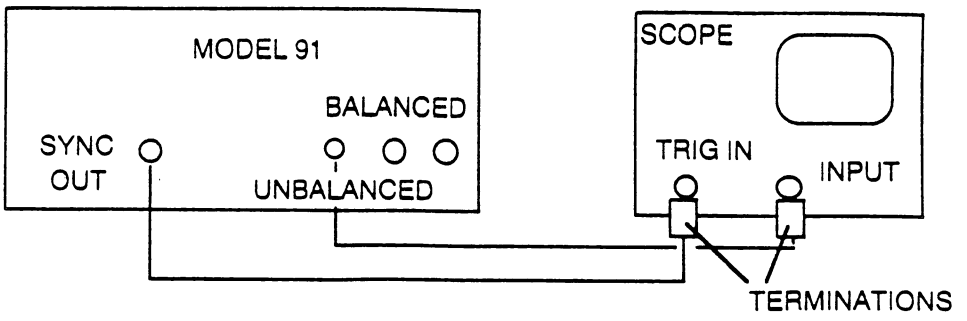


Figure 2-3. Function Checkout Interconnection

information on the operation of the keys and connectors refer to section 3. This procedure is designed to be performed in sequence from step 1 - FUNCTION CHECK to step 28 - PULSE OUTPUTS. At the beginning of each check is a figure reference for that Check.

FUNCTION CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3.

1. After connecting the power cable, press the "POWER" switch (*1*) to turn the Model 91 on. After Self-test the display shows the words: WAVETEK MODEL 91. The Function Output will be off. Terminate the UNBALANCED output (*38*) with a 50Ω termination.

2 Press "SHIFT" key (*31*) and "RESET ALL" key (*2*). Press the "ON/OFF" (*36*) key to turn on the output. The scope displays 1kHz, 5Vpp sine wave.

3. Press the "FUNCTION" key (*18*) to step through the triangle and square waveforms, and dc. Verify the scope displays a triangle and square waveforms, plus a dc level. Press the "FUNCTION" key to return to the sine function.

FREQUENCY CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3.

4. Press the "FREQ/PER" key (*4*).

5. Press the "KNOB" key (*39*) and then rotate the Knob (*41*) CW; observe the frequency increasing. Rotate the Knob CCW; observe the frequency decreasing.

6. Using the Keypad (*39*) press "5", "EXP", "4", and "ENTER" keys; observe the display shows the words: FREQ 50 kHz.

AMPLITUDE CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3.

7. Press the "AMPLITUDE" key (*5*).

8 Press the "KNOB" key (*39*) and then rotate the Knob (*41*) CW; observe the amplitude increases.

Rotate the Knob CCW; observe the amplitude decreases.

9. Using the Keypad (*39*) press "5" and "ENTER" keys; observe the display shows the words: AMPL 5Vpp.

TRIGGER MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-4.

10. Press the "MODE" key (*22*) until the TRIG indicator (*23*) lights.

The internal trigger source is the default - trigger frequency is 100 Hz. Scope displays a 50 kHz sine wave triggered at a 100 Hz rate.

11. To select the External Trigger Source, press the "TRIG SETUP" key (*24*) until SOURCE INT (0) appears on the display. Rotate the Knob until SOURCE EXT (1) appears. Set the external signal source to 100 Hz, 1Vpp square wave. Connect the signal source to the rear panel TRIG IN (*C*) connector of the Model 91 as shown in figure 2-4. Sync the scope from the signal source

GATE MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-4.

12. Press the "MODE" key (*22*) and select the Gate mode (unit displays the words MODE EXT. GATE) - GATE indicator (*23*) lights.

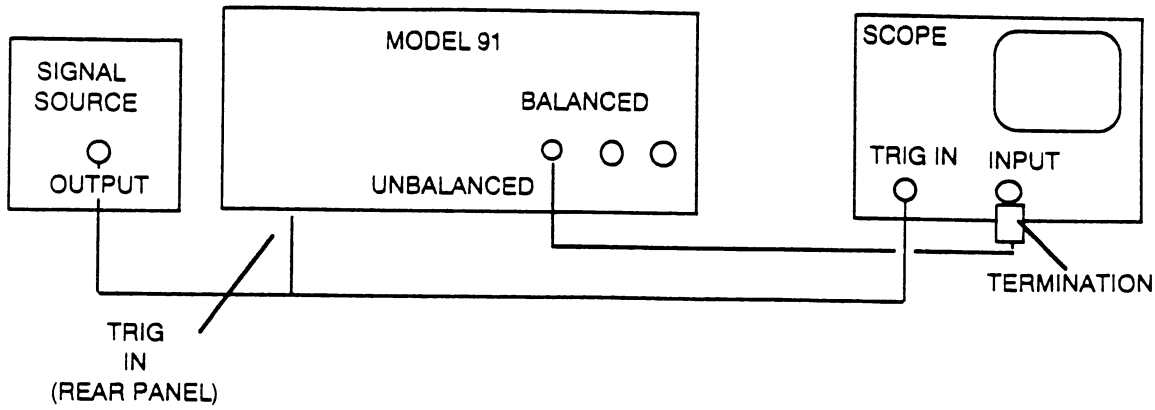


Figure 2-4. Trigger, Gate, and Burst Modes Check

Scope displays a gated output as long as the trigger signal remains within the set trigger level and slope.

BURST MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-4.

13. Press the "MODE" key (*22*) and select the Burst mode (MODE EXT. BURST displayed) - BURST indicator (*23*) lights.

    Press "SHIFT" and then the "BURST COUNT" key (*24*). Press the KNOB key (*39*) and then use the Knob (*41*) to change the count from 5 to 2.

    Scope displays a burst of two sine waves.

AMPLITUDE MODULATION MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-5.

14. Press the "MODE" key (*22*) and select the AM mode - AM indicator (*23*) lights. The unit displays the words: MODE AM 2V=F.S. If not, press the "LOCK SOURCE" key (*11*) until EXTLOCK is displayed. Connect the signal source to the MOD IN connector (*30*). Set the signal source to 100 Hz, 1Vpp sine wave; trigger the scope from the signal source.

    Scope displays an Amplitude Modulated signal.

SUPPRESSED CARRIER MODULATION MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-5.

15. Press the "MODE" key (*22*) and select the SCM mode - SCM indicator (*23*) lights. Also, the display shows the words: MODE SCM 2.4 V/V.

    Scope displays a SCM (double side-band) signal.

FREQUENCY MODULATION MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-5.

16. Press the "MODE" key (*22*) and select the FM mode - FM indicator (*23*) lights. Also the display shows the words: MODE FM .

    Scope displays a Frequency Modulated signal.

SWEEP MODE CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-6.

17. Press the "MODE" key (*22*) and select the Sweep

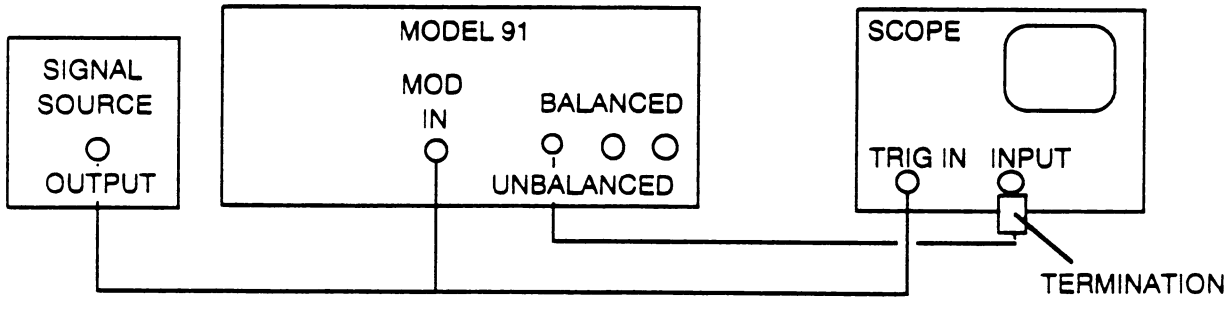


Figure 2-5. Modulation Setup

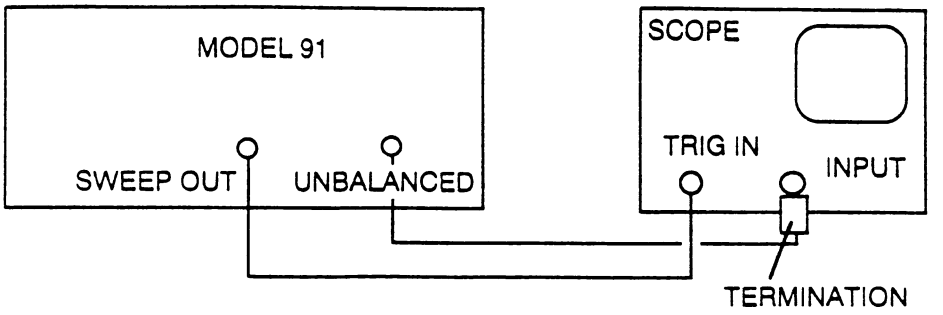


Figure 2-6. Sweep Mode Setup

mode - SWEEP indicator (*23*) lights, and the unit displays the words START 1 KHZ. Use the Keypad to enter 200 Hz. Press the "2", "EXP", "2", and "ENTER" keys. Display shows the words: START 200 HZ.

Now, press the "SWEEP MODE" key (*26*) and display shows the words: STOP 10 KHZ.

Once more, press the "SWEEP MODE" key (*26*) and the display shows the words: CONTINUOUS SWEEP.

Select external trigger on the scope. Scope displays 200 Hz to 10 kHz sweep at a 1 second rate.

PHASE SHIFT CHECK

Connect the Model 91 to the oscilloscope and signal source; see figure 2-7.

18. Press the "MODE" key (*22*) and select the continuous mode - CONT indicator (*23*) lights.

    Press the "LOCK SOURCE" key (*11*) until the words EXLOCK < 20 HZ are displayed (external source). The EXT indicator (*10*) lights and UNLOCK indicator (*9*) flashes.

    Set the signal source 2kHz, 5Vpp sine wave. Connecting the signal source output to the EXT FREQ IN connector (*12*) causes the UNLOCK indicator (*9*) to go out. The Model 91 displays EXTLOCK 2 KHZ (approximate value). Trigger the scope from the signal source (Chan 1 on the scope).

    Press the "PHASE" key (*8*) and verify the display shows the words: PHASE 0 DEG. Set the scope to display both channels. Align the displayed waveforms until both channels are in phase.

    Using the Keypad (*39*), press "1", "8", "0", and "ENTER" keys to set the phase shift to 180°. Observe the waveforms on the scope 180° out of phase with each other.

BALANCED OUTPUT

Connect the Model 91 to the oscilloscope and signal source; see figure 2-8

19. Press the "SHIFT" (*31*) and "RESET ALL" (*2*) keys to set the Model 91 to its default conditions.

20. Press the "SHIFT" (*31*) key and "SELECT" (*36*) keys until both the 600Ω and BAL indicators (*37*) flash. Next, press the ON/OFF key (*36*) to turn on the balanced output; the 600Ω and BAL indicators light.

21. Press the "AMPLITUDE" key (*5*), and use the

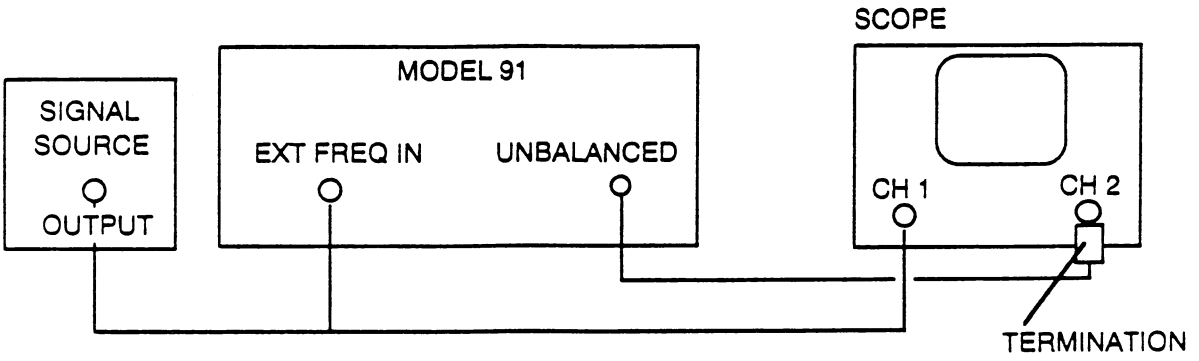


Figure 2-7. Phase Shift Setup

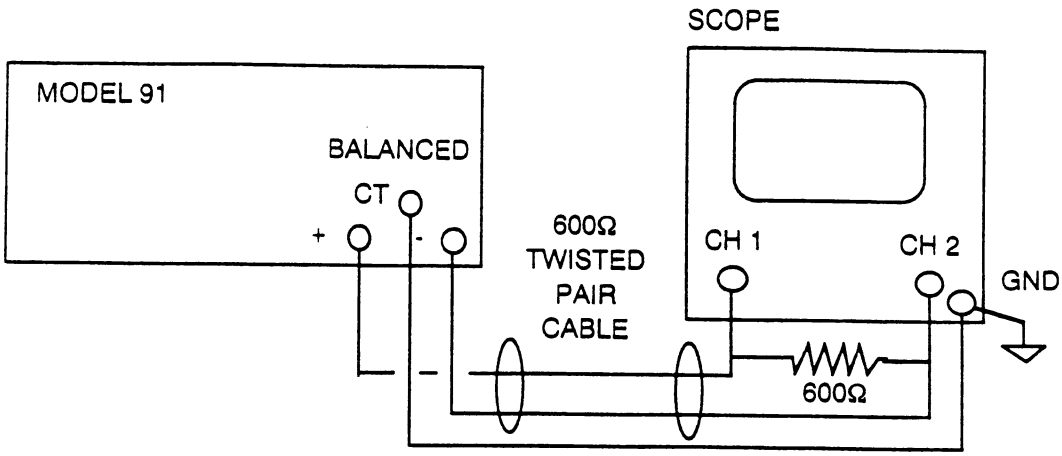


Figure 2-8. Balanced Output Setup

Keypad (*39*) to set the output level to 10 Vpp (press the "1", "0", and "ENTER" keys).

22. Connect the Balanced output to the scope inputs (properly terminate the Model 91 as shown in figure 2-8). Setup the scope as follows:
    CH 1 and CH 2 - dc coupled, adjust so both waveforms have same amplitude about the horizontal center line.

    Change VERT MODE to ADD and invert CH 2.

23 View balanced output on scope.

SINGLE PULSE CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3. The SYNC OUT from the Model 91 must be terminated in to 50Ω.

24. Press the "SHIFT" (*31*) and "RESET ALL" keys (2).

    Press the "ON/OFF" key (*36*) to turn on the output.

25. Press the "FUNCTION" key (*18*) to step to the single pulse function. Single pulse indicator will be lit.

    Change the frequency to 500 kHz by pressing "FREQ/PER" (*4*) followed by the "5", "EXP", and "5" keys. Also, press the "SYNC" key (*14*) and verify the display shows the words: SYNC REAR (1). Rotate the Knob (*41*) until the words SYNC FRONT (0) are displayed. Observe a 500 ns pulse at 2μs repetition rate.

    Press the "WIDTH" key (*16*). Next, press the KNOB key (*39*), and rotate the Knob (*41*) CW, observe the pulse width on the scope increasing. Rotate the Knob (*41*) CCW, observe the pulse width on the scope decreasing. Return to 500 ns pulse width by pressing the "WIDTH", "5", "EXP", "+/-", "7", and "ENTER" keys.

DELAYED PULSE CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3. The SYNC OUT from the Model 91 must be terminated in to 50Ω.

26. Press the "FUNCTION" key (*18*) to step to the delayed pulse function. Delayed pulse indicator will be lit.

    Observe a 500 ns pulse at 2μs repetition rate which is delayed 1μs relative to the SYNC OUT (*13*) signal.

    Press the "DELAY" key (*17*). Press the KNOB key (*39*) and rotate the Knob (*41*) CW, the pulse delay on the scope increases. Rotate the Knob (*41*) CCW, the pulse delay on the scope decreases. Return to 1μs pulse delay by pressing the "DELAY, "1", "EXP", "+/-", "6", and "ENTER" keys.

DOUBLE PULSE CHECK

Connect the Model 91 to the oscilloscope; see figure 2-3. The SYNC OUT from the Model 91 must be terminated in to 50Ω.

27. Press the "FUNCTION" key (*18*) to step to the double pulse function. Double pulse indicator will be lit.

    Observe on the scope two 500 ns pulses at 1ms repetition rate. The second pulse is delayed 1μs from the first pulse.

    Press the "DELAY" key (*17*). Rotate the Knob (*41*) CW, on the scope the time between the two pulses increases. Rotate the Knob CCW, the time between the two pulses on the scope decreases.

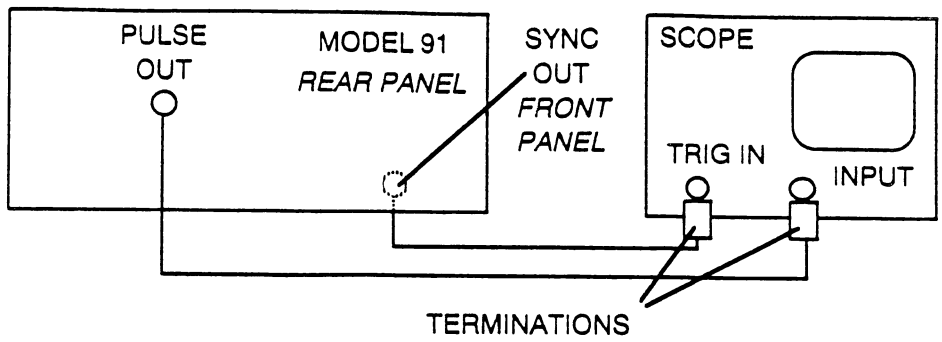


Figure 2-9. Pulse Output Setup

Return to 1μs pulse delay by pressing the "DELAY, "1", "EXP", "+/-", "6", and "ENTER" keys.

PULSE OUTPUT CHECK

Connect the Model 91 to the oscilloscope; see figure 2-9. The SYNC OUT from the Model 91 must be terminated in to 50Ω.

28. Press the "FUNCTION" key (*18*) to step to the single pulse function. Single pulse indicator will be lit.

    To enable the rear panel outputs, press the "PULSE SETUP" key (*19*) until the words REAR OUT OFF (0) appear on the display. Rotate the Knob (*41*) until REAR OUT ON (1) appears. Press "PULSE SETUP" key (*19*) and verify LOGIC NORMAL (0) is displayed. Once again, press the "PULSE SETUP" key and verify PULSE TTL (0) is displayed. Press the "SYNC" key (*14*) and rotate the Knob (*41*) until the words SYNC REAR (1) are displayed.

    On the scope, observe a 500 ns pulse at 2μs repetition rate.

2.6 ROUTINE MAINTENANCE

No tools or equipment are required for routine maintenance. Cleaning materials required are listed below:

Description	National Stock Number
Isopropyl Alcohol	6810-00-753-4993 MIL-A-10428, Grade A (81349)
Cotton Cheesecloth	8305-00-267-3015 CCC-C-440, Type II, Class 2 (81349)
Mild Liquid Detergent	None

Routine maintenance for the Model 91 is limited to routine checks such as listed below;

Cleaning,
Dusting,
Wiping,
Checking for frayed cables,
Storing items not in use,
Covering unused receptacle,
Checking for loose nuts, bolts, and screws.

Perform these routine check anytime they need to be done.

Fan Maintenance

The Model 91 contains a fan which is located on the right side of the unit. On the outside of the unit is the fan's filter. This filter should be cleaned about every month; more often if the unit is used in a dusty environment.

To clean the Filter,

1. Disconnect the Model 91 from the primary power source.
2. Using a screwdriver, gently pry off the filter's grill.
3. Remove the foam filter.
4. Clean the foam filter using a mild soapy solution. Thoroughly rinse the filter, and allow it to dry.
5. Place the filter back in the unit, and snap it in the filter grill.
6. Connect the Model 91 to the primary power source.

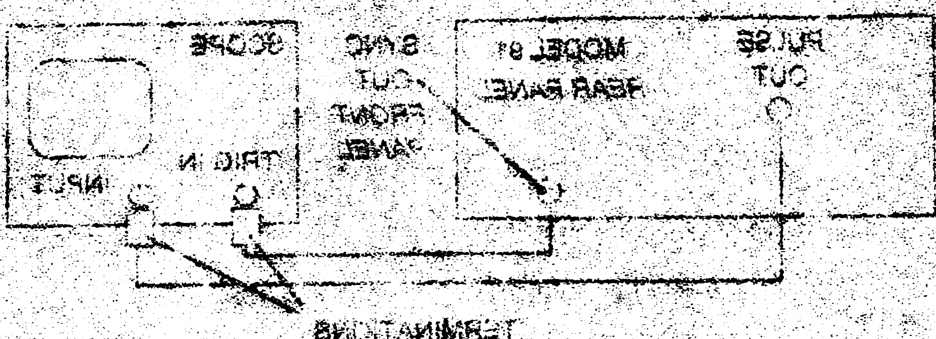


Figure 2-9. Pulse Output Setup

Return to the pulse delay by pressing the DELAY, ... and ENTER keys.

PULSE OUTPUT CHECK

Connect the Model 91 to the oscilloscope, see figure 2-9. The SYNC OUT from the Model 91 must be terminated into 50Ω.

a. Press the FUNCTION key (1) to step to the single pulse function. Single pulse indicator will be lit.

To enable the rear panel outputs, press the PULSE SETUP key (15) until the words REAR OUT OFF (0) appear on the display. Rotate the knob (2) until REAR OUT ON (1) appears. Press PULSE SETUP key (15) and verify LOGIC NORMAL (0) is displayed. Once again, press the PULSE SETUP key and verify PULSE TTL (0) is displayed. Press the SYNC key (16) and rotate the knob (2) until the words SYNC REAR (1) are displayed.

On the scope, observe a 400 ns pulse at 2 μs repetition rate.

2.6 ROUTINE MAINTENANCE

No tools or equipment are required for routine maintenance. Cleaning materials required are listed below:

Description	National Stock Number
Isopropyl Alcohol	6810-00-753-4993 MIL-A-10428 Grade A or (B)
Cotton Cheesecloth	8305-00-267-3015 CCC-C-440, Type II, Class 2 & 3
Mild Liquid Detergent	None

Routine maintenance for the Model 91 is limited to routine checks such as listed below:

- Cleaning
- Dusting
- Wiping
- Checking for frayed cables
- Storing items not in use
- Covering unused receptacles
- Checking for loose nuts, bolts, and screws.

Perform these routine checks any time they need to be done.

Fan Maintenance

The Model 91 contains a fan which is located on the right side of the unit. On the outside of the unit is the fan's filter. This filter should be cleaned about every month, more often if the unit is used in a dusty environment.

To clean the filter:

1. Disconnect the Model 91 from the primary power source.
2. Using a screwdriver, gently pry off the filter's grill.
3. Remove the foam filter.
4. Clean the foam filter using a mild soapy solution. Thoroughly rinse the filter and allow it to dry.
5. Place the filter back in the unit and snap on the filter grill.
6. Connect the Model 91 to the primary power source.

SECTION 3
OPERATION

3.1 INTRODUCTION

Section 3 describes how to operated the Model 91 Synthesized Pulse/Function Generator. This section contains the following major topics:

Paragraph 3.2 describes the unit's controls (keys and menus) and connectors.

Paragraphs 3.3 and 3.4 describe the Model 91 GPIB commands.

Paragraph 3.5 provides detailed instructions on how to set up the Model 91 for various tasks.

3.1.1 Error Messages

The Model 91 supplies both front panel and remote operator error messages. Appendix A descibes these error messages. If the operator is using a remote GPIB controller to operate the Model 91, the unit can return "SRQ" error messages; see paragraph 3.4.5.

3.2 CONTROLS CONNECTOR AND INDICATORS

Paragraph 3.2.1 describes all the operator "Controls, Indicators, and Connectors" for the Model 91, and paragraph 3.2.2 explains the rear panel's connectors.

3.2.1 Front Panel Controls, Indicators, and Connectors

Figure 3-1, which is located at the rear of this section (page 3-63), identifies Model 91 front panel controls and connectors. The numbers (*Italics*) in figure 3-1 are used throughout this section to identify the keys and connectors. Table 3-1 describes the function of each control and connector of the Model 91.

Table 3-1. Front Panel Controls, Indicators, and Connector

Key	Control, Indicator or Connector	Function
1	POWER switch	This switch turns Model 91 power on or off. Pressing the button turns the power on. Extending the button turns the power off. At power on, the Model 91 first performs a Self-Test that tests the motherboard memory, storage memory, and checks the internal battery. At power on the Model 91 returns to its last setup (the output will be off).
2	PARAM RESET key	Press this key to reset the parameter currently displayed to its default value; see *Model 91 Default Conditions* listed below. This does not change non-displayed parameters.
	RESET ALL key	Press the "SHIFT" key (*31*) and then the "RESET ALL" key to reset all Model 91 parameters to their default conditions. The GPIB address and selected alternate units remain unchanged. Underlined items represents alternate units for that parameter. *Model 91 Default Conditions* Amplitude — 5Vpp (2.5 Vp, 1.77 Vrms, 18 dBm) Burst Count — 5 Display — 25 Frequency/Period — 1kHz (1ms) Function — Sine Function Output On/Off — Output Off *(50Ω indicator flashes)* Linear/Logarithmic — Linear Sweep Lock Source — Internal Lock Logic — Normal

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		Model 91 Default Conditions (Continued) Lower Level: -2.5V Lower Level Custom: 0V Mode: Continuous Offset: 0V Phase: 0° (0 radians) Pulse Delay: 1µs Pulse Out: TTL Pulse Outputs: Off Pulse Width: 500 ns Recall: Last location stored Select Output: 50Ω, Unbalanced Store: Last location stored Sweep Mode: Continuous Sweep Sweep Start: 1kHz Sweep Stop: 10 kHz Symmetry: 50% Sync: Rear Sync Time: 1s (1Hz) Trigger Level: 0V Trigger Frequency: 100 Hz (10 ms) Trigger Slope: Positive Trig Source: Internal Trig Upper Level: +2.5V Upper Level Custom: +1V The following keys are not affected by the "RESET ALL" key: Address Calibrate Knob Local Man trigger
3	DISPLAY key	Press this key to adjust the intensity of the display values between 00 and 31 with 31 being the brightest setting. Use the Knob or Keypad to change intensity value. The Knob automatically accepts the new value; also see "KNOB" key (*39*). When using the Keypad, enter the new value and use the "ENTER" key to accept the new value.
	CALIBRATE key	Press the "SHIFT" key (*31*) and then the "CALIBRATE" key to start the Model 91's AutoCal prcedure. AutoCal performs a functional check and fine tuning of certain internal circuits. During AutoCal the display shows the words CALIBRATING. When finished with AutoCal, the Model 91 displays the words PASSED AUTOCAL. Allow the Model 91 to warm up 20 minutes before performing AutoCal.
4	FREQ/PER key	Press the "FREQ/PER" key to display the current frequency of the generator. Use the Knob or Keypad to change the frequency value. The Knob automatically enters the new value; also see "KNOB" key (*39*). When using the Keypad, enter the new value and use the "ENTER" key to accept the new value. Initially pressing the "FREQ/PER" key displays the output frequency or period (see the "UNITS" key (*4*)). Displayed frequency units are MHz, kHz, Hz, and mHz, and displayed period units are ns, µs, ms, and s (seconds). Default is 1.000 kHz.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		Specified Frequency Limits: 100 MHz for Square wave at rear panel Pulse Outputs, 50 MHz for all pulses at the rear panel Pulse Outputs, 20 MHz for all functions at the 50Ω and 75Ω Unbalanced output. 1MHz when 600Ω Unbalanced is selected, 1MHz when 135Ω Balanced is selected, 1MHz when 600Ω Balanced is selected.
	UNITS key	Press the "SHIFT" key (*31*) and then the Freq/Per's "UNITS" key to change the units of measure for use with the "FREQ/PER" key. Performing this key sequence displays the current selection. Use the Knob to step between Frequency and Period. Also, pressing the "SHIFT" and Freq/Per's "UNIT" keys sequence alternates between Frequency and Period.
5	AMPLITUDE key	Press the "AMPLITUDE" key to display the current output level. Use the Knob or Keypad to change the output level. The Knob automatically enters the new value; also see "KNOB" key (*39*). When using the Keypad, enter the new value and use the "ENTER" key to accept the new value. Amplitude units (see Amplitude's UNITS) can be Vpp, Vp, Vrms, or dBm which can be selected using the "SHIFT" (*31*) and Amplitude's "UNITS" key. Output level limits into 50Ω 1mVpp to 15.0 Vpp, 500 μVp to 7.5 Vp, 400 μVrms to 5.3 Vrms, –56.0 dBm to +27.5 dBm. Default value is 5Vpp. Amplitude Limiting Conditions Offset values limit the amplitude. AM limits the maximum AM amplitude to one half the maximum continuous amplitude. SCM sets the programmed level to 0V; output level depends on magnitude of the modulating signal. Vpp and Vp are the only units of measure when dc offset is not 0Vdc and symmetry is not 50%.
	UNITS key	Press the "SHIFT" key (*31*) and then the Amplitude's "UNITS" key to step between Vpp, Vp, Vrms, and dBm. When this key combination is performed, the current selection is displayed. Use the Knob to scroll through the list (Vpp, Vp, Vrms, and dBm). Also, pressing the "SHIFT" and Amplitude's "UNIT" keys sequences through the units.
6	STORE key	Press the "STORE" key to store a complete front panel instrument setup. When this key is pressed, the last storage address is displayed. Use the Keypad or Knob to select an address (1 to 5). Press "ENTER" to accept the setup. Use "SHIFT" (*31*) and "RECALL" keys to retrieve the stored settings.
	RECALL key	Press the "SHIFT" (*31*) key and then the "RECALL" key to select a stored instrument setup. Use the Knob or Keypad to select a stored setup, then use the "ENTER" key to initiate that instrument setup.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
7	OFFSET key	Press the "OFFSET" key to display the current dc offset level. Use the Knob or Keypad to change the dc offset value. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and use the "ENTER" key to accept the new value. DC offset levels can be programmed between +7.500V to -7.500V in 1mV increments. The default value is 0Vdc. In dc function, Offset controls the output polarity and level. In sine, triangle, and square functions, Offset controls the baseline level of output waveform. Offset Limits Offset values are limited to Offset + Amplitude (Vp) ≤7.5V. Selecting the Balanced output fixes the offset at 0Vdc. Selecting AM or SCM limits the offset range to 1/2 of the maximum programmed offset.
	SYMMETRY key	Press the "SHIFT" key (*31*) and then the "SYMMETRY" key to display the current waveform symmetry value. Symmetry values are expressed in percent (%). Waveform symmetry can be varied between 5% and 95% in 1% increments (≤2MHz). Use the Knob or Keypad to change the waveform symmetry value. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and use the "ENTER" key to accept the new value. The default is 50%. When either BAL, FM (VCG), or Sweep is selected, the symmetry is fixed at 50%. Symmetry has no meaning for pulse functions. Symmetry range decreases linearly between 2MHz and 20 MHz. At 20 MHz, the symmetry is fixed at 50%.
8	PHASE key	Press "PHASE" key to display the current selected phase shift. Use the Knob or Keypad to vary the phase. The Model 91 generates phase shift relative to the EXT FREQ IN signal. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, press the "ENTER" key to accept the new value. The phase can be varied from +180° to –180° (+3.14 to –3.14 radians) with one degree (3-1/2 digits) of resolution. Default is 0°. Use the Phase's "UNITS" key to shift between degrees and radians.
	UNITS key	Press the "SHIFT" key (*31*) and then the Phase's "UNITS" key to shift between Degrees and Radians. Also, rotate the Knob to step between Degrees and Radians.
9	UNLOCK indicator	When this indicator is off, the unit is locked to either the internal or external frequency reference. A flashing indicator means disconneted external reference or an internal reference failure. A continuously lit indicator means the current instrument setup does not allow locking to a frequency reference.
10	EXT indicator	When on, it indicates the Model 91 requires an external reference at the EXT FREQ IN connector. It does not indicate signal is present at the connector.
11	LOCK SOURCE key	In the Continuous, AM, and SCM modes, use this key to select either the

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		Model 91 internal (synthesizer) phase lock source (displays the words EXLOCK OFF) or an external phase lock source (displays the words "EXLOCK"). Press this key to toggle between Internal and External sources. The minimum phase lock frequency is 20 Hz. Selecting the internal source displays the Model 91 synthesizer frequency. Selecting the external phase lock source displays the frequency of the signal at the EXT FREQ IN connector. At frequencies above 20 Hz, the Model 91 measures the input frequency, sets its frequency to match, and locks itself to the external source.
12	EXT FREQ IN connector	This is the input connector for the phase lock source. Input impedance is 10 kΩ. Input signal can be either a logic level or bipolar sine wave (selected via internal jumper; paragrpah 2.4.6). To phase lock, the external source must be between 20 Hz and 20 MHz, and the level must be 600 mVpp to 30 Vpp or TTL level. The Model 91 automatically sets its frequency to match the external source. In addition, the Model 91 displays the frequency of the external source.
13	SYNC OUT connector	Use the signal from this output connector to synchronize external equipment to the Model 91. The output signal is a TTL pulse. The Sync signal will be the same frequency as the output waveform. The symmetry is same as square wave and "in phase" with square wave but leads sine and triangle waveforms by 90°. There will not be a Sync Out signal for the dc function. For pulse functions, Sync Out supplies a pulse coincident with the pulse trigger. The Model 91 permits selection of either a Sync Output coincident with the front or rear panels; see SYNC key (*14*). SYNC REAR is the default. For externally triggered pulses, SYNC OUT provides a pulse based on the TRIG SETUP conditions; see TRIG SETUP key (*24*). CAUTION The Sync Output must be terminated with 50Ω otherwise the sync pulse could be distorted which may cause timing errors..
14	SYNC key	Use this key to select the front and rear panel sync source for the Sync Out connector. To select a sync source, press the "SYNC" key and rotate the Knob to either SYNC REAR (1) or SYNC FRONT (0). Use the front panel sync source when using either the BALANCED or UNBALANCED outputs. Use the rear panel sync source when using the PULSE or PULSE Outputs.
15	DC indicator	When on, indicates that dc function is selected. To activate, press the "FUNCTION" key (*18*) until DC indicator lights. The dc function can not be selected when the external lock source is selected.
	⊓⊔ indicator	When on, indicates that a square waveform is selected. To activate, press the "FUNCTION" key (*18*) until square indicator lights.
	∿ indicator	When on, indicates that triangle waveform is selected. To activate, press the "FUNCTION" key (*18*) until triangle indicator lights.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
	⌒ indicator	When on, indicates that sine waveform is selected. To activate, press the "FUNCTION" key (*18*) until the sine indicator lights.
	⎍ indicator	When on, indicates that single pulse waveform is selected. To activate, press the "FUNCTION" key (*18*) until the single pulse indicator lights.
	⎍ indicator	When on, indicates that delayed pulse waveform is selected. To activate, press the "FUNCTION" key (*18*) until the delayed pulse indicator lights.
	⎍⎍ indicator	When on, indicates that double pulse waveform is selected. To activate, press the "FUNCTION" key (*18*) until double pulse indicator lights.
	E.W. indicator	When on, indicates that external width waveform is selected. To activate, press the "FUNCTION" key (*18*) until the E.W. (external width) indicator lights.
16	WIDTH key	Press this key to display the current pulse width value. Use the Knob or Keypad to change the pulse width value. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and press the "ENTER" key to accept the new value. The pulse width can be varied from 10 ns to 2000s with 4 digits of resolution. Default is 500 ns. Above 50 MHz, this key has no affect on the pulse even though it appears to be functioning.
17	DELAY key	Press this key to display the current pulse delay value. Use the Knob or Keypad to change the pulse delay value. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and press the "ENTER" key to accept the new value. The pulse delay can be varied from 0ns to 2000s with 4 digits of resolution. Default is 1μs. Above 50 MHz, this key has no affect on the pulse even though it appears to be functioning. For double pulses, this key sets the timng between the first and second pulses.
18	FUNCTION key	Press the "FUNCTION" key to select the output waveform. Press and hold this key to cycle the unit through its functions (sine, triangle, square, dc, single pulse, delayed pulse, double pulse, and external width). A lit indicator identifies the selected function. Release the "FUNCTION" key when the desired function indicator lights. To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the desired function indicator lights.
19	PULSE SETUP key	Press this key to set up the pulse outputs via three pulse set up menus. Repeatably pressing the PULSE SETUP key steps through the three menus. The first menu, REAR OUT, turns off or on. Use the Knob to step through REAR OUT OFF (0) or REAR OUT ON (1). The Keypad can also select off or on by pressing number in parenthesis, (0) for off or (1) for on. The second menu, LOGIC, selects normal or complemented pulse output from both front and rear outputs. Use the Knob to step through LOGIC NORM (0) or LOGIC COMP (1). The Keypad can also select normal or complement outputs by pressing number in parenthesis, (0) for normal or (1) for complement. The third menu, PULSE, selects the pulse type for the rear panel Pulse outputs. Use the Knob to step through PULSE TTL (0), PULSE CMOS (1), PULSE -ECL

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		(2), PULSE +ECL (3), and PULSE CSTM (4). The Keypad can also select pulse types by pressing number in parenthesis, (0) for TTL, (1) for CMOS, (2) for -ECL, (3) for +ECL, and (4) for CSTM. When "PULSE CSTM" is selected, use the Upper Lvl's "CUSTOM "(*20*) key and Lower Lvl's "CUSTOM " keys (*21*) to set the levels.
20	UPPER LVL key	Press this key to set the upper level of the pulse function from the BALANCED or UNBALANCED Outputs. The upper level can be programmed between -7V and +7.5V. The allowable negative upper level depends on the lower level setting. The upper level must be more positive than the lower level. Use the Knob or Keypad to change the upper level value. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and press the "ENTER" key to accept the new value. Changing the upper level affects the amplitude and offset.
	CUSTOM key	Press the "SHIFT" key (*31*) and the Upper Lvl's "CUSTOM " key to set the custom upper level for the rear panel Pulse Outputs. Custom upper level can be programmed between -1.4 and +4.2V (into 50Ω) and must be more positive than the custom lower level. Use the Knob or Keypad to change the custom upper level. The Knob automatically enters the new value; also see the "KNOB" key (*39*). When using the Keypad, enter the new value and press the "ENTER" key to accept the new value.
21	LOWER LVL key	Press this key to set the lower level of the pulse function from the Balanced or Unbalanced Outputs. The lower level can be programmed between +7 and -7.5V and must be more negative than the upper level. Use the Knob or Keypad to change the upper level value. The Knob automatically enters the new value. When using the Keypad, press the "ENTER" key to accept the new value; also see the "KNOB" key (*39*). Changing the lower level affects the amplitude and offset.
	CUSTOM key	Press the "SHIFT" (*31*) and the "CUSTOM" keys to set the custom lower level for the rear panel Pulse Outputs. Custom lower level can be programmed betweem -1.8 and +3.5V (into 50Ω) and must be more positive than the custom lower level. Use the Knob or Keypad to change the custom lower level. The Knob automatically enters the new value. When using the Keypad, press the "ENTER" key to accept the new value; also see the "KNOB" key (*39*).
22	MODE key	Press the "MODE" key (*22*)to step through the Model 91 operating modes: CONT (continuous) TRIG (triggered) GATE (gated) BURST AM (amplitude modulation) FM (frequency modulation) SCM (Suppressed Carrier Modulation) SWEEP To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the desired indicator lights.
23	CONT indicator	When on, it indicates the continuous mode is active. Use the "MODE" key (*22*) to select this operating mode.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
	TRIG indicator	When on it indicates the triggered mode is active. The Model 91 must be triggered to initiate a trigger cycle. Use the "MODE" key (*22*) to select this operating mode. Also see the "TRIG SETUP" key (*24*).
	GATE indicator	When on, it indicates the gated mode is active. The Model 91 must be triggered to initiate a gate cycle. Use the "MODE key (*22*) to select this operating mode. Also see the "TRIG SETUP" key (*24*).
	BURST indicator	When on, it indicates the burst mode is active. Use the "SHIFT" key (*31*) and "BURST COUNT" key (*24*) to select the burst count. The Model 91 must be triggered to initiate a burst cycle. Use the "MODE" key (*22*) to select this operating mode. Also see the "TRIG SETUP" key (*24*).
	AM indicator	When on, it indicates that the Amplitude Modulation mode is active. An external signal source connected to MOD IN connector (*30*) is required for AM operation. Use the "MODE" key (*22*) to select this mode. AM can not be selected when the sum of amplitude (Vpp) and Offset (Vdc) exceeds 7.5V.
	FM Indicator	When on, it indicates that FM/VCG modulation mode is active. An external signal source connected to MOD IN connector (*30*) is required for FM/VCG operation. External signal amplitude of 0 to 10 Vpp controls deviation. External signal frequency of dc to 100 kHz. Use the "MODE" key (*22*) to select this operating mode. FM can not be selected when symmetry is not 50% or when external phase lock is selected.
	SCM indicator	When on, it indicates the Suppressed Carrier Modulation mode is active. An external signal source connected to MOD IN connector (*30*) is required for SCM operation.
	SWEEP indicator	When on, it indicates the sweep mode is active. Use the "SWEEP MODE" key (*26*) to select the sweep start and stop frequencies, and sweep conditions. Sweep can not be selected when the symmetry is not 50% or the generator is in external phase lock.
24	TRIG SETUP key	Press this key when setting up the trigger conditions. Use it to select the trigger source, trigger slope, or trigger level. When the word SOURCE appears, use the Knob or Keypad to alternate between the internal trigger source, external trigger source, or manual trigger. Selecting the internal trigger source displays the trigger frequency (see "TRIG FREQ" key). The internal trigger frequency range is 1mHz to 20 MHz. Selecting the external trigger source displays the frequency of the signal at the rear panel TRIG IN connector (*C*). Selecting manual trigger allows the operator to trigger the unit using the "MAN TRIG" Key (*25*). When the word "SLOPE" is displayed, use the Knob to alternate between "SLOPE POS (0) " (rising edge) and "SLOPE NEG (1)" (falling edge). When the words TRIG LEVEL appear, use the Knob or Keypad to change the trigger level. The Knob automatically enters the new trigger level. When using the Keypad, press the "ENTER" key to accept the trigger level. Trigger level is between -5.0. to +5.0V in 100 mV increments.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
	BURST COUNT key	Press the "SHIFT" key (*31*) and then "BURST COUNT" key to display the currently selected burst count. Use the Knob or Keypad to change the burst count. The Knob automatically enters a new value. When using the Keypad, press the "ENTER" key to accept the new value. Burst count values range from 1 to 1,000,000 cycles.
25	MAN TRIG key	Press this key to manually trigger the generator. In the triggered mode, the generator produces one complete cycle of the waveform each time this key is pressed. In the gated mode, the generator produces continuous waveforms as long as the key is pressed. When the key is released, the waveforms stop. In the burst mode, the generator produces the set number (Burst Count) of cycles. To select Manual Trigger, refer to the TRIG SETUP (*24*) key.
26	SWEEP MODE key	Press the "SWEEP MODE" key to step through a list of sweep items: sweep start frequency, sweep stop frequency, continuous sweep, triggered sweep, and manual sweep. The Model 91 limits the sweep range to three decades. If the sweep start frequency is set and the sweep stop frequency exceeds the three decade limit, the start frequency will be pulled up. If the sweep stop frequency is set and the sweep start frequency exceeds the three decade limit, the stop frequency will be pulled down. Refer to paragraph 1.3.2.2 for sweep range limits Sweep Start displays and sets the generator to the current sweep start frequency. The unit displays sweep start frequency in mHz, Hz, kHz, and MHz. The sweep start frequency range is from 1mHz to 20 MHz. Default is 1kHz. Use the Knob or Keypad to change the sweep start frequency. The Knob automatically enters the new sweep start frequency; also see the "KNOB" key (*39*). When using the Keypad, press the "ENTER" key to accept the new sweep start frequency. Sweep start frequency can be set above or below the sweep stop frequency. Sweep Stop displays and sets the generator to the currently selected sweep stop frequency. The unit displays the sweep stop frequency in mHz, Hz, kHz, and MHz. The sweep stop frequency range is from 1mHz to 20 MHz. Default sweep start frequency is 10 kHz. Use the Knob or Keypad to change the sweep stop frequency. The Knob automatically enters the new sweep stop frequency; also see the "KNOB" key (*39*). When using the Keypad, press the "ENTER" key to accept the new sweep stop frequency. Sweep stop frequency can be set above or below the Sweep Start frequency. Continuous Sweep starts continuous sweeping between the sweep start frequency and the sweep stop frequency. The "TIME" key (*28*) sets the repetition rate of the sweep. The Sweep mode must be selected. Triggered Sweep allows the Model 91, upon receipt of a trigger, to sweep between the sweep start frequency and the sweep stop frequency. The "TIME" key (*28*) sets the rate of the sweep. Sweep mode must be selected. Manual Sweep allows operator to manually sweep the Model 91 between the sweep start frequency and the sweep stop frequency using the Knob or the Keypad. The Sweep mode must be selected.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
	LIN/LOG key	Press the "SHIFT" key (*31*) and then the "LIN/LOG" key to display the current sweep characteristic. LIN allows the unit to linearly sweep from the start to the stop frequency. LOG allows the unit to exponentially sweep between the start to the stop frequency. In addition, both sweep types allow log or linerar sweep up and down (start to stop and back to start frequency). Use the Knob or repeatably "SHIFT" and " LIN/LOG" keys to change the sweep characteristic.
27	TRIG FREQ key	Press the "TRIG FREQ" key to display the current internal trigger source frequency. Use the Knob or the Keypad to change the trigger frequency. The Knob automatically enters the new trigger frequency; also see the "KNOB" key (*39*). When using the Keypad, press the "ENTER" key to accept the new trigger frequency. Internal trigger frequency range is 1mHz to 20 MHz. Use the "TRIG SETUP" key (*24*) to select the internal trigger source. When using the Triggered Sweep Mode, the internal trigger frequency is limited to 1/2 the current sweep time (SWPTR on the display).
	UNITS key	Press the "SHIFT" key (*31*) and then the Trig Freq's "UNITS" key to change the units of measure for the trigger frequency. When this key sequence is performed, the current selection is displayed. Use the Knob to scroll between trigger frequency (TFREQ on display) or trigger period (TFPER on display); press "ENTER" key to accept the units.
28	TIME key	Press this key to display the currently selected sweep time. The sweep time range is 10 to 0.001 Hz or 0.2 to 3600 seconds (period). Default is 1 second. Use the Knob or the Keypad to change the sweep time. The Knob automatically enters the new sweep time; also see the "KNOB" key (*39*). When using the Keypad, press the "ENTER" key to accept the new sweep time.
	UNITS key	Press the "SHIFT" key (*31*) and then the Time's "UNITS" key to display the time's units of measure. Use the Knob or press the "SHIFT" and "UNITS" keys to toggle between sweep frequency (SWPRATE (HZ) on display) or sweep period (SWPTIME (SEC) on the display).
29	SWEEP OUT connector	This BNC connector supplies a 0 to +6V or +6 to 0V linear ramp. The ramp's end values represents start to stop frequencies. The ramp's rate depends on the selected sweep time. Output impedance is 600Ω. Use this output as an external sweep or horizontal signal source. The sweep out signal is only present during sweep modes.
30	MOD IN connector	This connector receives the modulation signal for the Model 91 FM, AM, and SCM modes. Input impedance is 10 kΩ. FM - The signal modulates the iinstantaneous frequency of the generator. A ±10V signal varies the frequency a maximum of 1000:1 frequency change on the same range (table 3-12). When FM is selected, the Model 91 holds its current frequency range. The frequency (dc to 100 kHz) of the external signal controls the modulation rate. When MODE: FM is selected, the Model 91 displays the scale factor in $Hz/Volt_{(input)}$.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		AM - The signal modulates the output level of the generator; the generator provides the carrier. The unmodulated output level will be the programmed level. The frequency range of the source is dc to 1MHz. When Mode: AM is selected, the Model 91 displays the scale factor as V = F.S. which represents the modulation voltage to produce 100% modulation. In the AM mode, the programmed amplitude cannot be greater than 7.5 Vpp. SCM - The signal modulates the output level of the generator; the generator provides the carrier. The unmodulated output level will be 0V regardless of the output level. When Mode: SCM is selected, the Model 91 displays a scale factor of 2.4V/V, 0.24V/V, or 0.024V/V. To change the scale factor, enable the Knob using the "KNOB" key (*39*) and use the Knob (*41*) to select a scale factor. SCM output level depends on the magnitude of the modulating signal. The frequency range of the source is dc to 1MHz.
31	SHIFT key	Press the "SHIFT" key to select alternate key items. Shift items are labeled in blue on the front panel.
32	LOCAL key	Press this key to return the Model 91 to front panel control from remote (GPIB only). Front panel displays the words "LOCAL". This key will not select if Local Lockout is set by external controller during remote operation.
33	REMOTE indicator	When on, indicates that Model 91 is in remote (GPIB) operation using an external controller. When on, instrument settings can be queried but not changed.
34	CMD RECALL key	Press this key (command recall) to display the last 240 parameters, values and actions (all in ASCII code) sent to the instrument via the GPIB. The display shows only 16 characters at a time, use the Knob (*41*) to step through the entire program string.
	ADDRESS key	Press the "SHIFT" key (*31*) and then the "ADDRESS" key (*34*) to display the current GPIB address as a decimal value. Use the Knob (*41*) or Keypad (*39*) to change the address. The Knob automatically enters the new GPIB address. When using the Keypad, press the "ENTER" key to accept the new GPIB address. Addresses range from 00 to 30, and the default address is 09. This key is inactive when Local Lockout is set by an external controller during remote operation.
35	UNBALANCED output	This BNC connector supplies the unbalanced (single ended) output of all Model 91 functions. Output impedance can be 50Ω, 75Ω, or 600Ω. Frequency range is 1 mHz to 20 MHz (50Ω and 75Ω) for standard functions and 1 mHz to 1 MHz for 600Ω. For pulse functions above 20 MHz, this output automatically turns off. Use the "SELECT" key (*36*) to select unbalanced output; the BAL indicator (*37*) will be off.
36	ON/OFF key	Press this key to toggle on and off the balanced and unbalanced outputs. At power up the output will be turned off, but the last selected output impedance indicator will flash. Once the key is pressed, the output turns on and the impedance indicator remains lit.
	SELECT key	Press the "SHIFT" key (*31*) and then the "SELECT" key to select the output

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
		connector and output impedance. Hold the key down to increment through the selections. Release the key to activate the output. Output impedance depends on the selected output: Unbalanced - 600Ω, 50Ω, and 75Ω, Balanced - 135Ω and 600Ω. Default is 50Ω UNBAL.
37	50Ω indicator	When on, it indicates 50Ω unbalanced output is selected. Use the "SELECT" key (*36*) to select 50Ω.
	75Ω indicator	When on, it indicates 75Ω unbalanced output is selected. Use the "SELECT" key (*36*) to select 75Ω.
	135Ω indicator	When on, it indicates 135Ω balanced output is selected. Use the "SELECT" key (*36*) to select 135Ω.
	600Ω indicator	When on, it indicates 600Ω unbalanced or balanced output is selected. Use the "SELECT" key (*36*) to select 600Ω.
	BAL indicator	When on, it indicates the Balanced output connectors are the selected generator outputs. When off, it indicates the Unbalanced output connector is the selected generator output. Use the "SELECT" key (*36*) to select balanced output.
38	BALANCED output	The balanced (differential) output consists of two jacks BALANCED (+) and (-) and one center tap (CT) terminal. The BALANCED (+) jack provides the positive (in phase) balanced output. The BALANCED (-) provides the negative (180° phase) balanced output. Output impedance between the (+) and (-) terminals can be 135Ω or 600Ω. Use the "SELECT" key (*36*) to select the BALANCED output; BAL indicator is lit.
39	Keypad	Press these keys to enter a 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9 for numeric data entry. Use them with +/–, • (decimal point), ENTER, EXP (exponent), and CE (clear entry) keys to enter data. Parameters that have not been entered using the "ENTER" key are preceded with *. For example, pressing "FREQ/PER 3 AMPLITUDE 3" and then pressing "FREQ/PER" key again displays * FREQ 3 HZ which means that the new frequency has not been entered, but will be when the "ENTER" key is pressed.
	+/- key	Press this key to enter a positive or negative sign for numeric data entry. Used for standard and exponent entry. Blank indicates positive, – indicates negative.
	• (Decimal) key	Press this key to enter a decimal point for numeric data entry.
	ENTER key	Press this key to accept entries from the keypad. Values exceeding resolution are rounded or entered to nearest allowable value. Also see Keypad.
	EXP key	Press this key to enter an exponent digit. To enter an exponent, use Keypad to enter prefix, press "EXP" key, then exponent value using numeric keys 0 to 9. Exponent can be entered as a negative by pressing "+/–" key.

Table 3-1. Front Panel Controls, Indicators, and Connector (Continued)

Key	Control, Indicator or Connector	Function
	CE key	Press this key to clear a numeric entry error when using the Numeric keys. Unwanted data must be cleared before pressing "ENTER" key. Press this key once to clear display of numeric entry. The unit returns to the last entered value.
	KNOB key	Press this key to enable or disable the Knob. Default is Knob off. Also, pressing key moves the flashing digit from least significant digit to most significant digit. After the final digit, the flashing digit disappears and the ENABLE indicator (*40*) goes out; now the knob is disabled.
40	ENABLE indicator	When on, it indicates that Knob (*41*) will change the value in the display. Press the "KNOB" key (*39*) to turn on this indicator.
41	Knob	Rotate the Knob to change numeric value of flashing digit as selected by "KNOB" key (*39*). Rotating the Knob clockwise increases a value, counter clockwise rotation decreases a value. The Knob is active when the ENABLE indicator is on.
42	Display	The display (a 16-digit alphanumeric display with decimal point and minus sign) shows output signal information, entry information, operator messages, and error codes.

3.2.2 Rear Panel Connections

This paragraph decribes the location , description, and use of the rear panel connectors. Refer to figure 3-2 for the location or the rear panel controls, indicators, and connectors. Table 3-2 provides the description and use of the rear panel controls, indicators, and connectors.

Table 3-2. Rear Panel Connectors

Key	Connector	Function
A	REF IN connector	This connector accepts an external reference input. The external source must be 10 MHz ±500 kHz at a TTL level. Option 001 must be installed.
B	REF OUT connector	This connector supplies a 10 MHz TTL reference signal. Option 001 must be installed.

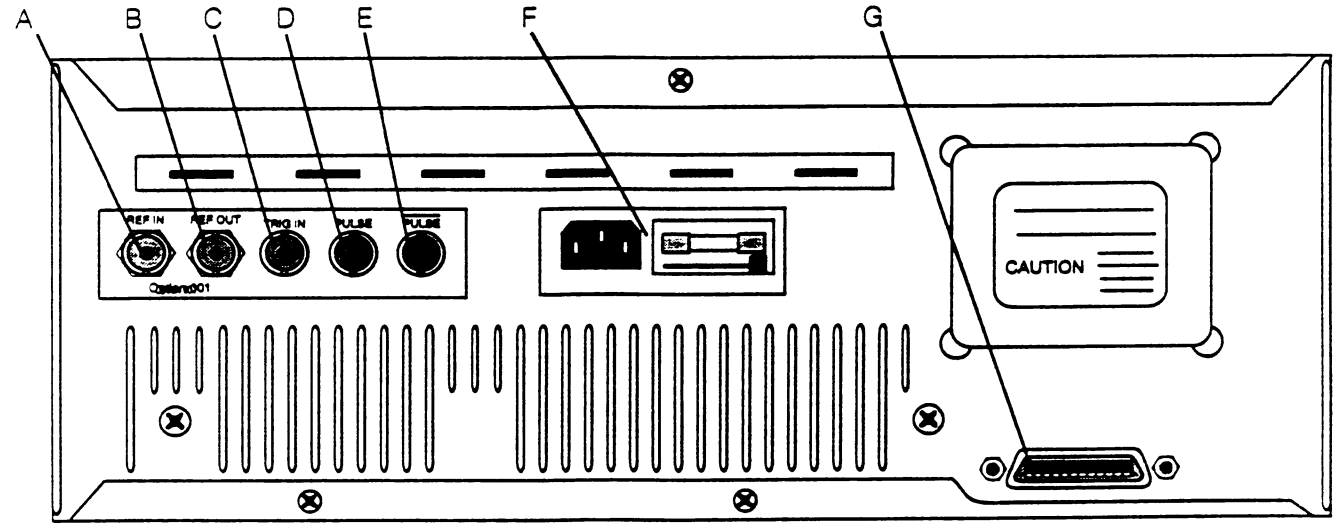


Figure 3-2. Model 91 Rear Panel Connectors

Table 3-2. Rear Panel Controls and Connectors (Continued)

Key	Connector	Function
C	TRIG IN connector	This connector accepts an external trigger input for both the function and pulse generators. Input impedance is 2kΩ shunted by <10 pF. The "TRIG SETUP" key (*24*) sets the trigger level and slope that initiates a trigger.
D	PULSE OUT connector	This connector supplies the pulse output at a level selected by the "PULSE SETUP" key (*19*). This connector must be properly terminated with a 50Ω termination.
E	$\overline{\text{PULSE}}$ OUT connector	This connector supplies the pulse complement output at a level selected by the the "PULSE SETUP" key (*19*). This connector must be properly terminated with a 50Ω termination.
F	Input Power connector	This is the primary ac power module for the Model 91. Included in the module is the line fuse and voltage selector. The input power connector accepts female end of power cable (supplied). A protective grounding conductor connects the Model 91 through this connector. Use the voltage selection card to setup the input voltage. *Voltage Range* — *Fuse* 90 to 108 Vrms — 1.5A, 250V, Slo Blo 108 to 126 Vrms — 1.5A, 250V, Slo Blo 198 to 231 Vrms — 0.7.5A, 250V, Slo Blo 216 to 252 Vrms — 0.7.5A, 250V, Slo Blo
G	GPIB connector	Use this connector to mate the Model 91 to an external GPIB controller for remote operation. The connector has 24 pins and threaded posts conforming to IEEE-488-1978. Figure 3-3 illustrates the GPIB connector pinouts.

3.3 INITIAL GPIB (REMOTE) SETUP

This paragraph describes the initial Model 91 to controller setup for remote (GPIB) operation. The Model 91 digital interface conforms to IEEE 488.1 subsets SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT0, C0, and E1.

In remote, an external controller transmits commands to the Model 91 and receives commands from the Model 91. Remote operation is similar to local operation (paragraph 3.2) except commands set up the Model 91. GPIB permits remote control of most functions except "POWER" switch, "LOCAL" key, "DISPLAY" key, all "UNITS" keys, and "ADDRESS" key. Refer to paragraph 3.2 for descriptions of controls, indicators, and connectors. GPIB connector wiring data is shown in figure 3-3.

Model 91 to Controller Setup

Perform the following steps to setup the Model 91 for remote operation. Keyed *numbers* are defined in table 3-1 and illustrated in figure 3-1. The *letters* refer to figure 3-2 and table 3-2.

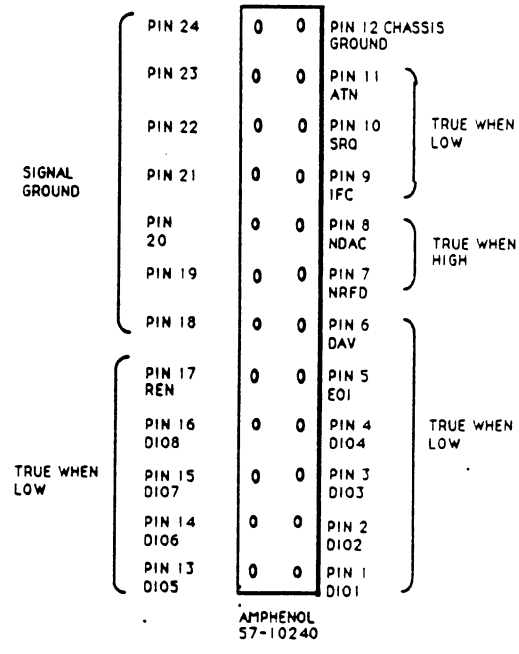


Figure 3-3. GPIB Connector Pinouts

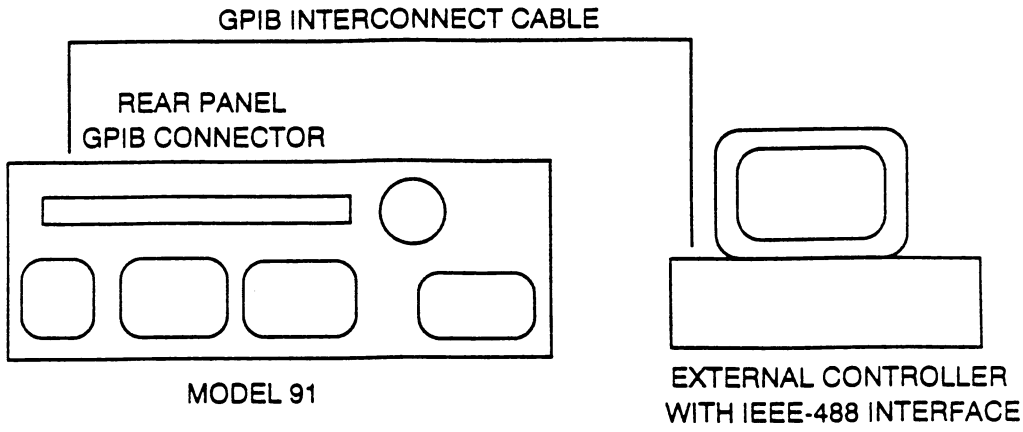


Figure 3-4. GPIB Interconnect Wiring

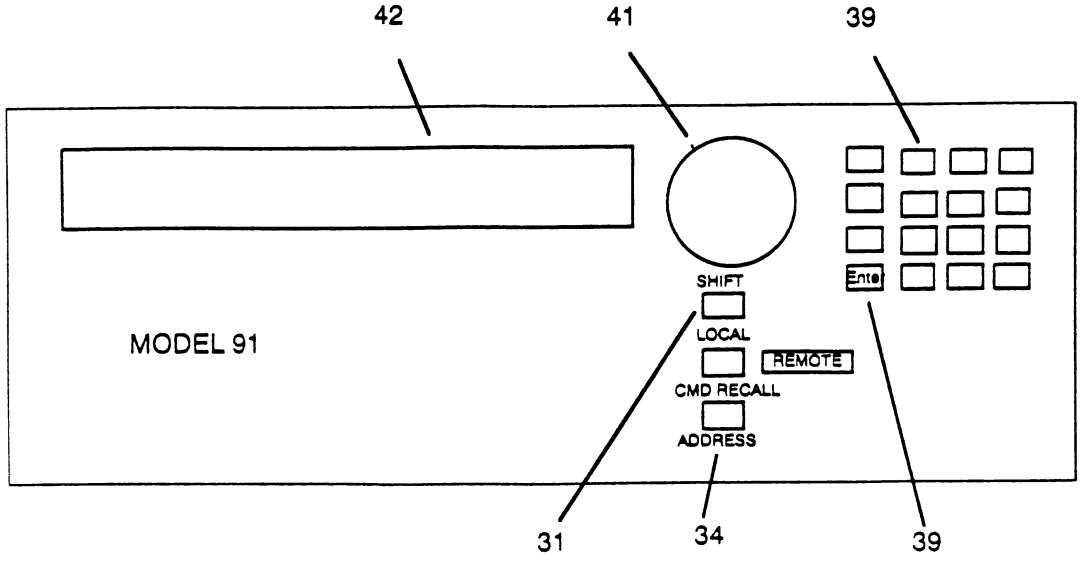


Figure 3-5. GPIB Operation Control Setup

1. Connect a GPIB interconnect cable between the Model 91 and the controller as shown in figure 3-4. The Model 91 GPIB connector (*E*) is located on the rear panel of the instrument.

NOTE

Keep GPIB interconnect cable length below 2 meters (6.6 feet)

2. Set the Model 91 GPIB address to match the address used by the controller; see figure 3-5.

   To set the GPIB address, press the "SHIFT" key (*31*) and then the "ADDRESS" key (*34*) to display (*42*) the current GPIB address as a decimal value. Use the knob (*41*) or keypad (*39*) to change the address. The knob automatically enters the new GPIB address. When using the keypad press the "ENTER" key (*39*) to accept the new GPIB address. Addresses range from 00 to 30. Default address is 09. When the controller sets local lockout, the "ADDRESS" key is inactive.

3. Use the controller and GPIB commands (table 3-4) to send a command string to the Model 91.

LOCAL Key

The "LOCAL" key (*32*) switches control of the Model 91 from the GPIB bus to the front panel. Receipt of any GPIB command (if the controller simultaneously asserts the REN line of the GPIB) by the Model 91 disables the front panel to the extent that parameter settings can be read but modes or numbers cannot be changed. Pressing the "LOCAL" key returns full control to the front panel except when the universal command LLO has been issued by the controller. LLO disables the "LOCAL" key so full control cannot be obtained at the frontpanel.

3.4 GPIB COMMAND STRUCTURE

3.4.1 Introduction

Paragraph 3.4 covers the following topics:

3.4.2 Model 91 Commands

3.4.2.1 Command Types

The Model 91 has four types of commands: parameter, enumerated, direct, and query. The following text discusses each type. A column in table 3-4 provides a link between the Model 91 GPIB commands and this paragraph. The examples terminate the commands with semicolons (;) or closing quotes ("). The controller may send just the command name without a value and the Model 91 will display that parameter's current value. Replacing the numerical value with a "?" (query) will make the Model 91 display and send the current value to the controller as a string of characters. Do not send an EXECUTE command after a query command, the string will not be sent because the EXECUTE command has put the Model 91 in a "listen for more commands" mode. See paragraph 3.4.2.2, Terminators for more information.

Parameter Commands

Parameter commands specify a particular numerical value within a continuous range of values. The values can be in exponential (E) notation or free format.

Format:

<header>SPACE<value>TERMINATION

The header specifies the parameter and the value specifies the numerical value. Table 3-4 lists the parameter commands and their allowable value ranges.

Examples

FREQUENCY 2E3; Sets the frequency at 2kHz.
PHASE 87; Sets the phase at 87°.
SWEEPTIME 2.3; Sets the sweep time at 2.3 seconds.

Enumerated Commands

Enumerated commands provide a list of distinct choices. Either the name or numerical value can be used.

Format:

<header>SPACE<argument>TERMINATION

The header specifies the parameter and the argument specifies the choice. A number or a descriptive character string can be used for the argument. Table 3-4, Range, Value lists the enumerated commands and their arguments.

Example

FU 2 or **FU SQ** Selects square wave.

Direct Commands

Direct commands make the Model 91 perform an immediate action.

Format:

<header>TERMINATION

The header specifies the action. Direct commands have no value or argument. Table 3-4 lists all the direct commands.

Examples

`RESET;`	Resets 91 parameters
`TRIGGER;`	Triggers waveform or sweep
`EXECUTE;`	Executes preceding commands in string.
`FASTEXECUTE;`	Executes the command string without error checking

Query Commands

Query commands tell the Model 91 to send information to the controller. However, the Model 91 will not send the information when it receives the command, but waits until the controller addresses it as a talker. Only one query command can be sent at a time. If two or more are sent in a query string, the Model 91 responds to the last query.

Format:

<header> <?>TERMINATION

The header specifies the type of information. Because all parameter command headers (and most enumerated command headers) can also serve as query headers, the question mark tells the Model 91 to send (rather than receive) the information. Certain other headers appear only in query commands.

Parameter Header Examples:

`FREQUENCY?;`	Returns current frequency.
`PHASE?;`	Returns current phase.

Enumerated Header Examples:

`FUNCTION?;`	Returns current output waveform.
`OUTPUT?`	Returns current output setting.

Query Header Examples:

`MAINPARAMETERS?;`	Returns current main parameters.
`SRQ?;`	Returns current SRQ byte.
`STATUSBYTE?;`	Returns status byte.

The controller does not read the query responses unless a program sends the query and the controller reads the results. The following BASIC program queries the Model 91 about its frequency and displays the results on the controllers screen.

```
10 CLEAR                    Clears screen.
20 WRITE @ 709:"FR?"        Write command to Model
                            95 (Port 7, address 09).
30 DIM STRING$*25           Dimension string to 25
                            characters.
40 READ @ 709:STRING$       Reads returning
                            string.
50 PRINT STRING$            Prints string to screen.
60 END                      Ends program.
```

3.4.2.2 Model 91 Command Syntax

Commands sent by an instrument controller to the Model 91 must follow the syntax given in table 3-3. The following text discusses command string operation, command processing, terminators, minimum uniqueness, and query commands.

Table 3-3. Model 91 Command Syntax

Typical Command Line: `WRITE @709:"FR 2E4;OP 1;FU SQ;FR;EX"`

Syntax	Explanation
`WRITE @709`	WRITE @709 is only an example, this command depends on the controller. This format tells the controller to send the command string out port 7 (the GPIB port) to the Model 91 (at address 09 on the GPIB bus).
`"__"` or `'__'`	Enclose the command string in quotes. Either single or double quotes can serve as string delimiters.
`;`	Separate commands with semicolons. See "terminators" in the text for the reasons for this requirement.
`E`	Use exponent notation to avoid entering long strings of zeros. For example, enter `20000` as `2E4` and `0.0005` as `5E-4`.
`FR`	Use the minimum uniqueness version (`FR`), a longer version that contains the `FREQ` minimum uniqueness letters (`FREQ`), or the full version (`FREQUENCY`) of each Frequency command in programming. Table 3-4 spells out the commands and indicates the minimum uniqueness with capital letters (`FR`). The text gives examples of full, partial, and minimum uniqueness command strings.
`FU 2`	Enumerated commands that select a function (such as `FU`, select channel output `FU SQ` waveform) allow the function to be selected by either number (2) or by name (SQ), (square waveform). Table 3-4 lists the enumerated commands and their arguments (names or numbers).
`;FR;`	Drop the numerical value of a parameter command to make the Model 91 display that parameter. For example, `;A;` will display the amplitude. Use this feature in step-by-step operation to follow and verify program operation.
`"EX"`	Place an EXECUTE command at the end of a command string to initiate the preceding commands. The Model 91 accepts commands and puts them in the pending setup

Table 3-3. Model 91 Command Syntax (Continued)

Typical Command Line: `WRITE @709:"FR 2E4;OP 1;FU SQ;FR;EX"`

Syntax	Explanation
	registers, but it will not generate their output until an **EX** command is sent. **EX** also puts the Model 91 in the "listen for more commands" mode; therefore, do not put EX after a query (?) command as it will prevent the Model 91 from returning the answer.
?	Replace the numerical value of a parameter command with a ? to make the Model 91 return the current setting of that parameter as a string of characters. Table 3-4 lists the query commands and shows the format of the returning strings. Query commands also make the Model 91 display the menu of the requested parameter. The text gives a short program that makes the controller accept and display the returning information. Do not use EXECUTE after a ? command.

Command String Operation

The command string works as follows:

```
WRITE @ 709:"FR 2E4;OS 1;FU
SQ;FR;EX"
```

`WRITE @ 709:`	This command depends on the controller used.
`FR 2E4`	Sets the frequency to 20 kHz.
`OS 1`	Selects unbal 75Ω output.
`FU SQ`	Selects a square waveform.
`FR`	Tells the Model 91 to display the frequency value.
`EX`	Makes the Model 91 convert all these commands to a signal output.

How Does the Model 91 Process Commands?

The Model 91 256-character listen buffer receives the commands from the instrument controller. If the listen buffer fills up before receiving an **EXECUTE** command, it will stop accepting commands, distribute its contents to the next-setup registers, then again accept commands. The commands in the next-setup registers will not take effect until the Model 91 receives an Execute.

The listen buffer accepts all commands regardless of syntax errors. When the Model 91 processes the commands in the listen buffer, it copies the defective commands over into the SRQ buffer and labels them with PE:0 to indicate defective syntax. The parameters and functions that the defective commands would have changed remain unchanged. If a command appears in the SRQ buffer, the Model 91 ignores it.

Terminators

A terminator tells the Model 91 that it has reached the end of the current command. The Model 91 recognizes spaces, semicolons (;), and the **EXECUTE** command as terminators.

3.4.2.3 Model 91 Command List

Table 3-4 contains a listing of all Model 91 GPIB commands. Table 3-4 uses the following format to list and briefly describe the complete Model 91 GPIB command set. For information on how the commands work together to perform a task, refer to paragraph 3.5.

Command Column

This column lists all the commands alphabetically by their full names. Arguments for the commands are indented. In the sample from table 3-4, the Model 91 recognizes the full command **FREQUENCY**.

Minimum Uniqueness (Min. Unin.) Column

Capital letters in this column indicate the minimum letter combination required by the Model 91. In the sample, the minimum command the Model 91 recognizes for **FREQUENCY** is **FR**. The unit also accepts a longer abbreviation that contains all capital letters **FREQ**.

Command Type Column

This column lists the command types described in paragraph 3.4.2.1. Refer to paragraph 3.4.2.1 to better understand the command syntax.

Range Column

This column contains three parts: minimum value, maximum value, and enumerated value. These are the numeric arguments for the command. The enumerated value represents a numeric value that can be used in place of a minimum unique argument.

Description Column

This column describes the function of the command or argument.

Associated Key Column

This column identifies front panel keys which are related to the GPIB command. Not all commands will have an equivalent key.

Other Sources of this Data

The **HELP?** command provides less complete forms of the data given in table 3-4. **HELP?** sends a list of all the commands, arguments, and ranges to the GPIB controller.

3.4.3 Universal and Addressed Commands

Universal and addressed (U/A) commands make most GPIB instruments perform generally accepted standard functions. Usually, universal commands control all the instruments on the GPIB bus, while addressed

Table 3-4. Model 91 GPIB Command Set

COMMAND	MIN UNIN.	COMMAND TYPE (3.4.2.1)	RANGE MIN	RANGE MAX	VALUE	DESCRIPTION	ASSOCIATED KEY
AMPLITUDE	AM	Parameter	1E-3	15		Set Amplitude Vpp .	AMPLITUDE (5)
AMPLITUDE?	AM?	Query				Request current amplitude.	AMPLITUDE (5)
AUTOCALIBRATE	AC	Direct				Start Auto-Calibrate.	CALIBRATE (3)
BURSTCOUNT	B	Parameter	1	1E6		Sets number of bursts.	BURSTCOUNT(24)
BURSTCOUNT?	B?	Query				Requests current burst count number	BURST COUNT (24)
CALIBRATIONDUMP?	Query						
CUSTOMLOWERLVL	CUL	Parameter	-1.9	3.8		Sets lower level of custom pulse (Vdc)	CUSTOM LOWER LVL (21)
CUSTOMLOWERLVL?	CUL?	Query				Requests current custom pulse lower level.	CUSTOM LOWER LVL (21)
CUSTOMUPPERLVL	CUU	Parameter	-1.5	4.2		Sets upper level of custom pulse (Vdc).	CUSTOM UPPER LVL (20)
CUSTOMUPPERLVL?	CUU?	Query				Request current custom pulse upper level.	CUSTOM UPPER LEVEL (20)
DCOUT	DC	Parameter	-7.5	7.5		In dc function, sets dc offset value.	OFFSET (7)
DCOUT?	DC?	Query				Request current dc offset value.	OFFSET (7)
DELAY	DL	Parameter	0	2E3		Set pulse delay for delayed and second pulse position for double pulse.	DELAY (17)
DELAY?	DL?	Query				Request current delay.	DELAY (17)
EXECUTE	EX	Direct				Executes previous commands.	ENTER (39)
FASTEXECUTE	FE	Direct				Same as EXECUTE except faster and no error checking.	
FREQUENCY	FR	Parameter	1E-3	1E8		Selects Frequency Hz.	FREQ/PER (4)
FREQUENCY?	FR?	Query				Requests current frequency.	FREQ/PER (4)
FUNCTION	FU	Parameter	0	7		Selects Function.	FUNCTION (18)
SINE	SI	Enumerated			0	Selects sine function.	FUNCTION (18)
TRIANGLE	T	Enumerated			1	Selects triangle function.	FUNCTION (18)
SQUARE	SQ	Enumerated			2	Selects square function.	FUNCTION (18)
DC	D	Enumerated			3	Selects dc function.	FUNCTION (18)
PULSE	P	Enumerated			4	Selects single pulse.	FUNCTION (18)
DELAYEDPULSE	DE	Enumerated			5	Selects delayed pulse.	FUNCTION (18)
DOUBLEPULSE	DO	Enumerated			6	Selects double pulse.	FUNCTION (18)
EXTERNALWIDTH	E	Enumerated			7	Selects external width pulse.	FUNCTION (18)
FUNCTION?	FU?	Query				Request current function.	FUNCTION (18)
GATEON	GN	Direct				Gate mode on.	MAN TRIG (25)
GATEOFF	GF	Direct				Gate mode off.	MAN TRIG (25)
HELP?	H?	Query				Requests a list of GPIB commands.	

Table 3-4. Model 91 GPIB Command Set (Continued)

COMMAND	MIN UNIN.	COMMAND TYPE (3.4.2.1)	RANGE MIN	RANGE MAX	VALUE	DESCRIPTION	ASSOCIATED KEY
LOCKSOURCE	LS	Parameter	0	1		Selects phase lock source.	LOCK SOURCE (*11*)
INTERNAL	I	Enumerated			0	Selects internal phase source.	LOCK SOURCE (*11*)
EXTERNAL	E	Enumerated			1	Selects external phase source.	LOCK SOURCE (*11*)
LOCKSOURCE?	LS?	Query				Requests current phase source.	LOCK SOURCE (*11*)
LOWERLEVEL	LL	Parameter	-7.5	7		Selects waveform amplitude lower level	LOWER LVL (*21*)
LOWERLEVEL?	LL?	Query				Request current lower level.	LOWER LVL (*21*)
MODE	MO	Parameter	0	7		Selects operating mode.	MODE (*22*)
CONTINUOUS	C	Enumerated			0	Selects continuous mode.	MODE (*22*)
TRIGGER	T	Enumerated			1	Selects triggered mode.	MODE (*22*)
GATE	G	Enumerated			2	Selects gated mode.	MODE (*22*)
BURST	B	Enumerated			3	Selects burst mode.	MODE (*22*)
AM	A				4	Selects AM mode.	MODE (*22*)
SCM	SC	Enumerated			5	Selects SCM mode.	MODE (*22*)
FM	F	Enumerated			6	Selects FM mode.	MODE (*22*)
SWEEP	SW	Enumerated			7	Selects Sweep mode	MODE (*22*)
MODE?	MO?	Query				Request current mode.	MODE (*22*)
MAINPARAMTERS?	MPM?	Query				Request current main parameter.	
OFFSET	OF	Parameter	-7.5	+7.5		Select waveform offset voltage (Vdc).	OFFSET (*7*)
OFFSET?	OF?	Query				Request current offset value.	OFFSET (*7*)
OUTPUT	OP	Parameter	0	1		Turns output on or off.	ON/OFF (36)
OFF	OF	Enumerated			0	Turns output off.	ON/OFF (36)
ON	ON	Enumerated			1	Turns output on.	ON/OFF (*36*)
OUTPUT?	OP?	Query				Request output condition.	ON/OFF (*36*)
OUTPUTSELECT	OS	Parameter	0	4		Selects output and impedance	SELECT (*36*)
UNBALANCED50	U50	Enumerated			0	Selects 50Ω Unbalanced output.	SELECT (*36*)
UNBALANCED75	U75	Enumerated			1	Selects 75Ω Unbalanced output.	SELECT (*36*)
UNBALANCED600	U600	Enumerated			2	Select 600Ω Unbalanced output.	SELECT (*36*)
BALANCED600	B600	Enumerated			3	Selects 600Ω Balanced output.	SELECT (*36*)
BALANCED135	B135	Enumerated			4	Selects 135Ω Balanced output	SELECT (*36*)
OUTPUTSELECT?	OS?	Query				Request current output selection.	SELECT (*36*)
PHASE	PH	Enumerated	-180	+180		Selects phase angle in degrees)	PHASE (*8*)
PHASE?	PH?	Query				Request current phase shift.	PHASE (*8*)
PARAMETERRESET	PR	Direct				Resets last transmitted parameter	PARAM RESET (*2*)

Table 3-4. Model 91 GPIB Command Set (Continued)

COMMAND	MIN UNIN.	COMMAND TYPE (3.4.2.1)	RANGE MIN	RANGE MAX	VALUE	DESCRIPTION	ASSOCIATED KEY
PULSELOGIC	PO	Parameter	0	1		Selects pulse output logic.	
NORMAL	N	Enumerated			0	Selects normal pulse output.	PULSE SETUP *(19)*
COMPLEMENT	C	Enumerated			1	Selects Complement pulse output.	PULSE SETUP *(19)*
PULSELOGIC?	PO?	Query				Request current pulse logic.	PULSE SETUP *(19)*
PULSETYPE	PY	Parameter	0	4		Selects logic level of Pulse Out.	PULSE SETUP *(19)*
TTL	T	Enumerated			0	Selects TTL pulse levels.	PULSE SETUP *(19)*
CMOS	CM	Enumerated			1	Selects CMOS pulse levels.	PULSE SETUP *(19)*
POSITIVEECL	P	Enumerated			2	Selects +ECL pulse levels	PULSE SETUP *(19)*
NEGATIVEECL	N	Enumerated			3	Selects -ECL pulse levels	PULSE SETUP *(19)*
CUSTOM	CU	Enumerated			4	Selects Custom pulse levels.	PULSE SETUP *(19)*
PULSETYPE?	PY?	Query				Request current pulse level type.	PULSE SETUP *(19)*
PULSEPARAMTERS?	PPM?	Query				Requests all pulse parameters.	
RESET	R	Direct				Reset all parameters except GPIB address, all units, and display intensity.	RESET ALL *(2)*
RANGELOCK	RA	Parameter	0	1		Locks generator to current freq. range.	
OFF	OF	Enumerated			0	Normal range.	
ON	ON	Enumerated			1	Locks range.	
RANGELOCK?	RA?	Query				Request current range lock condition.	
RECALLSETTING	RCL	Parameter	1	5		Recalls stored settings in selected location.	RECALL *(6)*
RECALLSETTING?	RCL?	Query				Requests last recalled setting.	RECALL *(6)*
REAROUTPUTS	RO	Parameter	0	1		Turns Pulse Outputs on or off.	PULSE *(19)*
ON	ON	Enumerated			1	Turns Pulse Output on.	PULSE SETUP *(19)*
OFF	OF	Enumerated			0	Turns Pulse Output off.	PULSE SETUP *(19)*
REAROUTPUTS?	RO?	Query				Request current Pulse Output state.	PULSE SETUP *(19)*
SELFTEST?	SLFT?	Query				Requests Self Test results.	
STORESETTING	STS	Parameter		1	5	Stores current setup in memory.	STORE *(6)*
STORESETTING?	STS?	Query				Requests last stored setting.	STORE *(6)*
SYMMETRY	SY	Parameter	5	95		Select variable symmetry value.	SYMMETRY *(7)*
SYMMETRY?	SY?	Query				Request current symmetry value.	SYMMETRY *(7)*

Table 3-4. Model 91 GPIB Command Set (Continued)

COMMAND	MIN UNIN.	COMMAND TYPE (3.4.2.1)	RANGE MIN	RANGE MAX	VALUE	DESCRIPTION	ASSOCIATED KEY
SWEEPSTART	STA	Parameter	1E-3	20E6		Select sweep start frequency (Hz).	SWEEP MODE (26)
SWEEPSTART?	STA?	Query				Request current sweep start frequency.	SWEEP MODE *(26)*
SWEEPSTOP	STO	Parameter	1E-3	20E6		Select sweep stop frequency (Hz)	SWEEP MODE *(26)*
SWEEPSTOP?	STO?	Query				Requests current stop frequency.	SWEEP MODE *(26)*
SWEEPTIME	STI	Parameter	100E-3	3600		Select sweep time (seconds).	TIME *(28)*
SWEEPTIME?	STI?	Query				Requests current sweep time.	TIME *(28)*
SWEEPTRIGFREQ	STF	Parameter	10E-3	10		Selects internal triggered sweep frequency (Hz).	TRIG FREQ *(27)*
SWEEPTRIGFREQ?	STF?	Query				Request current internal trigger sweep frequency.	TRIG FREQ *(27)*
SWEEPTYPE	STY	Parameter	0	3		Selects Lin or Log sweep.	LIN/LOG *(26)*
LINEAR	LI	Enumerated			0	Selects linear sweep.	LIN/LOG *(26)*
LOG	LO	Enumerated			1	Selects log sweep.	LIN/LOG *(26)*
UDLIN	ULI	Enumerated			2	Selects up/down linear sweep.	LIN/LOG *(26)*
UDLOG	ULO	Enumerated			3	Selects up/down log sweep.	LIN/LOG *(26)*
SWEEPTYPE?	STY?	Query				Requests current sweep type.	LIN/LOG *(26)*
SWEEPMODE	SMD	Parameter	0	4		Selects sweep modes.	SWEEP MODE *(26)*
START	SA	Enumerated			0	Sets generator to sweep start frequency	SWEEP MODE *(26)*
STOP	SO	Enumerated			1	Sets generator to stop frequency.	SWEEP MODE *(26)*
CONTINUOUS	C	Enumerated			2	Sets generator to continuous sweep.	SWEEP MODE *(26)*
TRIGGERED	T	Enumerated			3	Sets generator to triggered sweep.	SWEEP MODE *(26)*
MANUAL	M	Enumerated			4	Sets generator to manual sweep.	SWEEP MODE *(26)*
SWEEPMODE?	SMD?	Query				Requests current sweep mode.	SWEEP MODE *(26)*
STATUSBYTE?	STB?	Query				Requests current status byte value.	
SERIALNUMBERS?	SN?	Query				Requests unit's serial number.	
SRQMASK	SQM	Parameter	0	255		Allows selection of items that initiate a SRQ.	
SRQMASK?	SQM?	Query				Request current SRQ Mask value.	
SRQ?	SRQ?	Query				Reads SRQ value.	
SYNCTIMING	SC	Parameter	0	1		Selects Sync type.	SYNC *(14)*
FRONT	F	Enumerated			0	Selects front panel sync outputs.	SYNC *(14)*

Table 3-4. Model 91 GPIB Command Set (Continued)

COMMAND	MIN UNIN.	COMMAND TYPE (3.4.2.1)	RANGE MIN	RANGE MAX	RANGE VALUE	DESCRIPTION	ASSOCIATED KEY
REAR	R	Enumerated			1	Select rear panel sync outputs.	SYNC *(14)*
SYNCTIMING?	SC?	Query				Request current sync output..	SYNC *(14)*
TRIGGERFREQ	TF	Parameter	1E-3	50E6		Select internal t trigger frequency.	TRIG FREQ *(27)*
TRIGGERFREQ?	TF?	Query				Request current trigger frequency.	TRIG FREQ *(27)*
TRIGGER	TGG	Direct				Initiates a trigger.	MAN TRIG *(25)*
TRIGLEVEL	TV	Parameter	-5	5		Select trigger level.	TRIG SETUP *(24)*
TRIGLEVEL?	TV?	Query				Requests current trigger level.	TRIG SETUP *(24)*
TRIGSLOPE	TSL	Parameter		0	1	Selects trigger slope	TRIG SETUP *(24)*
NEGATIVE	N	Enumerated			1	Selects negative-going slope.	TRIG SETUP *(24)*
POSITIVE	P	Enumerated			0	Selects positive-going slope.	TRIG SETUP *(24)*
TRIGSLOPE	TSL?	Query				Request current trigger slope.	TRIG SETUP *(24)* RESET ALL *(2)*
TRIGGERSOURCE	TSO	Parameter	0	2		Selects trigger source.	TRIG SETUP *(24)*
INTERNAL	I	Enumerated			0	Selects internal trigger source.	TRIG SETUP *(24)*
EXTERNAL	E	Enumerated			1	Selects external trigger source.	TRIG SETUP *(24)*
MANUAL	M	Enumerated			2	Selects Manual Trigger as the trigger source.	TRIG SETUP (24)
TRIGGERSOURCE?	TSO?	Query				Requests current trigger source.	TRIG SETUP *(24)*
TRIGPARAMETERS?	TPM?	Query				Requests all current trigger parameters	TRIG SETUP (24)
UPPERLEVEL	UL	Parameter	-7	7.5		Selects waveform amplitude upper level (Vdc).	UPPER LVL *(20)*
UPPERLEVEL?	UL?	Query				Requests current upper level.	UPPER LVL *(20)*
VERSION?	V?	Query				Request software version number.	
WIDTH	W	Parameter	10E-9	2E3		Selects pulse width (sec)	WIDTH *(16)*
WIDTH?	W?	Query				Requests current pulse width.	WIDTH *(16)*

commands control individual instruments at specific addresses on the bus. The Model 91 accepts the following U/A commands:

Command	Type	Function
DCL	Universal	Device Clear
GET	Addressed	Group execute trigger
GTL	Addressed	Go to local
LLO	Universal	Local lockout command
SDC	Addressed	Selected device clear

Paragraph 3.4.4, Detailed Command Descriptions, discusses these U/A commands and selected Model 91 commands in detail.

Universal and Addressed Syntax

This manual uses generic names to identify the universal and addressed commands and the functions they perform. Individual controllers will use differently named commands to perform these same functions. See the manual for the controller being used to determine the actual command names and the syntax they require.

3.4.4 Detailed Command Descriptions

The following paragraphs describe in detail the unique Model 91 GPIB commands that perform functions not controlled by the front panel and the GPIB universal and addressed commands recognized by the Model 91. Use the following list to identify these specialized commands.

Command	Type	Description
DCL	Universal	Device Clear
GET	Address	Group Execute Trigger
GTL	Address	Go To Local
HELP?	Model 91	HELP?
LLO	Universal	Local Lock Out
MP?	Model 91	Main Parameters
SRQ?	Model 91	Service Request?
SQM	Model 91	Service Request Mask
SQM?	Model 91	Service Request Mask?
STB?	Model 91	Status Byte?
V?	Model 91	Version?

Front Panel Restrictions

The Model 91 limits the operator's use of the front panel with two levels of increasing restrictions as shown in table 3-5.

GPIB Control - The Model 91 switches to GPIB control when the instrument controller asserts the GPIB REN (remote enable) line and sends to the Model 91 its listen address. The controller command string WRITE@709:"-*command string*-" will automatically perform these two actions. The GPIB control restricts further front panel operation as described in table 3-5. The Model 91 will remain under the GPIB control until the operator presses the "LOCAL" key (*32*).

Table 3-5. Front Panel Restrictions

F P Op Limit >	No Control	GPIB Cmd	LLO
Operator Can:			
See Display?	Yes	Yes	Yes
Display Parameters?	Yes	Yes	Yes
Take Control From GPIB?	Yes	Yes	No
Change Parameters?	Yes	No	No

Local Lockout Command - All instruments on the bus recognize the universal local lock out command LLO; it cannot be directed to just one instrument. LLO restricts operation of the Model 91 front panel as described in table 3-5.

Go To Local Command - The Go To Local command (GTL) cancels the LLO command and returns the Model 91 front panel to full operator control. All instruments on the bus recognize the addressed command GTL; however, it must be sent to each instrument individually. GTL becomes effective on receipt; the Model 91 does not require that it be followed with another command.

Group Execute Trigger Command

The Group Execute Trigger command, GET, triggers whatever trigger function set up within the Model 91. All instruments on the bus recognize the GPIB addressed GET command. However, GET can be sent to just one instrument at a time. The Model 91 triggers the selected function immediately on receipt of the GET command.

HELP? Command

The HELP? command makes the Model 91 return a list of the Model 91 primary and secondary commands and their limits as a string to the controller. HELP? requires that a program be written to make the instrument controller accept and print the returned list. The following program requests the list, accepts it, and sends it to a printer connected to the GPIB bus. Table 3-4 provides the same information as the list this program prints.

HELP Print Program

```
10 DIM A$*255              Dimension String to 255
                           characters.
11 WRITE @709:"HELP?"      Write HELP to port 7,
                           address 09.
12 READ @709:A$            Read the String
13 IF A$="0" THEN 170      If string is "0" jump to
                           170
14 PRINT A$                Print the list
15 GO TO 12
17 END                     End Program
```

Main Parameters? Command

The MPM? command makes the Model 91 return the current setting of the Model 91 main parameters as a string to the controller. The controller can save this string, then send it back to the Model 91 at a later time to restore the parameters to their previous values. A typical response could be "`FR 1E3,FU 0,MO 0,AM 5,OF 0, LS 0, P 0, SYM 50, STA 1E3,STI 1,STY 0,SMD 0,OS 0,OP 0`".

Pulse Parameters? Command

The PPM? command makes the Model 91 return the current setting of the Model 91 pulse parameters as a string to the controller. The controller can save this string, then send it back to the Model 91 at a later time to restore the parameters to their previous values. A typical response could be "`W 500E-9,OL 1E-6,UL 2.5,LL -2.5,PY 0,RO 0,PO 0,CUU 500E-9,CUL 0,SC 0`".

Trigger Parameters? Command

The TPM? command makes the Model 91 return the current setting of the Model 91 trigger parameters as a string to the controller. The controller can save this string, then send it back to the Model 91 at a later time to restore the parameters to their previous values. A typical response could be "`B 5,TQ 100,TV 0,TSL 0,TSO 0`".

Device Clear Command

The device clear command DCL resets the Model 91 to the power-up conditions, but leaves it in the remote (GPIB controlled) mode. All instruments on the bus recognize the GPIB universal command DCL (device clear). To reset everything on the bus, use DCL @7, where 7 specifies the GPIB bus port of the controller. To reset just one instrument, use DCL @709, where 09 specifies the instrument address. The Model 91 resets itself immediately when it receives either command.

Reset Command

The RESET command resets the Model 91 to default conditions. Table 3-1 lists the Model 91 default conditions.

Version? Command

The VERSION? command makes the Model 91 return the software version of the Model 91 EPROM as a string of characters. Version? requires a program to make the instrument controller use the returned string. The following program requests the version, accepts it, and writes the data to the screen.

Version? Print Program

```
10 CLEAR                   Clear screen
20 WRITE @709:"V?"         Write VERSION? to port
                           7, address 09.
30 DIM  VERSION$*50        Dimension string to 50
                           characters.
40 READ @709:VERSION$      Read returning string
50 PRINT VERSION$          Print string to screen
60 END                     End program
```

Running the "Version? Print" program will produce the following print out: WVTK 91 XXX YY.YY, where X represents the any options installed and Y represent the firm ware version number.

3.4.5 Service Requests - SRQ

The following paragraphs discusses service requests, describes the commands associated with them, and lists the service request messages the Model 91 generates. The Model 91 can set the SRQ line whenever a programming error occurs, a hardware error occurs, an event is completed, Phase lock changes state, or a Calibration message is displayed.

SRQ Concepts

What Does the Service Request Tell the Controller?

The Model 91 service request tells the controller that the Model 91 wants attention by asserting the SRQ line of the GPIB bus. Because any instrument on the bus can assert this line, the controller must read the status byte of each instrument in turn to determine which one requested attention.

What Does the Status Byte Tell the Controller?

The Model 91 uses five of the eight bits in its status byte. One tells the controller if the Model 91 requested service. The others indicate the type or types of messages (programming error, event, Phase Lock state, or Calibration messages) the Model 91 wants to send. Figure 3-6 shows the format of the Model 91 status byte. If the controller wants to know the specific message within the category, it must read the Model 91 SRQ buffer.

What Does the SRQ Buffer Tell the Controller?

The Model 91 SRQ buffer stores the programming error, event complete, Phase Lock state, and Calibration messages until the controller can read them. Tables 3-6 through 3-9 list all of the SRQ messages.

SRQ COMMANDS

The following paragraphs discuss the commands related to the service request mask, the status byte and the service request messages.

SRQ Mask Command

The SQM command makes the Model 91 selectively ignore one or more of the four types of conditions that make it produce service requests. For example, if programming errors were masked out, the Model 91 would not load messages for specific programming errors into the SRQ buffers and it would not set the PE and service request bits in the status byte. Figure 3-6 shows the positions and the corresponding decimal mask values required to block out PE, CM, PL, and EV messages. The SRQ mask is reset to SRQ mask #1 (programming error only) at power on. It is not changed by "RESET". To set up the SRQ send the total decimal equivalent of the desired status items. Always end the string with an EXECUTE. For example, to allow the Model 91 to respond to programming errors and calibration messages, send: `SQM 3 EX`.

SRQ Mask? Command

The SQM? command makes the Model 91 return the current mask setting to the controller. The Model 91 sends the SRQ mask setting as the character string SRQMASK#, where # gives the decimal equivalent of the binary mask bits. To use SRQMASK?, write a program that first asks the Model 91 to send the mask, then tells the controller how to receive and process the returning string. Sending this command also causes the Model 91 to display the SRQ mask as a binary value.

Status Byte? Command

The STB? command makes the Model 91 send its current status byte to the controller over the GPIB bus. The Model 91 sends its status byte as a string of characters with the format STB=##, where ## gives the decimal equivalent of the status byte. STatusByte? reads, but does not reset, the status byte of the Model 91. To use STatusByte?, write a program asking the Model 91 to send the status byte, then tell the controller how to receive and process the returning string.

SRQ? Command

The SRQ? command makes the Model 91 send the contents of the SRQ buffer to the controller over the GPIB bus. The Model 91 sends its SRQ buffer contents as a string of characters with the format SRQ = MESSAGES, where MESSAGES represents a string of messages. Reading the SRQ buffer empties it. To use SRQ?, write a program that first asks the Model 91 to send the SRQ buffer messages, then tells the controller how to receive and process them.

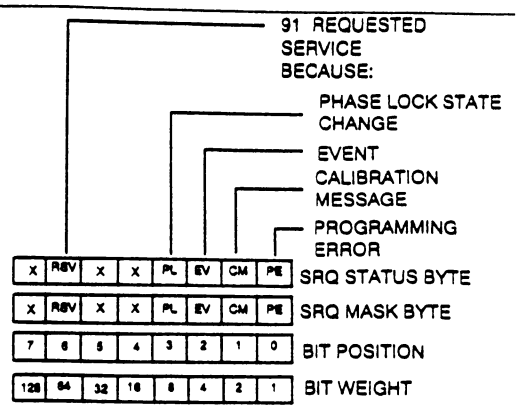


Figure 3-6. Model 91 Status Byte and SRQ Mask

The Model 91 puts messages in the SRQ buffer in this general format:

SRQ=/PE:n Description//CM:n Description//EV:n Description//PL:n Description/

Slashes (/) enclose each message. PE identifies a programming error message, CM identifies the calibration error message, EV is an event complete message, and PL indicated a phase lock state change. "n" identifies a specific message within the type. This fixed format header allows a computer to easily parse (decode) the message. "Description" describes the error in English for the benefit of human readers. Table 3-6. lists all the SRQ programming error messages, table 3-7 lists all the SRQ calibration error messages, table 3-8 lists all the SRQ event error messages, and table 3-9 lists all the SRQ phase lock state change error messages.

3.4.6 Displaying Messages

The Model 91 can accept messages from the GPIB bus and display them on the front panel display. Use this feature to give instructions to an operator or to display information.

Message Format

Send messages in this format:

```
WRITE @709:" 'TEXT'"
```

The standard double quotes (") identify the command string. The single quotes (') identify the contents as a message rather than commands. Messages do not require an Execute command.

Message Size

The Model 91 display allows a maximum message size of 16 characters. The Model 91 ignores any characters beyond these limits.

Erasing Messages

Press any key or send another GPIB command string to return to normal Model 91 displays. To erase the previous message, send a new message.

3.4.7 Self-test Query Responses

When the Model 91 receives a SELFTEST? command, it sends the total decimal value of selftest error that occurred at power on. Refer to table 3-6.

3.5 OPERATION

Paragraph 3.5 ties together the descriptions of the controls and connectors (paragraph 3.2), as well as GPIB commands (paragraph 3.4), into sets of instructions on performing various operations using the Model 91. To quickly get familiar with the Model 91, perform the Initial Checkout Procedure - paragraph 2.3.5.

The operations described in this paragraph are listed below.

Table 3-6. SRQ Programming Error Messages

Message	Description
/PE:0 < defective command string > /	The Model 91 did not recognize the command it received. A <defective command string > is whatever erroneous data the Model 91 received over the bus.
/PE:1 < parameter header > /	This is a limit error. An attempt was made to set a parameter to an illegal value. A <parameter header> is the maximum header string; that is "FREQUENCY" or "AMPLITUDE".
/PE:2:< param# >:< param# >	This is a setting conflict error. This service request will < param name >-< param name > occur after an execute command if there are CONFLICT/ conflicting settings. It will only flag the first conflict that it finds.

< param# >	< param name >	< param# >	< param name >
1	RNGLOCK	15	LWRLVL
2	MODE	16	UPRLVL
3	FUNC	17	LWRCSTM
4	SYM	18	UPCSTM
6	OFST	19	DELAY
7	AMPL	20	WIDTH
8	EXTLOCK	21	PERIOD
9	OUTSEL	22	FRNTOUT
10	SWPSTR	23	WD + DL
11	SWPSTP	24	SYNC
13	AMP + OFST		
14	FREQ		

Table 3-7. SRQ Calibration Messages

Message	Description
/CM:0 < cal index >< cal name >/	This is a failure to complete an AutoCal step. AutoCal< cal index > is a number associated with the calibration parameter that failed adjustment. < cal name > identifies a name associated with the failed calibration parameter.
/CM:1 WAIT < time > MIN/	AutoCal was attempted before the required 20 minute warm-up. < time > is the time (in minutes) remaining before an AutoCal can be performed.

Table 3-8. SRQ Event Complete Error Messages

Message	Description
/EV:0 AUTOCALIBRATION COMPLETE/	AutoCal was completed.
/EV:1 EXECUTE COMPLETE/	Execute was complete. After an execute command, the Model 91 will send either this service request or a PE:2 (assuming both PE and EV SRQ's are enabled by the SRQ mask).
/EV:2 SWEEP COMPLETE/	Sweep was completed.
/EV:3 BURST COMPLETE/	Burst count was completed.

Table 3-9. SRQ Phase Lock State Change Error Messages

Message	Description
/PL:0 PLL UNLOCKED/	The phase lock loop has changed from an unlocked state to a locked state.
/PL:1 PLL LOCKED/	The phase lock loop has changed from a locked state to an unlocked state.

Table 3-10. Selftest Query Error Messages

Message (Dec)	Description
128	RAM Lost Battery Backup - Calibration Corrupted
4, 2, and 1	Main RAM Failure

Before beginning the operation of the Model 91, review the general information in paragraphs 3.5.1 and 3.5.2.

3.5.1 Instrument Setup

Before using the Model 91, the primary power input must be connected and outputs properly terminated.

Primary Power

Before using the Model 91, verify the voltage selector and fuse (*F*) are set to match the primary power source; see paragraph 2.4.1.

Output Terminations

For proper waveform levels and quality, each output connector used must be properly terminated. Termination requires a correct combination of "load" or terminator and the cable impedance that matches the Model 91 source impedance. Most outputs (Sweep Out, Sync Out, Pulse Out, etc.) have fixed output impedances, listed in table 3-11. The Model 91 two function outputs (Balanced and Unbalanced) have selectable source impedances. The balanced and unbalanced outputs each require different interconnection techniques; see figure 3-7.

Unbalanced Output. For the unbalanced (single ended) output, connect the output from the Model 91 to the receiving instrument using a single cable or coax and a single termination impedance which matches the selected source impedance; see table 3-11 and figure 3-7 - Unbalanced Output. In figure 3-7, R_s represents the unit's selected output impedance.

Balanced Output. The primary use for balance outputs would be audio and telecommunication devices that drives differential inputs. To connect the Model 91 Balanced Output to the receiving instrument, use a twisted pair and terminating impedance to match the selected source impedance. The example shown in figure 3-7.

Pulse Out and $\overline{\text{Pulse Out}}$ For proper pulse levels and rise times, terminate these connectors with correct cables and 50Ω terminators.

Sync Out For proper sync levels and rise times, terminate this connector with correct cable and 50Ω terminator.

Table 3-11. Model 91 Input/Output Impedances

Connector	Impedance	Comments
UNBALANCED (*35*)	50Ω 75Ω, or 600Ω	Use SELECT (*36*)
BALANCED (*38*)	135Ω, 600Ω	Use SELECT (*36*)
SWEEP OUT (*29*)	600Ω	
MOD IN (*30*)	10 kΩ	
SYNC OUT (*13*)	50Ω TTL	
EXT FREQ IN (*12*)	10 kΩ	
REF IN (*A*)	>1kΩ	OPTION 001
REF OUT (*B*)	50Ω	OPTION 001
TRIG IN (*C*)	2 kΩ shunted by <10 pF	
PULSE OUT (*D*)	50Ω	
PULSE OUT (*E*)	50Ω	

3.5.2 Power On and Reset

Press the "POWER" key (*1*) to turn on or off the Model 91. Turning on the power, returns the Model 91 to the last instrument setup, except the output (Balanced or Unbalanced) will be off. The last selected output impedance indicator (*38*) will flash. Use the "ON/OFF" key (*36*) to activate the front panel output connectors.

Setting a Single Parameter to its Default Value

From the front panel use the "PARAMETER RESET" key (*2*) to reset the displayed parameter to its default value. Refer to table 3-1, key item 2, "Model 91 Default Conditions".

Over the GPIB, send the command **PARAMETERRESET** or **PR** to reset the last transmitted value to its default value.

Setting All Parameters To Their Default Values

From the front panel, use the "SHIFT" key (*31*) "RESET ALL" key (*2*) to reset all Model 91 parameters to their default values.

Over the GPIB, send the command **RESET** or **R** to reset all Model 91 parameters except the GPIB address.

3.5.3 Basic Generator Setup

The basic Model 91 produces continuous waveforms of all functions at a single frequency with a fixed amplitude. The frequency can be between 1mHz and 20 MHz for front panel oututs. At the rear panel Pulse outputs the frequency limit is 50 MHz for pulses and 100 MHz for square waves. Between 20 Hz and 100 MHz the Model 91 internal synthesizer controls the frequency accuracy and stability (±10 ppm). The frequency accuracy decreases to ±3% below 20 Hz.

Paragraph 3.5.3.1 describes the steps required to set up the Model 91 for continuous outputs using the front panel. Paragraph 3.5.3.2 describes the steps required to setup the Model 91 for continuous output using a GPIB controller. Figure 3-8 shows a typical instrument setup for continuous operation.

3.5.3.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for continuous output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the continuous mode (CONT indicator lit (*23*)).
   To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the Function. Use the "FUNCTION" key (*18*) to select the desired function: sine triangle, or square. For dc output, see step 5, DC Function. If using the Pulse Outputs, the Model 91 generates pulse (to 50 MHz) and square waves (to 100 MHz. Holding down the "FUNCTION" key causes the unit to cycle through the functions. Release the key to stop and select the function. The appropriate function indicator (*15*) will be lit.

   To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the indicator lights on the desired function.

3. Select the Frequency. Press the "FREQ/PER" key (*4*) to display the frequency. Use the keypad (*39*) or the Knob (*42*), if enabled (ENABLE indicator (*41*) lit), to change the frequency. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual numbers (5000) or exponential notation (5E3), press the "ENTER" key (*39*) to accept the new value. Frequency range for the function generator is 1mHz to 20.00 MHz (frequency selected) or 1000.0s to 50 ns (period selected)

   Use the frequency's "UNITS" key (*4*) to select the unit of measure: frequency or period for the function generator .

   Limitations:
   - Maximum frequency derates above 2MHz when symmetry not 50%
   - Maximum frequency limited to 1MHz when 135Ω and 600Ω Balanced selected.
   - Minimum frequency limited to 20 Hz for internal phase lock (accuracy ±10 ppm)

4. Set up the Amplitude. Use the "AMPLITUDE" key (*5*) to display the amplitude. Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the amplitude. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual number (10) or exponential notation (1E1), press the "ENTER" key (*39*) to accept the new value. Amplitude range for each function and each amplitude's units is listed below.

	Sine	Triangle	Square
Vpp	1m - 15 Vpp	1m - 15 Vpp	1m - 15 Vpp
Vp	0.6 m - 7.5 Vp	0.6 m - 7.5 Vp	0.6 m - 7.5 Vp
Vrms	0.4 ms - 5.3 Vrms	0.3 m - 4.33 Vrms	0.5 m - 7.5 Vrms
dBm	-56 - +27.5 dBm	- 57.8 - +25.7 dBm	- 53 m - +30.5 dBm

Use the Amplitude's "UNITS" key (*5*) to select the unit of measure: Vpp, Vp, Vrms, or dBm. Limitations:

Amplitude limited by Offset values (Offset + Vp ≤7.5V).

Amplitude limited to half of maximum level when AM selected.

Vpp and Vp only allowed when the dc offset is not 0Vdc, symmetry is not 50%.

5. Set up the Offset. Use the "OFFSET" key (*7*) to display the dc offset level. Offset is the waveform reference level relative to 0Vdc; see figure 3-9. Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the offset. The Knob increments or decrements the value starting with the flashing digit ("KNOB" key (*39*)) and automatically enters the new value. When using the keypad, enter values as actual number (0.01) or exponential notation (10E-3), press the "ENTER" key to accept the new value. Offset values range from +7.500V to –7.500V.

Limitations:

Offset plus peak amplitude value cannot exceed 7.5Vp.

Offset fixed at 0Vdc when BAL (Balanced output) selected.

Offset range limited to half of the maximum offset when AM selected.

DC Function. When the dc function is selected, the Model 91 produces a dc voltage. The "OFFSET" key, when used with the Keypad or Knob, controls the output polarity and level.

6. Turn on or off the output and select the output Impedance.

Use the "ON/OFF" key (*36*) to turn on or off the output. If the output is turned off, as it will be at power on, the impedance indicator flashes. Pressing the :ON/OFF" key turns on the output and returns the Model 91 to the last selected output and impedance. The impedance indicator remains on.

Use the "SHIFT" (*31*) and "SELECT" (*36*) keys to choose the output connector (balanced or unbalanced) and output impedance (50Ω, 75Ω, 135Ω, and 600Ω). Pressing the "SHIFT" key and then the "SELECT" key increments through the impedances and outputs in the following order:

50Ω Unbalanced Output
75Ω Unbalanced Output
600Ω Unbalanced Output (frequency limited to 1MHz)
600Ω Balanced Output (frequency limited to 1MHz)
135Ω Balanced Output (frequency limited to 1MHz)

Also after pressing the "SHIFT" key, hold down the "SELECT" key to auto-increment through the list in the same order as above. Release the key to select the impedance and output; the indicators remain lit.

The Sync Output pulse will be in phase with the Square wave, but will be 90° out of phase with the Sine and Triangle waves. The Sync Output must be terminated with 50Ω.

NOTE

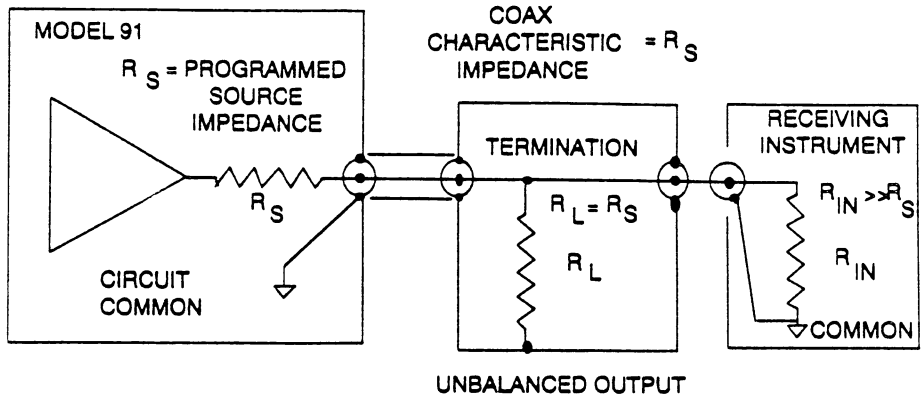
When connecting the Model 91 output connector to a load, use a cable with the correct impedance for the output selected. Balanced CT connector is internally connected to the shield of all the other Model 91 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.

3.5.3.2 GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for continuous output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the continuous parameter.
   Mode Commands: `MODE` or `MO`.
   Continuous Parameters: `C` or `0`.
   The commands and parameters can be mixed; "`MODE 0;`", "`MO 0;`", "`MODE C;`", or "`MO C;`" will select the continuous mode.

2. Select the Function. Send the Function command followed by the parameter.
   Function Commands: `FUNCTION` or `FU`.
   Sine Parameters: `SINE`, `SI`, or `0`
   Triangle Parameter: `TRIANGLE`, `T`, or `1`
   Square Parameter: `SQUARE`, `SQ`, or `2`.
   DC Parameter: `DC`, `D`, or `3`.



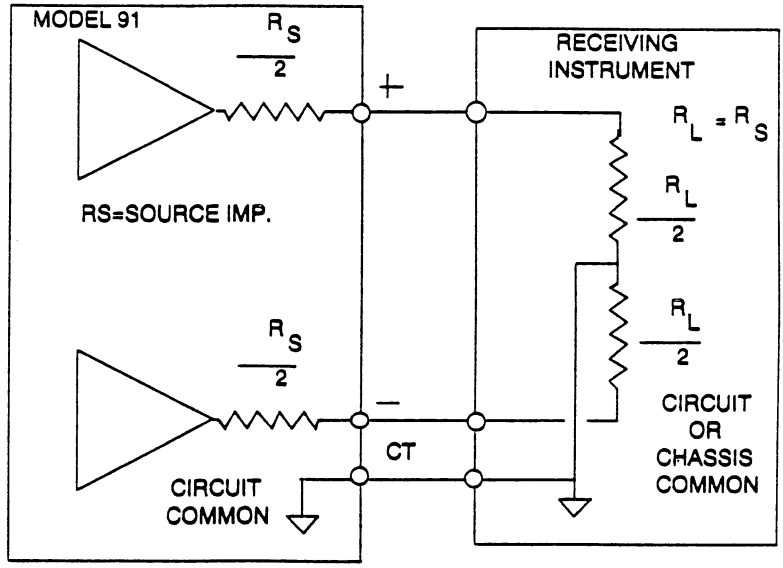


Figure 3-7. Output Terminations

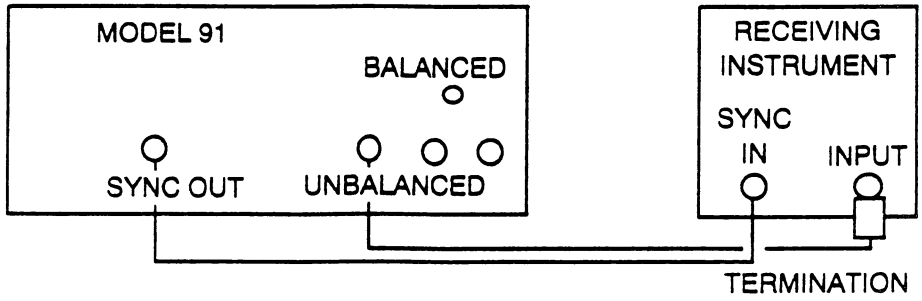


Figure 3-8. Continuous Operation Interconnection

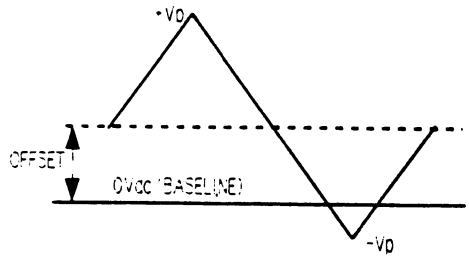


Figure 3-9. Offset Waveform Example

The commands and parameters can be mixed. For example, sending either the string "FUNCTION SINE;" or "FU 0;" will select the sine function.

3. Select the Frequency. Send the Frequency command followed by the parameter.
   Frequency Commands: FREQUENCY or FR.
   Frequency Parameters: Values in Hz between 2E-3 and 20E6.
   Values can be entered in any format. For example 2kHz can be entered as 2000, 2E3, 20E2, etc.
   For example, sending either "FREQUENCY 1E6;" or "FR 1000000;" will select 1MHz.

4. Select the Amplitude. Send the Amplitude command followed by the parameter.
   Amplitude Commands: AMPLITUDE or AM.
   Amplitude Parameters: Values in Vpp between 1E-3 and 15.
   Values can be entered in any format. For example 10 Vpp can be entered as 10, 1E1, 10E0, etc.
   For example, sending either "AMPLITUDE 12;" or "AM 1.2E1;" will select 12 Vpp amplitude.

5. Select the Offset. Send the Offset command followed by the parameter.
   Offset Commands: OFFSET or OF.
   Offset Parameters: Values in Vdc between -7.5 and 7.5.
   For example, sending either "OFFSET -3;" or "OF -3;" offsets the waveform by -3Vdc.

   DC Output. If the dc function ("FU DC;") is selected, send the DC Output command and parameters to control the dc output voltage.
   DC Output Command: DCOUT or DC,
   DC Output Parameter (Vdc): Values can be between -7.5 and +7.5.
   Values can be entered in any format.
   For example 2Vdc can be entered as 2 or 2E0.

6. Turn On or Off the Output. Send the Output enable command followed by the parameter.
   Output Commands: OUTPUT or OP.
   Parameters: 1 or ON turns the output on, and 0 or OFF turns the output off.
   For example, sending OP 1 will turn the output on.

7. Select an Output and Output Impedance. Send the Output Select command followed by the parameter.
   Output Select Commands: OUTSELECT or OS.
   50Ω Unbalanced Output Parameter: U50 or 0.
   75Ω Unbalanced Output Parameter U75 or 1.
   600Ω Unbalanced Output Parameter: U600 or 2.
   600Ω Balanced Output Parameter: B600 or 3
   135Ω Balanced Output Parameter: B135 or 4.
   For example, sending either "OUTSELECT 0;" or "OS U50;" selects the unbalanced 50Ω output.

8. Terminate the command string. Send the EXECUTE command "EX" to terminate the command string. The Model 91 also accepts the FASTEXECUTE command (FE) which can execute the command string significantly faster than the EXECUTE command. However, FASTEXECUTE only shortens execute times when the frequency, amplitude, offset, or dc offset is changed. In addition, the string will be executed without error checking.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a 2kHz triangle wave, 1.5 Vpp at the unbalanced output with 50Ω impedance.

```
"MODE C; FU T; FR 2E3; AM 1.5; OP 1;
OS U50;EX"
```

3.5.4 Variable (Time) Symmetry

Variable symmetry allows the duty cycle of the three standard functions (sine, triangle, and square) to be varied from 5% to 95% in 1% increments (≤2MHz). Use variable symmetry with square waves to produce pulses. Use variable symmetry with triangles to produce ramps. Between 2MHz and 20 MHz, the minimum and maximum symmetry values decrease linearly to 50% at 20 MHz; see figure 3-10. For example, at 10 MHz, the symmetry range is decreased to 25% to 75%. The

symmetry of the Sync Output will track the function outputs.

3.5.4.1 Local Operation

After power on (paragraph 3.5.2), set up the Model 91 as described in paragraph 3.5.3.1.

1. Select Symmetry. Press the "SHIFT" (*31*) and "SYMMETRY" key (*7*) to display the current symmetry value.

2. Change the Symmetry. Use the Keypad (*39*) or Knob (*42*), if enabled (ENABLE indicator (*40*) lit), to change the symmetry. The Knob increments or decrements the value and automatically enters the new value. When using the Keypad, enter the actual value. Symmetry values are 5% to 90% in 1% increments unless limited by frequency; see figure 3-10.

3.5.4.2 GPIB Operation

After power on (paragraph 3.5.2), setup the Model 91 as described in paragraph 3.5.3.2. Except add the symmetry command and parameter to the command string.

Symmetry Commands: **SYMMETRY** or **SYM.**
Symmetry Parameters: values in % between 5 and 95.

Send the **EXECUTE** command "**EX**" to terminate the command string.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a 2kHz triangle wave at 75% duty cycle, 1.5 Vpp at the unbalanced output with 50Ω impedance.

```
"MODE C; FU T; FR 2E3; SYM 75;
AM 1.5; OP ON; OS U50;EX"
```

3.5.5 Phase Lock and Phase Shift

Phase lock allows an external or internal frequency source to control the accuracy and stability of the Model 91. Using the internal source (synthesizer) improves the Model 91 frequency accuracy to ± 10 ppm. Option 001 improves the accuracy to ± 1 ppm. When an external source is connected, the Model 91 measures the frequency of the source, sets its frequency to match the source, and automatically phase locks itself to the source. Also, when an external source is used, the phase of the Model 91 output can be shifted relative to the source.

The Model 91 phase lock (internal and external source) limits:

Frequency – 20 Hz to 20 MHz.
Mode – Continuous, SCM, or AM.
Symmetry – 50% duty cycle only.

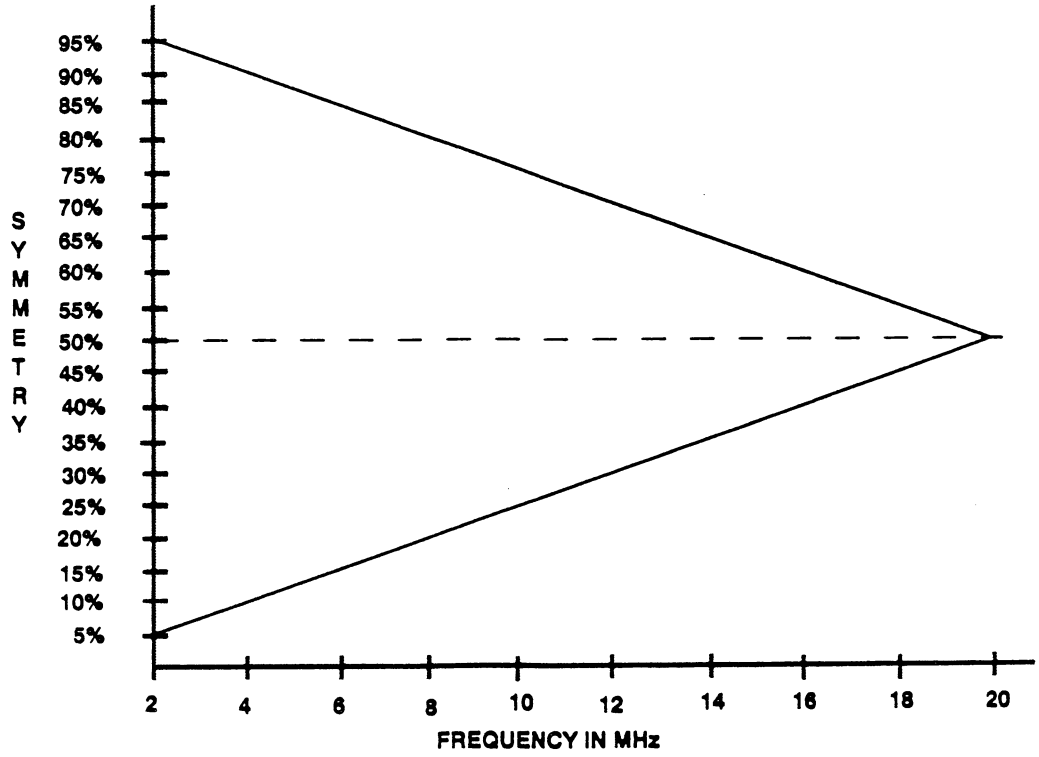


Figure 3-10. 2MHz to 20 MHz Symmetry

3.5.5.1 Internal Phase Lock

Local Operation

1. Set up the Model 91. Set up the Model 91 as described in paragraph 3.5.3.1.

2. Select the Internal Source. To select the internal source (default), press the "LOCK SOURCE" key (*11*) to display the internal reference frequency (EXLOCK OFF). Each time this key is pressed, the reference source toggles between internal and external.

3. Phase Lock Indicators. There are two front panel indicators used with phase lock: UNLOCK (*9*) and EXT (*10*).
   If the UNLOCK indicator is off, the unit is phase locked to the selected source.
   If the UNLOCK indicator is flashing, the internal synthesizer may be faulty.
   If the UNLOCK indicator is on steady, the instrument setup will not allow phase locking.
   If the EXT indicator is off, internal source is selected. If the EXT indicator is on, the external source is selected.

GPIB Operation

1. Set up the Model 91. Set up the Model 91 as described in paragraph 3.5.3.2. Except add the source command to the string.

2. Select the Phase Lock Source. To select the internal source, send the Source command followed by the parameter.
   Source Command : **LOCKSOURCE** or **LS.**
   Internal Source Parameter: **INTERNAL**, **I**, or **0**.
   The UNLOCK and EXT indicators respond the same as in local operation.
   Always terminate the string using the EXECUTE command.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a 2kHz triangle wave, 1.5 Vpp at the unbalanced output with 50Ω impedance phase locked to the internal reference. "**LSRC I**" does not need to be included because it is a default.

"**MODE C; FU T; FR 2E3; LS I; AM 1.5; OP 1; OS U50;EX**"

3.5.5.2 External Phase Lock

To set up the Model 91 for external phase lock, refer to Figure 3-11.

Local Operation

1. Set up the Model 91. Set up the Model 91 as described in paragraph 3.5.3.1.

2. Select External Source. To select the external source, press the "LOCK SOURCE" key (*11*) until the display reads EXLOCK. If the display reads EXLOCK < 20HZ, the unit does not have 1. an external signal connected to the EXT FREQ IN connector, 2. the external frequency is less than 20 Hz, 3. the external frequency is greater than 20 MHz, or 4. the setup conditions will not allow phase locking.

   If the external source is within the limits, the Model 91 displays EXLOCK XXXX where XXXX represents the external frequency. The EXT indicator also lights.

   Phase Lock Indicators. There are two front panel indicators used with phase lock: UNLOCK (*9*) and EXT (*10*).
   If the UNLOCK indicator is off, the unit is phase locked to the selected source.
   If the UNLOCK indicator is flashing, the internal reference is faulty, or the external reference is not connected.
   If the UNLOCK indicator is on steady, the instrument setup will not allow phase locking.
   If the EXT indicator is off, internal reference source is selected.
   If the EXT indicator is on, the external reference source is selected.

3. External Source. Connect the external source to the EXT FREQ IN connector (*12*). To set up the lock source level, refer to paragraph 2.4.6. The Model 91 measures the frequency of the external source (see external source limits), sets its generator to the measured frequency, and phase locks the generators together.

GPIB Operation

1. Set up the Model 91. Set up the Model 91 as described in paragraph 3.5.3.2.

2. Select the External Source. To select the external reference, send the Source command followed by the parameter.
   Source Command: **LOCKSOURCE** or **LS**
   Source Parameter: **EXTERNAL**, **E**, or **1**.
   The UNLOCK and EXT indicators respond the same as in local operation.
   Always terminate the string using the EXECUTE command.

3. External Source. Connect the external source to the EXT FREQ IN connector (*12*). The EXT

indicator also lights if the source is within the limits.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a 2kHz triangle wave, 1.5 Vpp at the unbalanced output with 50Ω impedance phase locked to a 2kHz external reference.

```
"MODE C; FU T; FR 2E3; LS E; AM 1.5;
OP 1; OS U50;EX"
```

3.5.5.3 Phase Shift

When connected to an external source, the Model 91 permits the phase of its output waveform to be shifted ±180° or ±3.14 (±π) radians relative to the external reference. See figure 3-11 for instrument setup.

Local Operation

1. Set up the Model 91. Set up the Model 91 for external phase lock as described in paragraph 3.5.5.2 - Local Operation. Use the signal at the EXT FREQ IN connector (*12*) as the phase reference.

2. Select the Phase Shift. Press the "PHASE" key (*8*) to display the current phase shift. Use the Keypad (*39*) or Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the phase. Use the "KNOB" key (*39*) to activate the Knob. The Knob increments or decrements the value and automatically enters the new value. When using the keypad, enter values as actual number (120) or exponential notation (12E1), press the "ENTER" key to accept the new value.

3. Selecting Alternate Units. Model 91 allows the phase shift in degrees or radians. Press the "SHIFT" key (*31*) and then the Phase's "UNITS" key (*8*) to step between degrees (°) and radians. After the "SHIFT–UNITS" key combination the Knob may be used to toggle between the units.

GPIB Operation

1. Set up the Model 91. Set up the Model 91 for external phase lock as described in paragraph 3.5.5.2 GPIB Operation. Use the signal at the EXT FREQ IN connector (*12*) as the phase reference.

2. Select the Phase Shift. Send the phase shift command followed by the parameter.
   Phase Shift Commands: `PHASE` or `PH`.
   Phase Shift Parameters: Values in degrees between −180 and +180. Values can be entered in any format. For example 120° can be entered as 120, 1.2E2, 12E1, etc.
   For example, sending either "`PHASE −120;`" or "`PH −12E1;`" selects −120° phase shift.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a 2kHz triangle wave, 1.5 Vpp at the unbalanced output with 50Ω impedance phase locked to a 2kHz external reference. Phase shift is −120°

```
"MODE C; FU T; FR 2E3; LS E; PH −
12E1; AM 1.5; OP 1; OS U50;EX"
```

3.5.7 Triggered Mode

In the triggered mode, the Model 91 output remains quiescent until triggered by a trigger source. All functions can be triggered. When triggered, the Model 91 produces one complete waveform and returns to the quiescent state. The Model 91 can be triggered from an external source such as a signal at the TRIG IN connector (*C*), the front panel "MAN TRIG" key, or a GPIB command. In addition, the unit can be triggered using its own internal synthesizer as a trigger source. For proper operation, the trigger source frequency must be less than the output frequency.

3.5.7.1 Internal Trigger

Local Operation

After power on (paragraph 3.5.2), use the following

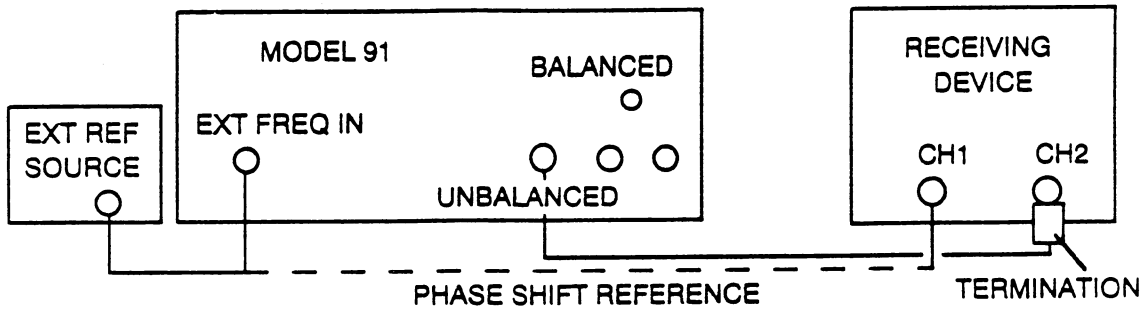


Figure 3-11. External Phase Lock Setup

steps to set up the Model 91 for triggered waveform output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the triggered mode (TRIG indicator lit (*23*)).
   To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the triggermode.

2. Select the Internal Trigger. Use the "TRIG SETUP" key (*24*) to step to trigger source (TRIG SOURCE). Then, use the Knob to select TRIG SOURCE INT. Or, press the "0" and "ENTER" keys.

3. Set the Trigger Frequency. Press the "TRIG FREQ" key (*27*) to display the current internal frequency. Use the Knob (*41*) or the Keypad (*39*) to change the trigger frequency. Use the KNOB key (*39*) to activate the Knob. The Knob automatically enters the new trigger frequency. When using the Keypad, press the "ENTER" key to accept the new trigger frequency. Internal trigger frequency range is 1mHz to 50 MHz or 1000s to 0.0002 ms. Press "SHIFT" (*31*) and the Trigger Frequency's "UNITS" (*27*) keys to alternate between frequency (TFREQ) and period (TPER). After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1. If variable symmetry waveform is selected, refer to paragraph 3.5.4.1.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for triggered output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the triggered parameter.
   Mode Commands: `MODE` or `MO`.
   Triggered Parameters: `TRIGGER`, `T`, or `1`.
   The commands and parameters can be mixed; "`MODE TRIGGER;`", "`MO 1;`", "`MODE T;`", or "`MO T;`" will select the triggered mode.

2. Select the Internal Trigger Source. Send the Trigger Source command and Internal parameter to select the internal trigger source.
   Source Command: `TRIGSOURCE` or `TSO`.
   Internal Source Parameter: `INTERNAL`, `I`, or `0`.
   For example send "`TSO 0;`" to select the internal trigger source.

3. Select the Internal Trigger Frequency. Send the internal trigger frequency command followed by its parameter.
   Internal Trigger Frequency Command: `TRIGGERFREQ` or `TF`.
   Internal Trigger Frequency Parameters: Values in Hz between 1E-3 and 50E6.
   Values can be entered in any format. For example 2kHz can be entered as 2000, 2E3, 20E2, etc.
   For example sending either "`TRIGGERFREQ 1E6;`" or "`TF 1000000;`" will select a 1MHz internal trigger frequency.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2.
   Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 to produce a single 2kHz, 1.5 Vpp triangle waveform which is triggered by the internal 100 Hz trigger source. The output is the unbalanced 50Ω output .

```
"MODE T; TSO 0; TF 1E2; FU T; FR 2E3;
AM 1.5; OP 1; OS U50;EX"
```

3.5.7.2 External Trigger

Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for an externally triggered waveform output. Figure 3-12 illustrates external trigger parameters.

1. Select the Mode. Use the "MODE" key (*22*) to step to the triggered mode (TRIG indicator lit (*23*)).

To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the External Trigger. Use the "TRIG SETUP" key (*24*) to step to SOURCE. Then, use the Knob to select SOURCE EXT (1). Also, the external source can be selected by pressing the "1" and "ENTER" keys

3. Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*). Press the "TRIG SETUP" key (*24*) until SLOPE appears, and use the Knob to select either SLOPE POS (0) (positive slope) or SLOPE NEG (0) (negative slope). Also, the slope can be selected via the Keypad by pressing either "0" key for positive slope or "1" key for negative slope. Press the "ENTER" key when finished.

   Next, press the "TRIG SETUP" key (*24*) until TRIG LEVEL appears, and use the Knob to set the trigger level (-5V to 5V); also see the "KNOB" key (*39*). Also, the Keypad can be used to enter trigger levels. To read the frequency of the external source, press the "TRIG FREQ" key (*27*).

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, and square waveforms are selected, set up the Model 91 the same as described in paragraph 3.5.3.1. If variable symmetry waveform is selected, refer to paragraph 3.5.4.1.

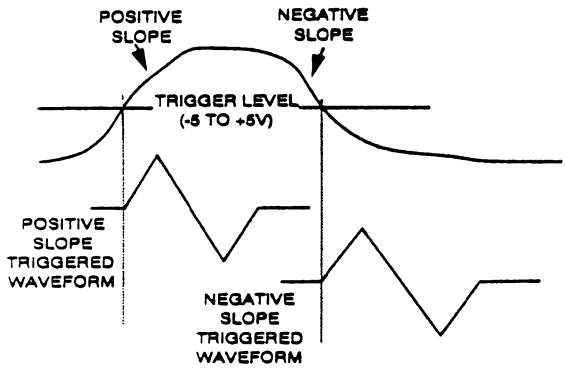


Figure 3-12. Trigger Parameters

Manual Trigger To use the "MAN TRIG" key (*25*) as a trigger source, first press the "TRIG SETUP" key (*24*) until SOURCE appears, and then use the Knob to select TRIG SOURCE MAN. Also, manual trigger can be selected by pressing the "2" and "ENTER" keys. Then use the "MAN TRIG" key to trigger the generator. When the key is pressed, the Model 91 produces one complete cycle of the selected waveform.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for triggered waveform output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the trigger parameter.
   Mode Commands: `MODE` or `MO`.
   Continuous Parameters: `TRIGGER`, `T`, or `1`.
   The commands and parameters can be mixed; "`MODE TRIGGER;`", "`MO 1;`", "`MODE T;`", or "`MO T;`" will select the triggered mode.

2. Select the External Trigger Source. Send the Source command and parameter to select the external trigger source.
   Source Command: `TRIGSOURCE` or `TSO`.
   External Trigger Source Parameter: `EXTERNAL`, `E`, or `1`.
   For example, send "`TSO 1;`" to select the external trigger source.

3. Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*).
   To set up the trigger slope, send the trigger slope command and parameter.
   Trigger Slope Command: `TRIGSLOPE` or `TSL`.
   Slope parameters: `NEGATIVE`, `N`, or `1` for negative going slope.
   `POSITIVE`, `P`, or `0` for positive going slope.
   To set up the trigger level, send the level command followed by its parameter.
   Trigger Level Command: `TRIGLEVEL` or `TV`.
   Trigger Level Parameter: a value between -5 and 5.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, and square waveforms are selected, set up the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2.
   Always terminate the string with the EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 to produce a single 2kHz, 1.5 Vpp triangle waveform which is triggered from an external source. The output is from the unbalanced output with 50Ω impedance.

```
"MODE T;TSO 1;TSL P;TV 1.5;FU T;FR
2E3;AM 1.5;OP 1;OS U50;EX"
```

Triggering with GPIB Commands. To trigger the Model 91 over the GPIB, send the following command:

Trigger Command: **TRIGGER** or **TGG**.

Trigger with Manual Trigger. To use the MAN TRIG key (*25*), it must first be selected by sending the trigger source command followed by the manual trigger command.

Trigger Source Command: **TRIGSOURCE** or **TSO**.

Manual Trigger Parameter: **MANUAL**, **M**, or **2**.

3.5.8 Gated Mode

The gated mode is identical to the triggered mode, except the output from the Model 91 supplies continuous waveforms as long as the "trigger" is true. All waveforms can be gated. When gated, the Model 91 starts from the quiescent state, produces continuous waveforms, and returns to the quiescent state. The last cycle started will always be completed. Either the internal (synthesizer) or external trigger source gates the generator. The Model 91 externally gates using a signal at the TRIG IN connector, the front panel MAN TRIG key, or a GPIB command. For proper operation, the trigger source frequency must be less than the output.

3.5.8.1 Internal Gate

In the internal gate mode, the Model 91 uses its internal trigger source to gate the generator. The gate on to gate off ratio while using the internal source is 1:1 (50%).

Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for gated waveform output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the gated mode (GATE indicator lit (*23*)). To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the Internal Trigger Source (Gate). Use the "TRIG SETUP" key (*24*) to step to SOURCE, and then use the Knob to select SOURCE INT (0). The internal source can be selected via the Keypad by pressing the the "0" and "ENTER keys.

3. Set the Gate Frequency. Use the "TRIG FREQ" key (*27*) to display the currently selected internal frequency. Use the Knob (*41*) or the Keypad (*39*) to change the trigger frequency. Use the KNOB key (*39*) to activate the Knob. The Knob automatically enters the new gate frequency. When using the Keypad, press the "ENTER" key (*39*)to accept the new gate frequency. Internal gate frequency range is 1mHz to 50 MHz or 1000s to 0.0002 ms. Press the "SHIFT" (*31*) and then the Trigger Frequency's "UNITS" (*27*) keys to alternate between frequency (TFREQ) and period (TPER). After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, and square waveforms are selected, set up the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for gated output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the gate parameter.

   Mode Commands: **MODE** or **MO**

   Gated Parameters: **GATE**, **G**, or **2**.

   The commands and parameters can be mixed; "**MODE GATE;**", "**MO 2;**", "**MODE G;**", or "**MO G;**" will select the gated mode.

2. Select the Internal Gate Source. Send the Source command and parameter to select the internal source.

   Source Command: **TRIGSOURCE** or **TSO**.

   Internal Source Parameter: **INTERNAL**, **I**, or **0**.

   For example send "**TSO 0;**" to select the internal source.

3. Select the Internal Trigger Frequency. Send the internal trigger frequency command followed by its parameter.

   Internal Trigger Frequency Command: **TRIGGERFREQ** or **TF**.

   Internal Trigger Frequency Parameters: Values in Hz between 1E-3 and 50E6.

Values can be entered in any format. For example 2kHz can be entered as 2000, 2E3, 20E2, etc.

For example sending either "`TRIGGERFREQ 1E6;`" or "`TF 1000000;`" will select a 1MHz internal trigger frequency.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a single 2kHz, 1.5 Vpp triangle waveform which is triggered by the internal trigger source at a 100 Hz rate. The output is from the unbalanced output with 50Ω impedance.

"`MODE G;TSO 0;TF 1E2;FU T;FR 2E3;AM 1.5; OP 1;OS U50;EX`"

3.5.8.2 External Gate

In the externally gated mode, either an external triggering signal, a manual trigger, or a GPIB command gates the generator. The gate-on to gate-off time depends on the Model 91 trigger slope and level. Figure 3-13 illustrates external gate parameters. This figure illustrates the positive slope as the trigger slope; the negative slope also can be used to enable the gate.

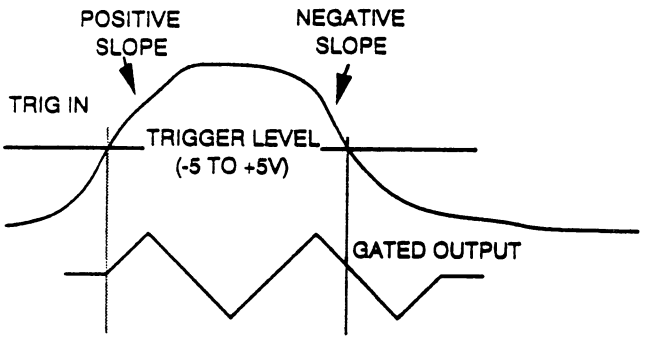


Figure 3-13. Gate Parameters

Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for gated waveform output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the gated mode (GATE indicator lit (*23*)).

   To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. To select the mode, release the "MODE" key when the gate indicator lights.

2. Select the External Gate Source. Use the "TRIG SETUP" key (*24*) to step to trigger source (SOURCE displayed). Then, use the Knob to select SOURCE EXTv (1). External trigger source also can be selected by pressing the "1" and "ENTER" keys.

3. Connect the External Gate (Trigger) Source. Connect the external gate source to the TRIG IN connector (*C*). Press the "TRIG SETUP" key (*24*) until SLOPE appears, and use the Knob to select either SLOPE POS (0) (positive slope) or SLOPE NEG (1)(negative slope). Also, the slope can be selected via the Keypad by pressing the "1" key (negative) or "0" key (positive) followed by the "ENTER" key.

   Next, press the "TRIG SETUP" key (*24*) until TRIG LEVEL appears, and use the Knob or keypad to set the trigger level (-5V to 5V).

   To read the frequency of the external source, press the "TRIG FREQ" key (*27*).

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

Manual Trigger To use the "MAN TRIG" key (*25*) as a gate source, first press the "TRIG SETUP" key until SOURCE appears, and then use the Knob to select SOURCE MAN (2). When the "MAN TRIG" key is pressed in, the Model 91 produces a continuous output until the key is released.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for triggered waveform output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the gate parameter.

   Mode Commands: `MODE` or `MO`.

   Gate Parameters: `GATE`, `G`, or `2`.

   The commands and parameters can be mixed: "`MODE GATE;`", "`MO 2;`", "`MODE G;`", or "`MO G;`" will select the triggered mode.

2. Select the External Source. Send the Source command and parameter to select the gate (trigger) source.

Source Command: **TRIGSOURCE** or **TSO**.
External Source Parameter: **EXTERNAL**, **E**, or **1**.

For example, send "**TSO 1;**" to select the external trigger source.

3. Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*).
To set up the trigger slope, send the trigger slope command and parameter.
Trigger Slope Command: **TRIGSLOPE** or **TSL**.
Slope parameters: **NEGATIVE**, **N**, or **1** for negative going slope.
POSITIVE, **P**, or **0** for positive going slope.
To set up the trigger level, send the level command followed by its parameter.
Trigger Level Command: **TRIGLEVEL** or **TV**.
Trigger Level Parameter: a value between -5 and 5.

4. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2. Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 to produce a gated 2kHz, 1.5 Vpp triangle waveform which is triggered by an external source. The output is from the unbalanced output with 50Ω impedance.

```
"MODE G; TSO 1;TSL 0;TV 1;FU T; FR
2E3; AM 1.5; OP 1; OS U50;EX"
```

Gating with GPIB Commands The Model 91 generates waveforms starting with the gate on command and ending with the gate off command. To Gate the Model 91 over the GPIB send the following commands:

Gate On Command: **GATEON** or **GN**.
Gate Off Command: **GATEOFF** or **GF**.

Gate with Manual Trigger. To use the "MAN TRIG" key (*25*), it must first be selected by sending the trigger source command followed by the manual trigger command. After manual trigger is selected, the Model 91 gates on and off as the Man Trig key is pressed in and released.

Trigger Source Command: **TRIGSOURCE** or **TSO**.
Manual Trigger Parameter: **MANUAL**, **M**, or **2**.

3.5.9 Burst Mode

The burst mode is identical to the gated mode except the Model 91 produces a user-defined number of cycles when triggered. In the burst mode, the Model 91 generates from 1 to 1,000,000 cycles. The Model 91 allows either the internal (synthesizer) or external trigger source to start the burst. External trigger sources can be the TRIG IN connector, the "MAN TRIG" key, or a GPIB command.

3.5.9.1 Internal Triggered Bursts

In the internally triggered burst mode, the Model 91 uses its internal synthesizer to trigger the generator.

Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for triggered waveform output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the burst mode (BURST indicator lit (*23*)).
To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the Internal Trigger. Use the "TRIG SETUP" key (*24*) to step to SOURCE, and then use the Knob to select SOURCE INT (0). Also, the internal source can be selected by pressing the "0" and "ENTER" keys.

3. Set the Trigger Frequency. Use the "TRIG FREQ" key (*27*) to display the currently selected internal frequency. Use the Knob (*41*) or the Keypad (*39*) to change the trigger frequency. The Knob automatically enter the new trigger frequency. When using the keypad, press the ENTER key to accept the new trigger frequency. Internal trigger frequency range is 1mHz to 20 MHz or 1000s to 0.0005 ms. Press "SHIFT" key (*31*) and then the Trigger Frequency's "UNITS" key (*27*) to alternate between frequency (TFRQ) and period (TPER). After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

4. Enter the Burst Count. Press the "SHIFT" (*31*) and "BURST COUNT" (*24*) keys to display the currently selected burst count. Use the Knob (*41*) or Keypad (*39*) to change the burst count. The Knob automatically enters the new value. When using the keypad, press the "ENTER" key to accept the new value. Burst count values range from 1 to 1,000,000 cycles.

5. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the

same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to setup the Model 91 for a waveform burst output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the burst parameter.
   Mode Commands: `MODE` or `MO`
   Burst Parameters: `BURST`, `B`, or `3`.
   The commands and parameters can be mixed; "`MODE BURST;`", "`MO 3;`", "`MODE B;`", or "`MO B;`" will select the burst mode.

2. Select the Internal Trigger Source. Send the trigger source command and its parameter to select the internal trigger source.
   Source Command: `TRIGSOURCE` or `TSO`.
   Internal Source Parameter: `INTERNAL`, `I`, or `0`.
   For example send "`TSO 0;`" to select the internal source.

3. Select the Internal Trigger Frequency. Send the internal trigger frequency command followed by its parameter.
   Internal Trigger Frequency Command: `TRIGGERFREQ` or `TF`.
   Internal Trigger Frequency Parameters: Values in Hz between 1E-3 and 50E6.
   Values can be entered in any format. For example 2kHz can be entered as 2000, 2E3, 20E2, etc.
   For example sending either "`TRIGGERFREQ 1E6;`" or "`TF 1000000;`" will select a 1MHz internal trigger frequency.

4. Enter the Burst Count. Send the burst count command and its parameter to enter the burst count.
   Burst Count Command: `BURSTCOUNT` or `B`.
   Burst count Parameter: 1 to 1E6.

5. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2. Always terminate the string with the EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 to produce a burst of ten 2kHz, 1.5 Vpp triangle waveforms which are triggered by the Model 91 internal synthesizer at a 1Hz rate. The output is from the unbalanced output with 50Ω impedance.

```
"MODE B;B 10;TSO 0;TF 1E0;FU T;FR
2E3;AM 1.5;OP 1;OS U50;EX"
```

3.5.9.2 External Triggered Bursts

In the external triggered burst mode, either an external triggering signal, a manual trigger, or a GPIB command gates the generator.

Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for triggered waveform output.

1. Select the Mode. Use the "MODE" key (*22*) to step to the burst mode (BURST indicator lit (*23*)). To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the External Trigger. Use the "TRIG SETUP" key (*24*) to step to SOURCE. Then use the Knob to select SOURCE EXT(0). The external source can also be selected by pressing the "1" and "ENTER" keys.

3. Connect the External Trigger Source. Connect the external triggering source to the TRIG IN connector (*C*). Press the "TRIG SETUP" key (*24*) until SLOPE appears, and use the Knob to select either SLOPE POS (0) (positive slope) or SLOPE NEG (1) (negative slope). Also, the slope can be selected using the keypad; press "0" key (positive slope) or "1" key (negative slope) and the "ENTER" key.

   Next, press the "TRIG SETUP" key (*24*) until TRIG LEVEL appears, and use the Knob to set the trigger level (-5V to 5V). To read the frequency of the external source, press the "TRIG FREQ" key (*27*).

4. Enter the Burst Count. Press "SHIFT" (*31*) and "BURST COUNT" (*24*)keys to display the current burst count. Use the Knob (*41*) or Keypad to change the burst count. The Knob automatically enters the new value. When using the keypad, press the "ENTER" key (*39*) to accept the new value (1 to 1000000).

5. Setup the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

Manual Trigger. To use the "MAN TRIG" key as a burst trigger source, first press the "TRIG SETUP" key until SOURCE appears, and then use the Knob to select SOURCE MAN (2). The manual trigger source can also be selected by pressing the "2" and "ENTER" keys. When the "MAN TRIG" key is pressed, the Model 91 begins the burst count.

GPIB Operation

After instrument setup (paragraph 3.5.1) and power on (paragraph 3.5.2), use the following steps to set up the Model 91 for burst output. The examples shown are terminated with a semicolon (;) which indicates the command is part of a string. If only the one command is sent to the Model 91, replace the semicolon with EXECUTE or EX.

1. Select the Mode. Send the Mode command followed by the burst parameter.
   Mode Commands: `MODE` or `MO`
   Burst Parameters: `BURST`, `B`, or `3`.
   The commands and parameters can be mixed; "`MODE BURST;`", "`MO 3;`", "`MODE B;`", or "`MO B;`" will select the burst mode.

2. Select the External Trigger Source. Send the Source command and parameter to select the external source.
   Source Command: `TRIGSOURCE` or `TSO`.
   External Source Parameter: `EXTERNAL`, `E`, or `1`.
   For example, send "`TSO 1;`" to select the external trigger source.

3. Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*). To set up the trigger slope, send the trigger slope command and parameter.
   Trigger Slope Command: `TRIGSLOPE` or `TSL`.
   Slope parameters: `NEGATIVE`, `N`, or `1` for negative going slope.
   `POSITIVE`, `P`, or `0` for positive going slope.
   To set up the trigger level, send the level command followed by its parameter.
   Trigger Level Command: `TRIGLEVEL` or `TV`.
   Trigger Level Parameter: a value between -5 and 5.

4. Enter the Burst Count. Send the burst count command followed by the burst parameter.
   Burst Count Command: `BURSTCOUNT` or `B`.
   Burst count Parameter: 1 to 1E6.

5. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.2.

Example

The following example uses a GPIB command string to setup the Model 91 to produce a burst of ten 2kHz, 1.5 Vpp triangle waveforms which are triggered by an external trigger source. The output is from the unbalanced output with 50Ω impedance.

```
"MODE B;B 10;TSO 1;TSL P;TV 1;FU T;FR
2E3;AM 1.5;OP 1;OS U50;EX"
```

Triggering with GPIB Commands. To trigger the Model 91 over the GPIB, send the following command:
Trigger Command: `TRIGGER` or `TGG`.

Bursts with Manual Trigger. To use the "MAN TRIG" key (*25*), it must first be selected by sending the trigger source command followed by the manual trigger command. After manual trigger is selected, the Model 91 gates on and off as the "MAN TRIG" key is pressed in and released.
Trigger Source Command: `TRIGSOURCE` or `TSO`.
Manual Trigger Parameter: `MANUAL`, `M`, or `2`.

3.5.10 Amplitude Modulation

In Amplitude Modulation (AM), a modulating signal controls the magnitude of the Model 91 output. The Model 91 (AM selected) produces the carrier (frequency, function, and amplitude). All waveforms can be amplitude modulated. In the AM mode, minimum carrier frequency is 0.1 Hz. When the AM mode is selected (Local Operation), the unit shows a scale factor (x.xV= FS) which represents the peak to peak voltage required to produce full scale (100%) modulation. The scale factor displayed depends on the Amplitude value. For example, for an amplitude of 7.5Vpp, the AM scale factor will be 4V=F.S. (100%). Also the input value varies linearly which means for a 4V=F.S. scale factor a 2Vpp input signal produces 50% modulation. Exceeding 100% modulation can cause distorted outputs. In AM, the continuous Amplitude is limited to 7.5 Vpp or less. Figure 3-14 illustrates the Model 91 AM setup.

3.5.10.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for amplitude modulation.

1. Select the Mode. Press the "MODE" key (*22*) to step to the AM mode (AM indicator lit (*23*)). To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE"

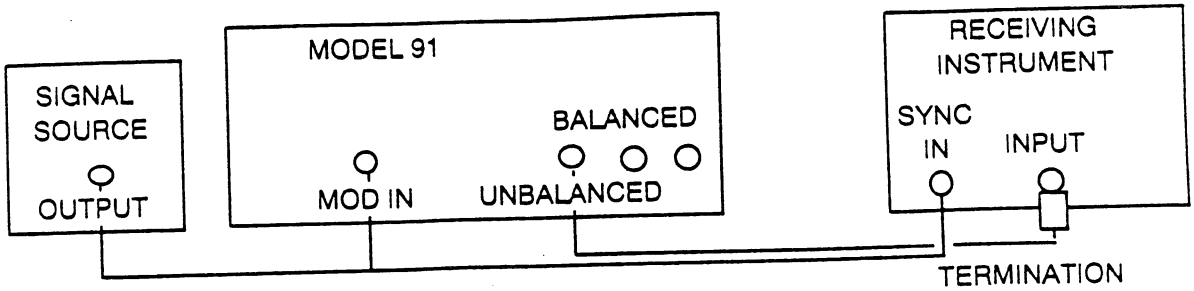


Figure 3-14. Model 91 AM and FM/VCG Setup

key. Release the "MODE" key when the indicator lights to select the mode. If the Amplitude is greater than 7.5V, the AM mode cannot be selected.

2. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the the Model 91 the same as described in paragraph 3.5.3.1. Minimum frequency is 0.1 Hz. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

3. Connect the Modulating Signal. Connect the modulating signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 150 kHz, and amplitude range is 0 to 4Vpp. The modulation depth is directly proportional to the modulation signal amplitude. The AM scale factor is shown on the display when MODE: AM is selected. When the Amplitude is changed, MODE: AM must be selected again to view the new scale factor.

3.5.10.2 GPIB Operation

1. Select the Mode. Send the Mode command followed by the AM parameter.
   Mode Commands: **MODE** or **MO**
   AM Parameter: **AM**, **A**, or **4**.
   The commands and parameters can be mixed; "**MODE AM;**", "**MO 4;**", "**MODE A;**", or "**MO A;**" will select the AM mode.

2. Set up the Function, Frequency, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveform is selected, refer to paragraph 3.5.4.2. To select the AM mode, the amplitude must be less than 7.5Vpp.

3. Connect the Modulating Signal. Connect the modulating signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 150 kHz, and amplitude range is 0 to 4Vpp. The amount of modulation depends on the "scale factor". There is no way to view the scale factor via the GPIB. For more information on scale factor, see the AM paragraph introduction and paragraph 3.5.10.1.

Example

The following example uses a GPIB command string to setup the Model 91 for the AM mode. In this example it is assumed a 10 kHz sine wave of 4Vpp is connected to the MOD IN connector. The Model 91 is set up for 1MHz sine wave and the peak to peak amplitude at 100% modulation. The output is from the unbalanced output with 50Ω impedance.

```
"MODE A; FU SI; FR 1E6; AM 7.5; OP 1; OS
U50;EX"
```

3.5.11 Suppressed Carrier Modulation

In the Suppressed Carrier Modulation mode (SCM), the Model 91 operates much the same as the AM mode, except unmodulated output level will be zero volts. In Suppressed Carrier Modulation (SCM), a modulating signal controls the magnitude of the Model 91's output. The Model 91 (SCM selected) produces the carrier (frequency, function, and amplitude). In the SCM mode, minimum frequency is 0.1 Hz. All waveforms can be modulated. When the SCM mode is selected (Local Operation), the unit shows a scale factor (2V/V) which represents Volts Output/Volts Input for required to produce an output. For example, the 2V/V scale factor means a 1V input will produce a 2V output. Figure 3-12 illustrates the Model 91 SCM setup.

3.5.11.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for suppressed carrier modulation.

1. Set up the Function, Frequency Offset, and Output. If sine, triangle, or square waveform is selected, set up the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, refer to paragraph 3.5.4.1.

2. Select the SCM Mode. Use the "MODE" key (*22*) to step until the unit displays MODE SCM (SCM indicator lit (*23*)). The display also shows the SCM Scale Factor. To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

3. Select the SCM Scale Factor. When the SCM is selected, the Model 91 displays a scale factor. There are three possible scale factors: 2.4V/V, 0.24V/V, and 0.024V/V (Output Vpp/ Input Vpp). Change the scale factors by using the Knob.

4. Null the Carrier. During AutoCal the Model 91 calculates the carrier null values. These values will be used in the SCM mode unless the operator needs to improve the carrier null.

   To improve carrier null, connect a scope or spectrum analyzer to the Model 91. Press the "AMPLITUDE" key (*5*) and the display shows SCM NULL 00. Rotate the Knob or press the Keypad (*39*) to change the carrier null. Null can be varied between ±500 digits.

5 Connect the Modulating Signal. Connect the modulating signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 1MHz and amplitude range is 0 to 4Vpp. The magnitude of the output is directly proportional to the modulating signal's amplitude.

3.5.11.2 GPIB Operation

1. Set up the Function, Frequency, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveform is selected, refer to paragraph 3.5.4.2.

2. Select the SCM Mode. Send the Mode command followed by the SCM parameter.
   Mode Commands: `MODE` or `MO`.
   SCM Parameter: `SC` or `5`.
   The commands and parameters can be mixed; "`MODE SC;`", "`MO 5;`", "`MODE SC;`", or "`MO SC;`" will select the suppressed carrier mode.

3. Connect the Modulating Signal. Connect the modulating signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 100 kHz, and amplitude range is 0 to 4Vpp. The modulation depth is directly proportional to the modulation signal's amplitude. The SCM scale factor is fixed at 2V/V when using GPIB commands.

Example

The following example uses a GPIB command string to setup the Model 91 for the SCM mode. In this example it is assumed a 10 kHz sine wave of 4Vpp is connected to the MOD IN connector. The Model 91 is set up for 1MHz sine wave and the peak to peak amplitude at full modulation will be 1.5Vpp. The output is from the unbalanced output with 50Ω impedance.

```
"MODE 5; FU SI; FR 1E6; AM 1.5; OP 1;
OS U50;EX"
```

3.5.12 Frequency Modulation

In the FM mode, an external signal varies the frequency of the Model 91 about its programmed frequency. The magnitude of the modulating signal determines the maximum frequency deviation, and the frequency of the modulating signal determines the rate of deviation. Figure 3-15 illustrates Model 91 FM setup.

The following steps describe the general FM mode setup.

1. Set the Model 91 to the Continuous mode.

2. Calculate upper and lower modulation frequency limits:
   Upper Limit = Center Frequency + Peak Deviation
   Lower Limits = Center Frequency – Peak Deviation
   Where:
   Upper Limit is the upper modulation limit required.
   Lower Limit is the lower modulation limit required.
   Center Frequency is the desired center frequency (set using the "FREQ/ PER" key (*4*).
   Peak Deviation is desired positive or negative deviation.
   Example:
   Desired Center Frequency = 200 kHz.
   Peak Deviation = ±25 kHz.
   Upper Limit = 200 kHz + 25 kHz
   = 225 kHz

Lower Limit = 200 kHz – 25 kHz
= 175 kHz

3. Using table 3-12, find and record the range number that contains the calculated upper limit. Also, verify that range contains the calculated lower limit.

Example

Range number 8 contains the calculated upper limit of 225 kHz, and the range also contains the calculated lower limit.

Exceeding the Lower Limit will cause output signal distortion.

Table 3-12. Range and Modulation Limits

Range No.	Mod Upper Limit Range	Mod Low Limit	Deviation per Volt
9	2.01 to 20 MHz	20 kHz	2MHz
8	201 kHz to 2.0 MHz	2.0 kHz	200 kHz
7	20.1 to 200 kHz	200 Hz	20 kHz
6	2.01 to 20 kHz	20 Hz	2kHz
5	201 Hz to 2kHz	2Hz	200 Hz
4	20.1 to 200 Hz	200 mHz	20 Hz
3	2.01 to 20 Hz	20 mHz	2Hz
2	200 mHz to 2Hz	2mHz	200 mHz
1	20 to 200 mHz	2mHz	20 mHz
0	2 to 20 mHz	2mHz	2mHz

4. Calculate the modulation source amplitude (Vpp):
Modulation Amplitude = P-P Deviation ÷ Deviation per Volt
Where:
Modulation Amplitude is the amplitude (Vpp) of the modulating source.
P-P Deviation is the total positive and negative deviation.
Deviation per Volt (see table 3-12) is the Hz/V of the range selected in step 3.

Example:
P-P Deviation = 50 kHz (+ and – 25 kHz)
Deviation per Volt from table 3-12 for range 8 = 200 kHz per Volt.
Modulation Amplitude = 50 kHz ÷ 200 kHz/V = 0.25 Vpp.

5. Set the Model 91 to the upper limit frequency (step 2).

6. Set the Model 91 to the FM mode.

7. Set the Model 91 to the center frequency.

8. Connect the Modulating signal.

3.5.12.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for frequency modulation.

1. Select the Mode. Use the "MODE" key (*22*) to step to the CONT mode (CONT indicator lit (*23*)). To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the continuous indicator lights.

2. Calculate the limits. Use step 2 in paragraph 3.5.12. to calculate the upper and lower frequency limits.

3. Select the Upper frequency limit. Press the "FREQ/PER" key (*4*) to display the current frequency. Use the Keypad (*39*) or Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to set up the upper limit frequency; see paragraph 3.5.3.1. Use the "KNOB" key (*39*) to activate the Knob. The Knob increments or decrements the value and automatically enters the new value. When using the keypad, enter values as actual number (120) or exponential notation

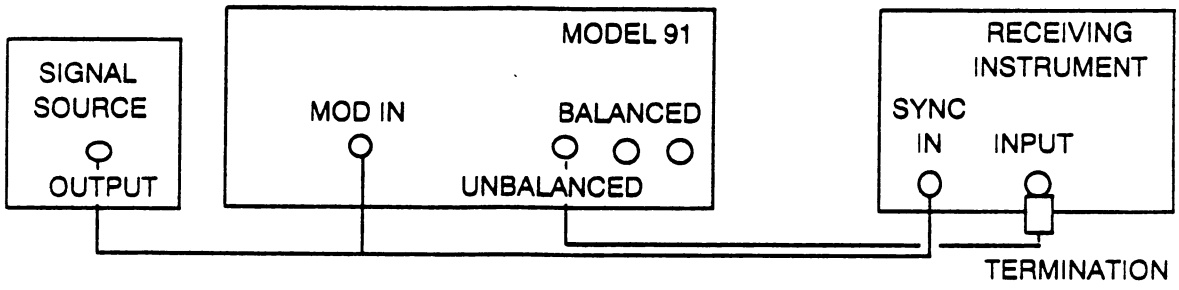


Figure 3-15. Model 91 FM Setup

(12E1), press the "ENTER" key to accept the new value.

4. Change the Mode. Use the "MODE" key (*22*) to step to the FM mode (FM indicator lit (*23*)). This "locks" the Model 91 to the fixed frequency range.

5. Select the Center frequency. Press the "FREQ/PER" key (*4*) again, and use the Knob or Keypad to set up the center frequency; see paragraph 3.5.3.1.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the the Model 91 the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, also refer to paragraph 3.5.4.1. The dc function is not allowed in the FM mode.

7. Calculate the Amplitude of the Modulating Signal. Use step 4 (paragraph 3.5.12) to calculate the peak to peak voltage required to modulate the Model 91.

8. Connect the Modulating Signal. Set the modulating source to the level calculated in item 7, and connect the signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 100 kHz, and the maximum level is 10 Vpp.

3.5.12.2 GPIB Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for Mode: Continuous.

1. Calculate the limits. Use step 2 in paragraph 3.5.12. to calculate the upper and lower frequency limits.

2. Select the Upper frequency limit. Send the Frequency command followed by the parameter.
   Frequency Commands: `FREQUENCY` or `FR`.
   Parameters: Values in Hz between 1E-3 and 20E6. Values can be entered in any format.
   For example 2kHz can be entered as 2000, 2E3, 20E2, etc.
   For example, sending either "`FREQUENCY 1E6;`" or "`FR 1000000;`" will select 1MHz.

3. Select the Mode. Send the Mode command followed by the FM parameter.
   Mode Commands: `MODE` or `MO`.
   FM Parameter: `F` or `6`.

4. Lock the Frequency Range. Send the Range Lock command followed by its parameter.
   Range Lock Command: `RANGELOCK` or `RA`.
   Range Lock Parameter: `ON` or `1`.
   NOTE: Range Lock should be turned off when finished with the FM mode: `RA 0`.

5. Select the Center frequency. Send the Frequency command followed by the parameter.
   Frequency Commands: `FREQUENCY` or `FR`.
   Parameters: Values in Hz between 1E-3 and 20E6.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. If variable symmetry waveforms are selected, also refer to paragraph 3.5.4.2. The dc function is meaningless in the FM mode.

7. Calculate the Amplitude of the Modulating Signal. Use step 4 of paragraph 3.5.12 to calculate the peak to peak voltage required to modulate the Model 91.

8. Connect the Modulating Signal. Set the modulating source to the level calculated in item 7, and then connect the modulating signal to the MOD IN connector (*30*). Frequency range of the modulating signal is dc to 100 kHz and the maximum level is 10 Vpp. Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to setup the Model 91 for the FM mode. In this example, the output will be a 1.5 Vpp sine wave from the 50Ω unbalanced output. To modulate the generator connect a 0.25 Vpp signal to the MOD IN/OUT connector.

```
"MODE C;FR 2E5;RA 1;MODE F;FR 1E5;FU
SI;AM 1.5;OP 1;OS U50;EX"
```

3.5.13 Voltage Controlled Generator – VCG

VCG operation is identical to the FM mode except the Model 91's set frequency becomes the start frequency. In this mode, the voltage applied to the MOD IN connector controls the frequency of the generator. Usually the modulating signal is a dc voltage between 0 and ±10V. Maximum generator frequency change is 1000:1.

The following steps generally describe the steps to setup the VCG operation.

1. Set the Model 91 to the Continuous mode.
2. Calculate upper and lower modulation frequency limits:
   Upper Limit = Initial Frequency + Frequency Change
   Lower Limits = Initial Frequency – Frequency Change
   Where:
   Upper Limit is the upper modulation limit required.
   Lower Limit is the lower modulation limit required.
   Initial Frequency is the starting frequency (set using the "FREQ/PER" key (*4*).
   Frequency Change is desired positive or negative frequency change.
   Example:
   Desired Center Frequency = 200 kHz.
   Frequency Change =(+25 kHz) and (-10 kHz)
   Upper Limit = 200 kHz + 25 kHz = 225 kHz
   Lower Limit = 200 kHz – 10 kHz = 190 kHz
3. Using table 3-12, find the range number that contains the calculated upper limit. Also, verify that range contains the calculated lower limit.
   Example:
   Range number 8 contains the calculated upper limit of 225 kHz, and the range also contains the calculated lower limit 190 kHz.
   Exceeding the Lower Limit will cause output signal distortion.
4. Calculate the level of the external dc source:
   VCG Voltage = Frequency Change ÷ Deviation per Volt
   Where:
   VCG Voltage is the external dc source voltage (±Vdc).
   Frequency Change is the positive or negative frequency change.
   Deviation per Volt (see table 3-12) is the Hz/V of the range selected in step 3.
   Example:
   Frequency Change = +25 kHz and -10 kHz
   Deviation per Volt from table 3-12 for range 8 = 200 kHz per Volt.
   VCG Voltage = +25 kHz ÷ 200 kHz/V = +0.125 Vdc
   VCG Voltage = –10 kHz ÷ 200 kHz/V = -0.05 Vdc
5. Set the Model 91 to the upper limit frequency (step 2).
6. Set the Model 91 to the FM mode.
7. Set the Model 91 to the initial frequency
8. Connect the Modulating signal.

3.5.13.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for VCG operation.

1. Select the Mode. Use the "MODE" key (*22*) to step to the CONT mode (CONT indicator lit (*23*)). To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the MODE key when the Continuous indicator lights.
2. Calculate the Limits. Use step 2 in paragraph 3.5.13. to calculate the upper and lower frequency limits.
3. Select the Upper Frequency Limit. Press the "FREQ/PER" key (*4*) to display the current frequency. Use the Keypad (*39*) or Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to set up the upper limit frequency; see paragraph 3.5.3.1. Use the "KNOB" key (*39*) to activate the Knob. The Knob increments or decrements the value and automatically enters the new value. When using the Keypad, enter values as actual number (120) or exponential notation (12E1), press the "ENTER" key to accept the new value.
4. Change the Mode. Use the "MODE" key (*22*) to step to the FM mode (FM indicator lit (*23*)). This "locks" the Model 91 to the fixed frequency range.
5. Select the Lower Frequency Limit. Press the "FREQ/PER" key (*4*) again, and use the Knob or Keypad to set up the lower frequency limit; see paragraph 3.5.3.1.
6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the same as described in paragraph 3.5.3.1. If variable symmetry waveforms are selected, also refer to paragraph 3.5.4.1. The dc function is not allowed for VCG operation.
7. Calculate the VCG Voltage. Use step 4 of paragraph 3.5.13 to calculate the voltages required to change the generator's voltage.
8. Connect the VCG Voltage. Set the voltage

source to the level calculated in step 7, and then connect the voltage to the MOD IN connector (*30*).

3.5.13.2 GPIB Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for VCG operation.

1. Calculate the Limits. Use the steps in paragraph 3.5.13 to calculate the upper and lower frequency limits.

2. Select the Upper Frequency Limit. Send the Frequency command followed by the parameter.
   Frequency Commands: **FREQUENCY** or **FR**.
   Parameters: Values in Hz between 1E-3 and 20E6.
   Values can be entered in any format. For example 2kHz can be entered as 2000, 2E3, 20E2, etc.
   For example, sending either "**FREQUENCY 1E6;**" or "**FR 1000000;**" will select 1MHz.

3. Lock the Frequency Range. Send the Range Lock command followed by its parameter.
   Range Lock Command: **RANGELOCK** or **RA**.
   Range Lock Parameter: **ON** or **1**.
   NOTE: Range Lock should be turned off when finished with the FM mode: **RA 0**.

4. Change the Mode. Send the Mode command followed by the FM parameter.
   Mode Commands: **MODE** or **MO**
   FM Parameter: **FM**, **F**, or **6**.

5. Select the Lower Frequency Limit. Send the Frequency command followed by the parameter.
   Frequency Commands: **FREQUENCY** or **FR**.
   Parameters: Values in Hz between 1E-3 and 20E6.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the same as described in paragraph 3.5.3.2. If variable symmetry waveform is selected, refer to paragraph 3.5.4.2. The dc function is not allowed in the VCG mode.

7. Calculate the VCG Voltage. Use step 4 of paragraph 3.5.13 to calculate the peak to peak voltage required to modulate the Model 91.

8. Connect the VCG Voltage. Set the voltage source to the level calculated in step 7, and then connect the voltage to the MOD IN connector (*30*). The maximum level is ±10 Vdc. Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 for the VCG operation. In this example the output will be a 1.5Vpp sine wave from the 50Ω unbalanced output. To change the frequency, apply +0.125 Vdc to the MOD IN connector to change the frequency to 225 kHz. Apply –0.05 Vdc to change the frequency to 190 kHz..

```
"MODE F;FR 2E5;RA 1;FU SI;AM 1.5;OP
1;OS U50;EX"
```

3.5.14 Continuous Sweep

In continuous mode, the Model 91 continuously sweeps between a start and stop frequency either linearly or logarithmically. The sweep time can be varied between 0.1 and 3600 seconds. The sweep start and sweep stop frequencies can be between 1mHz and 20 MHz. If the start frequency is less than the stop frequency, the generator sweeps up in frequency. If the start frequency is greater than the stop frequency, the generator sweeps down in frequency. Maximum sweep range is three decades (1000: 1 frequency change). If the

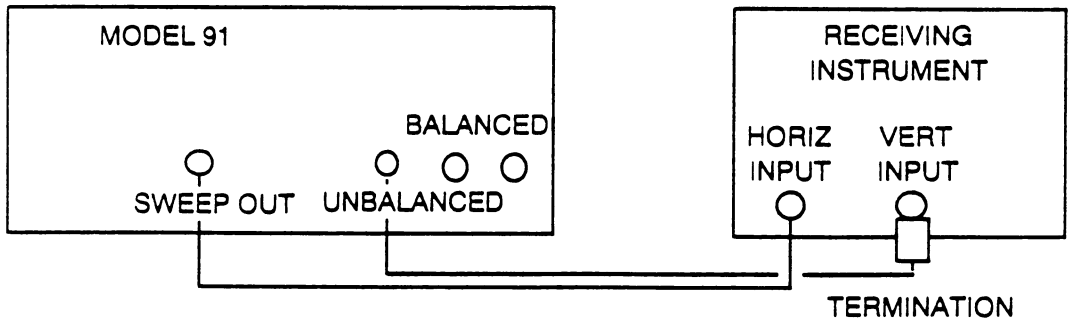


Figure 3-16. Model 91 Continuous Sweep Setup

frequency range exceeds three decades, the first frequency set will be pulled to within three decades. Figure 3-16 shows the instrument setup for sweep.

3.5.14.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to set up the Model 91 for continuous sweep.

1. Select the Sweep Mode. Use the "MODE" key (*22*) to step to the sweep mode (SWEEP indicator (*23*) lit. To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the Start Frequency. Use the "SWEEP MODE" (*26*) key to step to the start frequency. When START is displayed, the current start frequency is shown. To change the start frequency, use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). Use the KNOB key (*39*) to activate the Knob. The Knob increments or decrements the value starting from the flashing digit and automatically enters the new value. When using the keypad, enter values as actual number (5000) or exponential notation (5E3), press the "ENTER" key to accept the new value.

3. Select the Stop Frequency. Use the "SWEEP MODE" (*26*) key to step to stop frequency. When STOP is displayed, the current stop frequency is shown. To change the stop frequency, use the keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). Use the "KNOB" key (39) to activate the Knob. The Knob increments or decrements the value starting from the flashing digit and automatically enters the new value. When using the keypad, enter values as actual number (5000) or exponential notation (5E3), press the "ENTER key to accept the new value.

4. Select the Sweep Rate. Use the "TIME" key (*28*) to select the sweep rate. Sweep rate is the time it takes the Model 91 to sweep between the start and stop frequencies. To change the sweep time, use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). Use the "KNOB" key (*39*) to activate the Knob. The Knob increments or decrements the value starting from the flashing digit and automatically enters the new value. When using the keypad, enter values as actual number (90) or exponential notation (9E1), press the "ENTER" key to accept the new value. Sweep time values are between 100 ms and 100s. Press "SHIFT" (*31*) and then the Time's "UNITS" (28) key to shift between frequency and period. After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

5. Select the Sweep Type. Press the "SHIFT" key (*31*) and then the "LIN/LOG" key (*26*) to select the sweep function. Each time the SHIFT - LIN/LOG key combination is pressed or the Knob (*41*) rotated, the unit steps from LINEAR SWEEP, LOG SWEEP, LINEAR SWEEP UP/DOWN, and LOG SWEEP UP/DOWN.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1. The dc function can not be selected in the sweep mode. If variable symmetry waveform is selected, refer to paragraph 3.5.4.1.

7. Select Continuous Sweep. Press the "SWEEP MODE" (*26*) key until CONTINUOUS SWEEP is displayed. The unit now continuously sweeps.

8. Connect the Model 91. Connect the Model 91 to the receiving device. Use either the BALANCED output (*38*) or the UNBALANCED output (*35*)as the sweep output. The SWEEP OUT (*29*) provides a ramp 0 to +5V (sweep up) or +5 to 0V (sweep down).

3.5.14.2 GPIB Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for continuous output.

1. Select the Sweep Mode. Send the Mode command followed by the sweep parameter.
   Mode Commands: **MODE** or **MO**
   Sweep Parameter: **SW** or **7**.

2. Select the Start Frequency. To set up the start frequency send the start frequency command followed by the parameters.
   Start Frequency Command: **SWEEPSTART** or **STA**
   Start Frequency Parameters: Value between 1E-3 and 20E6.

3. Select the Stop Frequency. To set up the stop frequency send the stop frequency command followed by the parameters.
   Stop Frequency Command: **SWEEPSTOP** or **STO**
   Stop Frequency Parameters: Value between 1E-3 and 20E6.

4. Select the Sweep Rate. Send the sweep time (rate) command and its parameter.
   Sweep Time Commands: **SWEEPTIME** or **STI**.
   Sweep Time Parameters: 100E-3 to 3.6E3.

5. Select Linear or Logarithmic Sweep. Send the Sweep Type command and its parameter.
   Sweep Type Command: **SWEEPTYPE** or **STY**.
   Sweep type Parameter:
   LINEAR, **LI**, or **0** for linear sweep.
   LOG, **LO**, or **1** for logarithmic sweep.
   UDLIN, **ULI**, or **2** for linear sweep up/down.
   UDLOG, **UDLOG**, or **3** for log sweep up/down.

6. Setup the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. The dc function can not be selected in the sweep mode. If variable symmetry waveform is selected, refer to paragraph 3.5.4.2.

7. Select Continuous Sweep. Send the sweep mode command and its parameter.
   Sweep Mode Commands: **SWEEPMODE** or **SMD**.
   Continuous sweep Parameters: **CONTINUOUS**, **C**, or **2**.

8. Connect the Model 91. Connect the Model 91 to the receiving device. Use either the BALANCED output (*38*) or UNBALANCED output (*35*) as the sweep output. The SWEEP OUT (*29*) provides a ramp 0 to +5V (sweep up) or +5 to 0V (sweep down). Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 for the Continuous Sweep. In this example the output will be a swept 1.5Vpp sine wave from the 50Ω unbalanced output. The output frequency varies between 1kHz and 10 kHz, and swept at a 1 second rate.

```
"MODE SW;STA 1E3;STO 1E4 ;STI 1;SMD
2;FU SI;AM 1.5;OP 1;OS U50;EX"
```

3.5.15 Triggered Sweep

In the triggered sweep mode, the Model 91, when triggered, produces one sweep beginning at the start frequency and ending at the stop frequency. In general, the setup for triggered sweep is much the same as the continuous sweep mode combined with the triggered mode. As with the triggered mode, the trigger sweep mode can be triggered by an external source, the internal trigger source, the MAN TRIG key, or GPIB commands. In the triggered sweep mode, the Model 91 limits the internally generated trigger frequency to between 0.01 to 10 Hz. Also, if the internal trigger frequency is higher than the sweep time, the Model 91 places the internal trigger frequency less than the sweep time.

3.5.15.1 Local Operation

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for triggered sweep.

1. Select the Sweep Mode. Use the "MODE" key (*22*) to step to the sweep mode (SWEEP indicator (*29*) lit. To step backwards through the modes, press the "SHIFT" key and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

2. Select the Start Frequency. Use the "SWEEP MODE" (*22*) key to step to the start frequency. When START is displayed, the current start frequency is shown. To change the start frequency, use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). Use the KNOB key (*39*) to activate the Knob. The Knob increments or decrements the value starting from the flashing digit and automatically enters the new value. When using the keypad, enter values as actual number (5000) or exponential notation (5E3), press the "ENTER" key to accept the new value.

3. Select the Stop Frequency. Use the "SWEEP MODE" (*26*) key to step to stop frequency. When STOP is displayed, the current stop frequency is shown. To change the stop frequency, use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). Use the "KNOB" key (*39*) to activate the Knob. The Knob increments or decrements the value starting from the flashing digit and automatically enters the new value. When using the keypad, enter values as actual number (5000) or exponential notation (5E3), press the "ENTER" key to accept the new value.

4. Select the Sweep Time. Use the "TIME" key (*28*) to select the sweep rate. Sweep rate is the time it takes the Model 91 to sweep between the start and stop frequencies. To change the sweep time, use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit). The Knob increments or decrements the value starting from the flashing digit and automatically

enters the new value. When using the keypad, enter values as actual number (90) or exponential notation (9E1), press the "ENTER" key to accept the new value. Sweep time values are between 100 ms and 3600s. Press "SHIFT" (*31*) and then the Time's "UNITS" (*28*) key to shift between frequency and period. After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

5. Select the Sweep Type. Press the "SHIFT" key (*31*) and then the "LIN/LOG" key (*26*) to select the sweep function. Each time the "SHIFT LIN/LOG" key combination is pressed or the Knob (41) rotated, the unit step from LINEAR SWEEP, LOG SWEEP, LINEAR SWEEP UP/DOWN, and LOG SWEEP UP/DOWN.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1 . The dc function can not be selected in the sweep mode. If variable symmetry waveform is selected, refer to paragraph 3.5.4.1.

7. Select Triggered Sweep. Use the "SWEEP MODE" (26) key until INT TRIG SWEEP or EXT TRIG SWEEP appears. For internally triggered sweep setup, refer to step 8, and for externally triggered sweep setup, refer to step 9.

8. Select the Internal Trigger. Use the "TRIG SETUP" key (*24*) to step to trigger source (SOURCE). Then, use the Knob to select SOURCE INT (0).

   Set the Trigger Frequency. Press the "TRIG FREQ" key (*27*) to display the current internal frequency. Use the Knob (*41*) or the Keypad (*39*) to change the trigger frequency. Use the "KNOB" key (*39*) to activate the Knob. The Knob automatically enters the new trigger frequency. When using the keypad, press the "ENTER" key to accept the new trigger frequency. Internal trigger frequency range is 1mHz to 50 MHz or 1000s to 0.0002 ms. Press "SHIFT" (*31*) and the Trigger Frequency's "UNITS" (*27*) keys to alternate between frequency (TFREQ) and period (TPER). After the "SHIFT–UNITS" key combination, the Knob may be used to toggle between the units.

9. Select the External Trigger. Use the "TRIG SETUP" key (*24*) to step to trigger source (SOURCE). Then, use the Knob to select SOURCE EXT (1).

   Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*). The "TRIG FREQ" key must be pressed each time the frequency is to be read. Press the "TRIG SETUP" key (*24*) until SLOPE appears, and use the Knob to select either SLOPE POS (0) or SLOPE NEG (1). Next, press the "TRIG SETUP" key (*24*) until TRIG LEVEL appears, and use the Knob to set the trigger level (-5V to 5V). To read the frequency of the external source, press the "TRIG FREQ" key (27).

   Manual Trigger To use the "MAN TRIG" key (*25*) as a trigger source, first press the "TRIG SETUP" key (*24*) until SOURCE appears, and then use the Knob to select SOURCE MAN (2). Then, use the "MAN TRIG" key (*25*) to trigger the generator. When the key is pressed, the Model 91 produces one complete cycle of the selected waveform.

10. Connect the Model 91. Connect the Model 91 to the receiving device. Use either the BALANCED output (*38*) or the UNBALANCED output (*35*) as the sweep output. The SWEEP OUT (*29*) provides a ramp 0 to +5V (sweep up) or +5 to 0V (sweep down).

3.5.15.2 GPIB Operation

1. Select the Sweep Mode. Send the Mode command followed by the sweep parameter.
   Mode Commands: `MODE` or `MO`
   Sweep Parameter: `SWEEP`, `SW` or 7.

2. Select the Start Frequency. To set up the sweep start frequency, send the sweep start command followed by the parameters.
   Start Frequency Command: `SWEEPSTART` or `STA`
   Start Frequency Parameters: 1E-3 to 20E6.

3. Select the Stop Frequency. To set up the stop frequency, send the stop frequency command followed by the parameters.
   Stop Frequency Command: `SWEEPSTOP` or `STO`
   Stop Frequency Parameters: 1E-3 or 20E6.

4. Select the Sweep Time. Send the sweep time (rate) command and its parameter.
   Sweep Time Commands: `SWEEPTIME` or `STI`.
   Sweep Time Parameters: 100E-3 to 3.6E3 in seconds.

5. Select Linear or Logarithmic Sweep. Send the sweep type command and its parameter.

Sweep type Command: **SWEEPTYPE** or **STY**.
Sweep type Parameter:
LINEAR, **LI**,.or 0 for linear sweep.
LOG, **LO**, or 1 for logarithmic sweep.
UDLIN, **ULI**, or 2 for linear sweep up/down.
UDLOG, **ULO**, or 3 for log sweep up/down.

6. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.2. The dc function can not be selected in the sweep mode. If variable symmetry waveform is selected, refer to paragraph 3.5.4.2.

7. Select Triggered Sweep. Send the sweep mode command and its parameter.
Sweep Mode Commands: **SWEEPMODE** or **SMD**.
Triggered sweep Parameters: **TRIGGERED**, **T**, or 3.

Internal or External Trigger Source

8a. Select the Internal Trigger Source. Send the source command and its parameter to select the internal trigger source.
Source Command: **TRIGSOURCE** or **TSO**.
Internal Trigger Source Parameter: **INTERNAL**, **I**, or 0.
For example send "**TSO 0**;" to select the internal trigger source.

Select the Internal Sweep Trigger Frequency. Send the internal sweep trigger frequency command followed by its parameter.
Internal Trigger Frequency Command: **SWEEPTRIGFREQ** or **STF**.
Internal Trigger Frequency Parameters: Values in Hz between 10E-3 TO 10.
Values can be entered in any format. For example 0.1Hz can be entered as 1E-1, or 0.1, etc.
For example sending either "**SWEEPTRIGFREQ 1E0**;" or "**STF 1**;" will select a 1Hz internal trigger frequency.

8b. Select the External Sweep Trigger Source. Send the sweep trigger source command and parameter to select the external trigger source.
Source Command: **TRIGSOURCE** or **TSO**.
External Trigger Source Parameter: **EXTERNAL**, **E**, or 1.
For example, send "**TSO 1**;" to select the external trigger source.

Connect the External Trigger Source. Connect the external trigger source to the TRIG IN connector (*C*).
To set up the trigger slope, send the trigger slope command and parameter.
Trigger Slope Command: **TRIGSLOPE** or **TSL**.
Slope parameters:
NEGATIVE, **N**, or 1 for negative going slope.
POSITIVE, **P**, or 0 for positive going slope.
To set up the trigger level, send the level command followed by its parameter.
Trigger Level Command: TRIGLEVEL or TV.
Trigger Level Parameter: a value between -5 and 5.

Triggering with GPIB Commands. To trigger the Model 91 over the GPIB send the following command:
Trigger Command: **TRIGGER** or **TGG**.

Manual Trigger. To use the "MAN TRIG" key (*25*), it must first be selected by sending the trigger source command followed by the manual trigger command. After manual trigger is selected, pressing the "MAN TRIG" key (*25*) initates a triggered sweep.
Trigger Source Command: **TRIGSOURCE** or **TSO**.
Manual Trigger Parameter: **MANUAL**, **M**, or 2.

9. Connect the Model 91. Connect the Model 91 to the receiving device. Use either the BALANCED output (*38*) or the UNBALANCED output (*35*) as the sweep output. The SWEEP OUT (*20*) provides a ramp 0 to +5V (sweep up) or +5 to 0V (sweep down). Always terminate the string with an EXECUTE command.

Example

The following example uses a GPIB command string to set up the Model 91 for the Triggered Sweep. In this example the output will be a swept 1.5Vpp sine wave from the 50Ω unbalanced output. The output frequency varies between 1kHz and 10 kHz, and swept at a 0.1 second rate. The sweep is triggered internally at a 500 mHz rate.

```
"MODE SW;STA 1E3;STO 1E4 ;STI 1E-1;SMD
3;TSO 0;STF 5E-1;FU SI;AM 1.5;OP 1;OS
U50;EX"
```

3.5.16 Manual Sweep

Manual sweep allows the operator to step between the start and stop frequency using the Knob or Keypad. When using the Keypad, the Model 91 only allows

values between the the start and stop frequencies to be entered. Also, the Model 91 displays the frequency value closest to the value entered via the keypad. Manual sweep is a local (front panel) operation only.

After power on (paragraph 3.5.2), use the following steps to setup the Model 91 for continuous sweep.

1. Set up the Function, Amplitude, Offset, and Output. If sine, triangle, or square waveform is selected, set up the Model 91 the same as described in paragraph 3.5.3.1. The dc function can not be selected in the sweep mode. If variable symmetry waveform is selected, refer to paragraph 3.5.4.1.

2. Connect the Model 91. Connect the Model 91 to the receiving device. Use either the BALANCED output (*35*) or UNBALANCED output (*35*) as the sweep output. The SWEEP OUT (*29*) provides a ramp 0 to +5V (sweep up) or +5 to 0V (sweep down).

3. Select Sweep Mode. Set up the sweep mode, start frequency, stop frequency, sweep rate, and sweep type as described in paragraph3.5.14.1.

4. Manual Sweep. Press the "SWEEP MODE" (*26*) key until MANSWP appears on the display. Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the frequency. The Knob increments or decrements the value. When using the keypad, enter values as actual numbers (5000) or exponential notation (5E3), press the "ENTER" key to accept the new value.

3.5.17 Single Pulse

The single pulse function produces one pulse per period. This pulse has variable pulse width, but the single pulse cannot be delayed (see paragraph 3.5.18 Delayed Pulses). The Model 91 defines at the 50% points; see figure 3-17, Pulse Function Paramters: Single Pulse Function. The Model 91 generates pulses in all operating modes; however, some operating modes may not be practical for pulse functions. The unit provides two sets of pulse outputs: the front panel Balanced and Unbalanced Outputs, and the rear panel Pulse Out and Pulse Out connectors. When using the Balanced and Unbalanced outputs, the Model 91 allows the user to set the pulse levels as amplitude and offset values or upper and lower levels voltages values. The rear panel outputs, which supplies pulses with the maximum transitions, supply pulses at five preset levels (positive ECL, negative ECL, CMOS, TTL, and Custom. Custom) permits the user to define their own output levels. To minimize internal delay times, the unit allows either front panel sync pulse or rear panel sync pulse. Both sets of outputs can supply normal and complemented logic outputs. Figure 3-17 illustrates pulse paramteters.

NOTE

When setting up the Pulse function, remember the relationship between the width and delay times and the period (frequency). Otherwise, the Model 91 will generate an error message; see appendix A.

3.5.17.1 Local Operation

Perform the following steps to set up the Model 91 as a pulse generator.

1. Select the Mode. Use the "MODE" key (*22*) to step to the desired mode (mode indicator lit (*23*)).

   To step backwards through the modes, press the "SHIFT" key (*31*) and then hold down the "MODE" key. Release the "MODE" key when the indicator lights to select the mode.

   For more information on the Model 91 operating modes, refer to the following paragraphs:

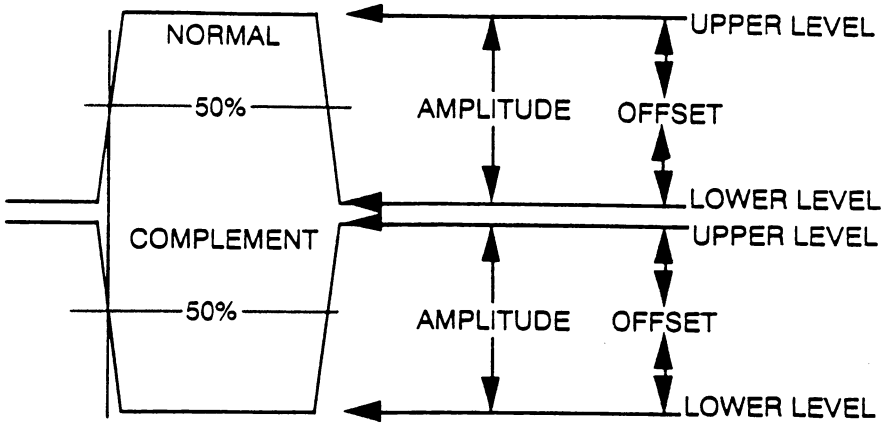
Continuous Mode	Paragraph 3.5.3
Triggered Mode	Paragraph 3.5.7
Gate Mode	Paragraph 3.5.8
Burst Mode	Paragraph 3.5.9
Amplitude Modulation	Paragraph 3.5.10
Suppressed Carrier Modulation	Paragraph 3.5.11
Frequency Modulation	Paragraph 3.5.12
Voltage Controlled Generator	Paragraph 3.5.13
Continuous Sweep	Paragraph 3.5.14
Triggered Sweep	Paragraph 3.5.15
Manual Sweep	Paragraph 3.5.16

2. Select the Function. Use the "FUNCTION" key (*18*) to select the single pulse function. Holding down the function key causes the unit to cycle through the functions. Release the key to stop and select the function. The single pulse indicator (*15*) will be lit.

   To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the indicator lights to select the function.

3. Select the Frequency. Press the "FREQ/PER" key (*4*) to display the frequency in Hz or the period in seconds (pulse repetition rate). Use the Keypad (*39*) or the Knob (*42*), if enabled

PULSE OUTPUT PARAMETERS



PULSE FUNCTION PARAMETERS

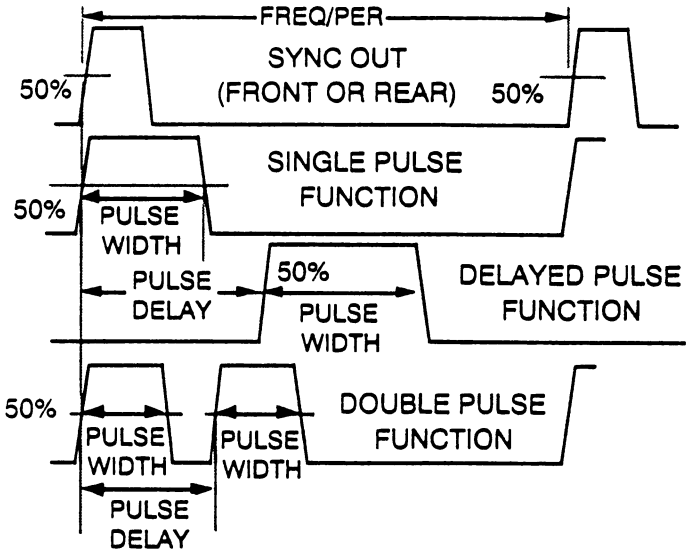


Figure 3-17. Pulse Parameters

(ENABLE indicator (*41*) lit), to change the frequency. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the keypad, enter values as actual numbers (5000) or exponential notation (5E3), press the "ENTER" key to accept the new value.

Frequency range for the pulse generator is 1mHz to 20.00 MHz (frequency selected) or 1000.0s to 50 ns (period selected) from the Balanced and Unbalanced Outputs. Above 1MHz, the waveform quality from the Balanced Output will deteriorated.

Range for the Pulse and Pulse Outputs is 1mHz to 50.00 MHz (Frequency) or 1000s to 20 ns (Period). If the square wave is selected, the frequency range is 1mHz to 100 MHz or 1000s to 10 ns, Pulse and Pulse Outputs only.

Use the frequency's UNITS key (*4*) to select the unit of measure: frequency or period. Because pulse parameters are in the time domain, it might be easier to use Period for pulses. For other frequency related setups, refer to Phase Lock - paragraph 3.5.5, or External Frequency Source - paragraph 3.5.5

Other Limitations:

Maximum frequency derates above 2MHz when symmetry not 50%

Maximum frequency limited to 1MHz when 135Ω and 600Ω Balanced selected.

Minimum frequency limited to 20 Hz for internal phase lock (accuracy ± 10 ppm).

4. Select the Pulse Width. Press the "WIDTH" key (*16*) to display the current pulse width in seconds. The Model 91 defines the pulse width between the 50% points of the leading and trailing edge of the waveform; see figure 3-17. Use the Keypad (*39*) or the Knob (*42*), if enabled (ENABLE indicator (*41*) lit), to change the pulse width. The Knob increments or decrements the value starting with the flashing digit ("Knob" key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual numbers (50) or exponential notation (5E-1), press the "ENTER" key to accept the new value. Pulse width range depends on the Frequency or Period programmed. The overall ranges is 10 ns to 2000s with four digits of resolution. Minimum resolution is 100 ps.

5A. Unbalanced and Balanced Outputs for Pulse Outputs

Set up the Amplitude (also see *5B Select the Upper and Lower Levels*). Use the "AMPLITUDE" key (*5*) to display the amplitude setting. Figure 3-17 illustrates pulse amplitude parameters. Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the amplitude. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual number (10) or exponential notation (1E1), press the "Enter" key to accept the new value.

Amplitude range is

1mVpp to 15.0 Vpp
500 μVp to 7.5 Vp
500 μVrms to 7.5 Vrms
–57.8 dBm to 25.7 dBm

Use the Amplitude's "UNITS" key (*5*) to select the unit of measure: Vpp, Vp, Vrms, or dBm.

Limitations:

Amplitude limited by Offset values (Offset + Vp ≤7.5V).
Amplitude limited to half of maximum level when AM selected.

Set up the Offset. Use the "OFFSET" key (*7*) to display the dc offset level in volts. Offset is the waveform reference level relative to 0Vdc; see figure 3-17. Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the offset. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual number (0.01) or exponential notation (10E-3), press the "ENTER" key to accept the new value. Offset values range from +7.500V to –7.500V.

Limitations:

Offset limited by the peak amplitude value (Offset + Vp ≤7.5V).
Offset fixed at 0Vdc when BAL (Balanced output)selected.
Offset range limited to half of the maximum offset when AM selected.

5B Select the Upper and Lower Levels. Upper and lower levels sets the peak levels of the pulse for the front panel Unbalanced and Balanced outputs; see figure 3-17, Pulse Output Parameters. Upper and lower Level, and Amplitude and Offset are interrelated, changing any one of each pair will affect the other pair.

To select the upper level, press the "UPPER LVL" key (*20*) to display the current upper level. Use the Keypad (*39*) or the Knob (*41*) , if enabled (ENABLE indicator (*40*) lit), to change the upper level. The Knob increments or decrements the value starting with the flashing digit (Knob key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual number (10), press the "ENTER" key to accept the new value. Upper level range is -7V to +7.5V and must be greater than the lower level value.

To select the lower level, press the "LOWER LVL" key (*21*) to display the current lower level. Use the Keypad (*39*) or the Knob (*41*) , if enabled (ENABLE indicator (*40*) lit), to change the upper level. The Knob increments or decrements the value starting with the flashing digit (KNOB key (*39*)) and automatically enters the new value. When using the keypad, enter values as actual number (10), press the "ENTER" key to accept the new value. Lower level range is –7.5V to +7V and must be less than the upper level value.

Turn "ON/OFF" the Output and Select the Output Impedance. Use the "ON/OFF" key (*36*) to turn on or off the output. If the output is turned off, as at power on, the impedance indicator flashes, and pressing the "ON/OFF" key turns

on the output and returns the Model 91 to the last selected output and impedance. The impedance indicator remains on.

Use the "SELECT" key (*36*) to choose the output connector (balanced or unbalanced) and output impedance (50Ω, 75Ω, 135Ω, and 600Ω). Pressing the "SHIFT" key (*31*) and then the "SELECT" key increments through the impedances and outputs in the following order:

50Ω Unbalanced Output ≤20 MHz,
75Ω Unbalanced Output ≤20 MHz,
600Ω Unbalanced Output ≤ 1MHz,
600Ω Balanced Output ≤1MHz,
135Ω Balanced Output ≤1MHz.

Also after pressing the "SHIFT" key, hold down the "SELECT" key to auto-increment through the list in the same order as above. Release the key to select the impedance and output; the indicators remain lit.

Sync Output To use the correct synchronizing output for the front panel outputs, press the "SYNC" key (*14*), then use the Knob to select SYNC FRONT. The Sync Output must be terminated with 50Ω.

NOTE

When connecting the Model 91 output connector to a load, use a cable with the correct impedance for the output selected. Balanced ct connector is internally connected to the shield of all the other Model 91 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.

6. Select the Pulse/Pulse Outputs

The Model 91 also provides two rear panel pulse output connectors: the Pulse and Pulse Outputs. Use these outputs for applications where fast trasnsition times are important. Also, use these outputs for pulses up to 50 MHz or the 100 MHz square waves. The Pulse and Pulse Outputs must be terminated with 50Ω terminators.

To turn on or off the Pulse and Pulse Outputs, press the "PULSE SETUP" key (*19*) until the display shows REAR OUT. Then use the Knob (*41*) to select REAR OUT ON (1). To turn the outputs off, use the Knob to select REAR OUT. This menu does not affect the front panel outputs.

To select the logic sense, press the "PULSE SETUP" key (*19*) until the display shows LOGIC. Then use the Knob to select either LOGIC NORM (0) or LOGIC COM (1). Logic sense affects both front and rear panel outputs. Normal pulses are in phase with the Sync Out; see figure 3-17, Pulse Output Parameters. Complement pulses are 180° out of phase with the Sync Out signal.

To select the pulse output level, press the "PULSE SETUP" key (*19*) until the display shows PULSE. Then use the Knob to select PULSE TTL (0), PULSE CMOS (1), PULSE -ECL (2), PULSE +ECL (3), or PULSE CSTM. (4) This menu only affects the rear panel Pulse Outputs.

PULSE CUSTOM permits the user to set up their own output levels for the rear panel Pulse and Pulse outputs. To set up the custom upper level in volts, press the "SHIFT" (*31*) key and then Upper Lvl's "CUSTOM" key (*20*). Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the custom upper level. The Knob increments or decrements the value starting with the flashing digit (KNOB key (*39*)) and automatically enters the new value. When using the keypad, enter values as actual number (1.3), press the "ENTER" key to accept the new value. Upper level range is -1.4 to +4.2V and must be greater than the lower level value by 0.4V.

To set up the custom lower level, press the "SHIFT" (*31*) key and then Lower Lvl's "CUSTOM " key (*21*). Use the Keypad (*39*) or the Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change the upper level. The Knob increments or decrements the value starting with the flashing digit ("KNOB" key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual number (-1.3), press the "ENTER" key to accept the new value. Lower level range is -1.8 to +3.8V and must be less than the upper level value by 0.4V.

Sync Output To use the correct synchronizing output for the rear panel outputs, press the "SYNC" key (*14*), then use the Knob to select SYNC REAR (1). The Sync Out must be properly terminated into a 50Ω terminator.

3.5.17.2 GPIB Operation

After power on (paragraph 3.5.2) use the following commands to set up the Model 91 for the single pulse function.

1. Select the Mode. Send the Mode Command followed by the desired parameter.
   Mode Command: **MODE** or **MO**.
   Continuous Paramter: **CONTINUOUS**, **C**, or **0**.
   Triggered Parameter: **TRIGGERED**, **T**, or **1**.
   Gate Paramter: **GATE**, **G**, or **2**.
   Burst Parameter: **BURST**, **B**, or **3**.
   Amplitude Modulation Paramter: **AM**, **A**, or **4**.
   Suppressed Carrier Modulation Paramter: **SCM**, **SC**, or **5**.
   Frequency Modulation Parameter: **FM**, **F**, or **6**.
   Sweep Parameter: **SWEEP**, **SW**, or **7**.
   For more information on triggered modes, refer to the following paragraphs:
   Triggered Mode: paragraph 3.5.7.
   Gate Mode: paragraph 3.5.8.
   Burst Mode: paragraph 3.5.9.
   For other modes, refer to the following paragraphs:
   Amplitude Modulation: paragraph 3.5.10.
   Suppressed Carrier Modulation: paragraph 3.5.11.
   Frequency Modulation: paragraph 3.5.12.
   VCG: paragraph 3.5.13.
   Sweep: paragraphs 3.5.14 and 3.5.15.

2. Select the Single Pulse Function. Send the function command followed by the single pulse parameter.
   Function Command: **FUNCTION** or **FU**.
   Single Pulse Parameter: **PULSE**, **P**, or **4**.
   For example: send "**FU P;**".

3. Setup the pulse repetition rate (frequency). Send the frequency command followed by the frequency value.
   Frequency Command: **FREQUENCY** or **FR**.
   Frequency Parameter Values:
   For rear panel Pulse and Pulse Outputs: 1E-3 to 5E7.
   For front panel Unbalanced Output: 1E-3 to 2E7.
   For front panel Balanced Output: 1E-3 to 1E6 (the Model 91 accepts values above 1MHz, but the pulse quality will be deteriated).
   For example, send "**FR 1E4;**".

4. Select the Pulse Width. To select the pulse width, send the pulse width command followed by the pulse width paramter value.
   Pulse Width Command: **WIDTH** or **W**.
   Pulse Width Paramter Values: 1CE-9 to 2E3.
   For example, send "**W 2E-4;**".

5A. Balanced and Unbalanced Output for Pulse Outputs. As an alternative to amplitude and offset commands, refer to uppper and lower level commands in 5B.
Select the Amplitude. Send the Amplitude command followed by the parameter.
   Amplitude Commands: **AMPLITUDE** or **AM**.
   Amplitude Parameters: Values in Vpp between 1E-3 and 15.
   Values can be entered in any format. For example 10 Vpp can be entered as 10, 1E1, 10E0, etc.
   For example, sending either "**AMPLITUDE 12;**" or "**AM 1.2E1;**" will select 12 Vpp amplitude.

   Select the Offset. Send the Offset command followed by the parameter.
   Offset Commands: **OFFSET** or **OF**.
   Offset Parameters: Values in Vdc between -7.5 and 7.5.
   For example, sending either "**OFFSET -3;**" or "**OF -3;**" offsets the waveform by -3Vdc.

5B. Select Upper and Lower Level. To use the Upper and Lower Level commands to set up the pulse output level instead of the Amplitude and Offset commands, send the level command followed by their parameters.
   Upper Level Command: **UPPERLEVEL** or **UL**.
   Upper Level Parameter Values: -7 to -7.5.
   Lower Level Command: **LOWERLEVEL** or **LL**.
   Lower Level Parameter Value: -7.5 to +7.
   For example, to set up an upper level of +1V and lower level of 0V; send "**UL 1;LL 0;**".

   Turn On or Off the Output. Send the Output enable command followed by the parameter.
   Output Commands: **OUTPUT** or **OP**.
   Parameters: **1** or **ON** turns the output on, and **0** or **OFF** turns the output off.
   For example, sending "**OP 1;**" will turn the output on.

   Select an Output and Output Impedance. Send the Output Select command followed by the parameter.
   Output Select Commands: **OUTSELECT** or **OS**.

50Ω Unbalanced Output Parameter: **U50** or 0.
75Ω Unbalanced Output Parameter **U75** or 1.
600Ω Unbalanced Output Parameter: **U600** or 2.
600Ω Balanced Output Parameter: **B600** or 3
135Ω Balanced Output Parameter: **B135** or 4.

For example, sending either "**OUTSELECT 0;**" or "**OS U50;**" selects the unbalanced 50Ω output.

Pulse Logic. To set up the pulse sense or logic relative to the Sync Out signal, send the Pulse Logic command followed by the Sense parameter.

Pulse Logic command: **PULSELOGIC** or **PO**.
Normal Parameter: **NORMAL**, **N**, or **0**.
Complement Parameter: **COMPLEMENT**, **C**, or **1**.
This command also affects the phase of the Pulse and Pulse Output pulses.

Sync Output To use the correct synchronizing output for the front panel outputs, send the Sync Command followed by the front panel sync parameter.

Sync Out Command: **SYNCTIMING** or **SC**.
Front Panel Sync Parameter: **FRONT**, **F**, or **0**.

6. Rear Panel Pulse and $\overline{\text{Pulse}}$ Outputs.

To enable or disable the rear panel Pulse and $\overline{\text{Pulse}}$ Outputs, send the Rear Outputs command followed by the appropriate parameter.

Rear Output Command: **REAROUTPUTS** or **RO**.
Off Parameter: **OFF**, **OF**, or **0**.
On Parameter: **ON** or **1**.

The Pulse and $\overline{\text{Pulse}}$ Outputs must be terminated with 50Ω terminations.

Pulse Logic. To set up the pulse logic relative to the Sync Out signal, send the Pulse Logic command followed by the Sense parameter.

Pulse Logic command: **PULSELOGIC** or **PO**.
Normal Parameter: **NORMAL**, **N**, or **0**.
Complement Parameter: **COMPLEMENT**, **C**, or **1**.
This command also affects the phase of the Balanced and Unbalanced Output pulses.

Pulse Type. To select the preset Pulse and Pulse Output levels, send the pulse type command followed by one of four parameters.

Pulse Type Command: **PULSETYPE** or **PY**.
TTL Type Parameter: **TTL**, **T**, or **0**.
CMOS Type Parameter: **CMOS**, **CM**, or **1**.
Negative ECL Type Parameter: **NEGATIVEECL**, **N**, or **2**.
Positive ECL Type Parameter: **POSITIVEECL**, **P**, or **3**.
Custom Type Parameter: **CUSTOM**, **CU**, or **4**. See Setting Custom Pulse Types.

Setting Custom Pulse Types. To set up the upper and lower levels for the Custom Type Parameter, send the level commands followed by their parameter values. The upper level value must always be greater than the lower level value.

Custom Upper Level Command: **CUSTOMUPPERLVL** or **CUU**.
Custom Upper Level Parameter Values: -1.4 to +4.2.
Custom Lower Level Command: **CUSTOMLOWERLVL**, or **CUL**.
Custom Lower Level Parameter Values: -1.8 to 3.7.

For example, to set up the custom level for a 0 to +1V pulse, send the string: "**CUU 1;CUL 0;**".

Sync Output To use the correct synchronizing output for the rear panel outputs, send the Sync Command followed by the rear panel sync parameter.

Sync Out Command: **SYNCTIMING** or **SC**.
Rear Panel Sync Parameter: **REAR**, **R**, or **1**.

3.5.18 Delayed Pulse

When the delayed pulse function is selected, the Model 91 produces one pulse each pulse period, but that pulse can be delay relative to the Sync Output. In addition, the width of the delay pulse can be varied. The Model 91 "measures" the delay relative to the 50% point of the leading edge of the Sync Out pulse to the leading edge of the delayed pulse. Figure 3-17, Pulse Function Parameters - Delayed Pulse Function, illustrates the delayed pulse.

NOTE

When setting up the Pulse function, remember the relationship between the width and delay times and the period (frequency). Otherwise, the Model 91 will generate an error message; see appendix A.

3.5.18.1 Local Operation

To set up the Model 91 as a delayed pulse generator,

1. Initial Set up. Set up the Frequecy/Period, Mode, Outputs, Output Level (Amplitude/Offset or Upper/Lower Level), and Pulse Width as described in paragraph 3.5.17.1.

2. Select the Delayed Pulse Function. Use the "FUNCTION" key (*18*) to select the delayed pulse function. Holding down the "FUNCTION" key causes the unit to cycle through the functions. Release the key to stop and select the function. The delayed pulse indicator (*15*) will be lit.

   To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the indicator lights to select the function.

3. Select the Pulse Delay. Press the "DELAY" key (*16*) to display the current pulse delay. Use the Keypad (*39*) or the Knob (*42*), if enabled (ENABLE indicator (*41*) lit), to change the pulse delay. The Knob increments or decrements the value starting with the flashing digit (KNOB key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual numbers (0.005) or exponential notation (5E-3), press the "ENTER" key to accept the new value. Pulse delay range depends on the Frequency or Period and Pulse Width programmed. The overall ranges is 0 ns to 2000s with four digits of resolution. Minimum resolution is 100 ps.

   NOTE

   Delay reqires a Sync Out otherwise the delayed pulse may not be seen. It is important select the proper sync output (front or rear panel sync) to minimize internal delays.

3.5.18.2 GPIB Operation

To use the Model 91 as a delayed pulse generator over the GPIB, perform the following steps.

1. Initial Setup. Set up the Model 91 a desribed in paragraph 3.5.17.2.

2. Select the Delayed Pulse Function. To set up the delayed function, send the function command followed by the delayed pulse parameter.

   Function Command: `FUNCTION` or `FU`.
   Delayed Pulse Parameter: `DELAYEDPULSE`, `DE`, or `5`.

3. Set up the Pulse Width. To select the pulse width, send the pulse width command followed by the pulse width paramter value.
   Pulse Width Command: `WIDTH` or `W`.
   Pulse Width Paramter Values: 10E-9 to 2E3.
   For example, send "`W 2E-3;`".

4. Set up Pulse Delay. To select the pulse delay, send the Pulse Delay command followed by the parameter value.
   Pulse Delay Command: `DELAY` or `DL`.
   Pulse Delay Parameter Values: 0 to 2E3; minimum resolution is 100 ps.

   NOTE

   Delay reqires a Sync Out otherwise the delay may not be seen. It is important select the proper sync output (front or rear panel sync) to minimize internal delays.

3.5.19 Double Pulse

When the double pulse function is selected, the Model 91 produces a pair of pulses each pulse period. The first pulse is coincident with the sync output and the position of the second pulse is determined by the pulse delay. Pulse width sets the width of both pulses. See figure 3-17 for an illustration of double pulse parameters. The Model 91 defines the position of the second pulse as the delay time between the 50% point of the first pulse's leading edge to the 50% point of the second pulse's leading edge.

NOTE

When setting up the Pulse function, remember the relationship between the width and delay times and the period (frequency). Otherwise, the Model 91 will generate an error message; see appendix A.

3.5.19.1 Local Operation

To set up the Model 91 as a double pulse generator,

1. Initial Set up. Set up the Frequecy/Period, Mode, Outputs, and Output Level (Amplitude/Offset or Upper/Lower Level), as described in paragraph 3.5.17.1.

2. Select the Double Pulse Function. Use the "FUNCTION" key (*18*) to select the double pulse function. Holding down the "FUNCTION" key causes the unit to cycle through the func-

tions. Release the key to stop and select the function. The double pulse indicator (*15*) will be lit.

To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the indicator lights to select the function.

3. Select the Pulse Width. Press the "WIDTH" key (*16*) to display the current pulse widthin seconds. Use the Keypad (*39*) or the Knob (*42*), if enabled (ENABLE indicator (*41*) lit), to change the pulse width. The Knob increments or decrements the value starting with the flashing digit (KNOB key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual numbers (50) or exponential notation (5E1), press the ENTER key to accept the new value. Pulse width range depends on the Frequency or Period programmed. However, the overall ranges is 10 ns to 2000s with four digits of resolution. Minimum resolution is 100 ps.

4. Position of the Second Pulse. Press the "DELAY" key (*16*) to display the current pulse delay. Use the Keypad (*39*) or the Knob (*42*), if enabled (ENABLE indicator (*41*) lit), to change the pulse delay. The Knob increments or decrements the value starting with the flashing digit (KNOB key (*39*)) and automatically enters the new value. When using the Keypad, enter values as actual numbers (0.005) or exponential notation (5E-3), press the "ENTER" key to accept the new value. Position of the second pulse (pulse delay range) depends on the Frequency or Period and Pulse Width programmed. The overall ranges is 0 ns to 2000s with four digits of resolution. Minimum resolution is 100 ps.

3.5.19.2 GPIB Operation

To use the Model 91 as a delayed pulse generator over the GPIB, perform the following steps.

1. Initial Set up. Set up the Model 91 for the double pulse function as described in paragraph 3.5.17.2.

2. Select the Double Pulse Function. Send the function command followed by the double pulse parameter.
   Function Command: `FUNCTION` or `FU`.
   Double Pulse Parameter: `DOUBLEPULSE`, `DO`, or `6`.

3. Select the Pulse Width. Send the Pulse Width command followed by the parameter value.
   Pulse Width Command: `WIDTH` or `W`.
   Pulse Width Parameter Values: 10E-9 to 2E3.

4. Position of the Second Pulse. To position the second pulse, send the Pulse Delay command followed by the parameter value.
   Pulse Delay Command: `DELAY` or `DL`.
   Pulse Delay Parameter Values: 0 to 2E3; minimum is 100 ps.

3.5.20 External Width Pulse

In the external width mode, the Model 91 produces a pulse output whose period and width are fixed by the external trigger signal and the trigger setup parameters. Amplitude and offset (Upper and Lower level too) controls the external width output level. Figure 3-18 illustrates the external width as it relates to a representative trigger setup. when using the front panel Unbalanced outputs, input frequency range is dc to 20 MHz. When using the rear panel Pulse outputs, the input frequency range is dc to 50 MHz.

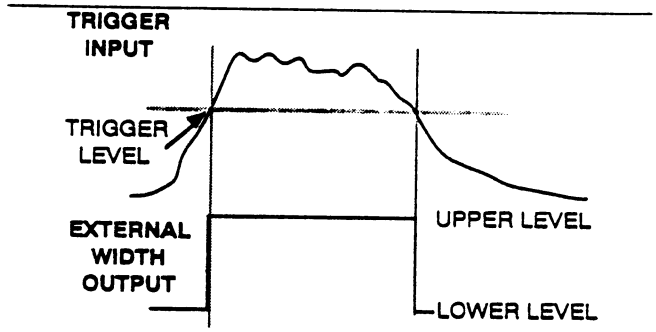


Figure 3-18. External Width

3.5.20.1 Local Operation

To set up the Model 91 for external width, perform the following steps.

1. Select the External Width Function. Use the "FUNCTION" key (*18*) to select the E.W. (External Width) function. Holding down the "FUNCTION" key causes the unit to cycle through the functions. Release the key to stop and select the function. The E.W. indicator (*15*) will be lit.

To step backwards through the functions, press the "SHIFT" key (*31*) and then hold down the "FUNCTION" key. Release the "FUNCTION" key when the indicator lights to select the function.

2. Set up the Trigger. Selecting the E.W. function automatically switches to the rear panel external TRIG IN as the trigger input. However, trigger slope and level can be varied.

   Press the "TRIG SETUP" key (*24*) until SLOPE appears; use the Knob (*41*) to toggle between POS (0) (positive) or NEG (1) (negative). SLOPE POS (0) is the default.

   Press the "TRIG SETUP" key (*24*) until TRIG LEVEL appears. Use the Keypad (*39*) or the Knob (*41*) , if enabled (ENABLE indicator (40) lit), to change the trigger level in volts. The Knob increments or decrements the value starting with the flashing digit (Knob key (39)) and automatically enters the new value. When using the Keypad, enter values as actual number (1.3), press the "ENTER" key to accept the new value. Trigger level range is -5.0 to +5.0V. Trigger level reset default is +1V.

3. Set up the Pulse Output. If using the Balanced and Unbalanced Outputs, refer to paragraph 3.5.17.1 - step 5, Balanced and Unbalanced Outputs for Pulse Outputs. If using the Pulse and Pulse Outputs, refer to paragraph 3.5.17.1 - step 6, Rear Panel Pulse and Pulse Outputs.

3.5.20.2 GPIB Operation

1. Select the External Width Function. Send the function command followed by the external width parameter.
   Function Command: **FUNCTION** or **FU**.
   External Width Parameter: **EXTERNALWIDTH**, **E**, or **7**.

2. Set up the Trigger. Selecting the E.W. function automatically switches to the rear panel external TRIG IN as the trigger input. However, trigger slope and level can be varied.
   To set up the trigger level, send the trigger level command followed by the parameter value.
   Trigger Level Command: **TRIGLEVEL** or **TV**.
   Trigger Level Parameter Values: -5 to +5.

   To set up the trigger slope, send the trigger slope command followd by the parameter.
   Trigger Slope Command: **TRIGSLOPE** or **TSL**.
   Postive Slope Parameter: **POSITIVE**, **P**, or **0**.
   Negative Slope Parameter: **NEGATIVE**, **N**, or **1**.

3. Set up the Pulse Output. If using the Balanced and Unbalanced Outputs, refer to paragraph 3.5.17.2 - step 5, Balanced and Unbalanced Outputs for Pulse Outputs. If using the Pulse and Pulse Outputs, refer to paragraph 3.5.17.2 - step 6, Rear Panel Pulse and Pulse Outputs.

3.5.21 Storing and Recalling Settings

All the operations described in paragraph 3.5 can be stored as a complete setup in the Model 91's memory and recalled for use when needed. Setups can be stored and recalled using both front panel keys and GPIB commands. The Model 91 allows up to 10 stored settings.

3.5.21.1 Local Operation

To Store a Setup,

1. Set up the Model 91 as described in paragraphs 3.5.3 through 3.5.20.

2. Press the "STORE" key (*6*) to display the number of the last stored setting. The Model 91 displays the state of the memory: FREE or USED.

3. Use the Keypad (*39*) or Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change to another stored setting.

4. Press the "ENTER" key to store the setup at that location. When "ENTER" key is pressed the Model 91 display flashes DONE and then USED.

To Recall a Setup,

1. Press "SHIFT" key (*31*) and then the RECALL key (*6*) display the number of the last recalled setting. If this is the first recalled setting since power on, the number will be lowest number stored.

2. Use the Keypad (*39*) or Knob (*41*), if enabled (ENABLE indicator (*40*) lit), to change to another stored setting. The Model 91 displays the memory status: FREE or USED.

3. Press the "ENTER" key to recall the setup. Selecting a FREE location, causes the Model 91 to flash NOSAVE.

3.5.21.2 GPIB Operation

To Store a Setup,

1. Set up the Model 91 as described in paragraphs 3.5.3 through 3.5.20.

2. Send the Store command followed by the Store parameter.

Store Command: **STORESETTING** or **STS**.
Store Parameter: 1 to 5.

3. Terminate the command string with an Execute command "**EX**".

EXAMPLE

To store a setup in setting number 2, send "**STS 2; EX**".

To Recall a Setup,

1. Send the Recall command followed by the Recall parameter.
   Recall Command: **RECALLSETTING** or **RCL**.
   Store Parameter: 1 to 5.

2. Terminate the command string with an Execute command "**EX**".

EXAMPLE

To recall a setup in stored setting number 2, send "**RCL 2; EX**".

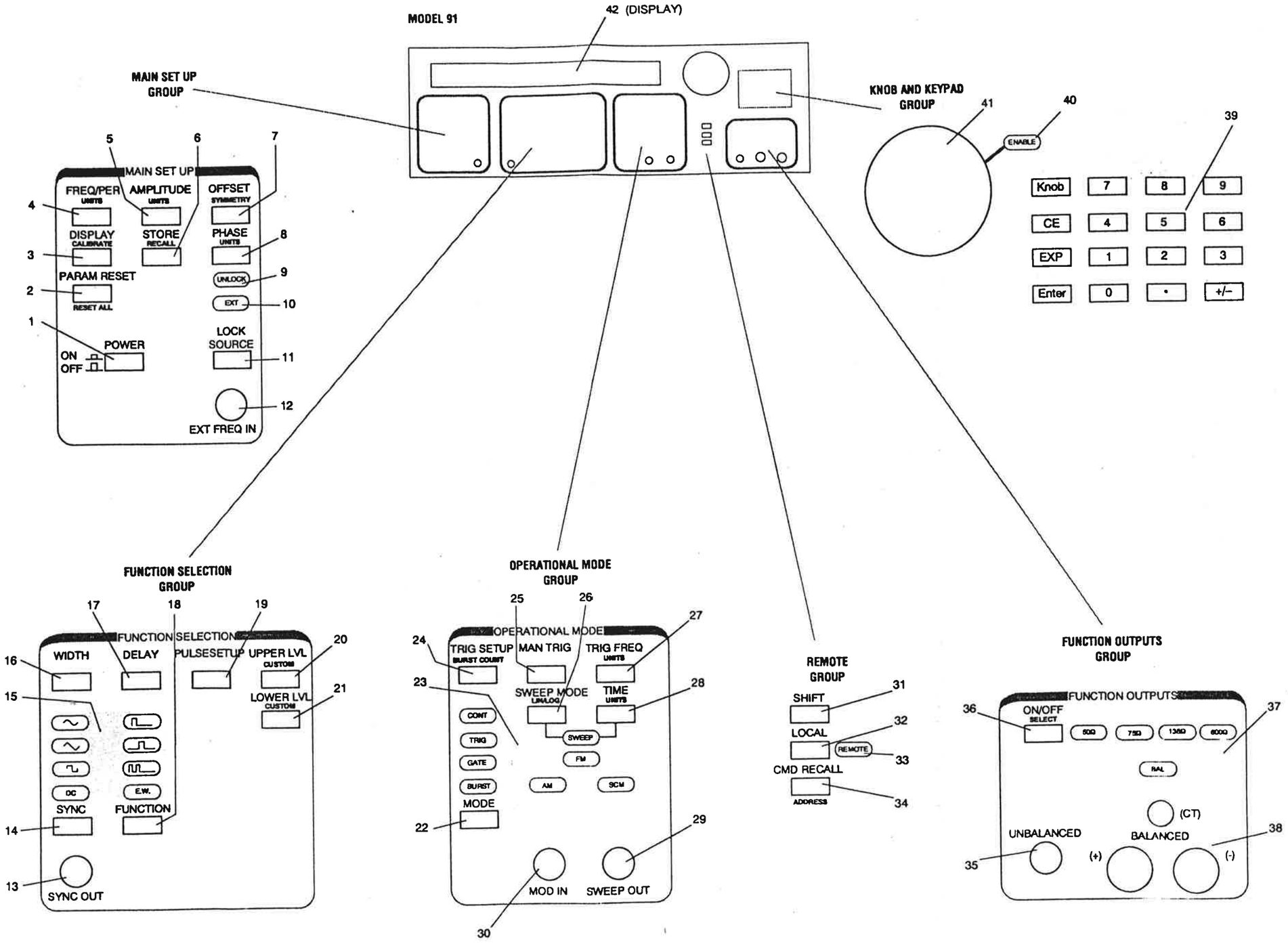


Figure 3-1. Model 91 Front Panel Controls and Connectors