OPERATOR'S & MAINTENANCE MANUAL

Model 178

50 MHz Programmable Waveform Synthesizer

WAVETEK

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Instrument Part Number: 1000-00-0168

WARRANTY

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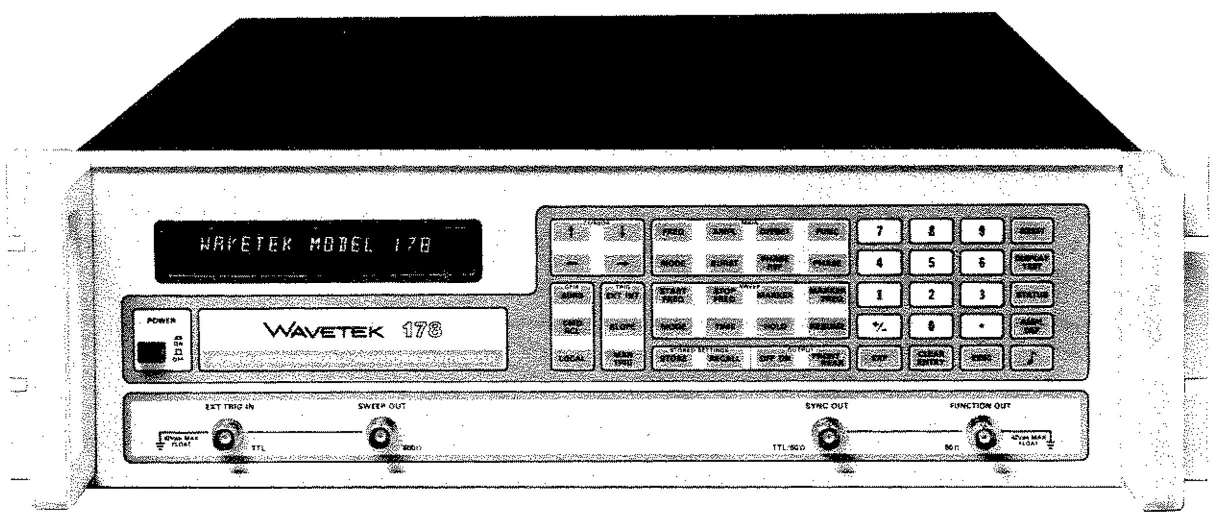
SAFETY FIRST

Protect yourself. Follow these precautions:

- Don't touch the outputs of the instrument or any exposed test wiring 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 adaptors.
- 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.



Model 178, 50 MHz Programmable Waveform Synthesizer

SECTION 1
GENERAL DESCRIPTION

1.1 MODEL 178

The Model 178 Programmable Waveform Synthesizer is a 1 μHz to 50 MHz multifunction sweep synthesizer that can operate as a trigger, gate or burst generator at levels to 20 volts peak-to-peak. It is synthesized to 8 digits in all modes.

Its main generator, an 8 digit 50 MHz synthesizer, produces sine and square waves and, at reduced frequencies, triangles, ramps, pulses and haverwaves.

An external reference input can phase lock the synthesizer by locking the reference source. Phase locking allows the synthesizer to operate as a variphase generator with phase offset in 0.01° increments.

The output level is specified into a 50Ω load from 1 mV to 20 Vp-p with 3 digits resolution. DC offset can be programmed to vary the waveform base line ±10V. Amplitude is displayed in units of Vp-p, Vrms or dBm for any waveform.

The internal sweep generator varies the main generator frequency (linearly or logarithmically) between the start and stop frequencies. The sweep generator has its own operating modes: triggered, gated, hold at start and hold at stop. In addition, ten programmable frequency markers, available one at a time, can be used to indicate critical frequencies within the sweep. The sweep generator can internally trigger the main generator to produce pulses with a 10 μs to 10 min. repetition rate and 5 μs to 5 days pulse width.

Two external inputs may be used to phase- or amplitude-modulate the synthesizer. If the synthesizer is phase modulated, the main generator (when operating at frequencies above 500 kHz) varies up to ±360°. When amplitude modulated, the output can be modulated up to 200%.

Data entry is from the front panel or GPIB with microprocessors controlling the data. Numeric input is entered in free format: fixed, floating or exponential notation. Parameters may be entered in any order. Internally, all entries are checked for errors and interactively displayed on the front panel.

Up to 5 complete sets of programming may be stored and rapidly recalled.

1.2 OPTIONS

Option 001 allows up to 40 sets of complete front panel settings to be stored in memory. Memory is battery backed up (internally recharged) for 60 days (minimum) retention of settings. Memory is expandable to 240 settings.

Option 002 provides an additional high stability frequency reference crystal for greater accuracy. The high stability frequency has an accuracy of $\pm 5 \times 10^{-8}$ and an aging rate of 5×10^{-9}/day (average) or $<4 \times 10^{-8}$/week.

1.3 SPECIFICATIONS

1.3.1 Versatility

Waveforms

Sine ∿, square ⊓⊔, triangle ∧∨, ramps /|, |\, haversine ⋀, ⋁, havertriangles ⋀, ⋁, AM (sine) ◊◊, and DC.

Operational Modes

NOTE

1. *All modes are synthesized.*
2. *See Frequency Range Section for frequency capability in each mode.*
3. *Trigger modes: Trigger jitter <1% of waveform period.*

Continuous: Generator runs continuously.

Triggered: Generator is quiescent until triggered by an external signal, internal sweep signal, GPIB or manual trigger, then generates one cycle at selected frequency.

Gated: As triggered mode, except generator oscillates for the duration of the gate signal plus the remainder of the waveform in progress.

Triggered Haverwave: As triggered mode, except output is a sine or triangle waveform starting at −90° (or +90°).

Gated Haverwave: As gated mode, except output is a sine or triangle waveform starting at −90° (or +90°).

Triggered Burst: As triggered mode, except the number of cycles output for each trigger input is selectable from 1 to 65,536 (2^{16}) counts.

Triggered Haverwave Burst: As triggered burst, except output is a sine or triangle waveform starting at −90° (or +90°).

Frequency Sweep: Output frequency can be swept by internal sweep generator. (See Sweep Generator).

Frequency Range

Low-end frequency for all waveforms is 1μHz.

Continuous Mode:
∿ , ⊓⊔ , ◇◇ (AM sine) to 50 MHz.
∧∨ to 500 kHz.
⊿, ◺ to 20 kHz.

All Triggered Gated and Burst Modes:
∿ , ⊓⊔ , ∧∨ , ◇◇ (AM sine) to 200 kHz.
⊿, ◺ to 20 kHz.

Main Output

All waveforms are available to 20 Vp-p maximum into 50Ω load. Combined amplitude/dc offset waveforms not to exceed ±10V peak into 50Ω. Output voltage into an open circuit is double indicated voltage when a voltage less than ±5V peak is selected. Output available from front or rear. Source impedance: 50Ω (for <10V output), hi Z (for >10V output). Output may be floated up to 42V peak.

Phase Offset: Output phase may be changed from ±1000 revolutions (±360,000°) in 0.01° resolution steps to 500 kHz and 0.1° (or better) resolution steps above 500 kHz.

Amplitude Conversion

Permits entry and display of amplitude for all waveforms in units of Vrms, Vp-p and dBm.

DC Offset and DC Voltage Output

0 to ±10 Vdc into 50Ω. Output voltage is double into open circuit when voltage less than ±5 Vdc is selected.

Auxiliary Outputs

TTL and TTL Sync: At generator frequency, 50Ω source impedance, 50% duty cycle, <5 ns transition time.

Reference Output: 10 MHz, 1 Vp-p sine, 50Ω source impedance.

Sweep Ramp: (See Sweep Generator).

Frequency Marker: (See Sweep Generator).

Inputs

Trigger: A TTL level transition can trigger or gate both main generator and/or internal sweep generator. Triggering slope up (⟋) or down (⟍) is selectable.

Reference: An external 0.5V to 10 Vp-p sine or pulse clock of ±5 ppm or better stability and accuracy automatically locks the internal reference. External clock may be 1, 2, 3..., 9 or 10 MHz. Input impedance is 1 kΩ.

Amplitude Modulation: Modulation levels up to 20 kHz. Input impedance is 600 ohms. Amplitude reduced by approximately 50% with 0V input. 5.4 Vp-p, ±15%, ac signal (with 0V offset) provides 99% modulation. AC signal with −2.7 Vdc, ±15%, provides 200% modulation. Modulation bandwidth typically 10 MHz. Sync output unaffected by modulation.

Phase Modulation: Rates from DC to 10 kHz minimum. Input impedance is 10 kΩ. ±5V input delivers approximately ±360° shift. Output deviation is ÷100 for main output frequencies 500 kHz and below.

Data Entry

Front panel keyboard with display and GPIB programming.

1.3.2 Main Generator

1.3.2.1 Frequency Resolution

8 digits or 1μHz.

1.3.2.2 Frequency Precision

Accuracy

Better than 0.0005% of program setting, ±0.01 μHz.

Stability

Long Term: $\pm 1 \times 10^{-6}$/mo.

Temperature: $\pm 1.2 \times 10^{-7}$/°C.

Signal to Phase-Noise

Better than −46 dB in a 30 kHz band centered on carrier but excluding a ±1 Hz band around the carrier.

Spurious

-60 dBc or 30 μV whichever is greater, 1 μHz to 200 kHz.
-54 dBc or 30 μV whichever is greater, >200 kHz to 500 kHz.
-44 dBc or 30 μV whichever is greater, >500 kHz to 50 MHz.

1.3.2.3 Amplitude Precision

Resolution and Accuracy

NOTE
DC offset range is 0 to ± 10 Vdc

Amplitude Range	Accuracy (Amplitude)
10.02 to 20.00 Vp-p	±1% ±20 mV
1.01 to 10.0 Vp-p	±1% ±10 mV
0.101 to 1.00 Vp-p	±3% ±2 mV
10.1 to 100 mVp-p	±4% ±100 µV
1.00 to 10.0 mVp-p	±5% ±20 µV

NOTE
Specified for 1 kHz sine wave, or for dc output into a precision 0.1% 50Ω load.

Resolution: 3 digit ≤10.0 Vp-p, 4 digit (20 mV) >10 Vp-p.
DC Offset: ±1% of setting ±40 mV (worst case).

NOTE
Amplitude and dc offset share the output attenuator.

Frequency Response

Frequency Range	Response
1 µHz to 20 kHz	±1%
>20 kHz to 500 kHz	±3%
>500 kHz to 25 MHz	±7%
>25 MHz to 50 MHz	±15%

Specified relative to 1kHz sine wave, >100 mV to 6Vp-p, 0V offset into 50Ω.

Frequency Range	Response
1 µHz to 20 kHz	±1%
>20 kHz to 500 kHz	±3%
>500 kHz to 7 MHz	±7%
>7 MHz to 20 MHz	±12%
>20 MHz to 50 MHz	±20%

Specified relative to 1 kHz sine wave, >6V to 10 Vp-p, 0V offset into 50Ω.

For square add 1%. For triangle add 1% to 20 kHz; for greater than 20 kHz, unspecified.

For ramps add 5% to 10 kHz; add 15% to 20 kHz.

Amplitude and Offset Stability
Short Term: 0.1% ±1 mV for 10 min.
Long Term: 0.5% ±5 mV for 6 months.
Measured at room temperature.

1.3.2.4 Waveform Characteristics

Sine Distortion
Harmonically related signals less than:
–55 dB to 50 kHz.
–40 dB to 500 kHz.
–30 dB to 50 MHz.
Specified for 1 Vrms (2.83 Vp-p) sine wave.

Square Wave Rise and Fall Time
Less than 10 ns, 1.01 to 10.00 Vp-p.
Less than 12 ns, greater than 10 Vp-p.

Square Wave Aberrations
≤5% ± 50 mV of p-p voltage.

1.3.3 Sweep Generator

Sweep generator is fully synthesized and may be used independently or for frequency sweeping and triggering the main generator. Frequency sweep may be selected linear or logarithmic, and up or down. Sweep may be triggered, interrupted with hold, and continued with resume.

1.3.3.1 Sweep Modes

Continuous Sweep: Sweep generator sawtooth runs continuously.

Triggered Sweep: Incoming trigger causes a single sweep and resets to the start frequency.

Triggered Sweep/Triggered Reset: As in triggered sweep, but sweep holds at stop frequency until subsequent trigger returns frequency to start frequency.

1.3.3.2 Sweep Characteristics

Sweep Time
0.01 to 600.00 sec, 10µs resolution.

Sweep Output
0 to approximately +5V ramp synthesized to 2000 steps per sweep. 600Ω output impedance.

Frequency Marker Output
TTL levels. One of the ten preset markers can be selected. Output is low when the main generator frequency is below marker frequency; output is high when above. Crystal clock accuracy equal to that of synthesizer.

Maximum Sweep Range
Low Band: 1 µHz to 500 kHz.

High Band: 5 kHz to 50 MHz.

Minimum Sweep Range

Linear: Any start and stop frequencies with a minimum separation of:

Low Band: 20 mHz per 1s of sweep time.
High Band: 2 Hz per 1s of sweep time.

Log: Any start and stop frequencies with ratio greater than 2.

Sweep Resolution
Frequency Resolution including Start, Stop, Hold, Markers: 8 digits or 1 μHz.

Sweep Frequency Update: Every 5 μs (lin and log).

Log Slope Update: Every 2 ms.

1.3.3.3 Pulses

Square function triggered by sweep generator. Pulse parameters of period and width are controlled by sweep time and main generator frequency respectively. Pulses are generated to high synthesizer resolution and accuracy. Pulse is continuous or triggered externally.

Period
10 μs to 600s.
4 digits or 10 μs resolution (Control: Sweep Time); jitter <2% of pulse width.

Width
5 μs to 500,000s (>5 days);
8 digits resolution (Control: Main Frequency);
<0.05% jitter.

NOTE
Width is usable to 1 μs.

1.3.4 General

Stored Settings
Up to 5 complete instrument setups can be stored and recalled from volatile (RAM) memory. Settings may be modified or deleted.

GPIB Programming
Standard General Purpose Interface Bus (GPIB) programming per IEEE Standard 488-1978. Interface is optically isolated from signal ground. Interface includes Listener (AH1 and L4), Talker (SH1 and T6), SRQ (SR1), Local Lockout (RL1), Device Clear (DC1), Group Execute Trigger (DT1) capabilities, and open collector logic (E2).

Parameter	**Time**
Command Handshake	15 μs
Data Handshake	65 μs
Frequency	11 ms
Amplitude	14 ms
DC Offset	14 ms
Mode	4 ms
Function	5 ms
Output	4 ms
Stored Settings	13 ms
Execute	8 ms

NOTE
Above programming speeds are typical. Programming times vary with different controllers. Data rate follows slowest listener on bus.

Environmental
Accuracy applies for 25°C ±10°C after 30 minutes warm-up unless otherwise noted. Instrument will operate from 0°C to 50°C to 10,000 ft altitude at 90% relative humidity. Storage temperature from −25°C to +65°C.

Dimensions
44.5 cm (17.5 in.) wide; 13.3 cm (5¼ in.) high; 53.4 cm (21 in.) deep. Supplied with rack mount adapters.

Weight
13.6 kg (30 lb) net; 19.4 kg (43 lb) shipping.

Power
90 to 105V, 108 to 126V, 198 to 231V or 216 to 252V; 48 to 67 Hz; less than 180 watts.

1.3.5 Options

001 Additional Stored Settings
Provides nonvolatile memory for 240 additional stored settings. Memory is battery backed up (internally recharged) for 60 day (minimum) retention of settings.

002 High Stability Frequency Reference

An additional frequency reference crystal for greater accuracy.

Accuracy: ±5 X-10^{-8}
Aging Rate: 5 X 10^{-9}/day (average) <4 X 10^{8}/week.

SECTION 2
INSTALLATION AND INTERFACE

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

CAUTION

Do not mount this instrument by front panel alone. Slides or tray support is necessary to prevent instrument damage. (Ref: Figure 2-1.)

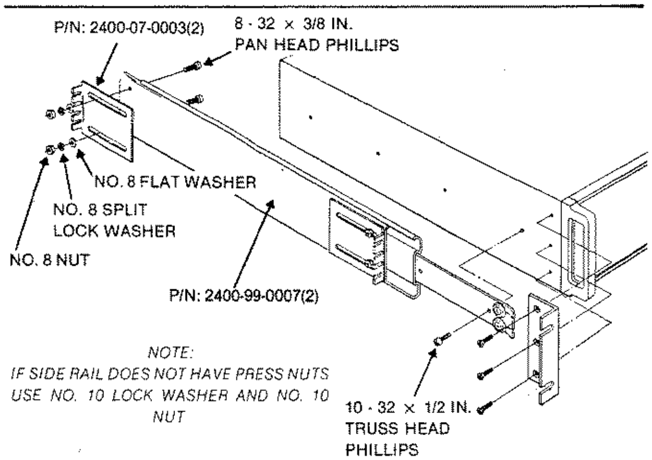


Figure 2-1. Optional Slide Mounting

The generator can be used as a bench instrument or rack mounted. In either use, ensure that there is no impedance to air flow at any surface of the instrument. Before rack mounting, it may be desirable to perform the initial checkout (paragraph 2.2.5) to verify operation of all functions.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 120 Vac line supply and with a 2 amp fuse.

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

1. Disconnect the power cord at the instrument, open fuse holder cover door and rotate fuse-pull to left to remove the fuse.

2. Remove the small printed circuit board and select operating voltage by orienting the printed circuit board to position the desired voltage to the top left side. Push the board firmly into its module slot.

Card Position	Input Vac	Fuse
100	90 to 105	2 amp
120	108 to 126	2 amp
220	198 to 231	1 amp
240	216 to 252	1 amp

3. Rotate the fuse-pull back into the normal position and insert the correct fuse into the fuse holder. Close the cover door.

4. Connect the ac line cord to the mating connector at the rear of the unit and the power source.

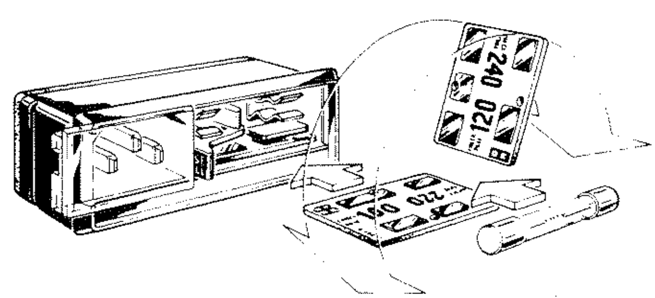


Figure 2-1A. Voltage Selector and Fuse

2.2.2 Signal Connections

NOTE
Use RG58U or equivalent 50Ω coaxial cables equipped with BNC connectors to distribute FUNCTION OUT signals.

Instrument BNC connectors are:

EXT TRIG IN, front and rear panel, TTL

SWEEP OUT, front panel, 0 to ≈5V, 600Ω impedance.

SYNC OUT, front panel, TTL, 50Ω impedance

SYNC OUT, rear panel, $\overline{TTL}$, 50Ω impedance

FUNCTION OUT, front and rear panel, 10 Vp-p, 50Ω impedance; 10 to 20 Vp-p, >10 kΩ impedance.

REF IN, rear panel, 0.5V to 10 Vp-p, 1 to 10 MHz

REF OUT, rear panel, 10 MHz, 2 Vp-p, 50Ω impedance

MARKER OUT, rear panel, TTL

AM IN, rear panel 5 Vp-p (100% modulation), 600Ω impedance

ϕ MOD IN, rear panel, 5 Vp-p Maximum, 10 kΩ impedance

Table 2-1. GPIB Data In/Out

Pin	Signal	
1	DIO1	
2	DIO2	
3	DIO3	True When Low
4	DIO4	
5	EOI	
6	DAV	
7	NRFD	True When High
8	NDAC	
9	IFC	
10	SRQ	True When Low
11	ATN	
12	Chassis Ground	
13	DIO5	
14	DIO6	
15	DIO7	True When Low
16	DIO8	
17	REN	
18		
19		
20		
21		Signal Ground
22		
23		
24		

Signal ground may be floated up to ±42 volts with respect to chassis ground. Be aware that if one signal ground is floated, all signal grounds, on both front and rear panels, are likewise affected.

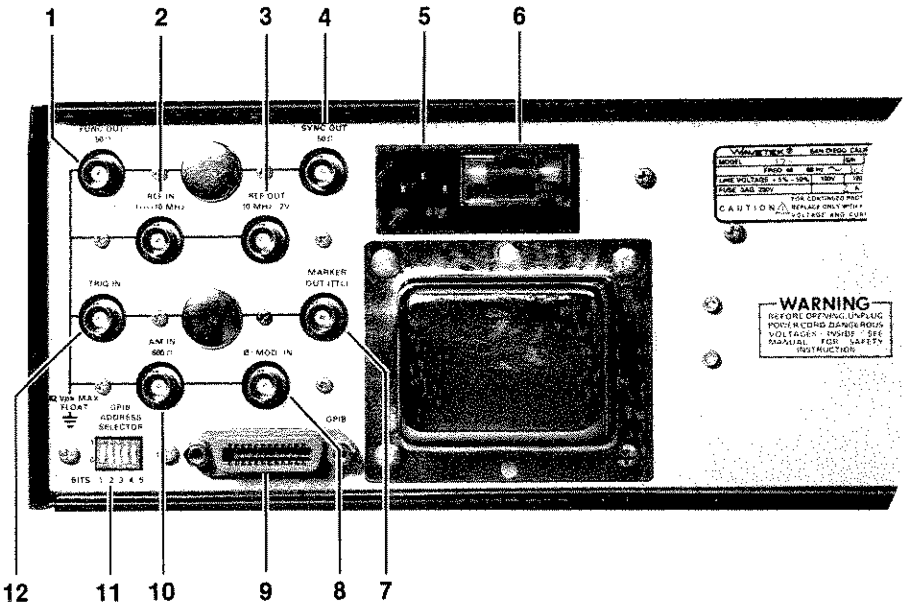
2.2.3 GPIB Connections

The GPIB I/O rear panel connection is shown in figure 2-2; pin connections and signal names are given in table 2-1. The panel connector is an Amphenol 57-10240 or equivalent and connects to a GPIB bus cable connector (available from Wavetek in 1 and 2 meter lengths). The GPIB interface is optically isolated from the main generator.

Table 2-2. GPIB Address Codes

	ASCII		Switch Position					Hexa-decimal	
Device	Listen	Talk	1	2	3	4	5	Listen	Talk
0	(space)	@	0	0	0	0	0	20	40
1	!	A	1	0	0	0	0	21	41
2	''	B	0	1	0	0	0	22	42
3	#	C	1	1	0	0	0	23	43
4	$	D	0	0	1	0	0	24	44
5	%	E	1	0	1	0	0	25	45
6	&	F	0	1	1	0	0	26	46
7	'	G	1	1	1	0	0	27	47
8	(	H	0	0	0	1	0	28	48
9	)	I	1	0	0	1	0	29	49
10	*	J	0	1	0	1	0	2A	4A
11	+	K	1	1	0	1	0	2B	4B
12	,	L	0	0	1	1	0	2C	4C
13	—	M	1	0	1	1	0	2D	4D
14	•	N	0	1	1	1	0	2E	4E
15	/	O	1	1	1	1	0	2F	4F
16	0	P	0	0	0	0	1	30	50
17	1	Q	1	0	0	0	1	31	51
18	2	R	0	1	0	0	1	32	52
19	3	S	1	1	0	0	1	33	53
20	4	T	0	0	1	0	1	34	54
21	5	U	1	0	1	0	1	35	55
22	6	V	0	1	1	0	1	36	56
23	7	W	1	1	1	0	1	37	57
24	8	X	0	0	0	1	1	38	58
25	9	Y	1	0	0	1	1	39	59
26	:	Z	0	1	0	1	1	3A	5A
27	;	[	1	1	0	1	1	3B	5B
28	<	\	0	0	1	1	1	3C	5C
29	=	]	1	0	1	1	1	3D	5D
30	>	↑	0	1	1	1	1	3E	5E

Address 31 is not allowed.



Location	Function	Paragraph
1	Function Output	2.2.2, 3.11, App E
2	Reference Input	2.2.2, 3.8.6
3	Reference Output	2.2.2, 3.8.6
4	Sync Output	2.2.2
5	Power Cord Receptacle	2.2.1
6	Fuse and Fuse Holder	2.2.1
7	Marker Output	2.2.2, 3.9.6
8	Phase Modulation Input	2.2.2, 3.8.6
9	GPIB (General Purpose Interface Bus) Connector	2.2.3, 3.16
10	AM Input	2.2.2, 3.8.4
11	GPIB Address Selector Switch	2.2.4
12	Trigger Input	2.2.2, 3.7

Figure 2.2 Rear Panel and Cross Reference

2.2.4 GPIB Address

For instruments on the General Purpose Interface Bus (GPIB), ensure that the GPIB address is correct. The GPIB address can be changed by the switch on the rear of the instrument (see figure 2-2) by simply setting the multiple section switch located on the rear panel according to table 2-2. The switch sections are labeled from 1 through 5 and their open position noted (OPEN = Binary "0" in table 2-2). To verify the address, press ADR on the front panel. The device number (decimal) and ASCII listen and talk addresses will be displayed.

2.2.5 Initial Checkout and Operation

Make the equipment setup as shown in figure 2-3 and perform the steps in table 2-3 to verify Model 178 operation. If further explanations are required, refer to figure 3-1 and table 3-1.

Table 2-3. Operation Verification

Step	Test	Tester & Setup	Program	Desired Results
1	Wake-up state and Self Test	Connect Model 178 and oscilloscope as shown in figure 2-3. Scope setting: CH1 0.5 V/div, CH2 0.1 V/div, select CH1 only, horizontal 0.2 ms/div, trigger to external	Power: ON	Display: All segments, decimal points and commas light up for one second TYPICAL OF 20, SELF-TEST for one second, then WAVETEK MODEL 178. Scope: CH1 1 kHz, 1 Vp-p sine wave.
2		Select CH2		CH2, sweep signal 0 to ≥ +200 mV, 2s per sweep.
3	Wake-up Status		Press STATUS key	Display (changes automatically): FREQ 1 kHZ AMPL 1 V P-P OFFSET 0 V FUNC SINE (0) MODE CONTINUOUS (0) BURST COUNT 2 PHASE 0 DEG SW STRT 500 HZ SW STOP 5 kHZ MKR FRQ 1 kHz SWP OFF (0) SWEEP TIME 2 SEC OUTPUT ON (1) FRONT OUTPUT (0) EXTERNAL TRIGGER (0) TRIG SLOPE POS (0)

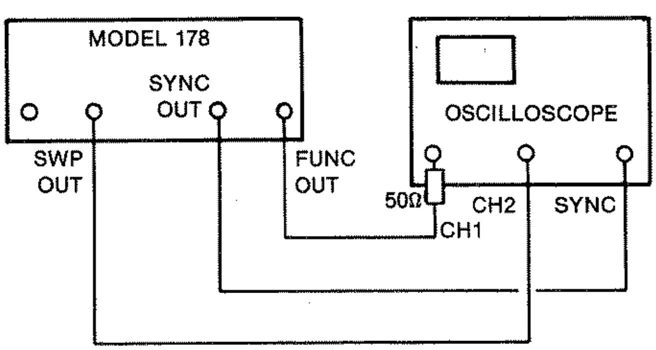


Figure 2-3. Step 1 Setup

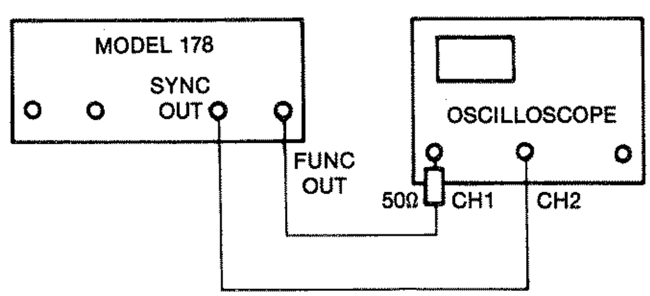


Figure 2-4. Step 59 Setup

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
4	Status Search		STATUS	Status display sequence stops.
5			↑	Status progresses forward.
6			↓	Status progresses backward.
7			STATUS	Status display sequentially continues.
8	Display Test		DISPLAY TEST	All segments decimal points, and commas light up. Back to last display when released.
9			Press FREQ key a few times	Beeper sounds everytime key is pressed.
10			Press ♪, then FREQ key a few times	Beeper is silent.
11			♪	Beeper enabled.
12	Command Recall		Press each of the 8 keys in the MAIN generator section 4 times then CMD RCL	Strings of characters shown on display.
13			Press ← or →	Moves characters left or right, 4 at a time.
14	GPIB Address and Status		ADRS	Display: GPIB ADDR ________ (Ref: Table 2-2)
15	Set Frequency		FREQ	Display: FREQ 1 kHZ.
16			←	Display: FREQ 1.0000000 kHZ.
17			↑	Frequency LSD increases.
18			↓	Frequency LSD decreases.
19			←or→	Different digits are intensified (selected for editing).
20	Reset Frequency	Select CH1	←or→ until digit selection (intensification) stops.	Display: FREQ 1 KHZ Scope: 1 kHz, 1 Vp-p sine wave.
21	Set Amplitude		AMPL	Display: AMPL 1 V P-P
22			Use cursor, ← → ↑ ↓, to increase or decrease amplitude	Scope: Amplitude increasing or decreasing.
23	Amplitude	Scope setting: 5 V/div	AMPL 20 EXEC	Scope: Sine wave 20 Vp-p. Display: AMPL 20 VP-P

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
24		2 V/div	AMPL 10 EXEC	Scope: 10 Vp-p
25		20 mV/div	AMPL .1 EXEC	Scope: 100 mVp-p
26		5 mV/div	AMPL 1 EXP – 2 EXEC	Scope: 10 mVp-p
27		5 mV/div	AMPL 1 EXP – 3 EXEC	Scope: .1 mVp-p
28		0.5 V/div	AMPL 1 EXEC	Scope: 1 Vp-p
29	Offset	Scope setting: 1 V/div	OFFSET 2 EXEC	Scope: 1 Vp-p sine wave, + 2 Vdc offset.
30			OFFSET – 2 EXEC	– 2 Vdc offset.
31			Use cursor to increase or decrease offset	Offset increases or decreases.
32			OFFSET 0 EXEC	1 Vp-p sine wave, 0 Vdc offset.
33	Function (Waveform, Low Frequency)	Scope setting: 0.2 V/div	FUNC	Display: FUNC SINE (0). Scope: 1 Vp-p, sine wave.
34			↑	Display: FUNC TRIANGLE (1). Scope: 1 Vp-p triangle wave.
35			↑	Display: FUNC SQUARE (2). Scope: 1 Vp-p square wave.
36			↑	Display: FUNC RAMP (3). Scope: 1 Vp-p ramp.
37			↑	Display: FUNC DC (4). Scope: 0 Vdc.
38			↑	Display: FUNC AM SINE (5). Scope: 0.5 Vp-p, sine wave.
39	Function (Waveform, High Frequency)	Scope setting: Horizontal 50 ns/div	FUNC 0 FREQ 1 EXP 7 EXEC	Display: FREQ 10 MHz Scope: 10 MHz, 1 Vp-p sine wave.
40			FUNC 2 EXEC	Display: FUNC SQUARE (2). Scope: 10 MHz, 1 Vp-p square wave.
41		Scope setting: Vert 2V/div, Horiz 10 ns/div	AMPL 10 FREQ 5 EXP 7 EXEC	Display: FREQ 50 MHz. Scope: 50 MHz, approx 8 Vp-p square wave.
		NOTE: Quality of waveform is dependent on cable length and speed of scope.		
42	System Reset (Reset to wake-up state)	Scope setting: Horizontal 0.5 ms/div CH1 0.5 V/div	RESET	Display: RESET. Scope: 1 kHz, 1 Vp-p sine wave.
43	Amplitude Definition		AMPL	Display: AMPL 1 V P-P
44			AMPL DEF	Display: AMPL IN VP-P (0).

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
45			↑	Display: AMPL IN VRMS (1)
46			AMPL	Display: AMPL 354 mV RMS.
47			FUNC 1 EXEC AMPL	Display: AMPL 289 mV RMS. Scope: 1 Vp-p triangle.
48			FUNC 2 EXEC AMPL	Display: AMPL 500 mV VRMS. Scope: 1 Vp-p square wave.
49			FUNC 0 AMPL 1 EXEC	Display: AMPL 1 V RMS. Scope: 2.83 Vp-p, sine wave.
50			FUNC 1 EXEC AMPL	Display: AMPL 1 V RMS. Scope: 3.46 Vp-p, triangle wave.
51			FUNC 2 EXEC AMPL	Display: AMPL 1 V RMS. Scope: 2 Vp-p square wave.
52			FUNC 3 EXEC AMPL	Display: AMPL 1 V RMS. Scope: 3.46 Vp-p, ramp.
53			AMPL DEF 2 EXEC	Display: AMPL IN dBm (2).
54			AMPL	Display: AMPL 13 dBm. Scope: 3.46 Vp-p ramp.
55			FUNC 2 EXEC AMPL	Display: AMPL 13 dBm. Scope: 2 Vp-p square wave.
56			FUNC 1 EXEC AMPL	Display: AMPL 13 dBm. Scope: 3.46 Vp-p triangle wave.
57			FUNC 0 EXEC AMPL	Display: AMPL 13 dBm. Scope: 2.83 Vp-p sine wave.
58	System reset		RESET	Display: RESET. Scope: 1 kHz, 1 Vp-p sine wave.
59	Triggered	Attach scope per figure 2-4. Scope: CH1 0.5 V/div CH2 1 V/div Horizontal 2 ms/div Trigger to CH2	EXT/INT 1 TIME .01 MODE (Main) 1 EXEC	Display: MODE TRIGGERED (1). Scope: CH1, 1 cycle of sine wave, CH2, Sync pulse, 0 to ≥2.5V
60	Gated		↑	Display: MODE GATED (2). Scope: CH1-Burst of sinewave. CH2-Burst of sync pulses.
61	Burst		↑	Display: MODE BURST (3). Scope: CH1-2 cycles of sine wave. CH2-2 sync pulses.
62			BURST ↑ ↑	Display: BURST COUNT 4. Scope: CH1-4 cycles of sine wave. CH2-4 sync pulses.

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
63	Trigger Haver		MODE (Main) ↑	Display: MODE TRIG HAVER(4). Scope: CH1-1 cycle of haversine CH2-One sync pulse.
64	Gated Haver		↑	Display: MODE GATED HAVER(5) Scope: CH1-Burst of haversine. CH2-Burst of sync pulses.
65	Burst Haver		↑	Display: MODE BURST HAVER (6). Scope: CH1-4 cycles of haversine. CH2-4sync pulses.
66			FUNC	Display: FUNC SINE (0)
67			↑	Display: FUNC TRIANGLE (1). Scope: CH1-4 cycles of havertriangle. CH2-4 sync pulses.
68			↑	Display: FUNC SQUARE (2). Scope: CH1-4 cycles of square wave. CH2-4 sync pulses.
69			↑	Display: FUNC RAMP (3). Scope: CH1-4 cycles of ramp. CH2-4 sync pulses.
70	Inverted Burst Haver		AMPL −1 EXEC	Display: AMPL −1 V P-P Scope: CH1-4 cycles of inverted ramp. CH2-4 sync pulses.
71			FUNC ↓	Display: FUNC SQUARE (2). Scope: CH1-4 cycles of inverted square. CH2-4 sync pulses.
72			↓	Display: FUNC TRIANGLE (1). Scope: CH1-4 cycles of inverted havertriangle. CH2-4 sync pulses.
73			↓	Display: FUNC SINE (0). Scope: CH1-4 cycles of inverted haversine. CH2-4 sync pulses.
74	System Reset		RESET	Display: RESET. Scope: CH1-1 kHz, 1 Vp-p sine wave. CH2-0 to ≈2.5V sync pulses.
75	Continuous Sweep, Linear.	Attach scope per figure 2-3. Scope: Trigger to internal. Horizontal to .5 ms/div. Vertical mode to chop. Sync to CH1.	MODE (Sweep) 1 EXEC	Display: SWP CONT LIN (1). Scope: CH1-Frequency sweeping from 500 Hz to 5 kHz, 2s per sweep. CH2- 0 to ≈5V, 2 sec ramp.

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
76	Trigger Sweep, Reset, Linear		↑	Display: SWP TRIG RST LIN (2). Scope: CH1-500 Hz sine wave. CH2-0 Vdc.
77			MAN TRIG	Scope: CH1-Sweeping to 5 kHz and reset back to 500 Hz. CH2-Ramp to ≈5V and reset to 0V.
78	Trigger Sweep and Hold, Linear		↑ Scope: CH1-500 Hz sine wave. CH2-0 Vdc.	Display: SWP TRIG HOLD LIN (3) Scope: CH1-500 Hz sine wave. CH2-0 Vdc.
79			MAN TRIG	Scope: CH1-Sweep to and hold at 5 kHz. CH2-Ramp to ≈5 Vdc.
80			MAN TRIG	Scope: CH1-Reset to 500 Hz. Ch2-Reset to 0 Vdc.
81	Sweep Hold and Resume		TIME 10 EXEC MAN TRIG	Display SWEEP TIME 10 SEC Scope: CH1-Frequency sweep starts. CH2-Ramp to ≈5Vdc
82			HOLD	Scope: CH1-Constant frequency. CH2-Stops ramping. Display: Indicates frequency at hold.
83			RESUME	Scope: CH1-Sweep continues, stops at 5 kHz. CH2-Continues to ≈5 Vdc. Display: RESUME
84			MAN TRIG	Scope: CH1-Reset to 500 Hz. CH2-0 Vdc. Display: SWEEP TIME 10 SEC
85	Sweep Hold, Search and Resume		MAN TRIG	Scope: Sweep starts.
86			HOLD	Scope: Constant frequency.
87			← ↑ ↓ →	Scope: CH1-Frequency increasing or decreasing. CH2-Sweep output level remains constant.
88			RESUME	Scope: CH1-Sweep continues from where it was held. CH2-2 ramps to ≈5 Vdc.
89	Continuous Sweep, Logarithmic		START FREQ 100 STOP FREQ 1E5 MODE (Sweep) 4 EXEC	Display: SWP CONT LOG (4). Scope: CH1-Frequency sweeping from 100 Hz to 100 kHz logarithmically. CH2-2 ramps to ≈5 Vdc.
90	Triggered Sweep, Reset, Logarithmic		↑	Display: SWP TRIG RST LOG (5). Scope: CH1-100 Hz. CH2-0 Vdc.

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
91			MAN TRIG	Scope: CH1-Frequency sweeps from 100 Hz to 100 kHz logarithmically, then resets to 100 Hz. CH2-Ramps to ≈5 Vdc, resets to 0 Vdc.
92	Triggered Sweep and Hold, Logarithmic		↑	Display: SWP TRIG HOLD LOG (6). Scope: CH1-100 Hz. CH2-0 Vdc.
93			MAN TRIG	Scope: CH1-Frequency sweeps from 100 Hz to, and holds at, 100 kHz, logarithmically. CH2-2 ramps to ≈5 Vdc.
94			MAN TRIG	Scope: CH1-Reset to 100 Hz. CH2-Resets to 0 Vdc.
95	Sweep with Marker	Scope: Connect scope as in figure 2-5. Sync to external input. Horizontal 2 ms/div	MODE (SWEEP) 4 TIME .02 MARKER 1 EXEC	Display: MKR (1) 1 KHZ. Scope: CH1-Frequency sweeps from 100 Hz to 100 kHz. logarithmically. CH2-Marker switches from low to high when swept frequency is at 1 kHz.
96	Enter Marker Frequency		MARKER 2 MARKER FREQ 3E3 MARKER 3 MARKER FREQ 1E4 MARKER 4 MARKER FREQ 3E4	
97	Recall Marker Frequency		MARKER 1 EXEC	Display: MKR (1) 1 kHZ. Scope: Marker at 1 kHz of swept frequency.
98			↑	Display: MKR (2) 3 kHZ. Scope: Marker at 3 kHz of swept frequency.
99			↑	Display: MKR (3) 10 kHZ. Scope: Marker at 10 kHz of swept frequency.
100			↑	Display: MKR 30 kHZ. Scope: Marker at 30 kHz of swept frequency.
101	Modify Marker Frequency		MARKER FREQ ← ↑ ↓ or →	Scope: Marker on CH2 will move left or right, and display will indicate the up-dated frequency.
102	Store Stored Settings. (If Option 001 is installed, use procedure similiar to steps 102 through 110 to verify storage locations 6 thru 45.)	Connect scope as in figure 2-6. Horizontal to 1 ms/div.	RESET FUNC 1 EXEC	Scope: 1 kHz triangle.
103			STORE 1 EXEC	Display: NO. 1 LAST STORED
104			FUNC 2 AMPL 2 EXEC	Scope: 1 kHz, 2 Vp-p squarewave.

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
105			STORE 2 EXEC	Display: NO. 2 LAST STORED
106			FREQ 2E3 FUNC 0 EXEC	Scope: 2 kHz, 2 Vp-p sine wave.
107			STORE 3 EXEC	Display: NO. 3 LAST STORED
108	Recall Stored Settings.		RECALL 1 EXEC	Display: SETTING 1 RECALLED Scope: 1kHz, 1Vp-p triangle
109			↑	Display: SETTING 2 RECALLED Scope: 1kHz, 2 Vp-p square wave.
110			↑	Display: SETTING 3 RECALLED Scope: 2kHz, 2 Vp-p sine wave.
111	Output OFF/ON		RESET	Display: RESET. Scope: 1 kHz, 1 Vp-p sine wave.
112			OFF/ON 0 EXEC	Display: OUTPUT OFF, LD OUT (0) Scope: No signal, FUNCTION OUT open circuit.
113			OFF/ON 2 EXEC	Display: OUTPUT OFF, LD IN (2). Scope: No signal, FUNCTION OUT shorts to ground through a 50Ω resistor.
114			↓	Display: OUTPUT ON (1). Scope: 1 kHz, 1 Vp-p sine wave.
115	Front or Rear Output		FRONT/REAR	Display: FRONT OUTPUT (0). Scope: (CH1) 1 kHz, 1 Vp-p sine wave. (CH2) no signal.
116			FRONT/REAR 1 EXEC	Display: REAR OUTPUT (1). Scope: (CH1) no signal. (CH2) 1 kHz, 1 Vp-p sine wave.
117			↓	Return to front output.
118	External Trigger	Connect scope and Model 182A (TTL source) as in figure 2-7. Set Model 182A frequency to 100 Hz. Sync on CH2. Horizontal to 2 ms/div. Scope trigger to internal.	RESET	Display: RESET.
119			MODE (Main) 2 EXEC	Display: MODE GATED (2). Scope: Burst of sine wave (CH1) when square (CH2) is high.
120			SLOPE 1 EXEC	Display: TRIG SLOPE NEG (1). Scope: Burst of sine wave (CH1) when square (CH2) is low.

Table 2-3. Operation Verification (Continued)

Step	Test	Tester & Setup	Program	Desired Results
121	Amplitude Modulation	Connect scope and sine generator as shown in figure 2-8. Sync on CH2. Set Model 182A to 100 Hz, 3 Vp-p sine wave. Scope trigger internal. Horizontal to 2 ms/div.	RESET	Display: RESET.
122			FREQ 1 EXP 4 FUNC 5 EXEC	Display: FUNC AM SINE (5). Scope: Modulated sine wave (CH1), 100 Hz, 3 Vp-p sine wave (CH2).

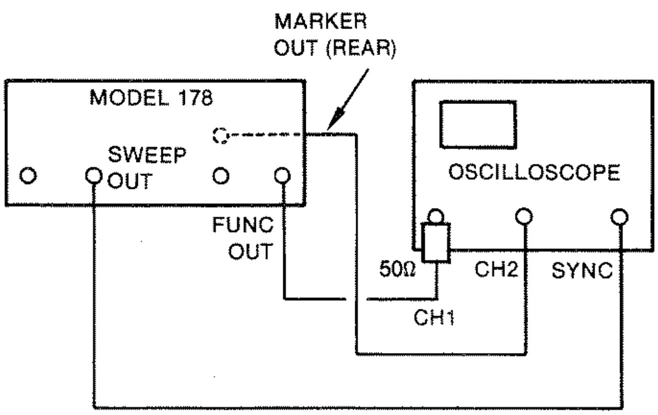


Figure 2-5. Step 95 Setup

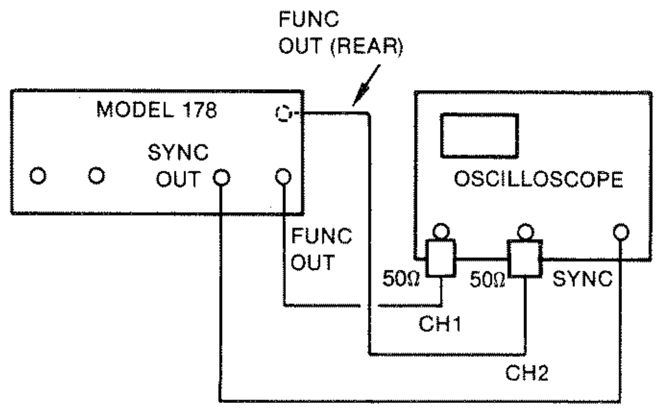


Figure 2-6. Step 102 Setup

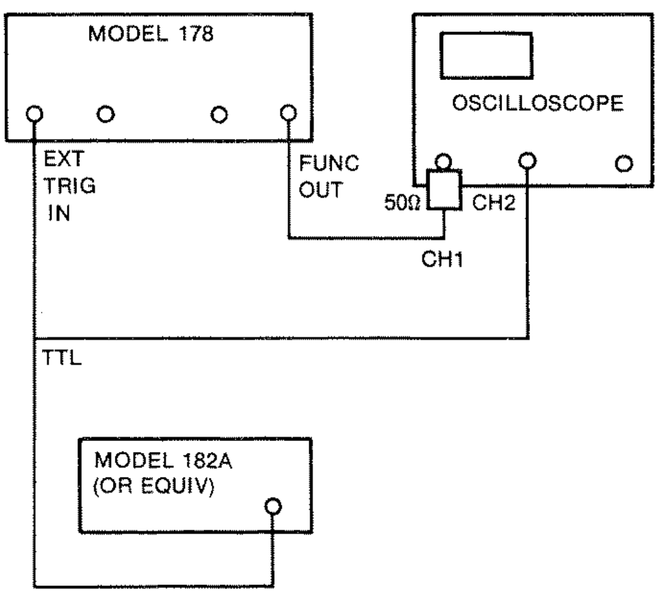


Figure 2-7. Step 118 Setup

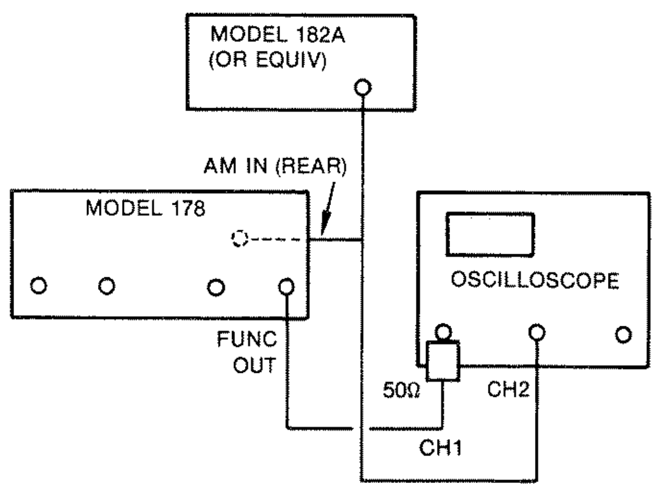
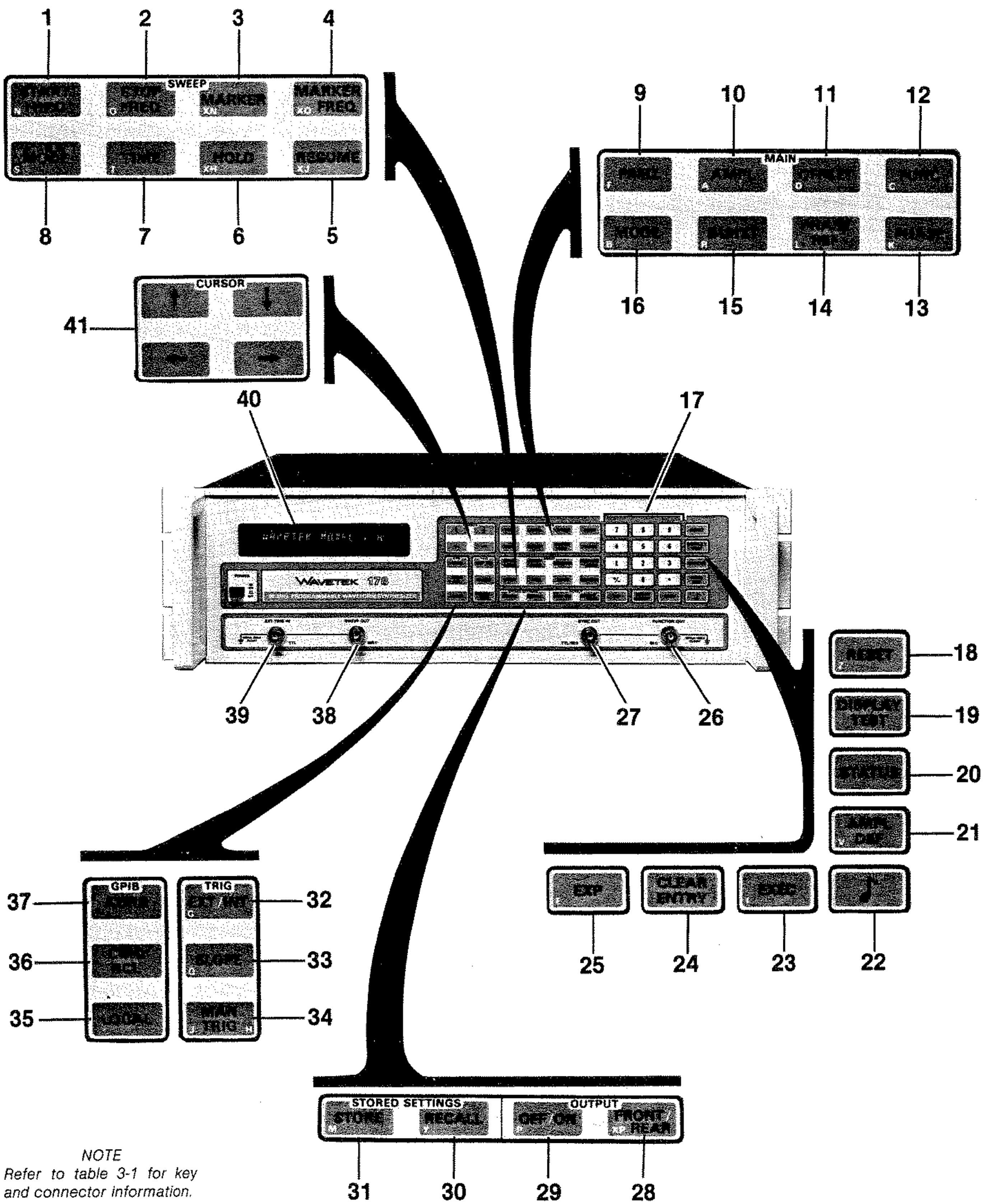


Figure 2-8. Step 121 Setup



NOTE
Refer to table 3-1 for key and connector information.

Figure 3-1. Front Panel Controls and Connectors

SECTION 3 OPERATIONS

3.1 DATA ENTRY

Using the Model 178 is quite straight forward and is easily understood by trial and error method while the microprocessor "converses" with you during operating, informing you what was programmed, what is possible to program and when an error is made. Perform the procedures of table 2-3 to familiarize yourself with Model 178 operation. Keyboards are shown in figure 3-1 and cross referenced to table 3-1, which in turn references the applicable text. Readout that occurs when the keys are pressed are listed in Appendix C. Readout is literal and in two slightly different modes. For example, for frequency, amplitude and offset, when FREQ, AMPL or OFFSET keys are pressed, as for an inquiry as to status, the words MICROHERTZ, MILLIVOLTS, etc., are used; when the operator starts keying in the parameter argument, no unit of measure is displayed. Coded parameters, such as function, mode and output show their programmed argument in parentheses.

An audible tone indicates that a key is pressed. Pressing ♪ will prevent or restore the key tone. If there is no tone when keys are pressed, pressing ♪ restores the tone and vice versa.

Information exclusive to the GPIB is given in paragraph 3.16.

Additional reference information appears in the appendixes:

Appendix A - ASCII and IEEE (GPIB) Code Chart
Appendix B - Programming Command Summary
Appendix C - Displays
Appendix D - Output and Timing for Basic Modes and Functions.
Appendix E - Mode Combinations and Output

Table 3-1 Function Cross Reference

Location in Figure 3-1	ASCII Character	Function	Action (A) or Parameter (P)	Appendix C and Paragraph
1	N	Sweep Start Frequency	P	3.9.1
2	O	Sweep Stop Frequency	P	3.9.1
3	XN	Marker Selection	P	3.9.6
4	XO	Marker Frequency	P	3.9.6
5	XJ	Resume Sweep	A	3.9.5
6	XH	Sweep Hold	A	3.9.5
7	T	Sweep Time	P	3.9.2
8	S	Sweep Mode	P	3.9.4
9	F	Frequency	P	3.8.1
10	A	Amplitude	P	3.8.2
11	D	DC Offset	P	3.8.3
12	C	Function (Waveform)	P	3.8.4
13	K	Phase	P	3.8.6
14	L	Set Phase Zero Reference	A	3.8.6
15	R	Burst Count	P	3.8.5
16	B	Main Generator Mode	P	3.8.5
17	0 thru 9	Number Characters	P	3.3
18	Z	Reset	A	3.13
19		Display Test	A	3.14
20		Status	A	3.15

Table 3-1 Function Cross Reference (Continued)

Location in Figure 3-1	ASCII Character	Function	Action (A) or Parameter (P)	Appendix C and Paragraph
21	V	Amplitude Definition	P	3.8.2
22		♩(Tone On/Off)	A	3.1
23	I	Program Execution	A	3.5
24		Clear Entry	A	3.12
25	E	Exponent	P	3.3.3
26		Function Output		3.11.1, App E
27		Sync Output		2.2, 3.11.3
28	XP	Output Front/Rear	P	3.11.1
29	P	Output Off/On	P	3.11.2
30	Y	Recall Stored Setting	P	3.10
31	M	Store Setting	P	3.10
32	G	Trigger, Int/Ext	P	3.7
33	Q	Triggering Slope	P	3.7
34	J	Manual Trigger Pressed	A	3.7
34	H	Manual Trigger Released	A	3.7
35		Local Control Enable	A	3.16
36		Command Recall	A	
37		GPIB Address	A	2.2.4, 3.16.2.1
38		Sweep Generator Output		3.9.4, App E
39		External Trigger Input		3.9.4
	U	Recall Previous Program	A	3.10.2
	W	Recall Next Program	A	3.10.3
	XG	GET Mode	P	3.16.7
	XQ	SRQ Enable	P	3.16.5
	XT	Talk Message	P	3.16.4
	XV	Terminator Select	P	3.16.6
40		Readout		3.16.9, App C
41		Cursor	A	3.6

3.2 POWER

Power is turned on and off with a front panel push-button. When the power is turned on, the entire display lights up for a display element test. Then, the generator automatically performs a self test routine. "SELF TEST" is displayed at this time. When testing is completed, "WAVETEK 178" is displayed. At least two seconds must elapse between power OFF and power ON for proper reinitialization of logic. When the power comes on, the output is automatically enabled.

3.3 BASIC COMMAND STRUCTURE

The Model 178 is programmed by sending ASCII coded characters (ref: table 3-1 and Appendix A) to the microprocessor via one of the two possible input ports (keyboard or GPIB) shown in figure 3-2. If input characters are present on more than one input port, they are read first from the GPIB and then from the keyboard. Thus, if the GPIB port is continuously supplied with characters, then no characters will ever be read from the keyboard.

3.3.1 Characters

Characters used to program the 178 are divided into classes:

1. **Alphabetic Characters**—The characters A through Z (except E) select actions or commands. The X character used in front of another alphabetic character selects an alternate set of actions or commands. The X must directly precede the alphabetic character without intervening characters of any kind. For example, P selects the output and off/on and XP selects front/rear function output, but X ∧ P (where ∧ is a space character) selects output off/on, not front/rear output because a space character,

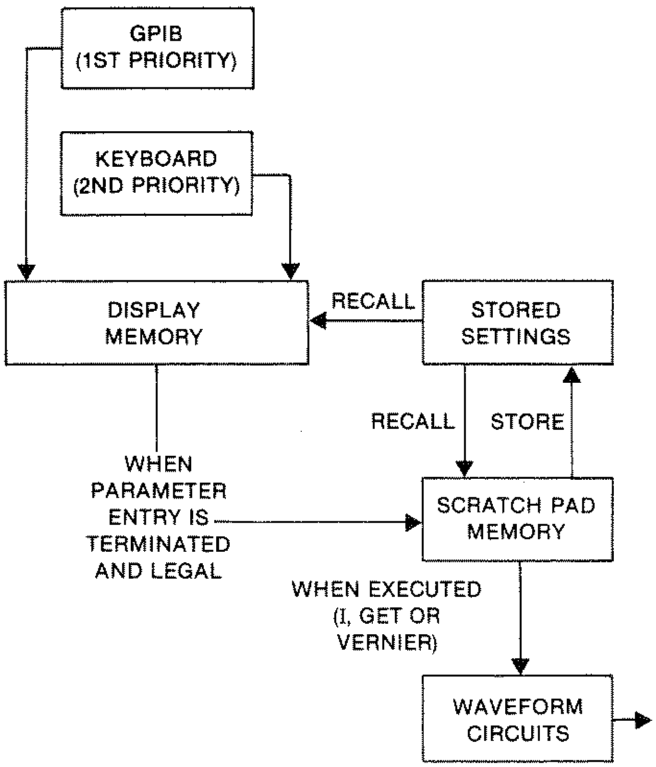


Figure 3-2. Memory Structure

not X, was placed immediately before the **P**. Alphabetic characters are generated from the keyboard by pressing the labeled action and parameter keys. The characters generated by such keys are printed in a corner of the key.

2. **Numeric Characters—**The characters 0 through 9, E, –, and decimal point (.).

3. **Special Character—**Quote (').

4. **Terminator Character—**Initially the ASCII new line character (NL). This can be changed by programming.

5. **Nonprogramming Characters—**Any character not in one of the previously described classes. They have no effect on programming and may be interspersed freely among programming characters, except after X (refer to item 1).

3.3.2 Action Vs Parameter

The alphabetic characters are used to select either actions or parameters (ref: table 3-1). An action is a sequence of events which happens when the letter that selects it is programmed or the key that selects it is pressed. There is no need for a numerical suffix. A programming parameter has one or two letters (and most have keys) plus a numeric value which controls some aspect of the instrument's operation.

To program an action, simply program the proper alphabetic character from either the front panel or GPIB port. The action will then take place, but only if the instrument is in the *enable* state at the moment when that character is read by the microprocessor (ref: REN, paragraph 3.16.1).

To examine the current value of a parameter, simply program the proper alphabetic character from either the front panel or GPIB port. The current value is then displayed on the front panel. Display occurs whether or not the instrument is enabled. If the character programmed does not correspond to a legal parameter in the instrument, nothing happens.

3.3.3 Programming Parameter Values

The numeric characters (**0** through **9**, **E**, **–**,) are used to program new parameter values. To change a parameter value, first program the alphabetic character which selects the desired parameter (**F** = frequency, etc.). Next, program the new value using numeric characters. Any sequence of characters which gives the new value is acceptable. For example, all of the sequences in table 3-2 cause the value 100 to be programmed.

Table 3-2. Examples of Value Programming

ASCII	Keyboard	Standard Notation
100	100	100
0100	0100	100 (leading zeros are ignored)
1E2	1 EXP 2	1×10^2
.01E4	.01 EXP 4	$.01 \times 10^4$
.01E304	.01 EXP 304	$.01 \times 10^4$ (last two exponent digits only are used)
1000E-1	1000 EXP ±1	1000×10^{-1}
1E-2-	1 EXP ±2 ±	1×10^2 (two minus signs cancel)
1E.2	1 EXP .2	1×10^2 (decimal points in exponent are ignored).

The numbers to the left of the **E** are the mantissa; the digits to the right (only two are allowed) are the exponent. The result value is the mantissa times 10 to the exponent power: for example $9.99\text{ E2} = 9.99 \times 10^2 = 999$.

Only one decimal point and one E (keyboard EXP) are allowed per number; additional ones are ignored. The sign toggle character may appear any number of times. It causes the sign of the mantissa (if E has not been programmed) or the exponent (if E has been programmed) to be reversed (if negative, then positive, and vice versa) each time it appears. Any number of nonprogramming characters may be interspersed with the numeric characters, as they have no effect. If an undesired value is entered, the CLEAR ENTRY key can be used to erase it.

Several parameters required codes for specific selections; for example, function codes 0 through 3 select sine wave. triangle wave. square wave and ramp waveform. Refer to Appendix B for codes.

Table 3-3. Round Offs

Parameter	Round Offs
Frequency	Up to 8 Digits, 1 μHz minimum.
Amplitude	To Nearest 20 mV, 10.02 to 20.00V To Nearest 10 mV, 1.01 to 10.00V To Nearest 1 mV, 99 to 1000 mV To Nearest 100 μV, 9.9 to 100.0 mV To Nearest 10 μV, 1.00 to 10.00 mV
Offset	Up to 3 Digits: To Nearest 10 mV, 5.01 to 10.00V To Nearest 5 mV, 1.005 to 5.00V To Nearest 1 mV, 100.5 to 10.00 mV To Nearest 100 μV, 10.05 to 100.0 mV To Nearest 10 μV, 1.00 to 10.00 mV
Phase	Up to 5 Digits: ±360.00° ±.01°
Time (Sweep)	Up to 4 Digits or 10 μs To Nearest .01s
Time (Sweep Off)	Up to 8 Digits: 10 μs to 600.00s to nearest 10 μs
All Other Parameters	To Nearest Integer

Since the number input format is so general, the microprocessor must be told when the last numeric character has been entered so it can evaluate the number. This is done by programming either an alphabetic, special or terminator character. When this is done, the new value is rounded off (ref: table 3-3) and tested to see if it is a legal value for the setting being changed (ref: paragraph 3.4). If it is legal, the new value is entered into the instrument's scratch pad memory; however, it is not yet sent to the waveform circuits. That is usually done by programming the I action (EXEC key on the front panel). Other methods of execution are GET and cursor, which are described later. An asterisk (*) on the display indicates that the new parameter value programmed has not been executed and resides in scratch pad memory only (ref: figure 3-2). All parameter values may be erased before execution by using the CLEAR ENTRY key, the value stored in scratch pad is erased and the original value is displayed.

3.4 ERRORS

When an illegal value is programmed or interdependent parameter errors are detected, an error signal is indicated on the front panel or GPIB. Keyboard errors only are indicated on the front panel display and by a double "beep" of the key tone. For errors made via the GPIB (but not the keyboard), a service request (SRQ) is made, providing the service request function has been enabled (ref: paragraph 3.16.5). The controller can then serial poll its instruments to verify that the 178 sent the SRQ and can then inquire as to the nature of the error. The method of reporting errors on the GPIB is given in paragraph 3.16.4.

3.4.1 Class 1 Errors

Class 1 errors are caused by programming values outside the legal limits of the parameter being programmed. For example, programming an amplitude of 500 volts will cause a parameter error when the next alpha character is programmed. At this time, the 178 disregards the new values and retains the previously programmed values in scratch pad memory (see figure 3-2).

3.4.2 Class 2 Errors

Class 2 errors are interparameter inconsistencies, such as frequency greater than specified for a particular function. Tests are made every time an execute (I) is given, a setup is stored (M) or a cursor key is pressed. Resulting errors are displayed, and transfers of values are made to waveform circuits or storage regardless of the error indicated. Notice that upon receiving a Group Execute Trigger (refer to paragraph 3.16.7), the 178 programming is executed without error checking.

3.4.3 Class 3 Error

Class 3 error occurs if an empty stored setting is retreived. The error is displayed and the state of the 178 remains unchanged from the previously executed program.

3.5 EXECUTING THE PROGRAM

A program or setting can be executed, i.e., transferred to the waveform circuits, by the execute commands, GET (Group Execute Trigger) command, and the action keys: CURSOR ↑ and CURSOR ↓.

GPIB I and the front panel EXEC key are execute commands that cause parameter value and inter-parameter tests to be made and transfers the programmed values to the waveform generation circuits.

GET is a GPIB only command (no front panel key) that causes the 178 to execute and trigger, but without time consuming microprocessor error checking (ref: paragraph 3.16.7).

CURSOR ↑ and CURSOR ↓ are exclusively front panel functions which perform an execute with error checks after each digit increment or decrement.

GPIB Z and the front panel RESET are commands which reset the 178 to the original power up conditions (as described in table 2-3, step 3) and perform an automatic execute.

An asterisk (*) on the display indicates that the new parameter value programmed has not been executed and resides in scratch pad memory only (ref: figure 3-2).

3.6 CURSOR

The four cursor keys can modify a parameter value or code.

NOTE
The modified value is automatically executed.

The ← and → cursor keys move the cursor left and right; cursor position is indicated by a flashing digit on the display. The ↑ and ↓ cursor keys increment and decrement, respectively, the flashing digit. Holding a cursor key down causes a continued change at a constant rate.

The ↑ and ↓ keys can also increment and decrement parameter codes, such as function and mode codes. Cursor positioning (← →) is not necessary for codes and codes do not flash to indicate cursor position.

When storing a program, press STORE key and then ↑. The program will be stored in the next memory location in numerical sequence. Keys ↑ and ↓ can also be used to recall stored settings in numerical sequence.

During command recall, cursor ← and → keys shift the display four characters to the left or right, respectively.

Cursors ↑ and ↓ can also be used to recall marker frequency and status.

3.7 TRIGGER MODE AND SLOPE

Triggered and gated modes of the main generator are initiated either by external or internal triggers. External triggers are: external TTL level signal at front or rear panel BNCs, manual trigger at MAN TRIG key on the front panel or GPIB **J** and **H** commands. Internal trigger is the sweep generator; that is, each sweep generator cycle triggers or gates the main generator.

The sweep generator is triggered by the above named external triggers only.

NOTE
*"External/Internal" trigger mode (**G0** or **1**) has no effect on sweep generator triggering. If the sweep generator is in a trigger-mode, external triggers (TTL level signals at front or rear panel BNCs, manual trigger at MAN TRIG key on the front panel or GPIB **J** and **H** programming codes) will initiate sweep generator output.*

Both the main generator and sweep generator can be triggered by the same source, one may be triggered and the other not, or the external trigger may trigger the sweep generator which in turn triggers the main generator—all depends upon the generator modes (ref: table 3-4).

G followed by its code selects either internal or external trigger (affects main generator only):

G0 Selects external trigger.

Table 3-4. Mode Matrix

	MAIN GENERATOR			SWEEP GENERATOR			
					Linear Sweep (Logarithmic Sweep)		
			Trig Mode	Sweep Off S0	Continuous Sweep S1 (S4)	Trigger Sweep S2 (S5)	Trigger Sweep/ Trigger Reset S3 (S6)
Standard Waveforms (Haverwave Waveforms)	Continuous	B0	*	B0,S0	B0,S1	B0,S2	B0,S3
	Triggered	B1 (B4)	Ext G0	B1,S0,G0	B1,S1,G0	B1,S2,G0	B1,S3,G0
			Int G1	B1,S0,G1	B1,S1,G1	B1,S2,G1	B1,S3,G1
	Gated	B2 (B5)	Ext G0	B2,S0,G0	B2,S1,G0	B2,S2,G0	B2,S3,G0
			Int G1	B2,S0,G1	B2,Si,G1	B2,S2,G1	B2,S3,G1
	Burst	B3 (B6)	Ext G0	B3,S0,G0	B3,S1,G0	B3,S2,G0	B3,S3,G0
			Int G1	B3,S0,G1	B3,S1,G1	B3,S2,G1	B3,S3,G1

Log Sweep Modes S4, S5 and S6

Haverwave modes B4, B5 and B6.

Refer to these codes in Appendix E for output explanation regardless of waveform (standard or haverwave) and sweep (linear or log).

* Trigger mode is applicable to main generator only. Trigger mode does not affect main generator continuous modes.

G1 Selects internal trigger.

J (pressing MAN TRIG) - Start trigger for the main and sweep generator. In main generator gated mode, the main generator is gated on.

H (releasing MAN TRIG) - In main generator gated mode, terminates the output of the main generator (the last cycle started is always completed).

Q followed by its code selects triggering either on the rising edge of the trigger signal or the falling edge:

Q0 Selects triggering on the rising edge (⟋) of the trigger signal. The main generator gates on at the high level.

Q1 Selects triggering on the falling edge (⟍) of the trigger signal. The main generator gates on at the low level.

3.8 MAIN GENERATOR

The following sections describe the keys and codes related to main generator operation. This block of keys are labeled MAIN on the front panel.

3.8.1 Frequency

Selecting **F** following a value (up to 8 digits) programs the main generator frequency. The frequency is programmable in hertz. See table 3-2 for value programming. At any time the frequency may be modified by the cursor (ref: paragraph 3.6). Upper frequency is limited by the operating mode and function, as shown in table 3-5.

Table 3-5. Mode/Function/Frequency

Mode	Function	Frequency
Cont	∿ , ⊓⊔ , AM	to 50 MHz
	∿	to 500 kHz
	⟋| ⟍	to 20 kHz
Trigger, Gate, and Burst	∿ , ⊓⊔ , ∿ , AM	to 200 kHz
	⟋| ⟍	to 20 kHz

3.8.2 Amplitude

V followed by its code selects the unit of measure for amplitude programming into a 50Ω load. (DC offset is always Vpeak.):

V0 Selects volts peak-to-peak into 50Ω.

V1 Selects volts rms into 50Ω.

V2 Selects dBm into 50Ω.

An **A** followed by a value (up to 3 digits) programs the amplitude at the function output. Amplitude may be programmed in volts peak-to-peak from 1 mV to 20 Vp-p specified into a 50Ω load. See table 3-2 for value programming, table 3-3 for round off and paragraph 3.11 for function output and load operation.

Amplitude values may be modified by the cursor (ref: paragraph 3.6).

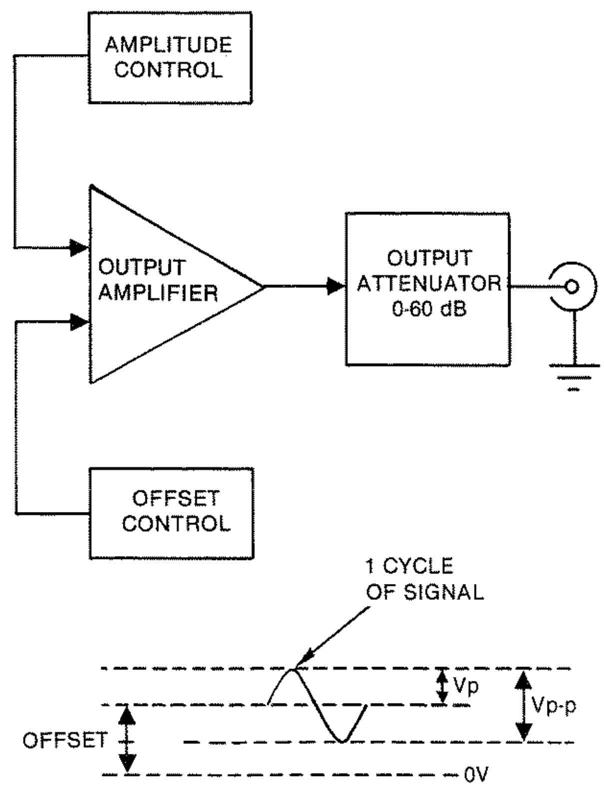


Figure 3-3. Amplitude and Offset Schematic

The amplitude and offset are not completely independent of one another, because they share a common output amplifier and attenuator (see figure 3-3). In certain cases it may be necessary to decrease the number of digits of resolution of amplitude or offset in order to prevent clipping in the output amplifier or to make the programmed value of offset (or amplitude) appear at the output despite an unfavorable attenuator setting necessitated by a larger value of amplitude (or offset).

The sum of amplitude and offset control the output amplifier and attenuator. The output amplifier is limited to ±10.00 volts peak and a 3 digit input (X.X X). The attenuator can operate at only $\times 10^0$, $\times 10^{-1}$, $\times 10^{-2}$, or $\times 10^{-3}$. Figure 3-4 is a guide to expected resolution.

3.8.3 Offset

D followed by a value (up to 3 digits) offsets the function output from 0 to +10V specified into a 50Ω load. Offset is programmed in volts dc. See table 3-2 for value programming, table 3-3 for round off and paragraph 3.11 for function output and load operation. Offset value may be modified by the cursor (ref: paragraph 3.6).

NOTE
When offset is used, 3 digit resolution of offset or amplitude may be reduced in some cases (ref: paragraph 3.8.2).

3.8.4 Function

C followed by a single digit parameter value selects function at the FUNCTION OUT BNC. Six function codes are used.

C0 Selects sine wave. Frequency maximum is 50 MHz in continuous mode and 200 kHz in trigger, gated or burst modes.

C1 Selects triangle wave. Frequency maximum is 500 kHz in continuous mode and 200 kHz in trigger, gated or burst modes.

C2 Selects square wave. Frequency maximum is 50 MHz in continuous mode and 200 kHz in trigger, gate or burst mode.

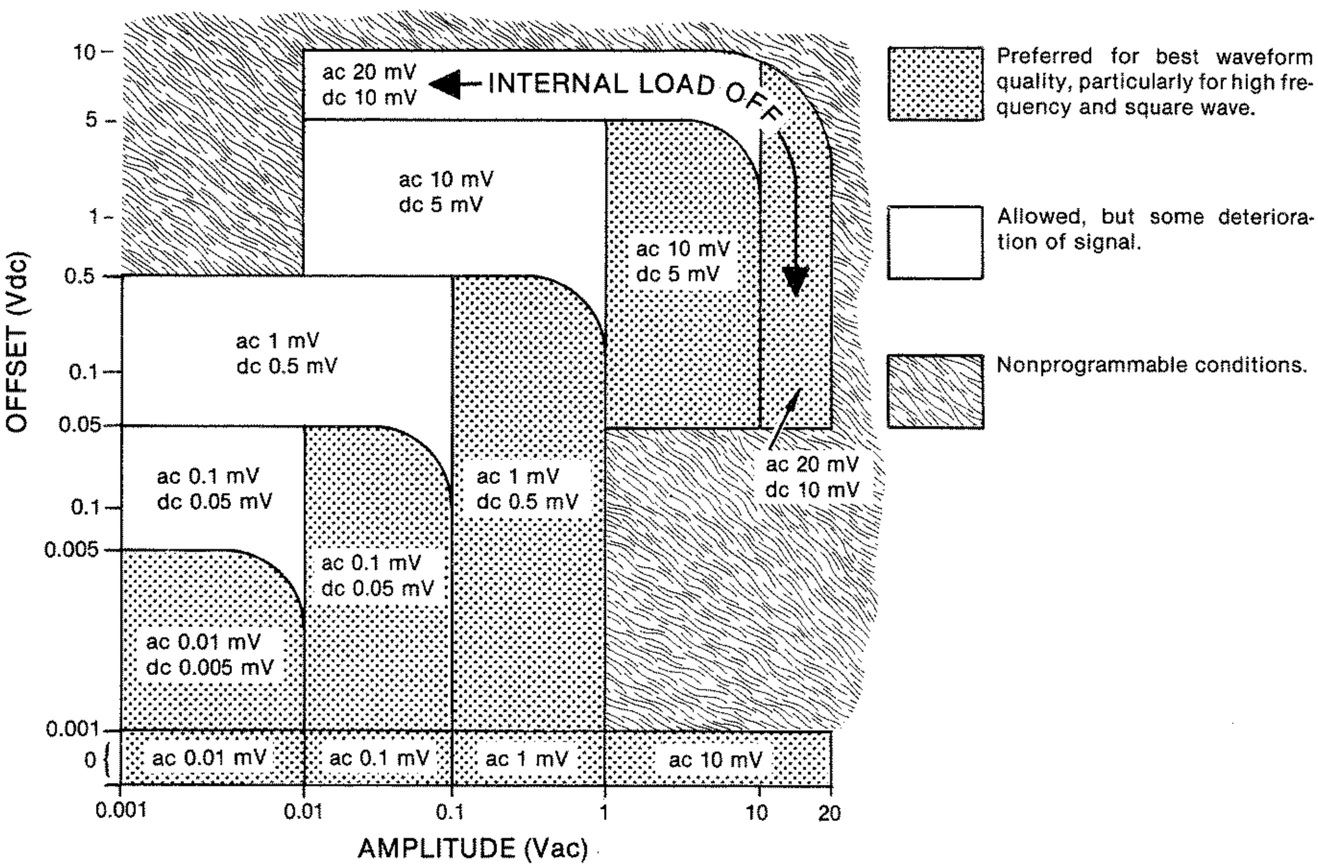


Figure 3-4. Resolution for Combinations of Amplitude and Offset

C3 Selects ramp. Frequency maximum is 20 kHz in continuous, trigger, gated burst modes.

C4 Selects dc output voltage. The dc level is set by programming offset as described in paragraph 3.8.3.

C5 Selects amplitude modulation. When AM is selected the main out level is reduced to half the programmed amplitude. An ac voltage (±2.5 Vp, typical, for 100% modulation; dc to 10 MHz minimum rate) at the AM IN BNC modulates the function output. When modulation levels vary between −2.5V and −7.5V the output level is inverted as shown in figure 3-5. Figure 3-6 show AM timing relationship.

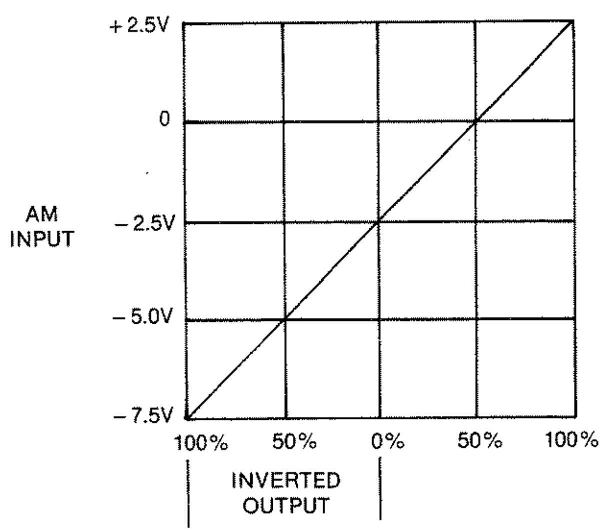


Figure 3-5. AM Input Vs Envelope Output

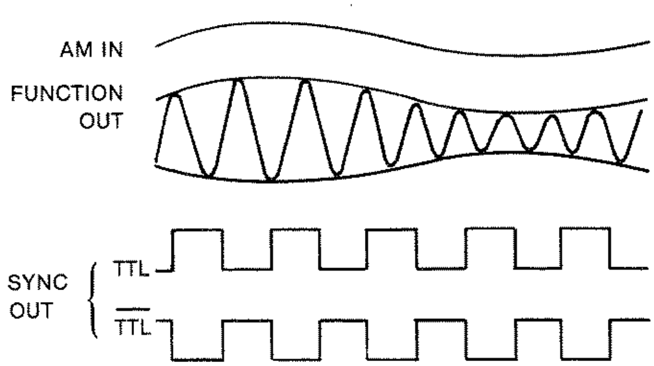


Figure 3-6. AM Timing Relationships.

3.8.5 Modes

B followed by its code (0 through 6) selects the operating mode. The selected mode is indicated on the front panel readout when the MODE key is pressed. In addition to the main generator mode selection, output is affected by other variables (ref: table 3-4 and Appendix E). Many of the modes depend on a trigger. Refer to paragraph 3.7 for trigger mode and format selection.

B0 Selects continuous operation of the main generator.

B1 Selects triggered mode. The main generator is triggered by external signal, internal sweep signal, manual trigger of GPIB commands. When triggered, one cycle is generated.

B2 Selects gated mode. The onset of the trigger, regardless of its source (ref: mode **B1**), enables the main generator for the duration of the trigger signal plus the time required for the completion of the last cycle started.

B3 Selects burst mode. Burst is the output of a preprogrammed number of cycles each time the generator is triggered at a preselected rate.
R followed by its value (1 to 65,536) denotes the number of cycles in the burst each time it is triggered.

B4 Selects triggered haverwave. For ramp and square waveforms, triggered haverwave is identical to mode **B1**, triggered waveforms. For sine and triangle, triggered haverwave is one cycle of the waveform starting and ending at phase angle −90°. Square wave starts and ends at its negative peak. If waveform amplitude is programmed negative, the waveform starts and ends at +90° phase angle. Square wave starts and ends at its positive peak.

B5 Selects gated haverwave. For ramp and square waveforms, gated haverwave is identical to mode **B2**, gated waveforms. For sine and triangle waveforms, gated haverwave is one or more cycles of the selected waveforms starting at phase angle −90°, if any. If waveform amplitude is programmed negative, the waveform starts at +90° phase angle. The onset of the trigger, regardless of its source (ref: mode **B1**), enables the main generator for the duration of the trigger signal plus the time required for the completion of the last cycle started.

B6 Selects burst haverwave. For ramp and square waveforms, burst haverwave is identical to mode **B3**, burst mode. For sine and triangle, burst is the output of a preprogrammed number of cycles of selected haverwave starting at phase angle −90°. If waveform amplitude is programmed negative, the waveform starts at +90° phase angle.

R followed by its value (1 to 65,536) denotes the number of cycles in the burst.

3.8.6 Phase

To shift output signal phase relative to some external signal, the basic 10 MHz reference must be locked to the reference clock of the external instrument; an external reference input can be a sine wave or pulse of a 500 mV to 10 Vp-p amplitude at 1, 2, 3, . . . or 10 MHz ±5 ppm. A message REFERENCE NOT LOCKED is displayed if the 178 internal reference and the external reference source are not synchronized or if the external reference has high jitter.

The frequencies of the two signals to be phase locked should be adjusted to be identical or integer multiples. The phase angle of these two signals is not defined, but by programming **L**(PHASE REF) that phase angle becomes the reference phase "zero" for subsequent phase changes.

K followed by a value selects the phase shift (relative to phase "zero") measured in degrees. Phase value is programmable from ±1000 revolutions (±360,000°) with 0.01° resolution steps to 500 kHz and 0.1° above 500 kHz. When executed, the phase shifts to the programmed angle relative to Phase Reference. Phase Reference may be redefined at any time by programming **L** (PHASE REF). Phase relationships relative to the reference generator are shown in figure 3-7.

NOTE

When function is square wave, there may be a ±3.6° phase offset error after you have phase shited the first time. This error is eliminated by programming **L** *and noting the new phase reference angle from which to shift. Subsequent shifts will be to specified accuracy.*

An input to ϕMOD IN BNC phase modulates the 178. A 5 Vp signal deviates the function output approximately 360° when output frequency is >500 kHz. For frequencies ≤500 kHz, phase modulation is reduced by 100 times. Phase modulation is relative to the reference source and at a deviation rate determined by ϕMod frequency (dc to 10 kHz minimum).

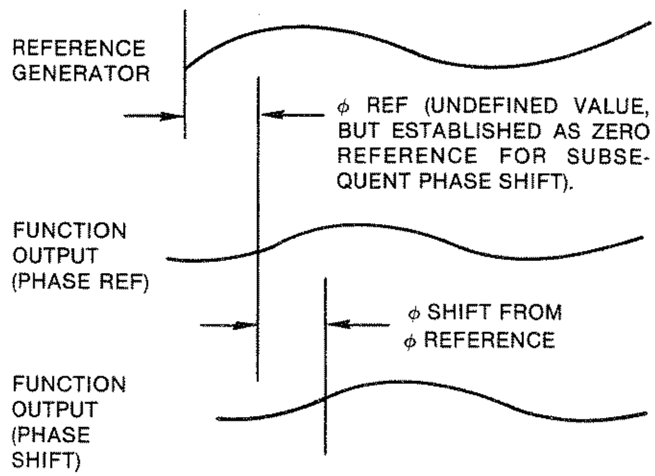


Figure 3-7. Phase Shift

Rear Panel REF OUT BNC is a source of 10 MHz, 2 Vp-p sine wave locked to the reference clock. Source impedance is 50Ω.

3.9 SWEEP GENERATOR

An internal generator sweeps the main generator either linearly or logarithmically from the start frequency to the stop frequency. Two overlapping sweep ranges are used: the low range 1 μHz to 500 kHz and the high range 5 kHz to 50 MHz. A class 2 error occurs when start and stop frequencies are not in the same range.

In addition to sweeping the main generator, when trigger mode is "internal" and the main generator is in a trigger or gate mode, the sweep generator triggers the main generator.

The following sections discuss sweep generator controls and operation.

3.9.1 Start and Stop Frequency

The main generator sweeps from the start frequency to the stop frequency. For sweep up (increasing frequency) the start frequency is lower than the stop frequency. For sweep down (decreasing frequency), the start frequency is higher than the stop frequency.

N followed by its value (up to 8 digits or 1 μHz) programs the start frequency. The start frequency is programmed in hertz. (See table 3-2 for value programming.)

O followed by its value (up to 8 digits or 1μHz) programs the stop frequency. The stop frequency is programmed in hertz.

3.9.2 Sweep Time

T followed by a value selects the time required to sweep between the start and stop frequencies. The value is programmed in seconds. (See table 3-2 for value programming.) Time can be programmed from 10 ms to 600.00s with 10 ms resolution in all sweep modes except "sweep off," which can be programmed from 10 μs to 600.00s with 10 μs resolution.

When sweeping, altering sweep time, sweep frequency or stop frequency causes the generator to reset to the start frequency.

3.9.3 Sweep Width

Sweep width is the difference between the start and stop frequencies. Maximum sweep width is limited by the sweep range, either 5 μHz to 500 kHz or 5 kHz to 50 MHz.

Minimum sweep is dependent on the sweep range and time. Any start and stop frequencies may be used provided a minimum separation is maintained:

Low band: 20 mHz per 1s of sweep time.
High band: 2 Hz per 1s of sweep time.

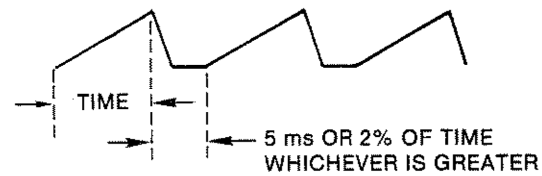
Minimum width in logarithmic sweep mode is limited to the above restrictions and a start/stop frequency ratio of 2.

3.9.4 Sweep Mode

S followed by its single numeric value selects the sweep operating mode. The selected mode is indicated on the front panel readout when the MODE key is pressed. In addition to the sweep generator mode selection, output mode is affected by other variables (ref: table 3-4 and Appendix E). Many of the modes depend on a trigger. Refer to paragraph 3.7 for trigger mode and format selection.

S0 Selects sweep off mode.

S1 Selects continuous ramp. Normally used with continuous main generator mode to give continuous linear sweep. SWEEP OUT is a continuous 0 to approximately +5V ramp.



S2 Selects triggered linear ramp. For each trigger, the main generator, in continuous mode, sweeps once and returns to the start frequency. SWEEP OUT is one 0 to approximately +5V ramp starting with the trigger.

S3 Selects triggered linear ramp and triggered reset. Upon receiving a trigger, the main generator, in continuous mode, will sweep from the start frequency to the stop frequency and hold at the stop frequency. Upon receipt of a second trigger the main generator returns to the start frequency. SWEEP OUT is a 0 to approximately +5V ramp starting with the first trigger and holding at approximately +5V until the second trigger occurs.

S4 Selects continuous logarithmic ramp. Normally used with continuous main generator mode to give continuous logarithmic sweep. SWEEP OUT is a continuously recurring 0 to approximately +5V linear ramp.

S5 Selects triggered logarithimic ramp. Logarithmic version of mode **S2**.

S6 Selects triggered logarithmic ramp and triggered reset. Logarithmic version of mode **S3**.

3.9.5 Hold and Resume

XH (Hold) will stop the sweep and hold the main generator frequency until **XJ** (Resume) resumes the sweep. When held, the precise frequency is displayed as HOLD AT XX.XXXXXX Hz. When resumed, SWEEP RESUME is displayed.

While the sweep is being held, the FUNCTION OUT frequency can be modified by the cursor keys. When RESUME is pressed, the frequency returns to the "hold" frequency and then sweep continues. However, the ramp voltage at SWP OUT is not modified by cursor action even if the frequency during hold is. To return the output to the start frequency rather than completing the sweep from the hold frequency, manual trigger or an external trigger is used. If the sweep generator is in triggered sweep/reset mode, two triggers will be necessary to restart the output at the start frequency.

Ramp voltage may drift during hold because of leakage current in the charging circuit; even so, the frequency remains constant. For most applications, this drift is negligible for holds less than 600 seconds.

3.9.6 Marker, Marker frequency and Marker Output

The frequencies of 10 markers can be preset but only one marker can be selected at a time. The marker output is a TTL-level low-to-high transition to indicate that the frequency has swept through the programmed marker frequency, as shown in figure 3-8. The marker output remains low at frequencies less than the marker frequency and at frequencies greater than the marker frequency the marker output remains high regardless of sweep direction.

At power on, all ten markers are preset to 1 kHz. If new marker frequencies are entered into each marker location, a reset, either from the keyboard or GPIB resets only marker #1 to 1 kHz. All other marker frequencies are unaltered. Marker frequencies can also be stored for convenience (ref: paragraph 3.10.1).

XN followed by a value (1 through 10) selects the marker number. Only the selected marker's frequency is indicated by the marker output. After a marker has been selected, the marker's frequency may be altered by programming **XO**, and the frequency (up to 8 digits) in hertz. The value replaces the former value upon the programming of the next alpha character.

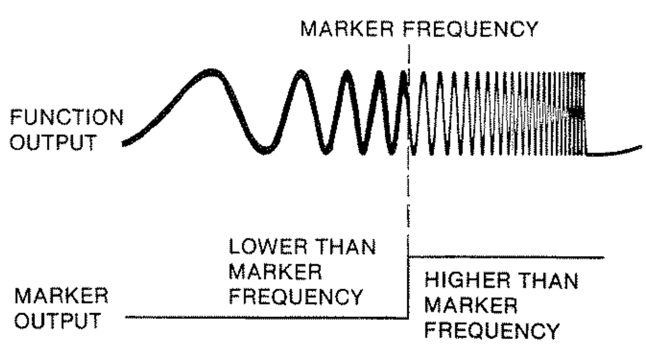


Figure 3-8. Marker Output and Sweep Frequency

3.10 STORED SETTINGS

Up to 5 different sets of front panel settings can be stored in and recalled from Random Access Memory (RAM). Option 001 provides nonvoltile memory for 40 additional stored settings. Option memory is battery backed up (internally recharged) for 60 day (minimum) retention of settings. Memory is expandable to 240 stored settings.

3.10.1 Storing Program Sets

Program sets may be stored by keyboard or GPIB command. To store the program set that is in scratch pad memory (ref: figure 3-2), enter **M** followed by the storage location (1 through 5, or if option 001 is installed, 1 through 45). The next alpha programmed is the terminator, which allows the storage to occur. If a program was previously stored in that location, it will be erased and replaced by the new set. When a program is stored, the settings are tested for class one errors in the same manner as with an execute command (ref: paragraph 3.5). The program is always stored, whether or not errors were detected. Programs can be stored without interrupting the output of the 178 if a terminator other than EXEC (I) is used: this is possible because it is the scratch pad memory that is stored rather than the actual settings of the waveform circuits (ref: figure 3-2). Notice that during 178 operation, scratch pad memory can be changed and stored without affecting 178 output.

3.10.2 Recalling Stored Programs

The information stored in a program may be recovered either from the front panel or by a command over the GPIB. To recall, program a **Y** followed by the number of desired program. When the next alpha entry is made, the settings stored in the selected program are transferred to display memory and the scratch pad memory (ref: figure 3-2). Then data is available to be sent to the waveform circuitry of the instrument, or, if desired, it may be examined and altered by use of the front panel keys.

The identifying numbers of programs in RAM range from 1 through 5 (1 through 245 for full memory options). If the number of a program which does not exist or an illegal identifying number is programmed, an error will result.

Pressing the cursor ↑ key or programming **W** causes the program next in sequence after the last program accessed to be recalled. This provides an automatic way to recall a sequence of programs. However, the programs need not be numbered consecutively. If there is no program following the last program accessed, an error occurs.

Pressing the cursor ↓ key or programming **U** is similar to the cursor ↑ or **W** action previously described, except that programs are recalled in descending numeric order.

3.10.3 High Speed Recall of Stored Programs

The Group Execute Trigger (GET) allows a rapid GPIB recall of stored programs. In the GET mode of operation, the program is recalled and executed, and the waveform circuits are triggered, all within 2.5 ms of receiving the GET command. There are three possible modes of GET operation (ref: paragraph 3.16.7). There is no error checking.

3.10.4 Deleting Programs

To delete a program, program the letter **M** followed by a *minus* sign and a number of the program to be removed. When the number is terminated (by the next alpha character), the program is removed from storage; there is no other effect.

3.11 OUTPUTS

3.11.1 Front/Rear Function Output

One function output BNC is located on the front panel and one on the rear panel. At power up and reset the signal is from the front panel BNC only, the rear panel output is safely turned off for ATE applications. After power is on, programming selects front or rear output.

XP followed by a numerical code selects the front or rear panel BNC:

XP0 Selects front panel output and disconnects the signal from the rear panel.

XP1 Selects rear panel output and disconnects the signal from the front panel.

3.11.2 Output On/Off

P followed by a code switches the output on or off.

P0 Internally disconnects the signal from the selected function output BNC (as described in paragraph 3.11.1) making the signal unavailable at the connector. In **P0**, the function output presents a high source impedance at the BNC.

P1 Internally connects the signal to the selected function output BNC.

P2 Internally disconnects the signal from the selected function output making the signal unavailable. The function output source impedance is 50Ω.

3.11.3 Sync Outputs

Sync outputs of TTL and $\overline{\text{TTL}}$ square wave are provided, respectively, at the BNC's on the front and rear panels. The sync signal is 0V to approximately 3V (TTL) from a 50Ω source. Sync outputs are in phase with the main generator square wave output only. Other timing relationships are shown in Appendix D.

3.12 CLEAR ENTRY

The CLEAR ENTRY key erases a parameter value which is being entered. The key removes the numeric digits entered after the last parameter letter entry. (Clearable entries are always prefixed by an asterisk on the display.) The display is replaced by the previous value (scratch-pad value) of the parameter being programmed.

3.13 RESET

The RESET key returns the 178 waveform parameters to their power-on condition. The readout becomes "RESET". Significant parameters values and conditions are given in table 2-3, step 3. In addition, the reset command resets marker #1 to 1 kHz, but markers 2 through 10 remain unaltered.

3.14 DISPLAY TEST

The DISPLAY TEST Key lights all 20 sets of character segments and semicolon as shown in figure 2-4.

3.15 STATUS

Pressing STATUS automatically displays the current waveform generator status one parameter and value at a time (ref: Appendix C). When STATUS is pressed a second time the cycling immediately stops. The parameters can then be manually searched by using the CURSOR (↓ or ↑) keys (ref: table 2-3, steps 2 through 7).

3.16 GPIB

Almost all of the information in Section 3 is applicable to the General Purpose Interface Bus (GPIB) programming of the 178, but the information in this paragraph is *exclusive* to the GPIB.

The GPIB interface is an implementation of IEEE Standard 488-1978. It supports the following interface functions: Source Handshake (SH1), Acceptor Handshake (AH1), Talker (T6), Listener (L4), Service Request (SR1), Remote Local (RL1), Device Clear (DC1) and Device Trigger (DT1). The talk capability allows a device to send data (such as error message readings) out over the bus. The listen capability allows a device to receive data (such as device programming information) from the bus.

3.16.1 Bus Lines Defined

The GPIB consists of 16 signal lines:

DIO1 - DIO8	Data In/Out Lines
ATN	Attention
REN	Remote Enable
DAV	Data Available
NRFD	Not Ready For Data
NDAC	Not Data Accepted
EOI	End Or Identify
SRQ	Service Request
IFC	Interface Clear

1. **DIO1 - DIO8—**These eight lines (Data In/Out) are used to send commands from the controller and transfer data back and forth between instruments and the controller.

2. **ATN—**This line (Attention) is operated only by the controller. It specifies whether the information on lines DIO1 - DIO8 is data (ATN false) or a command (ATN true). Whenever ATN is set true, no activity is allowed on the bus except for controller-originated messages; additionally, every device connected to the bus is required to receive and process every command sent by the controller.

3. **REN—**This line (Remote Enable) controls whether devices on the GPIB are in local or remote modes. In local mode, devices respond to front panel commands and do not respond to GPIB originated commands. In remote mode, the situation is reversed: GPIB originated commands are obeyed, while front panel commands are ignored. The 178 enters the remote state when it receives its listen address (ref: paragraph 3.16.2.1) and REN is enabled. The 178 then stays in the remote mode until the REN line is put in the local state, a Go To Local (GTL) command is received or the LOCAL front panel key is pressed (ref: paragraph 3.16.2.4, item 4).

4. **DAV, NRFD, NDAC—**These are the "handshake" lines (Data Valid, Not Ready For Data and Not Data Accepted) which regulate the transmission of information over the lines DIO1 -DIO8. For each command or data byte transferred, a complete handshake cycle occurs. This handshake is designed to holdup the bus until the slowest device has accepted the information.

5. **EOI—**When ATN is false, EOI (End Or Identify) indicates that the data on lines DIO1 - DIO8 is the last byte of a data message. When the 178 receives a data byte with EOI true, the 178 automatically supplies a terminator character (ref: paragraph 3.16.6) following the data byte. When the 178 transmits the last byte of a message (which is always a terminator character), it also sets EOI true.

6. **SRQ—**This line (Service Request) is used by the 178 and other devices on the bus to signal the controller that they request attention. (Ref: paragraph 3.16.5 for 178 Service Request Enable.) Since the SRQ line is common to all devices, additional tests must be made to determine which devices are signaling. The controller performs a Serial Poll to accomplish this.

7. **IFC—**This line (Interface Clear) is used by the controller to reset the interface logic in all devices connected to the bus to a known initial state.

3.16.2 Commands

Commands are sent over lines DIO1 - DIO8 with ATN true. They are divided into five classes.

1. Listen Addresses

2. Talk Addresses

3. Secondary Addresses

4. Universal Commands

   DCL—Device Clear
   SPE—Serial Poll Enable
   SPD—Serial Poll Disable
   LLO—Local Lockout

5. Addressed Commands

GTL—Go To Local
SDC—Selective Device Clear
GET—Group Execute Trigger

These commands and command groups are shown with their binary codes in Appendix A and further explanation follows.

3.16.2.1 Listen Addresses

Listen addresses are used to command a device to read any data bytes transmitted over lines DIO1 -DIO8. There are 31 different available addresses (hexadecimal codes 20 through 3E, ASCII codes **SP** through **>**). A 32nd address, called unlisten (hexadecimal **3F**, ASCII **?**), is used to command all devices to not read data bytes. The 178 listen address is selected by the rear panel switches, which specify the lower 5 bits of the address. (Ref: table 2-2.) Pressing the front panel ADRS key displays the GPIB address as a decimal device number followed by the ASCII character listen and talk addresses.

3.16.2.2 Talk Address

Talk addresses are used to command a device to transmit data over lines DIO1 - DIO8 whenever ATN is false. There are 31 different available addresses (hexadecimal codes **40** through **5E**, ASCII codes @ through ↑). A 32nd address, called untalk (hexadecimal **5F**, ASCII →) is used to command all devices to cease talking. The lower 5 bits of the 178 talk address are selected by the same rear panel switches used to select the listen address. Thus, if the 178 listen address is hexadecimal **21** (ASCII **!**), the talk address is hexadecimal **41** (ASCII **A**). Pressing the front ADRS key displays the GPIB address as a decimal device number followed by the ASCII character listen and talk addresses.

3.16.2.3 Secondary Address

Secondary addresses are used following a talk or listen address to provide the ability to address more than the 31 devices provided for by simple talk or listen addresses. Secondary addresses are ignored by the 178.

3.16.2.4 Universal Commands

Universal commands are used to command a device to perform designated actions. Universal commands are recognized at all times. Universal commands performed by the 178 are:

1. **Device Clear (DCL)—**Resets the 178 to the initial power on settings. Refer to table 2-3, step 3 for power on conditions. DCL affects all devices on the bus. This information is also set into the waveform generating circuitry.

2. **Serial Poll Enable (SPE)—**Causes the instrument to engage in a serial poll by responding with the serial poll status byte when addressed as a talker. Data line DIO7 will be on, if service is being requested on the SRQ line. When the status byte is read, it is reset to an ASCII blank, and the SRQ line is released (of course, it may still be held down by other devices). The status byte is also available by reading the 178 talk message number 2. When this message is read, the status byte is reset and SRQ released as for the serial poll.

3. **Serial Poll Disable (SPD)-**Discontinues serial poll. Returns instruments to normal talk modes.

4. **Local Lockout (LLO)—**Causes the GPIB interface to enter a state where the front panel LOCAL key is inoperative. Once in this state, the only way to take the interface out of it is to put the REN line in the local state (ref: paragraph 3.16.1, item 3). Local lockout must be sent to the 178 to totally disable front panel modification of the state of the instrument.

3.16.2.5 Addressed Commands

Addressed commands are used to command a device to perform designated actions. Addressed commands are recognized only when the instrument is addressed as a *listener*. Addressed commands performed by the 178 are:

1. **Go To Local (GTL)—**Commands 178 to go to local mode (ref: paragraph 3.16.1 for explanation to the REN line).

2. **Selective Device Clear (SDC)—**Resets the 178 to initial power on conditions. Refer to paragraph 3.13 for power on conditions. SDC affects only the selected unit.

3. **Group Execute Trigger (GET)—**Causes the actions as specified by the GET mode (**XG**) code (refer to paragraph 3.16.7). If the 178 micro-

proccessor is idle (i.e., not processing a previously sent programming string), a GET command will be completed within 2.5 ms of receipt. Otherwise, it will not be done until current programming is processed.

3.16.3 Data Transfer

In addition to accepting programming characters, the 178 will transmit status information over the bus. To program the instrument, first send the listen address (with ATN on), followed by the programming data (in ASCII, with ATN off). The instrument microprocessor accepts the data as fast as possible, until either 64 charactes are received or there is a pause during the transfer of data. At that time, the entire string of received characters is scanned by the microprocessor, which carries out the scan and accepts the next 64 character string. Whenever the microprocessor finished scanning a string, it puts a display on the front panel which reflects the state of input processing at that point. If the EOI line is asserted while sending a character to the 178, the currently programmed terminator character will be put into the input string following the character with the EOI.

3.16.4 Talker

To read a message from the 178, first send the talk address (with ATN on) over the bus. The instrument will then send the message currently selected by the Talk Message Select (**XT**) setting. The last character of the 178's message will be the currently programmed terminator character with the EOI line asserted.

0 Sweep Status. When read: 0 - No sweep.
1 - Sweeping.
1 List of programming errors. When read, message sets to null.
2 Serial poll byte message.
3 Value of most recently programmed selector.
4 Main generator settings.
5 Sweep generator settings.
6 Current marker frequency.
7 Model and software version.

3.16.5 Service Request Enable

XQ followed by its code selects the conditions under which the GPIB SRQ signal will be sent by the 178. The codes are:

0 SRQ off.

1 SRQ sent if a programming error occurred.

3.16.6 End of String or Terminator Specification

XV followed by its argument designates a new End Of String (EOS) or terminator character. The argument is the decimal value of the ASCII character that is to be the new terminator: an EOS character recognized by the 178. Any ASCII character except NUL is accepted.

The terminator character has two uses. During output, it is appended to the end of every response to a talk request on the GPIB. During input, it signals, the end of a group of programming characters. Since it is always recognized, even in a quoted string, it can be used to insure that the instrument is in a known state, so that following programming characters will be interpeted correctly.

At power on time, the EOS character is the line feed control character, ASCII character LF (10_{10}). When the 178 issues a talk message, the EOS character is the last byte sent. In addition, the End Or Identify (EOI) line is pullsed low (END message) during the EOS character transmission. If the GPIB controller does not look for the END message (EOI line low), and it does not recognize the Line Feed (LF) as a string terminator, a new EOS character will be needed. For example, to change the EOS character from an LF to a Carriage Return (CR), program **XV**13.

3.16.7 GET Mode

XG followed by its code selects what actions occur when a Group Execute Trigger (GET) command is sent to the 178. The code may be **0, 1** or **−1.**

0 Upon receipt of GET, the programmed waveform values in the scratch pad memory are transferred to the waveform generator circuits, and then the microprocessor sends a trigger pulse if the mode is not continuous. This is the same sequence of events that would occur if an execute, then a trigger action (**IJ**) were programmed, except that no error checking is done.

NOTE
Codes 1 and −1 are applicable for Option 001 (stored settings 6 through 245) only.

1 Upon receipt of GET, the stored setting next in sequence after the last stored setting accessed is recalled if it exists. This is the same sequence of events that would occur if an execute, then a trigger action were programmed (**WIJ**) except no error checking is done.

−1 Upon receipt of GET, the stored setting previous in sequence before the last stored setting accessed is recalled if it exists. Then the actions described for code **0** are performed. This is the same sequence of events that would occur if a previous setting, an execute and a trigger action (**UIJ**) were programmed, except that no error checking is done.

3.16.8 Local

The front panel LOCAL key switches the GPIB interface to the local mode if it is not locked out (ref: paragraph 3.16.2.4, item 4).

3.16.9 Display

The single quote character (') is used to program a string of characters to be displayed on the front panel display. Program a single quote, the characters to be displayed, followed either by another single quote or by the terminator character. When the second quote or the terminator is programmed, the first 20 characters programmed after the first quote are displayed on the front panel. If fewer than 20 characters are programmed, then blanks are added to fill the display.

Examples (∧ indicates a blank character)

Three programmed inputs

1. '20∧CHARACTER∧LIMIT'
2. 'THIS∧STRING∧IS∧TOO∧LONG∧TO∧DISPLAY∧ENTIRELY'
3. ' '
   └─ (no characters in string)

The Resulting Displays

1. 20∧CHARACTER∧LIMIT∧∧
2. THIS∧STRING∧IS∧TOO∧L
3. (blank display)

3.17 PULSE OPERATION

Model 178 is capable of continuous pulse operation at frequencies up to 100 kHz. In this mode, the sweep generator internally triggers the main generator. Pulse period is set by programming sweep time to any value between 10 μs and 600 sec, with 4 digit or 10 μs resolution (whichever is less). Pulse width equals 1/2f, where f equals the frequency of the main generator from 5 μs to 500,000 sec, with 8 digit resolution. For pulse operation, set up the Model 178 as follows:

Function:	Square Wave
Main Mode:	Triggered
Sweep Mode:	Off
Ext/Int Trigger:	Internal
Sweep Time:	Pulse Period
Frequency:	Reciprocal of two times the pulse width
Amplitude:	Peak-to-peak pulse amplitude
Offset:	As required to set pulse baseline

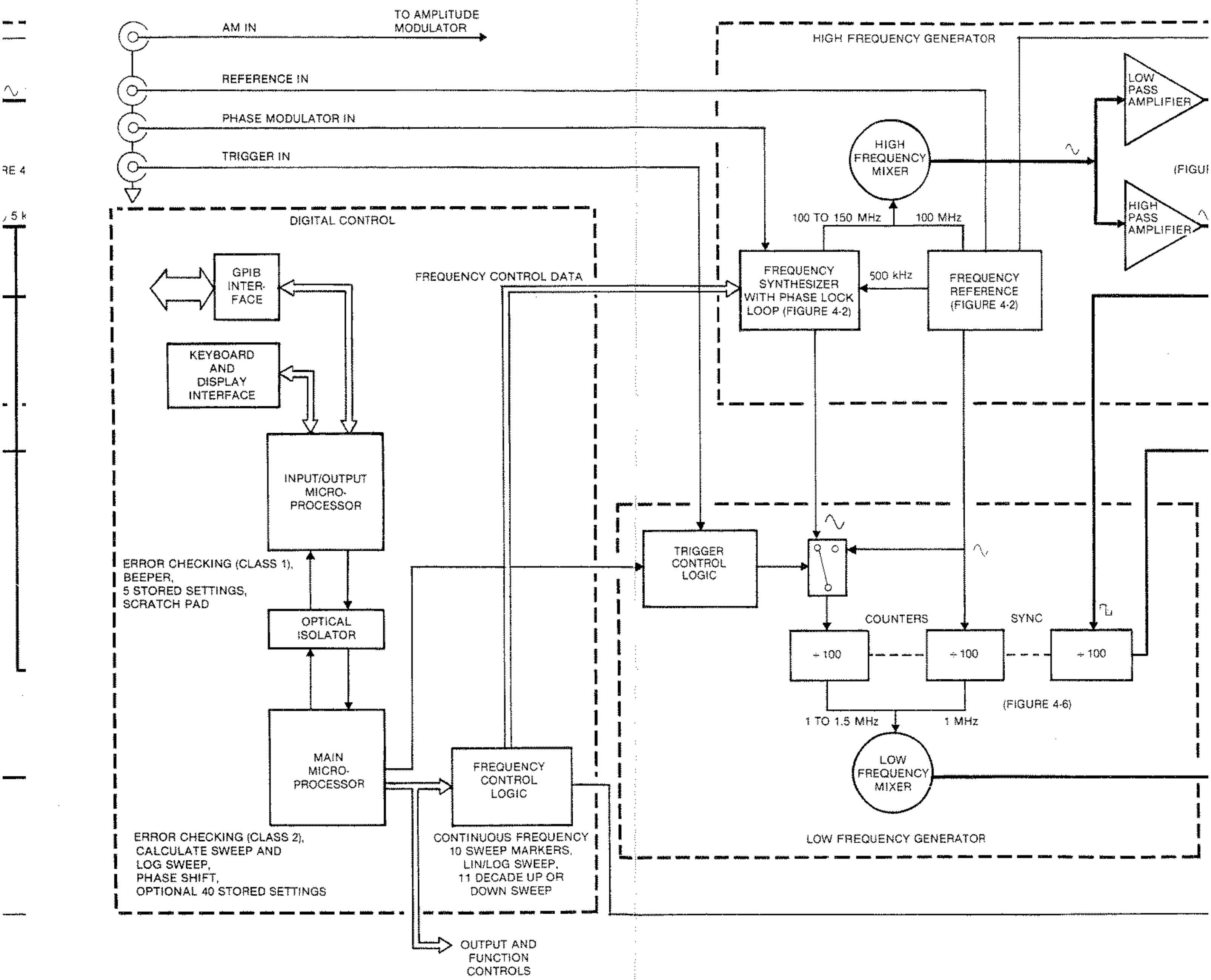


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Figure 4-1. Ov