About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual is the best copy we could find; it may be incomplete or contain dated information. If we find a more recent copy in the future, we will add it to the Agilent website.

Support for Your Product

Agilent no longer sells or supports this product. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available. You will find any other available product information on the Agilent Test & Measurement website, www.tm.agilent.com.

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. In other documentation, to reduce potential confusion, the only change to product numbers and names has been in the company name prefix: where a product number/name was HP XXXX the current name/number is now Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

HP 8643A and HP 8644B SYNTHESIZED SIGNAL GENERATOR (OPTIONS 001, 002, 003, 005, 009, 010, 011)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed:

3147A and above

For additional important information about serial numbers, refer to "INSTRUMENTS COVERED BY THIS MANUAL" in Chapter 2.

User's Guide HP Part Number: 08643-90019

Printed in U.S.A.: June 1998
Supersedes: October 1996

HEWLETT PACKARD

Sound Emission

Manufacturer's Declaration

This statement is provided to comply with the requirements of the German Sound DIN 45635 T. 19 (Typprufung).

This product has a sound pressure emission (at the operator position) < 70 dB(A).

- Sound Pressure Lp < 70 dB(A).
- At Operator Position.
- Normal Operation.
- According to ISO 7779 (Type Test).

Hersteller-bescheinigung

Diese Information steht im Zusammenhang mit den Anforderungen der schinenlarminformationsverordnung vom 18 Januar 1991.

- Schalldruckpegel Lp < 70dB (A).
- AM Arbeitsplatz.
- Normaler Betrieb.
- Nach DIN 45635 T. 19 (Typprufung).

Printed in FRG March 1991

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to the Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.

SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

SAFETY SYMBOLS

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents.)

⚡ Indicates hazardous voltages.

⏚ Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could resulting personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection).

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to the earth terminal of the power source.

Servicing instructions are for use by service trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at may points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source os supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.) Do not use repaired fuses or short circuited fuseholders.

ATTENTION
Static Sensitive
Devices

This instrument was constructed in an ESD (electro-static discharge) protected environment. This is because most of the semi-conductor devices used in this instrument are susceptible to damage by static discharge.

Depending on the magnitude of the charge, device substrates can be punctured or destroyed by contact or mere proximity of a static charge. The results can cause degradation of device performance, early failure, or immediate destruction.

These charges are generated in numerous ways such as simple contact, separation of materials, and normal motions of persons working with static sensitive devices.

When handling or servicing equipment containing static sensitive devices, adequate precautions must be taken to prevent device damage or destruction.

Only those who are thoroughly familiar with industry accepted techniques for handling static sensitive devices should attempt to service circuitry with these devices.

In all instances, measures must be taken to prevent static charge build-up on work surfaces and persons handling the devices.

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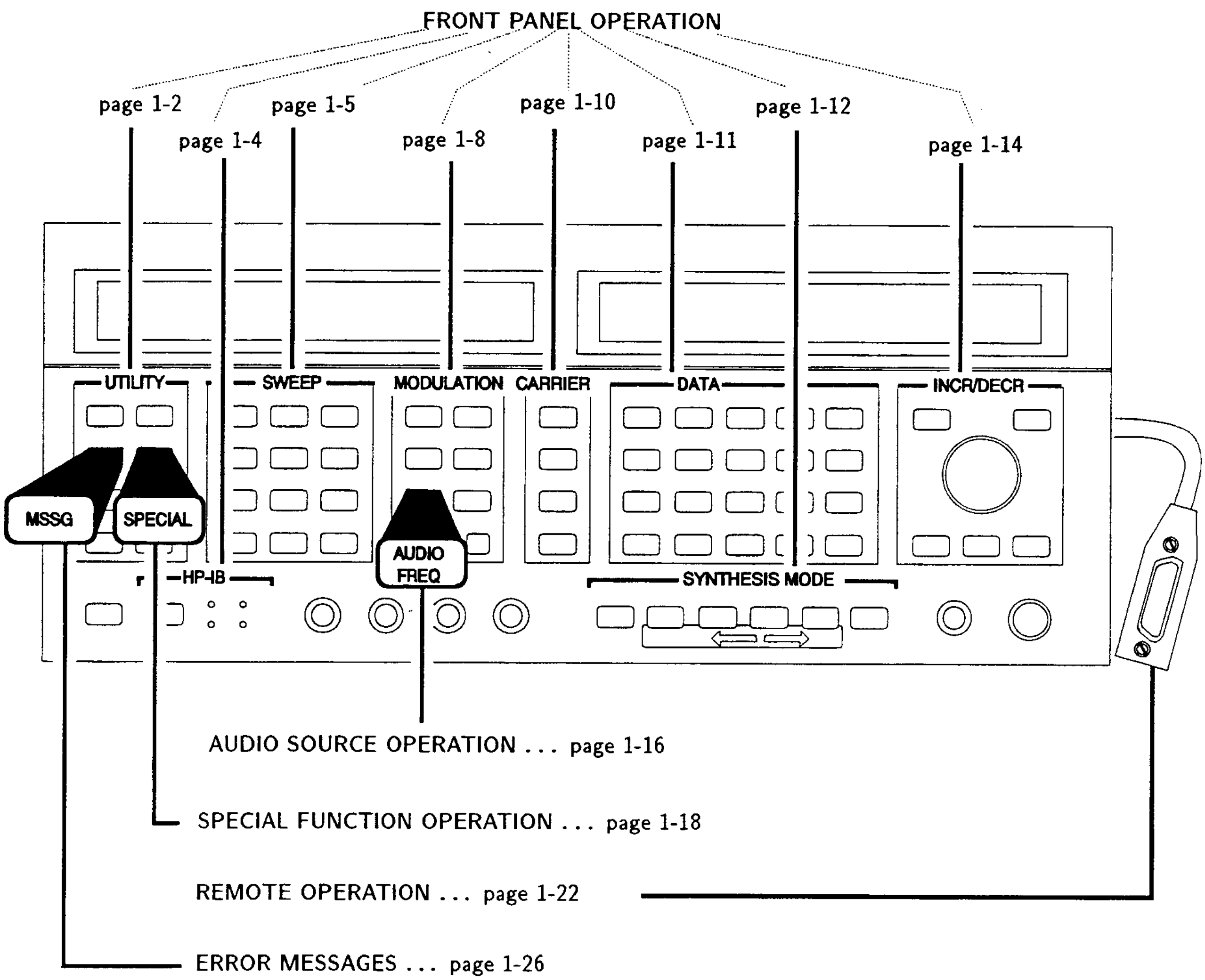
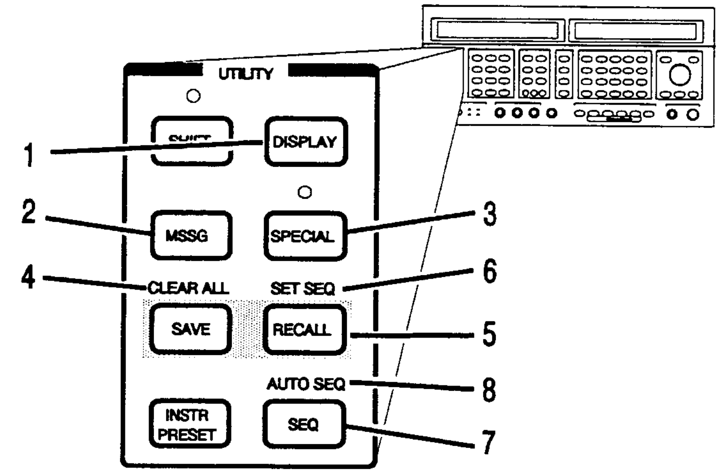


UTILITY



1. DISPLAY Use DISPLAY to display a list of the active special functions, the contents of a storage register, or to list the storage registers in the current sequence setting. Press [DISPLAY] then [SPECIAL], [RECALL], or [SEQ] to display the current settings.

2. MSSG Use MSSG when the MSSG annunciator lights in the Frequency/Status display to view error and status messages.

To View Each Message

Press [MSSG] to view the first message in the list. Press [MSSG] again to view each additional message in the list. To return to the first message in the list, press [SHIFT], then [MSSG].

Note Messages concerning transient events are removed from the message list after they have been displayed.

3. SPECIAL Press [SPECIAL] to access the special functions. (For further information about special functions, refer to *Special Function Operation* on page 1—18.)

4. CLEAR ALL

Press (SHIFT), (SAVE) (CLEAR ALL), (ON) to delete all the information in all of the storage registers.

5. SAVE, RECALL

Press (SAVE), a storage register number (0 to 49), and (ON) (ENTER) to save an instrument setup.

Note

Storage registers 0 to 9 provide storage of all instrument settings. Storage registers 10 to 49 store frequency and amplitude settings only.

Press (RECALL), the desired storage register number, and (ON) (ENTER) to recall an instrument setup.

6. SET SEQ

Use SET SEQ to define a sequence of storage registers. Only storage registers 0 through 9 can be used with the sequence function.

To Set a Storage Register Sequence

Press (SHIFT), (RECALL) (SET SEQ). Then enter the storage register number you want to store in the first position (position 0), and press (ON) (ENTER). To add another register to the sequence, enter the number and press (ON) again. You can enter up to 10 registers. You can use a register more than once in the sequence. To exit the sequence, press (SHIFT) (⇐ +) (EXIT).

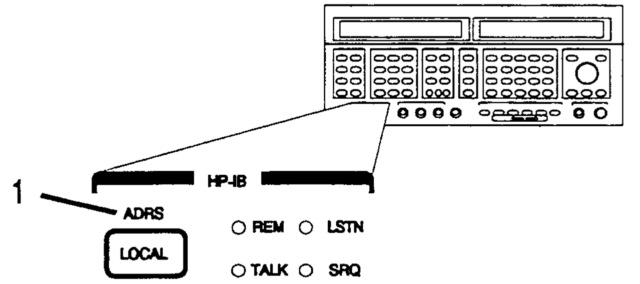
7. SEQ

Press (SEQ) to manually step through the storage register sequence.

8. AUTO SEQ

Use AUTO SEQ to automatically sequence through the storage register sequence. Press (SHIFT), (SEQ) (AUTO SEQ) to start the automatic sequence function. The sequence will repeat until you press (OFF).

HP-IB



1. ADRS **To View the HP-IB Address setting**

Press (SHIFT), (LOCAL) (ADRS).

To Change the HP-IB Address Setting

Press (SHIFT), (LOCAL) (ADRS), then enter a two digit address from 00 to 30 and press (ENTER) to set the HP-IB address.

SWEEP

Sweep Modes

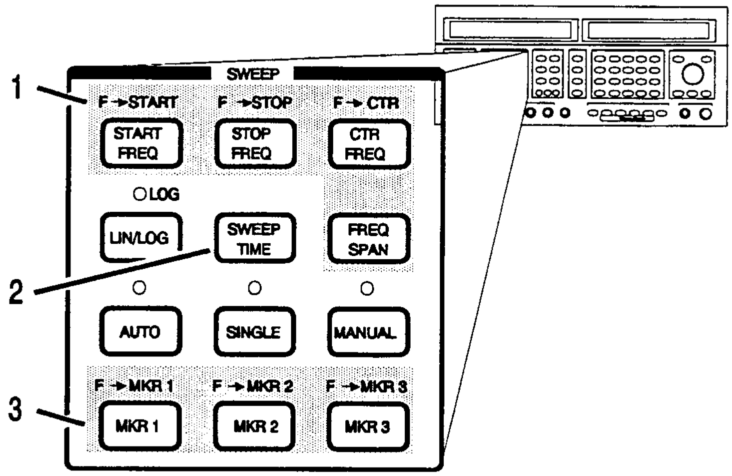
Use the sweep keys to sweep the RF carrier frequency in either of two modes, digitally-stepped sweep or phase-continuous sweep. Digitally-stepped sweep is the default sweep mode. It provides a broadband frequency sweep capability. Phase-continuous sweep provides a linear, narrowband frequency sweep. Turn on Special Function 112 to select phase-continuous sweep.

Press (AUTO), (SINGLE), or (MANUAL) to start or stop a sweep.

Phase-Continuous Sweep Spans*

Carrier Frequency (MHz)	(FREQ SPAN) Min. (Hz)	(FREQ SPAN) Max. (MHz)	Carrier Frequency (MHz)	(FREQ SPAN) Min. (Hz)	(FREQ SPAN) Max. (MHz)
1030 to 2060	400.0	40.0	8 to 16	3.13	0.31
515 to 1030	200.0	20.0	4 to 8	2.0	0.15
257 to 515	100.0	10.0	2 to 4	2.0	0.078
128 to 257	50.0	5.0	1 to 2	2.0	0.039
64 to 128	25.0	2.5	0.5 to 1	2.0	0.019
32 to 64	12.5	1.25	0.25 to 0.5	2.0	0.009
16 to 32	6.25	0.625			

* Limits for wide FM deviation for HP 8644B Synthesis Mode 1 and HP 8643A Special Function 125



1. Sweep Formats

There are two ways to set up the signal generator to sweep the carrier frequency. One way is to specify a start frequency and a stop frequency using the (START FREQ) and (STOP FREQ) keys. Another way is to set the frequency span you want to sweep using the (FREQ SPAN) key, and then enter the center frequency for the span using the (CTR FREQ) key.

Use F → START, F → STOP, and F → CTR to set the start, stop and center frequencies to the displayed RF carrier frequency.

2. Sweep Time

Use (SWEEP TIME) to set the time to complete each sweep (within the range of 0.5 to 1000 seconds). The sweep time, frequency span, and synthesis mode you have selected determine the step time, number of steps, and step size for the digitally-stepped sweep mode.

Step Time

Step time is determined by the synthesis mode selected.

Synthesis Mode		Step Time
HP 8643	HP 8644	
(SPECIAL) (1) (2) (5)	(MODE 1)	0.125 s
Preset Condition	(MODE 2)	0.225 s
Not Used	(MODE 3)	0.3 s

Number of Steps

The number of steps is calculated with the following formula:
$Number\ of\ Steps = \frac{Sweep\ Time-(Step\ Time \times 0.3)}{Step\ Time}$

The maximum number of steps possible is 1023. Fractions are always rounded down (for example, 9.7 = 9 steps).

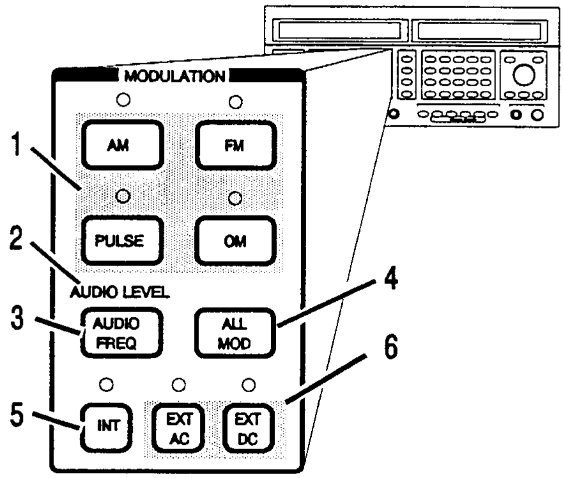
Step Size

The step size is calculated with the following formula:
$Step\ Size\ (Hz) = \frac{Frequency\ Span\ (Hz)}{Number\ of\ Steps}$

3. Markers

Use (MKR 1), (MKR 2), and (MKR 3) to set marker points within the frequency sweep span. The marker signals are available at the Z-AXIS connector on the rear panel. Press a marker key, then the desired frequency value and units. Use F→MKR 1, F→MKR 2, or F→MKR 3 to set the value of a sweep marker frequency to the displayed RF carrier frequency.

MODULATION



1. Modulation Mode Keys

Use the modulation keys to set the desired modulation mode.

To Set Modulation

Press a modulation key. Then enter the desired value and units, or press [ON] to select the modulation mode. The LED annunciator above the modulation key will light when a mode is selected.

2. AUDIO LEVEL

Use AUDIO LEVEL to set the level of the internal audio source.

To Set the Audio Level

Press [SHIFT], [AUDIO FREQ] (AUDIO LEVEL). Enter the audio level using the DATA keys, or turn the knob, or press the [⇩] or [⇧] key.

To Turn Off the Audio Level

Press [SHIFT], [AUDIO FREQ] (AUDIO LEVEL), then press [OFF].

Note

When using the internal audio source, the modulation level displayed on the front panel is accurate only when the audio level is set to 2.0 V. Reducing the audio level causes the actual modulation level to be less than the displayed level.

3. AUDIO FREQ

Use (AUDIO FREQ) to set the internal audio frequency for Channel 1 of the audio source. (For additional information about Channel 1 and Channel 2 operation, refer to Audio Source Operation on page 1—14.)

To Set the Audio Frequency for Channel 1

Press (AUDIO FREQ). Enter the desired frequency using the DATA keys, or turn the knob, or press the (⇩) or (⇧) key.

To Turn Off the Audio Frequency

Press (AUDIO FREQ), (OFF). This turns the internal audio source completely off.

4. ALL MOD

Use (ALL MOD) to turn all selected modulation modes (AM, FM, PM, or Pulse) on or off. (A modulation mode is selected if the LED annunciator above the key is lit.)

To Turn Modulation Off or On

Press (ALL MOD), (OFF) to turn all modulation off. To turn modulation back on, press (ALL MOD), (ON). This turns on all modulation modes that were on when (ALL MOD), (OFF) was pressed.

5. INT

Use (INT) to select the internal audio source for modulating the RF carrier signal.

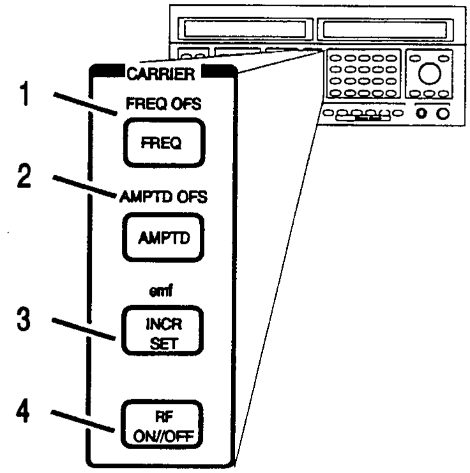
To Select the Internal Audio Source

Select a modulation mode (AM, FM, PM, or Pulse), then press (INT).

6. EXT AC, EXT DC

Use (EXT AC) or (EXT DC) to modulate the signal generator with an external audio source connected at one of the modulation inputs.

CARRIER



1. FREQ OFS

Use FREQ OFS to offset the displayed Carrier Frequency from the output frequency. Press (SHIFT), (FREQ) (FREQ OFS), (ON). Enter the offset value using the DATA keys. The signal generator will display the Carrier Frequency as the sum of the Carrier Frequency setting and the offset value you have entered. To turn off the frequency offset, press (SHIFT), (FREQ) (FREQ OFS), (OFF).

2. AMPTD OFS

Use AMPTD OFS to offset the displayed Carrier Amplitude from the output amplitude (up to 50 dB maximum). Press (SHIFT), (AMPTD) (AMPTD OFS), (ON). Enter the offset value using the DATA keys. The signal generator will display the Carrier Amplitude as the sum of the carrier amplitude setting and the offset value you have entered. To turn off the amplitude offset, press (SHIFT), (AMPTD) (AMPTD OFS), (OFF).

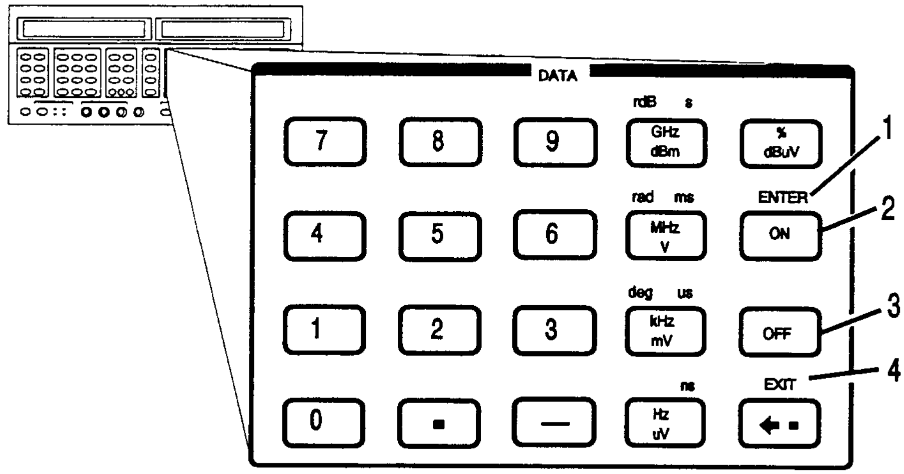
3. INCR SET

Use (INCR SET) to set an increment value for RF frequency, amplitude, FM, AM, or the internal audio source. Use (⇧) and (⇩) to increment and decrement the selected function.

4. RF ON/OFF

Use (RF ON/OFF) to turn off the RF output. The instrument turns off the output by switching in full attenuation.

DATA



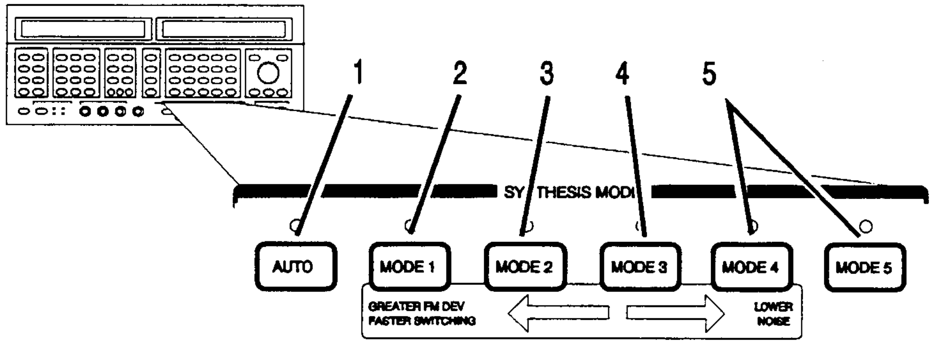
1. ENTER Press (ON) (ENTER) to terminate data entries that do not require specific units, such as Save/Recall entries and Special Function numbers.

2. ON Press (ON) to activate functions such as amplitude offset, frequency offset, audio level, and Special Functions.

3. OFF Press (OFF) to turn off functions such as amplitude offset, frequency offset, audio level, and Special Functions.

4. EXIT Press (SHIFT) (⇐) (EXIT) to exit a function and return to operation.

SYNTHESIS MODE



These keys are available only on the HP 8644B. (The HP 8643 defaults to Mode 2 operation. Mode 1 operation, for the HP 8643, can be selected using Special Function 125.)

1. AUTO

Press (AUTO) to have the Signal Generator automatically choose the signal path that provides the best spectral purity for the control settings you select.

2. MODE 1

Press (MODE 1) to get maximum FM deviation, and minimum RF output switching time. Noise level is highest in this mode, as shown in the following table.

3. MODE 2 Press (MODE 2) to get a median range of FM deviation and RF output switching time, with a medium noise level at the RF output, as shown in the following table.

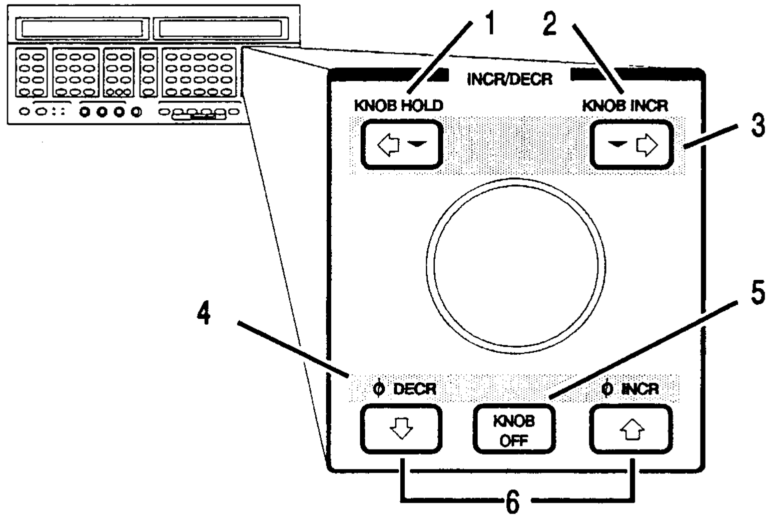
4. MODE 3 Press (MODE 3) to get the lowest noise level at the RF output. FM deviation bandwidth is narrower, and RF switching time is slower than for Mode 1 or Mode 2.

5. MODE 4, MODE 5 Modes 4 and 5 are reserved for special applications.

Operating Characteristics for Modes 1, 2, and 3.

Characteristic	Synthesis Mode		
	MODE 1	MODE 2	MODE 3
RF Frequency Switching Time	90 ms	200 ms	350 ms
FM Deviation at 1 GHz	10 MHz	1 MHz	100 kHz
Phase Noise (20 kHz offset at 1 GHz)	−120 dBc	−130 dBc	−136 dBc

INCR/DECR (Increment/Decrement) Keys



1. KNOB HOLD

Use KNOB HOLD to assign knob control to a specific function. Knob hold can be assigned to the following functions: Frequency, Amplitude, Audio Frequency, AM Depth, FM Deviation, Start Frequency, Stop Frequency, Center Frequency, Frequency Span, or Marker Frequency.

To Assign Knob Hold

Press a function key. Press (SHIFT), (⇐ ▽) (KNOB HOLD).

To Turn Off Knob Hold

Press (KNOB OFF).

2. KNOB INCR

Press (SHIFT), (▽ ⇒) (KNOB INCR) to configure the knob to emulate the operation of the (⇑) and (⇓) keys described in item 6, ⇑ ⇓.

To Turn off KNOB INCR

Press (KNOB OFF), or (⇐ ▽).

3. ⇐ ▽ or ▽ ⇒

Use (⇐ ▽), and (▽ ⇒) to move the cursor (▽) on the display. The cursor indicates which digit will be incremented when the knob is turned.

4. ϕ DECR, ϕ INCR

Press (SHIFT), (⇓) (ϕ DECR) to decrease the phase of the RF output relative to another source that is locked to the same timebase as this signal generator. The phase is decreased by 1° each time the key is pressed.

Press (SHIFT), (⇑) (ϕ INCR) to increase the phase of the RF output by 1° each time the key is pressed.

5. KNOB OFF

Use (KNOB OFF) to turn off the knob.

6. ⇓ ⇑

Use these keys to change the displayed value of the selected function by the INCR SET value.

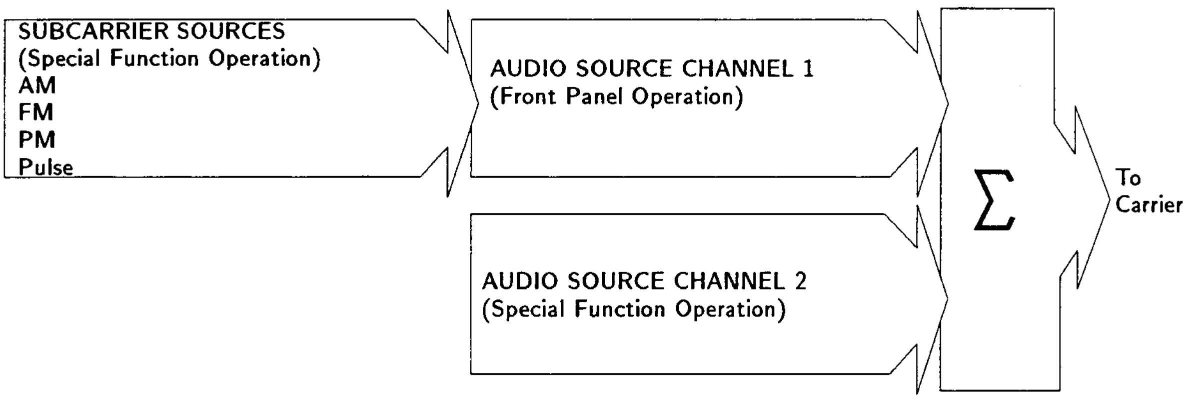
To Set the Increment Set Value

Press (INCR SET) and enter the desired value.

Internal Audio Source

Two internal audio sources (Channels 1 and 2) are available in the signal generator. They can be used individually or summed together to modulate the carrier. In addition, four subcarrier sources are available for modulating the Channel 1 audio signal (an AM source, an FM source, a PM source, and a pulse modulation source). The subcarrier sources can be used individually or simultaneously.

Channel 1 is operated from the front panel. Channel 2 and the subcarrier sources are operated using Special Functions.



To Set Up the Audio Sources

Perform the following steps to set up each audio channel. (If you need additional information for entering the Special Functions shown in the table, refer to the Special Functions section of this *Quick Reference* on page 1—18).

Step	Audio Source Channel 1	Control
1. Frequency	Press (AUDIO FREQ)	Enter frequency
2. Audio Level	Press (SHIFT) (AUDIO FREQ)	Enter level
3. Waveform	Press (SPECIAL) (1) (3) (0) (ON)	Turn knob to select waveform

Step	Audio Source Channel 2	Special Function Control
1. Frequency	Press (SPECIAL) (1) (3) (3) (ON)	Enter frequency
2. Audio Level	Press (SPECIAL) (1) (3) (4) (ON)	Enter level
3. Waveform	Press (SPECIAL) (1) (3) (5) (ON)	Turn knob to select waveform
4. Phase	Press (SPECIAL) (1) (3) (6) (ON)	Enter phase (relative to Channel 1)

Note

The audio level of the internal source must be set to 2-volts-peak for the displayed FM deviation to be accurate. For two-tone testing, the composite audio level settings of Channel 1 and Channel 2 set the level of the audio source and cannot exceed 2-volts-peak. The FM deviation provided by each channel is proportional to its audio level setting. For example, when Channel 1 is set to 1 volt, the FM deviation it provides is one-half of the displayed deviation setting.

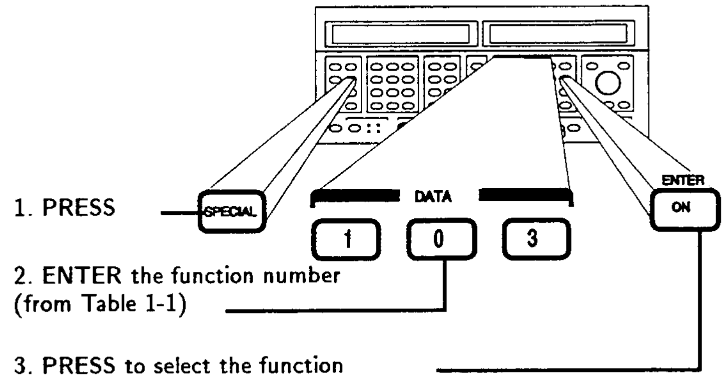
To Set Up the Subcarrier Source

Perform the following four steps to set up each subcarrier source. (If you need additional information for entering the Special Functions shown in the table, refer to the Special Functions section of this *Quick Reference* on page 1—18.)

Step	Special Function Number				Special Function Control
	AM	FM	PM	Pulse	
1. Subcarrier source	137	141	145	149	Press (ON)
2. Frequency	138	142	146	150	Enter frequency
3. Waveform	139	143	147	151	Turn knob to select waveform
4. Phase	140	144	148	152	Enter phase (relative to Channel 1)

For additional information about the Internal Audio Source, refer to chapter 5 in the *User's Guide*.

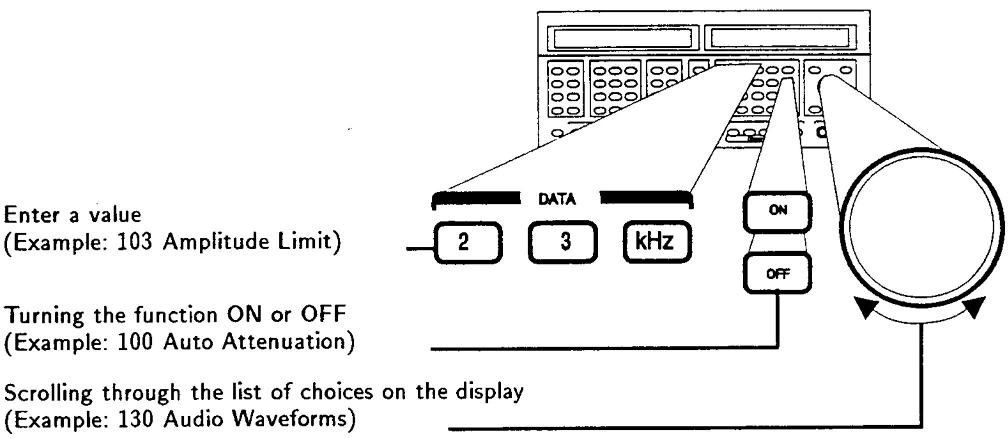
To Select a Special Function



Note After the SPECIAL key has been pressed, the knob can be used to scroll through the list of Special Functions.

To Control the Special Function

Once a Special Function has been selected, it may be necessary to perform an additional step to control its operation. If the Special Function you have selected requires an additional step, it will be one of the following control steps. (Refer to table 1—1 for further control information.)



To Reset all Special Functions

Press (INSTR PRESET) to reset all special functions to their preset conditions.

Table 1-1. Special Functions

Function Number	To Control	Preset Condition
Amplitude		
100: Auto Attenuation	ON = Automatic attenuator switching	ON
	OFF = Attenuators held at current setting providing transient-free level adjustment over a 20 dB range	
101: Attenuation	Turn knob to select attenuators and turn off Special Function 100	Auto
102: Amplitude Correction	ON = Internal calibration data is used,	ON
	OFF = Internal calibration data is not used	
103: Amplitude Limit	Enter upper amplitude limit in dB	19.9 dBm
104: Wideband ALC	ON = Wide ALC bandwidth,	OFF
	OFF = Narrow ALC bandwidth	
105: Amplitude Muting	ON = Output amplitude attenuated during frequency or amplitude changes.	ON
Frequency		
110: Rel Φ Adjust	Turn knob to change carrier's phase in 1° steps	0°
111: Frequency Multiplier	Enter multiplier or divider value:	+1
	+ integer = Frequency multiplier	
	− integer = Frequency divider	
112: Phase Continuous Sweep	ON = Phase-continuous sweep,	OFF
	OFF = Digitally-stepped sweep	
FM		
120: FM Synthesis	Turn knob for Digitized or Linear FM	Digitized
121: F(t)	Displays phase-locked frequency during digitized FM	
122: FM Pre-emphasis	ON or OFF	OFF
124: FM Delay Equalizer	ON or OFF	ON
125: Wide FM Deviation (HP 8643 only)	ON = 10 times greater FM deviation	OFF
	OFF = 1 MHz maximum at 1 GHz	

Table 1-1. Special Functions (continued)

Function Number	To Control	Preset Condition
Internal Audio Source		
130: Audio Waveform	Turn knob to select sine, square, triangle, sawtooth, or white-Gaussian-noise waveforms	Sine
131: Audio Triggered	ON = Special Function 132 and rear- panel AUDIO TRIG input enabled, OFF = Special Function 132 and rear-panel AUDIO TRIG input disabled	OFF
132: Triggered Audio	ON = Trigger 360° cycle of audio (requires that Special Function 131 is on) OFF = Normal audio output	OFF
133: Audio 2 Frequency	ON = Activate audio source in channel 2, and set its frequency	OFF
134: Audio 2 Level	Enter level of audio source in channel 2	100 mV
135: Audio 2 Waveform	Turn knob to select waveform of audio source in channel 2	Sine
136: Audio 2 Phase	Turn knob to select phase of audio source in channel 2 relative to channel 1	0.0°
137: Audio AM Depth	ON = Activate subcarrier AM source, and select its modulation depth	OFF
138: Audio AM Frequency	Enter frequency for subcarrier AM source	100.0 Hz
139: Audio AM Waveform	Turn knob to select audio waveform for subcarrier AM source	Sine
140: Audio AM Phase	Turn knob to select phase for subcarrier AM source	0.0°
141: Audio FM Deviation	ON = Activate subcarrier FM source, and select its deviation value	OFF
142: Audio FM Frequency	Enter frequency for subcarrier FM source	100.0 Hz
143: Audio FM Waveform	Turn knob to select audio waveform for subcarrier FM source	Sine
144: Audio FM Phase	Enter phase for subcarrier FM source	0.0°
145: Audio ΦM Deviation	ON = Activate subcarrier PM source, and select its deviation value	OFF
146: Audio ΦM Frequency	Enter frequency for subcarrier PM source	100.0 Hz
147: Audio ΦM Waveform	Turn knob to select audio waveform for subcarrier PM source	Sine
148: Audio ΦM Phase	Enter phase for subcarrier PM source	0.0°
149: Audio Pulse	ON = Activate subcarrier pulse source	OFF
150: Audio Pulse Frequency	Enter frequency for subcarrier pulse source	100.0 Hz
151: Audio Pulse Phase	Enter phase for subcarrier pulse source	0.0°

Table 1-1. Special Functions (continued)

Function Number	To Control	Preset Condition
Reference		
161: Reference Source	Monitors internal/external reference oscillator connection	EXT
Service		
170: Test	ON = Test instrument/modules for failures (takes several minutes)	OFF
171: Recalibration	ON = Recalibrate instrument (takes several minutes)	OFF
172: RAM Wipe	ON = Erase contents of RAM memory (takes several minutes)	OFF
300: Service Mode	ON = Allow access to diagnostic tests	OFF
Internal Meters		
180: DC Voltmeter	Displays internal dc voltmeter reading	
181: AC Voltmeter	Displays internal ac voltmeter reading	
182: Power Meter	Displays internal power meter reading (connector is located under top cover of instrument)	
Serial Number		
190: Serial #	Displays instrument serial number	
Display		
173: Security	ON = Secure Special Functions 191 through 195,	OFF
	OFF = Unsecure Special Functions 191 to 195 and perform Special Function 172 (RAM wipe)	
191: Blank Display	ON = Blank all front-panel displays	OFF
192: Blank Frequency	ON = Blank FREQUENCY/STATUS display	OFF
193: Blank Modulation	ON = Blank MODULATION display	OFF
194: Blank Audio	ON = Blank audio FREQUENCY display	OFF
195: Blank Amplitude	ON = Blank AMPLITUDE display	OFF
196: European Radix	ON = European decimal/comma separation	OFF
	OFF = U.S. decimal/comma separation	

Note

For additional information about Special Functions, refer to chapter 4 in the *User's Guide*.

Frequently Used HP-SL Commands

Frequently Used HP-SL Commands

Command Statement	Choices Available	Comments	HP 8642 HP-IB Command
Amplitude Commands			
AMPL:LEV	<value> <units> UP | DOWN	Set amplitude level	AP <value> <units>
AMPL:LEV:STEP	<value> <units>	Set amplitude step increment	AP15 <value> <units>
AMPL:STAT	ON | OFF	Set RF on or off	APON or APOF
AMPL:UNIT	<units>	Set amplitude units (dBm, dBmW, V, or dBμV)	AP <units> (DM, VL, or DU)
AMPL:GAIN	<value> dB	Set amplitude offset	RA <value> DB
Amplitude Modulation			
AM:DEPT	<value> <units>	Set AM depth (% or PCT)	AM <value> <units>
AM:STAT	ON | OFF	Set AM on or off	AMON or AMOF
AM:SOUR	<source list>	Select AM source	AMNT or AMBD
AM:COUP	<coupling type>	Select type of AM coupling (ac or dc)	AMXA or AMXD
AM:FREQ	<value> <units>	Set Audio frequency (Hz or kHz). Same as LFS:FREQ	MF <value> <units>
Common Commands			
*RCL	<value>	Recall register	RC <value>
*RST		Instrument preset	IP
*SAV	<value>	Save instrument setting	SV <value>
Frequency Modulation			
FM:DEV	<value> <units>	Set maximum FM deviation	FM <value> <units>
FM:STAT	ON | OFF	Set FM on or off	FMON or FMOF
FM:MODE	LIN | DIG	Select type of FM synthesis	none
FM:SOUR	<source list>	Select FM source (INT, EXT or both)	FMNT or FMBD
FM:COUP	<coupling type>	Select type of FM coupling (ac or dc)	FMXA or FMXD
FM:FREQ	<value> <units>	Set audio frequency (Hz or kHz). Same as LFS:FREQ	MF <value> <units>

Frequently Used HP-SL Commands (continued)

Command Statement	Choices Available	Comments	HP 8642 HP-IB Command
Frequency Commands			
FREQ:CW	<value> <units>	Set RF frequency (HZ, KHZ, MHZ, MAHZ, or GHZ)	FR <value> <units> (HZ, KHZ, MHZ, MAHZ, or GHZ)
FREQ:STEP	<value> <units>	Set frequency step increment	FRIS <value> <units>
FREQ:STAR	<value> <units>	Sweep start frequency	FA <value> <units>
FREQ:STOP	<value> <units>	Sweep stop frequency	FB <value> <units>
FREQ:CENTER	<value> <units>	Sweep center frequency	none
FREQ:SPAN	<value> <units>	Sweep span frequency	none
FREQ:OFFS	<value> <units>	Set frequency offset	RF <value> <units>
FREQ:SYNT:AUTO	ON | OFF	Set Auto Synthesis Mode	none
FREQ:SYNT 1 (HP 8643)		Select Normal FM Deviation	none
FREQ:SYNT 2 (HP 8643)		Select Wide FM Deviation	none
FREQ:SYNT (HP 8644)	<value>	Frequency synthesis mode	none
FREQ:MODE	CW | SWE	Selects CW or sweep operation	FAOF or FAON
Low Frequency Source			
LFS:FREQ	<value> <units>	Set audio frequency (Hz or kHz)	MF <value> <units>
LFS:WAV	SIN | SQU | SAWT | WGN | TRI	Select the type of audio waveform	none
LFS:STAT	ON | OFF	Set audio source state	none
LFS:LEV	<value> <units>	Set amplitude of audio source (V, mV, or μV)	ML <value> <units>
Pulse Modulation			
PULS:STAT	ON | OFF	Set pulse state	PLOF or PLON
PULS:SOUR	<source list>	Select pulse source	PLNT or PLXD
Sweep Commands			
SWE:TIME	<value> <units>	Set sweep time (s, ms, μs, or ns)	ST <value> <units>
SWE:MODE	AUTO | MAN	Select type of sweep	SG or SM
SWE:SPAC	LIN | LOG	Select sweep spacing	none
SWE:GEN	STEP | ANAL	Select digitally-stepped or phase-continuous sweep	none

Example HP-SL Program

```
100  OUTPUT 719; "*RST"
200  OUTPUT 719; "FREQ:CW 500 MHZ"
300  OUTPUT 719; "AMPL:LEV 10 DBM"
400  OUTPUT 719; "AMPL:STAT ON"
500  OUTPUT 719; "FM:DEV 10 KHZ"
600  OUTPUT 719; "FM:STAT ON"
700  OUTPUT 719; "AM:DEPTH 50%"
800  OUTPUT 719; "AM:STAT ON"
900  OUTPUT 719; "AM:SOUR EXT"
1000 OUTPUT 719; "AM:COUP AC"
```

To Combine Command Statements

A major advantage of HP-SL is that it allows instrument settings to be programmed in a single output statement. The colon (:) and semicolon(;) are used to string together HP-SL commands. The semicolon is used to separate command statements in a single message. The colon is used with the semicolon to restart commands from the root (as shown in line 200 below).

```
100  OUTPUT 719; "*RST"
200  OUTPUT 719; "FREQ 500 MHZ;:AMPL:LEV 10 DBM;STAT ON"
300  OUTPUT 719; "FM:DEV 10 KHZ;STAT ON"
400  OUTPUT 719; "AM:DEPTH 50%;STAT ON"
500  OUTPUT 719; "AM:SOUR EXT;COUP AC"
```

Special Function HP-SL Commands

HP-SL Commands for Frequently Used Special Functions

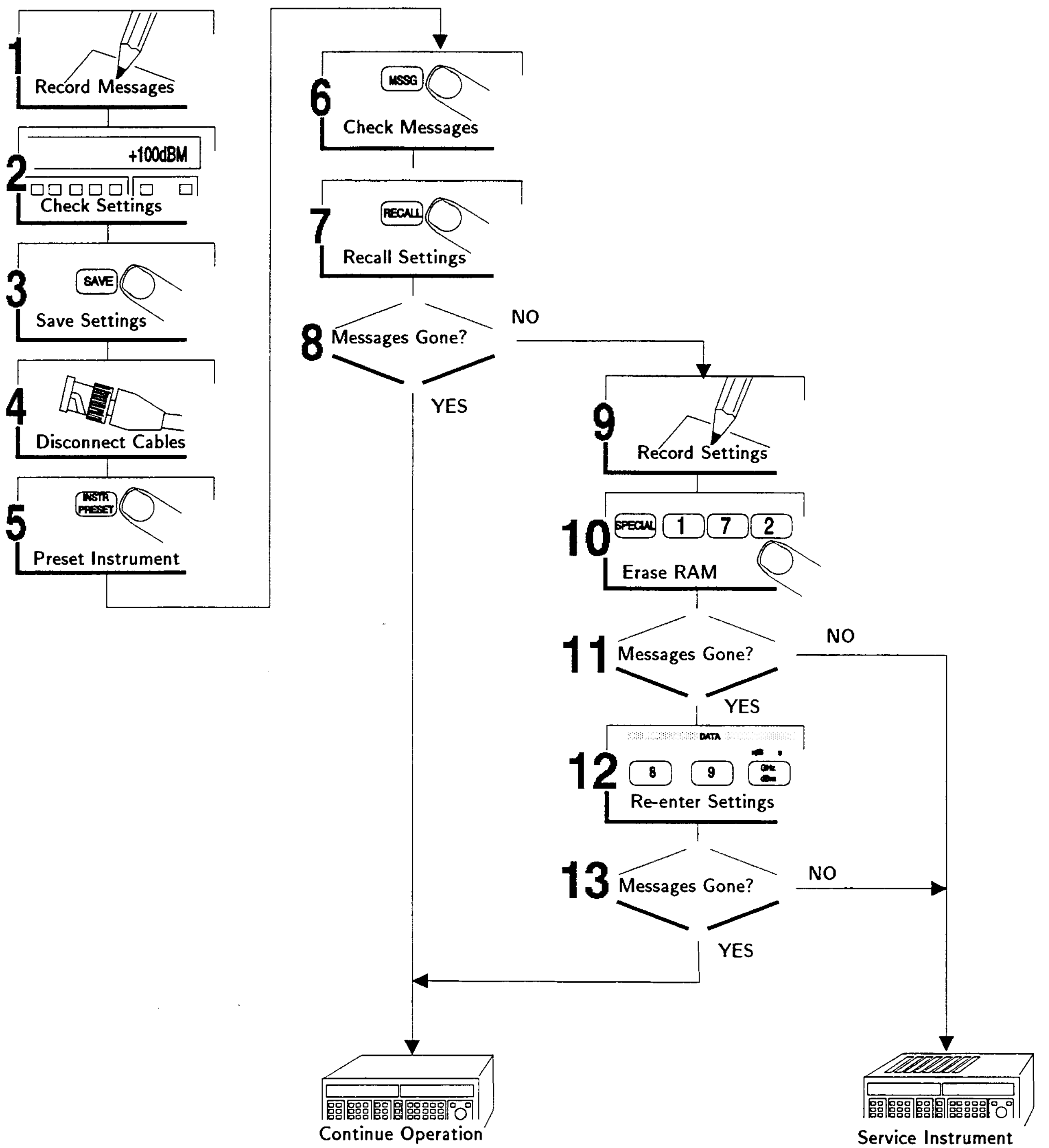
Special Function	Command Statement	Choices Available
100: Auto Attenuation	AMPL:ATT:AUTO	OFF
105: Amplitude Muting	AMPL:MUT	ON | OFF
110: Rel Φ Adjust	PHAS:ADJ	<value>
112: Phase Continuous Sweep	SWE:GEN	ANAL | STEP
120: FM Synthesis	FM:MODE	LIN | DIG
122: FM Pre-emphasis	FM:PRE:STAT	ON | OFF
124: FM Delay Equalizer	FM:DEL	ON | OFF
125: Wide FM Deviation (HP 8643 only)	FREQ:SYNT	1 | 2
130: Audio Waveform	LFS:WAV	SIN | SQU | TRI | SAWT | WGN
131: Audio Triggered	LFS:TRIG:IMM	
132: Triggered Audio	LFS:STAT2	ON | OFF
133: Audio 2 Frequency	LFS:STAT2	ON | OFF
	LFS:FREQ2	<value>
134: Audio 2 Level	LFS:LEV2	<value>
135: Audio 2 Waveform	LFS:WAV2	SIN | SQU | TRI | SAWT | WGN
170: Test	*TST?	
171: Recalibration	*CAL?	
180: AC Voltmeter	VMET:MODE	DC
181: DC Voltmeter	VMET:MODE	AC
190: Serial Number	*IDN?	
191: Blank Display	DISP:ANN:ALL	ON | OFF

Note

For additional information about remotely operating the signal generator, refer to the chapter 6 in the *User's Guide*.

Error Messages

The flowchart below describes a procedure for determining the appropriate response to the following error messages: Hardware Failure, Calibration Failure, Amplitude Error, User Memory Cleared, Reverse Power Detected. Each step is explained on the next page.



2 General Information and Specifications

Where to Find Information

This User's Guide contains information required to install, operate, and test the Hewlett-Packard Model 8643A and Model 8644B Synthesized Signal Generators. The HP 8643A/HP 8644B will generally be referred to as the Signal Generator throughout this manual.

The information to operate, calibrate, and service this instrument is as follows:

- The *User's Guide* and the *Quick Reference Guide* are provided with each instrument. They contain operation and calibration information. The information presented in the Quick Reference Guide is repeated chapter 1 of the *User's Guide.*
- The *Assembly Level Repair, Service Diagnostics Manual* for assembly level repair is not included with the instrument (unless you ordered Option 910 or Option 915, where available) but can be obtained separately by ordering through your nearest Hewlett-Packard office.

User's Guide

The *User's Guide* documents front-panel operation, including special functions, error messages, and HP-SL programming. All operating information for the Signal Generator is found in the *User's Guide.* Application notes for the Signal Generator are also provided.

Chapter 1, Quick Reference is an overview of the Signal Generator's front-panel operation. It also provides an abbreviated list of HP-SL commands for remote operation and a brief overview of Special Function operation. An error message troubleshooting flowchart is also provided.

Chapter 2, General Information describes the Signal Generator, options, accessories, specifications, and other basic information.

Chapter 3, Installation provides information about initial inspection, preparation for use (including address selection for remote operation), instrument storage, and shipment.

Chapter 4, Special Functions describes the Special Functions.

Chapter 5, Internal Audio Source provides a quick demonstration, an explanation, and typical applications of the Signal Generator's multifunction synthesis capability using the internal audio source.

Chapter 6, Remote Operation provides information for the beginning and advanced HP-SL programmer. Command statements are described, and programming examples and syntax drawings are provided.

Chapter 7, Error Messages describes the error messages that are displayed in the FREQUENCY/STATUS display, and the error messages that are written to the message queue. Some error recovery information is provided.

Chapter 8, Performance Tests documents the tests that verify performance of the instrument against the critical specifications in table 1–1.

Chapter 9, Adjustments documents the procedures that need to be performed to adjust the instrument's electrical performance. The procedures can be used for periodic calibration.

Service Diagnostics Manual

The *Assembly Level Repair, Service Diagnostics Manual* documents repairing the Signal Generator to the assembly level. This manual does not include component level repair.

Additional copies of any operation, calibration, or service manual can be ordered separately through your nearest Hewlett-Packard office. The part numbers are listed on the title page of this manual.

Specifications

Instrument specifications are listed in table 2–1, *Specifications*. These are the performance standards, or limits, against which the instrument may be tested after a 24 hour warm-up (connection to ac power line), and after 10 minutes turn-on. The Signal Generator has a general operating temperature range of 0 to +55°C. Whenever the instrument senses an ambient temperature variation of ±10°C, a recalibration should be done to ensure that all specifications are being met. The error message **Temp Drift. Recalibrate** is put into the message queue if the temperature variation occurs. Activate Special Function 171 to recalibrate the instrument.

Safety Considerations

This product is a Safety Class I instrument (that is, one provided with a protective earth terminal). Review the Signal Generator and all related documentation to become familiar with safety markings and instructions before operation. Refer to the *Warnings* and *Cautions* found in chapter 3 for safety information.

Safety information pertinent to the task at hand (installation, operation, performance testing, adjustment, or service) are found throughout these manuals.

Description

The Hewlett-Packard Model 8643A and Model 8644B Synthesized Signal Generators have an RF output range of 251 kHz to 1030 MHz (2060 MHz with Option 002). The output amplitude is leveled and calibrated from +16 to −137 dBm. AM, FM, Pulse, or Phase Modulation functions can be selected. The RF output frequency, output amplitude, and modulation functions may be remotely programmed through the Hewlett-Packard Interface Bus using the new Hewlett-Packard Standard Language (HP-SL). The unique modular design, internal calibration, and service diagnostic features permit accurate calibration and service.

RF Output

The Signal Generator covers an RF output range of 251 kHz to 1030 MHz which can be extended to 2060 MHz with the optional Doubler Module (Option 002). Frequency resolution is 0.01 Hz. A 12-digit display of the RF output in Hz, kHz, MHz, and GHz gives easy viewing of the desired frequency. Pushbutton keys and rotation of the Knob permit accurate tuning, and incrementing of the RF output.

Frequency accuracy and stability are dependent upon the reference source being used, which will be either the internal reference oscillator or an external source operating at 10 MHz. An optional 10 MHz reference with a temperature stabilized crystal is available for increased stability (Option 001).

Output Amplitude

The Signal Generator has precise power levels from +16 to −137 dBm over the entire frequency range. For instruments equipped with Option 002 (Doubler Module), the maximum output levels are +14 dBm for frequencies from 251 kHz to 1030 MHz, and +13 dBm at frequencies from 1030 to 2060 MHz. Output amplitude display resolution is 0.1 dBm. An 8 digit display provides easy viewing of the desired output. Easy conversion of units between dBm, +V, EMF, and so forth is possible.

Reverse Power protection is 50 Watts from a 50 Ω source, 25 V dc.

Modulation

The Signal Generator features AM, FM, ΦM, and Pulse modulation which can be simultaneously mixed, for example, AM/FM, AM/ΦM, AM/Pulse, FM/Pulse, ΦM/Pulse, AM/FM/Pulse, or AM/ΦM/Pulse. The Signal Generator also features versatile simultaneous internal and external modulation capability for AM, FM, Pulse, and ΦM.

With the Synthesized Audio Oscillator, the Internal Audio Source produces sine, square, triangle, sawtooth, and white Gaussian noise waveforms from 0.1 Hz to 400 kHz. However, the **AUDIO** output has a typical bandwidth of 400 kHz which affects complex waveforms with frequency components greater than 400 kHz. A 16-digit display and LED annunciators shows information for the internal or external modulation source. Direct keyboard entry for modulation selection is provided.

Sweep

The Signal Generator has two types of sweep: phase-continuous, and digitally-stepped. Linear or log frequency spacing may be selected with digitally-stepped sweeping; only linear frequency spacing is available when phase-continuous sweeping.

Hewlett-Packard Interface Bus (HP-IB)

The Signal Generator is fully programmable via the HP Interface Bus. The The Signal Generator's capabilities are defined by the following interface functions: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT0, C0, E2. The Signal Generator interfaces with the bus via open-collector TTL circuitry. An explanation of the compatibility code may be found in IEEE Standard 488.2, in *IEEE Standard and Digital Interface for Programmable Instrumentation* or the identical ANSI Standard MC1.1.

For detailed information relating to programmable control of the Signal Generator over HP-IB using HP-SL, refer to *chapter 6*.

Selecting the HP-IB Address

The instrument's HP-IB address is preset to 19 (decimal) when shipped from the factory.

The HP-IB address is front-panel programmable. To change your instrument's HP-IB address, press the blue SHIFT key, and then the ADRS key.

You will see the current address in the FREQUENCY/STATUS display. Key in the desired decimal number between 00 and 30 if you want to change the HP-IB address, and then press the ENTER key.

Instruments Covered by this Manual

This manual documents Signal Generators supplied with electrical options 001, 002, 003, 005, 009, 010 and 011. These, and various mechanical options are described later in this chapter.

Serial Numbers

This instrument has a two-part serial number in the form 1234A00123 which is stamped on the serial number plate attached to the rear of the instrument (above and slightly to the right of the fan louvre). The first four digits and the letter are the serial number prefix, and the last five digits form the sequential suffix that is unique to each instrument. The prefix is the same for all identical instruments; it changes only when a change is made to the instrument.

The contents of these manuals apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the respective manual title pages.

For information concerning a serial number prefix not listed in the range provided on the title page, contact your nearest Hewlett-Packard office.

Additional Equipment Information

Options are variations to the standard instrument which can be ordered during, or after the original purchase. If options were not ordered with the shipment but are now desired, they may be ordered from your nearest Hewlett-Packard office using the part number included in the following paragraphs. The following list defines all currently available options.

Electrical Options

High Stability Timebase, (Option 001). This option provides the Signal Generator with a temperature regulated 10 MHz crystal High Stability Time Base for increased frequency stability (less than 5×10^{-10}/day). Option 001 is installed in addition to the standard reference oscillator. With Option 001, the rear-panel OVEN REF output connector from the High Stability Time Base should be connected with a BNC cable to the REF IN input connector. (The Signal Generator will sense when the internal reference is connected, and will use an external reference when connected.) A BNC 10 MHz time base output connector is provided on the rear panel as a time base reference.

2 GHz Doubler Output, (Option 002). The Signal Generator RF output range is extended from 1030 MHz to 2060 MHz.

Rear Panel Inputs/Outputs, (Option 003). This option provides rear-panel (instead of front-panel) connections for AM/FM/PULSE/PHASE MODULATION INPUTS, AUDIO and RF OUTPUTs.

Electronic Attenuator, (Option 005). This option provides the Signal Generator with an electronic attenuator for high-cycle production applications. The Option 005 cannot be used with instruments equipped with the 2 GHz doubler Option 002.

Specified VOR/ILS Performance, (Option 009). This option provides a set of VOR/ILS test specifications. Option 009 must be ordered without Option 002 or Option 005.

Reduced Leakage Configuration, (Option 010). This option provides the Signal Generator with RF leakage performance reduced to less than 0.05μV (typically).

2 GHz Frequency Counter, (Option 011). This option provides the Signal Generator with a progammable counter that can measure frequencies from 20 Hz to 2 GHz with up to 0.1 Hz resolution from a single input.

Mechanical Options

Front Handle Kit (Option 907). Ease of handling is increased with the front-panel handles. Order HP part 5061-9690.

Rack Flange Kit (Option 908). This kit contains all necessary hardware and installation instructions for mounting the Signal Generator in a rack with 482.5 millimeter (standard 19-inch) spacing. Order HP part 5061-9678.

Rack Flange and Front Handle Combination Kit (Option 909). This kit is simply a front handle kit and a rack flange kit packaged together. The combination is made up of unique parts which include both functions. Order HP part 5061-9684.

Documentation Options

Extra Manual Set (Option 910). Provides an additional copy of the *User's Guide* (HP part 08643-90001), the *Quick Reference Guide* (HP part 08643-90019), and two copies of the *Assembly Level Repair, Service Diagnostics Manual* (HP part 08645-90104).

Add Service Manual (Option 915). Provides one copy of the *Assembly Level Repair, Service Diagnostics Manual* (HP part 08645-90104).

Available Electrical and Mechanical Equipment

Chassis Slide-Mount Kit. This kit is extremely useful when the Signal Generator is rack mounted. Access to internal circuits and components or the rear panel is possible without removing the instrument from the rack. Order HP part 1494-0059 for 432 mm (17 in.) fixed slides. (To order adapters for non-HP rack enclosures, use HP part 1494-0023.)

Chassis-Tilt, Slide-Mount Kit. This kit is the same as the Chassis Slide Mount Kit above except it also allows the tilting of the instrument up or down 90°. Order HP part 1494-0063 for 432 mm (17 in.) tilting slides. To order adapters for non-HP rack enclosures, use HP part 1494-0023.

Service Accessory Kit. A Service accessory Kit (HP part 08645-61116) is available which contains accessories (special test fixtures, cables, etc.) useful in servicing the Signal Generator.

Transit Case. Protection when transporting is increased with the Transit Case. Order HP part number 9211-2662. For ease of use when handling, Transit Case Wheels can be ordered using HP part number 1490-0913 (includes 4 wheels).

Accessories Supplied

The Accessories Supplied are pieces of equipment which are shipped with every Signal Generator.

Line Power Cable. The line power cable may be supplied in several different plug configurations according to the Mains voltage available, and the country of destination of the original shipment. For the part numbers of the power cables and Mains plugs available, refer to *Power Cables* in chapter 3 of this manual.

Fuses. A fuse with a 6A rating for 110 to 220 V ac (HP 2110-0556) is supplied for the HP 8643A. Fuses with a 4A rating for 115 V ac (HP 2110-0055) and a 2.5A rating for 230 V ac (HP 2110-0083) are supplied for the HP 8644B. One fuse is factory installed according to the voltage available in the country of original destination. This same information (part numbers and ratings of the fuses available) is in the paragraph *Line Voltage and Fuse Selection* in chapter 3 of this manual.

Table 2-1. Specifications (1 of 4)

Specifications	HP 8643A	HP 8644B
Frequency		
Range:	.252 - 1030 MHz .252 - 2060 MHz Opt. 002	.252 - 1030 MHz .252 - 2060 MHz Opt. 002
Resolution:	.01 Hz	.01 Hz
Accuracy (Std. Timebase): < 1 year of calibration	.375 x 10^{-6} times carrier in Hz	.375 x 10^{-6} times carrier in Hz
Internal Reference Oscillator	Standard High Stability	Option 001 High Stability with EFC
Aging:	±1.5 x 10^{-8}/day after 10 days	±3 x 10^{-10}/day after 10 days
Temperature:	±7 x 10^{-10}, 0 to 55°C	±6 x 10^{-10}, 0 to 55°C
Line Voltage:	±2 x 10^{-10}, (+5%, −10%)	±1 x 10^{-10}, ±10%
Output:	10 MHz, > 0.15 V_{rms} level into 50Ω	10 MHz, > 1 V_{rms} level into 50Ω
External Reference Input:	Accepts 10 MHz ±5 ppm and a level range of 0.5 V to 2 V_{rms} into 50Ω	
Electronic Frequency Control (EFC):	Option 001 only, ±0.01 ppm for ±1 Vdc at rear panel connector, voltage range 10 Vdc, input impedance 10 kΩ	
Spectral Purity		
SSB Phase Noise (dBc/Hz): (@ 20 kHz offset)		
Carrier (MHz)		
1030 - 2060	−124 (Opt. 002)	−130 (Opt. 002)
515 - 1030	−130	−136
257.5 - 515	−136	−142
128.5 - 257.5	−140	−145*
.25 - 128.5	−142	−145*
Nonharmonics	< −100 dBc, > 10 kHz offset, .252 - 1030 MHz < −94 dBc, > 10 kHz offset, 1030 - 2060 MHz	< −105 dBc, > 10 kHz offset, .252 - 1030 MHz < −100 dBc, > 10 kHz offset, 1030 - 2060 MHz
Harmonics	< −25 dBc, output ≤ +8 dBm	< −25 dBc, output ≤ +10 dBm
Subharmonics	None, .252 - 515 MHz < −52 dBc, 515 - 1030 MHz < −40 dBc, 1030 - 2060 MHz	None, .252 - 515 MHz < −52 dBc, 515 - 1030 MHz < −40 dBc, 1030 - 2060 MHz
Residual FM (Hz rms):		
Carrier (MHz)	3 kHz BW / 15 kHz BW	3 kHz BW / 15 kHz BW
1030 - 2060	< 4 / < 8	< 2 / < 4
515 - 1030	< 2 / < 4	< 1 / < 2
257.5 - 515	< 1.2 / < 2	< 0.5 / < 1
.25 - 257.5	< 1 / < 1.2	< 0.5 / < 0.5
Residual AM: (.3 to 3 kHz Post Det. BW)	< 0.01% AM rms	< 0.01% AM rms
SSB AM Noise Floor (dBc/Hz): (offsets > 100 kHz) (typical)	< −157, 10 dBm, < 1030 MHz < −150, 10 dBm, < 2060 MHz	< −157, 10 dBm, < 1030 MHz < −150, 10 dBm, < 2060 MHz

* Note: The HP 8644B with Option 005 has a phase noise floor of −143 dBc.

Table 2–1. Specifications (2 of 4)

Specifications (cont.)	HP 8643A	HP 8644B
Output Level		
Range:	+13 to −137 dBm	+16 to −137 dBm +13 dBm, Opt. 002, Opt. 005
Resolution:	.01 dB	
Absolute Accuracy:	±1 dB, output ≥ −127 dBm ±3 dB, output < −127 dBm	
Reverse Power Protection	50 watts	
Amplitude Modulation		
Depth:	0 - 100%, output ≤+7 dBm	
Resolution:	.1%	
Bandwidth (3 dB):	dc to .100 kHz, 128 MHz < f_c < 1030 MHz dc to .75 kHz, f_c > 1030 MHz	
Accuracy (1 kHz rate):	±(7% of setting + 1%) up to 80% depth	
Distortion (30% depth, 1 kHz rate):	< 3%; < 4% Opt. 002	
Incidental Phase Modulation (30% depth, 1 kHz rate)	< 0.2 radians peak	
External Input Impedance	600Ω	
Frequency Modulation		
Maximum Peak Deviation:	2 MHz, 1030 - 2060 MHz 1 MHz, 515 - 1030 MHz 500 kHz, 257.5 - 515 MHz 250 kHz, 128.5 - 257.5 MHz 125 kHz, 64 - 128.5 MHz 62.5 kHz, 32 - 64 MHz Deviation halves per lower octave (> 16, > 8, > 4, > 1, > .5 MHz)	20 MHz/200 kHz[3], > 1030 MHz 10 MHz/100 kHz[3], > 515 MHz 5 MHz/50 kHz[3], >257.5 MHz 2.5 MHz/25 kHz[3], > 128.5 MHz 1.25 MHz/12.5 kHz[3], > 64 MHz 625 kHz/6.25 kHz[3], > 32 MHz Deviation halves per lower octave (> 16, > 8, > 4, > 1, > .5 MHz)
Resolution:	2.5% of setting	2.5% of setting
Bandwidth (3 dB):	dc to 100 kHz	dc to 100 kHz
Carrier Accuracy in FM:	±0.5% of setting	±0.5% of setting
Indicator Accuracy:	< 5%, < 30 kHz rates	< 6%[3], < 30 kHz rates
Indicator Accuracy:	< 10%, < 100 kHz rates	< 15%[3], < 100 kHz rates
Distortion:	< 5%, 20 Hz to 100 kHz rates	< 5%, < 1%[3] 20 Hz to 100 kHz
Incidental AM:	< 0.5%, deviation ≤ 20 kHz	< 0.5%, deviation ≤ 20 kHz
External Group Delay:	< 10 µs, ≤ 100 kHz rates	< 10 µs, ≤ 100 kHz rates
External Input Impedance	600Ω	600Ω

Table 2-1. Specifications (3 of 4)

Specifications (Cont.)	HP 8643A / HP 8644B
Pulse Modulation	
On/off ratio:	>50 dB(HP8643A ≤ 1030 MHz), >35 dB(HP8644B ≤ 1030 MHz), >80 dB for fc >1030MHz
Rise/fall time, 10 – 90%:	<100 ns
Repetition rate:	dc to 1 MHz
Minimum width:(typical)	0.5 μs
Video feedthrough/overshoot:(typical)	<15%
Output level accuracy:	±2 dB
External inputs/outputs:	Input level: On state; >3.0Vpk (600Ω input impedance) Off state; <0.8Vpk
Internal Modulation Source	
Number of sources:	Two sources simultaneously available through summation, independently adjustable in frequency, phase, amplitude and waveform. Source One may also be internally modulated with AM, FM, phase modulation and pulse modulation to create a subcarrier waveform.
Waveforms and rates:	Sine, white Gaussian noise; 0.1 Hz to 400 kHz Triangle, Sawtooth, Square; 0.1 Hz to 50 kHz
Frequency accuracy:	Same as timebase
Max output level (into 600Ω):	2 Vpk
Output resolution:	2 mV pk
Total harmonic distortion:	<0.2%,≤20 kHz rates
Frequency Sweep	
Digital sweep:	Digitally stepped sweep over entire frequency range. Linear/log selection. .5 to 1000 sec sweeps .
Markers/Z axis output:	Three markers available /Z axis ouput nominally +5 V/X axis output nominally 0 to 10V.
Phase continuous sweep:	40 MHz of span available at maximum carrier frequency. 20 ms to 10 sec sweep times.
Remote Programming	
Interface:	HP-IB (IEEE 488.2-1987).
Control language:	Hewlett-Packard Systems Language (HP-SL). All functions controlled except power.
IEEE-488 functions:	SH1, AH1, T6, TEO, L4, LEO, SR1, RL1, PPO, DC1, DTO, CO, E2.
Avionics Option 009	Option 009 provides guaranteed specifications for testing VOR and ILS (Localizer, Glide Slope and Marker Beacon) receivers.
VOR (108 to 118 MHz)	Bearing accuracy: 0.1°, Frequency accuracy: Same as timebase, AM accuracy (30%): ±5% of setting, AM distortion: 2%, FM accuracy (480 Hz dev.): ±1.5 Hz
ILS: localizer/glide slope (108 to 112 MHz/329.3 to 335 MHz)	DDM resolution: Localizer: 0.0002 Glide Slope: 0.0004 DDM accuracy: Localizer: ±0.0004±5% of DDM Glide Slope: ±0.0008±5% of DDM AM accuracy: ±5% of setting AM distortion: 2%
Marker beacon (75 MHz):	AM accuracy (95%): ±5% of setting +1% AM distortion: 5%

Table 2–1. Specifications (4 of 4)

Specifications (Cont.)	HP 8643A	HP 8644B
2 GHz Counter Option 011		
Frequency range:	20 Hz to 2 GHz in three ranges	
Sensitivity:	40 mV_{rms} (-15 dBm into 50Ω)	
Maximum input:	2.25 V_{rms} (+20 dBm into 50Ω)	
Impedance:	50Ω, 10 MHz to 2 GHz; 1 MΩ shunted by <65pf, <10MHz	
Coupling:	ac	
Gate times:	0.1s to 1s in 0.1s steps	
Measurement resolution:	Measured frequency (Hz) x 10^{-8}/gate time or 0.01 Hz if greater	
Measurement uncertainty:	(± timebase accuracy) plus (± measurement resolution)	

[3] When used in low noise mode three

General	
Power requirements:	±10% of 100V, 120V, 220V or 240V; 48 to 440 Hz; 500 VA except 48 to 100 Hz; 400 VA.
Operating temperature:	0 to 55°C
Leakage:	Conducted and radiated interference meets MIL STD 461B REO2 and FTZ 1046. Leakage is measured into a resonant dipole antenna one inch from the instrument's surface with output level <0dBm (all inputs/outputs properly terminated, f_c <1 GHz). Leakage is typically <16μV or <2μV with Option 010, measured at the front panel. The older two-turn loop method of measurement is typically <1μV or <0.1μV for Option 010.
Acoustic noise:	Typically <5.5bels
Storage registers:	Ten full function and 40 frequency/amplitude registers.
Calibration/diagnostics:	Internal calibration and diagnostics funtions are available to the user. Built-in test capability locates circuit malfunctions to allow repair through module replacement.
Calibration interval:	Recommended two years (MTBC).
Weight:	HP8643A; 23 kg (50 lbs). HP8644B; 30 kg (67 lbs).
Dimensions:	177H X 426W X 601D mm (7 X 16.8X 23.7in.). Opt. 010 adds 35 mm (1.4 in.) to depth.

Last Rev: 3-30-93

DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Co.

Manufacturer's Address: Microwave Instruments Division
1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799
USA

declares that the product

Product Name: Synthesized Signal Generator

Model Number: HP 8643A

Product Options: This declaration covers all options of the above product.

conforms to the following Product specifications:

Safety: IEC 348:1978/HD 401 S1:1981
CAN/CSA-C22.2 No. 231 (Series M-89)

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 3 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV Sig. Lines, 1 kV Power Lines

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Product safety qualification testing for this product was performed prior to 1 December 1993.

Santa Rosa, California, USA 23 Dec. 1996

John Hiatt/Quality Engineering Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department HQ-TRE, Herrenberger Strasse 130, D-71034 Böblingen, Germany (FAX +49-7031-14-3143)

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Co.

Manufacturer's Address: 1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799

Declares that the products:

Product Name: Synthesized Signal Generator

Model Number: HP 8644B, HP 8645A, HP 8664A,
HP 8665A, HP 8665B

Product Options: This declaration covers all options of the above products

Conform to the following Product specifications:

Safety: IEC 61010-1:1990 / EN 61010-1:1993
CAN/CSA-C22.2 No. 1010.1-92

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 2 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV sig. lines, 1 kV power lines

Supplementary Information:

The products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carry the CE-marking accordingly.

Santa Rosa, CA, USA 19 May 1998

Greg Pfeiffer/Quality Engineering Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH Department HQ-TRE, Herreneberger Strasse 130, D71034 Boblingen, Germany (FAX +49-7031-14-3143

3 Installation

Unpack Your Signal Generator

Inspect the shipping container for damage. If the shipping container is damaged or the cushioning material inside is stressed, keep them until you have checked the shipment for completeness and the instrument for proper operation.

If items are missing from your shipment, or if there is mechanical damage or defect, notify the nearest Hewlett-Packard office. If the shipping container or cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for inspection by the carrier.

Connect Power

The Signal Generator requires a power source of 100 to 120 V ac (±10%) at 48 to 60 Hz, or 220 to 240 V ac (±10%) at 48 to 60 Hz. Power consumption is 400 VA maximum.

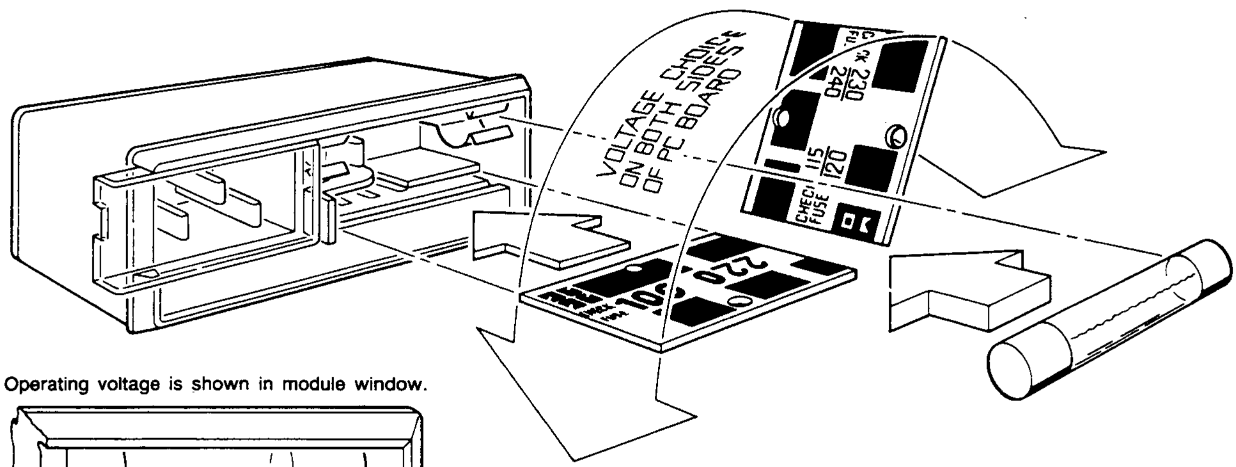
Warning

This is a Safety Class I product (that is, provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the Main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

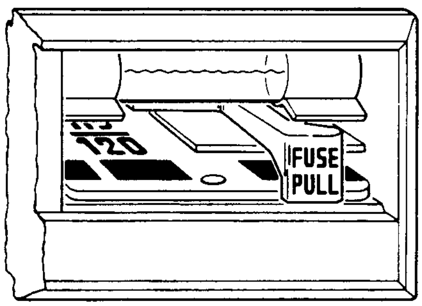
If this instrument is to be energized through an external autotransformer for voltage reduction, make sure that the common terminal is connected to the earthed pole of the power source.

To avoid hazardous electrical shock, do not perform electrical tests when there are any signs of shipping damage to any portion of the outer enclosure (covers and panels).

BEFORE PLUGGING THIS INSTRUMENT into the Mains (line) voltage, be sure the correct voltage and fuse has been selected. For protection against fire hazard, the line fuse should only be a 250 V fuse with the correct current rating.



Operating voltage is shown in module window.



WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left cover. Push the card firmly into the slot.
3. Rotate the Fuse Pull lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

Figure 3–1. Line Voltage and Fuse Selection for the HP 8644

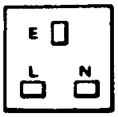
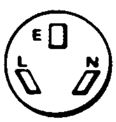
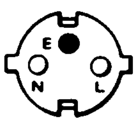
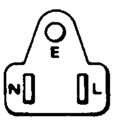
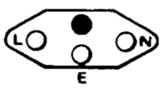
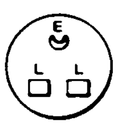
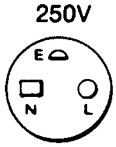
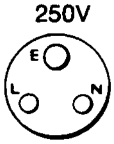
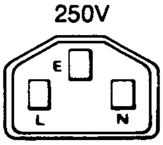
Select Line Voltage and Fuse

Verify that the Line Voltage Selection Card and fuse are matched to the power source. See figure 3-1. (***The HP 8643 does not require a line voltage selection card.***) Fuses may be ordered under the HP part numbers listed in table 3-1.

Table 3–1. Line Fuse Rating and HP Part Number

Instrument	Line Voltage	Rating	Part Number
HP 8644	100, 120 V ac 220, 240 V ac	4A, 250 V 2.5A, 250 V	2110-0055 2110-0083
HP 8643	100 to 240 V ac	6A, 250 V	2110-0056

Table 3–2. Power Cable and Mains Plug Part Numbers

Plug Type	Cable HP Part Number	C D	Plug Description	Cable Length (inches)	Cable Color	For Use In Country
250V 	8120-1351 8120-1703	0 4	90°/STR BS1363A* 90°/90°	90 90	Mint Gray Mint Gray	United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore
250V 	8120-1369 8120-0696	0 4	STR/STR NZSS198/ASC112* STR/90°	79 80	Gray Gray	Austrailia, New Zealand
250V 	8120-1689 8120-1692	7 2	STR/STR* STR/90°	79 79	Mint Gray Mint Gray	East and West Europe, Saudi Arabia, Egypt, (unpolarized in many nations)
125V 	8120-1378 8120-1521 8120-1751	1 6 1	STR/STR NEMA5-15P* STR/90° STR/STR	80 80 90	Jade Gray Jade Gray Jade Gray	United States, Canada, Mexico, Phillipines, Taiwan U.S./Canada
100V (Same plug as above)	8120-4753 8120-4754	2 3	STR/STR STR/90°	90 90	Dark Gray Dark Gray	Japan only Japan only
250V 	8120-2104 8120-2296 8120-3997	3 4 4	STR/STR SEV1011 1959-24507 Type 12 STR/90° STR/90°	79 79 177	Gray Gray Gray	Switzerland
250V 	8120-0698	6	STR/STR NEMA6-15P	90	Black	United States, Canada
250V 	8120-2956 8120-2957 8120-3997	3 4 4	90°/STR 90°/90° STR/STR	79	Gray	Denmark
250V 	8120-4211 8120-4600	7 8	STR/STR*IEC83-B1 STR/90°	79 79	Black Gray	South Africa, India
250V 	8120-1860 8120-1575 8120-2191 8120-4379	6 0 8 8	STR/STR*CEE22-V1 (Systems Cabinet Use) STR/STR STR/90° 90°/90°	59 31 59 80	Jade Gray Jade Gray Jade Gray Jade Gray	

* Part number shown for plug is industry identifier for plug only. Number shown for cable is HP Part Number for complete cable including plug. E = Earth Ground; L = Line; N = Neutral; STR = Straight

Connect Power Cable

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of Mains plug shipped with each instrument depends on the country of destination. Refer to table 3–2, *Power Cable and Mains Plug Part Numbers* for the part numbers of the power cables and Mains plugs available.

Warning

BEFORE CONNECTING THIS INSTRUMENT, the protective earth terminal of the instrument must be connected to the protective conductor of the (Mains) power cord. The Mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

Select an HP-IB Address

The instrument's HP-IB address is preset to 19 (decimal) when shipped from the factory.

The HP-IB address is front-panel programmable. To change your instrument's HP-IB address, press the blue SHIFT key, and then the ADRS key to show the current address in the FREQUENCY/STATUS display. Key in the desired decimal number between 00 and 30, then press the ENTER key.

Connect the Signal Generator with Other Instruments

Coaxial Connectors

Coaxial mating connectors used with the Signal Generator should be either 50 Ω BNC male connectors or 50 Ω Type N male connectors that are compatible with those specified in US MIL-C-39012.

Interface Connector

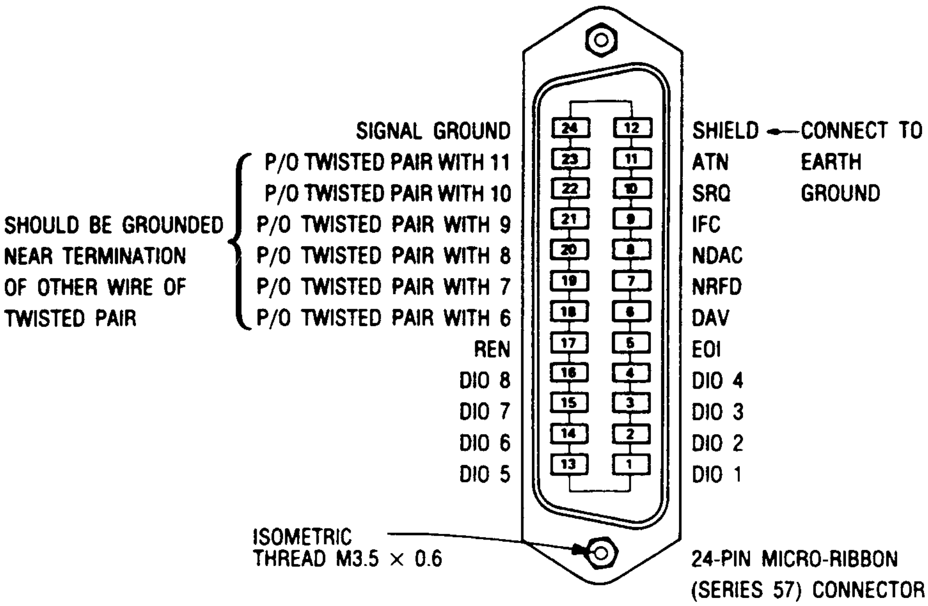
The HP-IB mating connector is shown in figure 3–2, *Hewlett-Packard Interface Bus Connections.* Note that the two securing screws are metric.

Turn On the Signal Generator

If you are operating this instrument in extreme environmental conditions, refer to *Operating Environment* for specific operating limitations.

Press the POWER key to the ON position. The front panel annunciators momentarily light up for a quick visual inspection.

If the MSSG annunciator is displayed in the lower right corner of the FREQUENCY/STATUS display, an instrument error has occurred. Press the UTILITY MSSG key as many times as needed to scroll



Logic Levels

The Hewlett-Packard Interface Bus logic levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is 2.5 Vdc to +5 Vdc.

Programming and Output Data Format

Refer to Section III, "Operation".

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

HP 10833A, 1 metre (3.3 ft.), HP 10833B, 2 metres (6.6 ft.)
HP 10833C, 4 metres (13.2 ft.), HP 10833D, 0.5 metres (1.6 ft.)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft.) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20 metres (65.6 ft.).

Figure 3–2. Hewlett-Packard Interface Bus Connections HP-IB through the error messages. Error messages may be viewed again by first pressing the blue **SHIFT** key and then repeatedly pressing the **MSSG** key.

Operating Environment

The operating environment should be within the following limitations:

Temperature .... 0° C to + 55° C
Humidity.................................... < 95% relative at 40° C
Altitude .... < 4570 meters (15,000 feet)

Stack or Rack-Mount the Signal Generator

The instrument cabinet has plastic feet that are shaped to ensure self-alignment of instruments when they are stacked.

The HP 8643A weighs approximately 23 kg (50 lbs) net. The HP 8644B weighs approximately 30 kg (67 lbs) net depending upon the options ordered. Lift properly and carefully to avoid personal injury. Use equipment slides when rack mounting.

Specific rack-mounting information is provided with rack-mounting kits. If a kit was not ordered with the Signal Generator as an option, it may be ordered through the nearest Hewlett-Packard office. *Mechanical Options*, in chapter 2, includes information and part numbers for rack-mount kits.

Slide, rack-mount, kits allow the convenience of rack-mounting with the flexibility of easy access. Slide-kits for the Signal Generator are listed below.

Standard Slide Kit for HP rack enclosures............ HP 1494-0059
Special Tilt Slide Kit for HP rack enclosures .... HP 1494-0063
Slide Adapter Bracket Kit for Standard Slides .... HP 1494-0023
(for non HP rack enclosures)

Storing or Shipping the Signal Generator

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment.

Temperature .... –55° C to + 75° C
Humidity... < 95% relative
Altitude .... 15 300 meters (50,000 feet)

Packaging

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also, mark the container FRAGILE to assure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for repackaging with commercially available materials.

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, attach a tag indicating the type of service required, return address, model number, and full serial number.)

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

c. Use enough shock-absorbing material (75 to 100 millimeter layer; 3 to 4 inches) around all sides of the instrument to provide a firm cushion and to prevent movement in the container. Protect the front-panel with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

4 Special Functions

How to Access the Special Functions

There are two ways to access special functions.

1. Press the **SPECIAL** key and then turn either the knob or press one of the knob ⇩⇧ keys to show the available special functions in the FREQUENCY/STATUS display. Access the special function of your choice by pressing the **ENTER** key.

–OR–

2. Press the **SPECIAL** key and enter the special function number of your choice. Access the special function by pressing the **ENTER** key.

The yellow annunciator above the **SPECIAL** key lights up to indicate that a special function is invoked. At any time, you may display all of the special functions that are invoked by pressing the **DISPLAY** key, and then the **SPECIAL** key.

Descriptions of Special Functions

`100:Auto Attenuation`

This special function allows you to lock or unlock the attenuators at their present setting. When ON (unlocked), the instrument's output amplitude can be set at any level within the range of the instrument. When OFF (locked), the instrument's output amplitude can only be set within the vernier range of the locked attenuators.

`101:Attenuation`

This special function gives you the choice of manually selecting which attenuators to switch in for operating the instrument. Activating this special function essentially turns off Auto Attenuation described in Special Function 100.

`102:Amptd Correction`

This special function allows you to either have a calibrated or an uncalibrated output amplitude level. When ON, internal calibration data is used. When OFF, the internal calibration data is not used.

`103:Amptd Limit`

This special function allows you to specify the upper limit for the instrument's output amplitude.

104:Wideband ALC

This special function allows you to determine the ALC bandwidth. When OFF, the ALC is configured for the most narrow bandwidth. When ON, the ALC is configured for the widest bandwidth possible for the RF output selected.

105:Amplitude Muting

This special function, when OFF, allows you to minimize the affect of changes that occur when the Signal Generator is in transition from one output amplitude level to another or from one center frequency value to another as seen at the RF Output. Typically, the carrier frequency can swing several MHz while in transition, and the output amplitude may change ±6 dBm while in transition. In the default condition, Amplitude Muting ON, output amplitude and center frequency changes occur with 20 to 40 dB of attenuation.

110:Rel Φ Adjust

This special function allows you to increment or decrement the phase of the RF output signal in one-degree steps relative to the present frequency reference.

111:Freq Multiplier

This special function allows you to use an external divider or multiplier on the RF output and still have the instrument display the final RF output signal. A positive integer, for example +2 would cause the frequency display to be multiplied by 2. A negative integer, for example −2 would cause the frequency display to be divided by 2. The front-panel **OFFSET** annunciator turns on when the frequency multiplier is a value other than +1.

112:Phase Cont Sweep

This special function allows you to put the instrument's sweep in a phase-continuous mode. During phase-continuous frequency sweep, the instrument sweeps between two selected endpoints in a linear, phase-continuous manner. This sweep function resembles a true sweeper in that it has no frequency transients; yet it is fully synthesized, yielding a very linear, precise sweep.

120:FM Synthesis

This special function allows you to have the instrument synthesize the FM signal in a digitized or linear manner. Digitized FM is best for single-tone modulation and provides a very accurate center frequency at low deviation rates. Linear FM is best for multi-tone modulation and provides a more constant group delay than the Digitized FM.

121:F(t)

This special function displays the phase-locked loop frequency during digitized FM. The display is continually updated.

122:FM Pre-emphasis

This special function allows you to pre-emphasize internal or external FM modulating signals with a 750 μsec time constant. Pre-emphasis boosts high frequencies in the modulating signal prior to modulating the RF output. With pre-emphasis turned ON, the displayed FM deviation applies for rates at approximately 3 kHz. Refer to figure 4-1 for specific details:

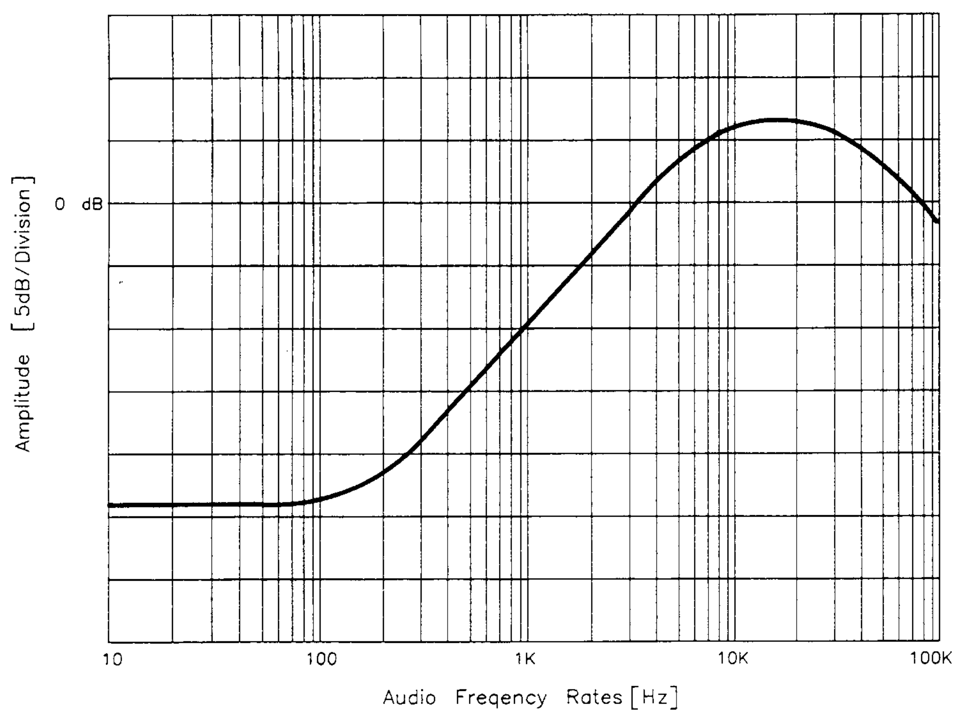


Figure 4-1. FM Audio Pre-emphasis.

124:FM Dly Equalizer

This special function allows you to turn off the FM Delay Equalizer circuitry. When ON (the preset condition), 30 μsec of group delay is added to the FM modulating signal to get better FM frequency response.

You may want to turn OFF the FM Delay Equalizer circuitry when the Signal Generator is used as the VCO in a phase-locked loop application to reduce phase shift, or when you want to extend the FM bandwidth to 200 kHz. When OFF, FM Indicator Accuracy is worse for rates of 1-5 kHz and better beyond 30 kHz, refer to figure 4-2 for specific details:

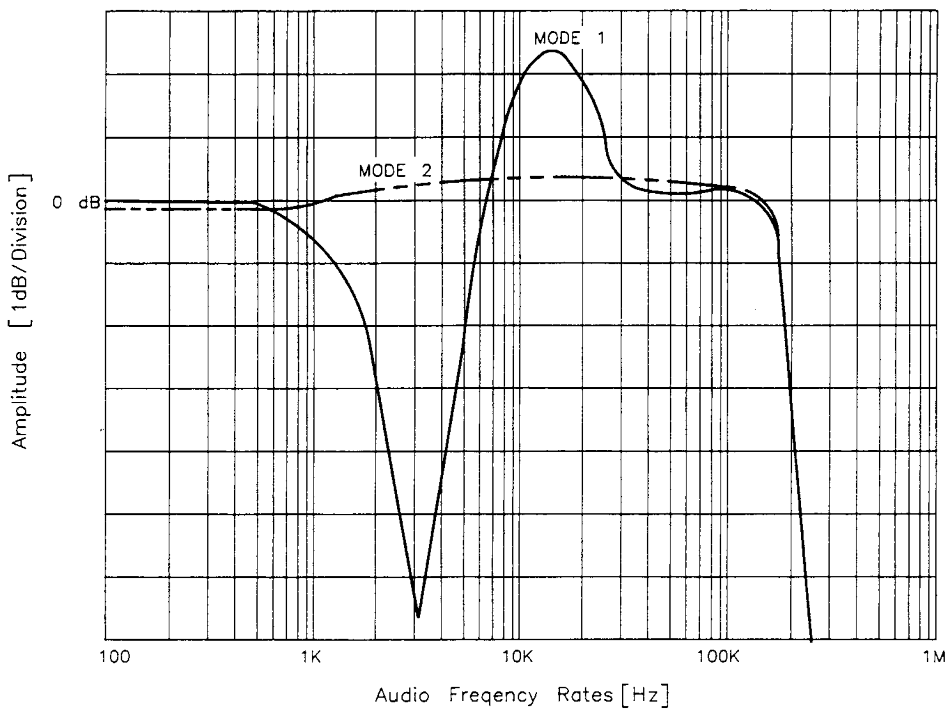


Figure 4-2. FM Indicator Accuracy with Special Function 124 Off.

125:Wide FM Deviation (HP 8643A only)

This special function allows you to turn on wide FM deviation. Wide FM deviation provides the maximum FM deviation and minimum RF output switching time. In this mode, the maximum deviation is increased, by a factor-of-10, to 10 MHz (for a 1 GHz carrier). The noise level of the signal generator is also increased in this mode, however.

130:Audio Wave

This special function allows you to select the waveform for the audio source in Channel 1. You have five choices: Sine, Square, Triangle, Sawtooth, or White Gaussian Noise.

131:Audio Triggered

This special function, when ON, enables Special Function 132.

132:Trig Audio

When enabled by Special Function 131, this special function allows you to trigger the audio source to output a single 360° cycle. When the audio is triggered for a single cycle of White Gaussian Noise, the result is a burst of noise for the duration of "1/audio frequency". You can output any one of the five audio waveforms. Triggering is done from either the front-panel **ON** key or from the rear-panel **AUDIO TRIG** connector.

133:Aud2 Freq

This special function allows you to turn on and off the audio source for Channel 2, and it allows you to set the audio source frequency for Channel 2. The audio source frequency for Channel 2 may be set to a minimum of 0.1 Hz, a maximum of 400 kHz, or any value in between.

134:Aud2 Level

This special function allows you to adjust the level of the audio source for Channel 2. The level for the audio source in Channel 2 may be set to a minimum of 0 V, a maximum of 2 V, or any value in between.

135:Aud2 Wave

This special function allows you to select the waveform for the audio source in Channel 2. You have five choices: Sine, Square, Triangle, Sawtooth, or White Gaussian Noise.

136:Aud2 Φ

This special function allows you to adjust the phase of the audio source in Channel 2. Phase may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield –160°.

137:Aud AM Depth

This special function allows you to turn on and off the AM source in Channel 1, and it allows you to set the percentage of depth for the AM source. Depth may be set to a minimum of 0%, a maximum of 100%, or any value in between.

138:Aud AM Freq

This special function allows you to set the frequency for the AM source in Channel 1. The frequency may be set to a minimum of 0.1 Hz, a maximum of 400 kHz, or any value in between.

139:Aud AM Wave

This special function allows you to select the waveform for the AM source in Channel 1. You have five choices: Sine, Square, Triangle, Sawtooth, or White Gaussian Noise.

140:Aud AM Φ

This special function allows you to adjust the phase of the AM source in Channel 1. Phase may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield –160°.

141:Aud FM Dev

This special function allows you to turn on and off the FM source in Channel 1, and it allows you to set the amount of deviation for the FM source. Deviation may be set to a minimum of 0 Hz, a maximum of 400 kHz, or any value in between.

`142:Aud FM Freq`

This special function allows you to set the frequency for the FM source in Channel 1. The frequency may be set to a minimum of 0.1 Hz, a maximum of 400 kHz, or any value in between.

`143:Aud FM Wave`

This special function allows you to select the waveform for the FM source in Channel 1. You have five choices: Sine, Square, Triangle, Sawtooth, or White Gaussian Noise.

`144:Aud FM Φ`

This special function allows you to adjust the phase of the FM source in Channel 1. Phase may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield −160°.

`145:Aud ΦM Dev`

This special function allows you to turn on and off the ΦM source in Channel 1, and it allows you to set the amount of deviation for the ΦM source. Deviation may be set to a minimum of 0° , a maximum of 179.9°, or any value in between. ΦM deviation may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield −160°.

`146:Aud ΦM Freq`

This special function allows you to set the frequency for the ΦM source in Channel 1. The frequency may be set to a minimum of 0.1 Hz, a maximum of 400 kHz, or any value in between.

`147:Aud ΦM Wave`

This special function allows you to select the waveform for the ΦM source in Channel 1. You have five choices: Sine, Square, Triangle, Sawtooth, or White Gaussian Noise.

148:Aud ΦM Φ

This special function allows you to adjust the phase of the ΦM source in Channel 1. Phase may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield –160°.

149:Aud Pulse

This special function allows you to turn on and off the Pulse source in Channel 1.

150:Aud Pulse Freq

This special function allows you to set the frequency for the Pulse source in Channel 1. The frequency may be set to a minimum of 0.1 Hz, a maximum of 50 kHz, or any value in between.

151:Aud Pulse Φ

This special function allows you to adjust the phase of the Pulse source in Channel 1. Phase may be expressed in terms of radians or degrees. The front panel display immediately changes units of degrees and radians when you switch between the **deg** and **rad** keys. Entries may be scaled; for example, entering 560° would yield –160°.

161:Ref Source

This special function monitors whether the instrument is using its internal reference oscillator source or if an external timebase source is connected. The display is continuously updated.

170:Test

This special function tests the instrument and module hardware for failures. Turn the knob to select the test you want, and then press the **ENTER** key. The message Result Code = 0 indicates that the instrument is operating normally. A result code other than the numeral "0" appearing on the front-panel display indicates a failure. All error codes are defined in the Service Diagnostics Manual. For Option 011, add cable between RF-Out and Measurement In.

171:Recal

This special function allows you to recalibrate the whole instrument. A recalibration takes about five minutes. The message Result Code = 0 appears if the recalibration passes. All error codes are defined in the Service Diagnostics Manual. For Option 011, add cable between RF-Out and Measurement In.

172:RAM Wipe

This special function allows you to do a 'hard' reset of the instrument to wipe out the memory contents of RAM (including the calibration data). This eliminates any instrument settings entered by the user through the front panel or through HP-IB. An instrument recalibration is then automatically done. For Option 011, add cable between RF-Out and Measurement In.

173:Security

This special function allows you to secure Special Functions 191 to 195. When ON, Special Functions 191 to 195 cannot be turned off without first forcing an automatic RAM wipe as described in Special Function 172. When this special function is active (turned ON), it executes a RAM wipe when turned OFF. Also, if the instrument's power switch is turned to STBY and then back to ON, a RAM wipe will be executed.

180:DC Voltmeter

This special function allows you to use the instrument as a DC voltmeter. DC voltages are monitored from the rear-panel **VOLTMETER IN** connector. The front-panel displays a continuously updated DC voltage reading. The following typical operating characteristics apply:

Range: ±50 V dc
Sensitivity: 0.5 V dc
Maximum Input Voltage: ±180 V dc
Input Impedance: 130 kΩ

181:AC Voltmeter

This special function allows you to use the instrument as an AC voltmeter. AC voltages are monitored from the rear-panel **VOLTMETER IN** connector. The front-panel displays a continuously updated AC voltage reading in V rms. The following typical operating characteristics apply:

Range: ±50 Vpk
Bandwidth: 10 kHz
Sensitivity: 0.5 Vpk
Maximum Input Voltage: ±180 Vpk
Input Impedance: 130 kΩ

182:Power Meter

This special function allows you to use the instrument as a power meter. Power is monitored from a connector located under the instrument's top cover. The front-panel displays a continuously updated power reading in dBm. The following typical operating characteristics apply:

Power Range: −10 to +20 dBm
Frequency Range: 250 kHz to 2 GHz
Accuracy: ±5 dBm at −10 to 0 dBm
±3 dBm at 0 to +10 dBm
±1 dBm at +10 to +20 dBm
Maximum Input Power: 25 dBm
Input Impedance: 50Ω AC coupled

183:Counter Range

This special function is available with option 011. It allows you to select the correct frequency range for accurate measurements when using the Signal Generator's Frequency Counter. The three ranges are:

20 Hz to 10 MHz
10 MHz to 640 MHz
640 MHz to 2 GHz.

The INSTRUMENT PRESET default range for the Frequency Counter is 20 Hz to 10 MHz. (If the instrument power is cycled without pressing INSTRUMENT PRESET, then the previously set counter range is still in effect.)

184:Cntr

This special function is available with option 011. It allows you to use the Signal Generator as a frequency counter for frequencies up to 2 GHz. Frequencies are monitored in Hz, through the front panel **MEAS INPUT** connector and displayed in the left screen. Frequency resolution is always displayed to within 0.01 Hz. Actual measurement resolution is a function of frequency and gate time.

185:Counter Gate

is available with option 011. It This special function allows you to select the gate time that determines how often the frequency counter makes and updates the displayed frequency reading. Gate time selection can be from 0.1 s to 1.00 s in 100 ms increments. The larger the gate time (that is, the longer the sampling time), the more accurate the reading. The INSTRUMENT PRESET default gate time for the Frequency Counter is 0.1 s. (If the instrument power is cycled without pressing INSTRUMENT PRESET, then the previously set gate time is still in effect.)

190:Serial #

This special function displays the instrument's serial number.

191:Blank Display

This special function allows you to blank out all instrument settings displayed on the front panel (including the LED annunciator lights). User interaction with the instrument is not displayed on the front panel.

192:Blank Frequency

This special function allows you to blank out just the frequency setting from being displayed on the front panel. When ON, each segment in the Frequency/Status display will show a dash, Mode Select LED annunciators turn off, and any special functions relating to frequency are blanked.

193:Blank Modulation

This special function allows you to blank out just the modulation level setting from being displayed on the front panel. When ON, each segment in the Modulation Level display will show a dash, Modulation LED annunciators turn off, and any special functions relating to modulation are blanked.

194:Blank Audio

This special function allows you to blank out just the audio frequency setting from being displayed on the front panel. When ON, each segment in the Modulation Frequency display will show a dash, and any special functions relating to audio frequency are blanked.

195:Blank Amptd

This special function allows you to blank out just the RF amplitude setting from being displayed on the front panel. When ON, each segment in the Amplitude display will show a dash, and any special functions relating to RF amplitude are blanked.

196:European Radix

This special function allows you to determine which 'radix mark' and which 'separator mark' to use in a number. A radix mark is the divider between the integer portion of a number and the fractional portion of a number. The separator mark is the separator between groups of digits in a large number.

When OFF, the radix mark displayed on the front panel is a period and the separator mark is a comma. When ON, the radix mark displayed on the front panel is a comma, and the separator mark is a period. For example, 123456789 Hz would be shown as 123,456,789.00 Hz in normal operation, however, it would be shown as 123.456.789,00 with the European Radix ON.

220:VOR Setup

This special function allows you to generate a composite VOR test signal. The instrument is set for a bearing of 0° to the station on a carrier of 108.0 MHz.

221:Localizer Setup

This special function allows you to generate a composite Localizer test signal. The instrument is set for 0 DDM on a carrier of 108.1 MHz.

222:Glideslope Setup

This special function allows you to generate a composite Guideslope test signal. The instrument is set for 0 DDM on a carrier of 334.7 MHz.

223:OM Beacon Setup

This special function allows you to generate an OM Beacon test signal. The instrument is set for a 2 Hz pulsed tone beacon.

224:MM Beacon Setup

This special function allows you to generate an MM Beacon test signal. The instrument is set for a 2 Hz pulsed tone beacon.

225:IM Beacon Setup

This special function allows you to generate an IM Beacon test signal. The instrument is set for a 2 Hz pulsed tone beacon.

300:Service Mode

This special function allows you to run the instrument's service diagnostic routines. The service-diagnostic switch (referred to in the Service Diagnostics Manual) must be in the correct position in order to access and run any of the diagnostic tests.

5 Internal Audio Source

The multifunction synthesis capabilities of the internal audio source allow you to generate a subcarrier from complex audio signals. The subcarrier is applied, in turn, as a modulating wave to the RF carrier signal.

The **AUDIO** connector provides access to the complex audio signals for external applications.

The internal audio source consists of two audio-source channels that may be summed together. In addition, the audio signal in one channel may be modulated with a combination of AM, FM, ΦM, or Pulse. Five fundamental waveforms are available: sine, square, triangle, sawtooth, and white Gaussian noise.

Read this chapter to do the following:

- Learn how to use the audio source as a subcarrier to modulate the RF carrier.
- Understand the multifunction synthesis capabilities by reviewing block diagrams.
- Create complex audio signals by activating Special Functions.
- Apply the internal audio source, feature-set to your specific testing or experimental needs.

A brief description of special functions that are available with the internal audio source is found in chapter 4.

The Directory

Use the table of contents below as your guide for each subject in this chapter. Two choices are recommended for first time users:

1. Get some "hands on" experience by doing the *Quick Demonstration* starting on the next page.
2. Otherwise, turn to the section titled *An Explanation of the Internal Audio Source* for specific information about the multifunction synthesis capabilities of the Signal Generator.

Refer to the section titled *Typical Applications* once you are familiar with this feature.

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A Quick Demonstration .... page 5-3
An Explanation of the Internal Audio Source .... page 5-7
Typical Applications 5-22

A Quick Demonstration

In the following procedure (which takes about 15 minutes), you will learn how to make the Signal Generator sum the audio source in Channel 1 with the audio source in Channel 2 to simulate dual-tone modulation on a subcarrier. The next section of this chapter, *An Explanation of the Internal Audio Source,* fully describes both Channels 1 and 2.

Use an oscilloscope to observe the results of the following procedure:

Procedure to Sum Channel 1 with Channel 2.

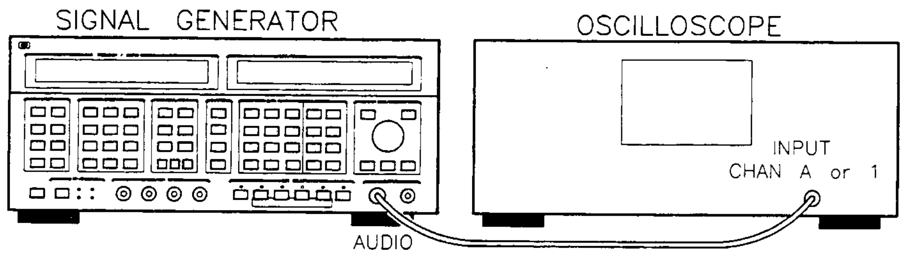


Figure 5-1. Equipment Setup for the Quick Demonstration

Set Up and Adjust the Oscilloscope

1. **Connect the oscilloscope as shown in figure 5-1.** Turn on the equipment and make the following adjustments:

   On the Oscilloscope:
   Volts/Div 1
   Time/Div .... 300 μsec

Adjust the Audio Source in Channel 1

2. **Press the green INSTR PRESET key.** Doing so presets the Signal Generator to a known state for the following steps.
3. **Press the AUDIO FREQ key, and then the ON key.** An audio frequency of 1 kHz should be displayed on the front panel.
4. **Press the blue SHIFT key, and then the AUDIO LEVEL key.** The Signal Generator should now show the following in the MODULATION/AMPLITUDE display:

2.000 V 1.000kHz RF OFF
AUDIO

5. **Turn the knob counterclockwise to reduce the audio level to 1 V.** In a following step, the audio source in Channel 2 will also be set to 1 Vpk; this is because the Signal Generator cannot sum together more than 2 Vpk from both channels.

   A 1 kHz sine wave 1 Vpk is then applied to the oscilloscope from the 600 Ω **AUDIO** output connector.

Adjust the Audio Source in Channel 2

6. **Press the SPECIAL key, number "134", and press the ON key.**
7. **Adjust the audio source level in Channel 2 to be 1 Vpk.** The Signal Generator should now show the following in the FREQUENCY/STATUS display:

```
134:Aud2 Level    1.000 V
```

8. **Press the SPECIAL key, number "133", and press the ON key.** The Signal Generator should now show the following in the FREQUENCY/STATUS display:

```
133:Aud2 Freq     OFF
```

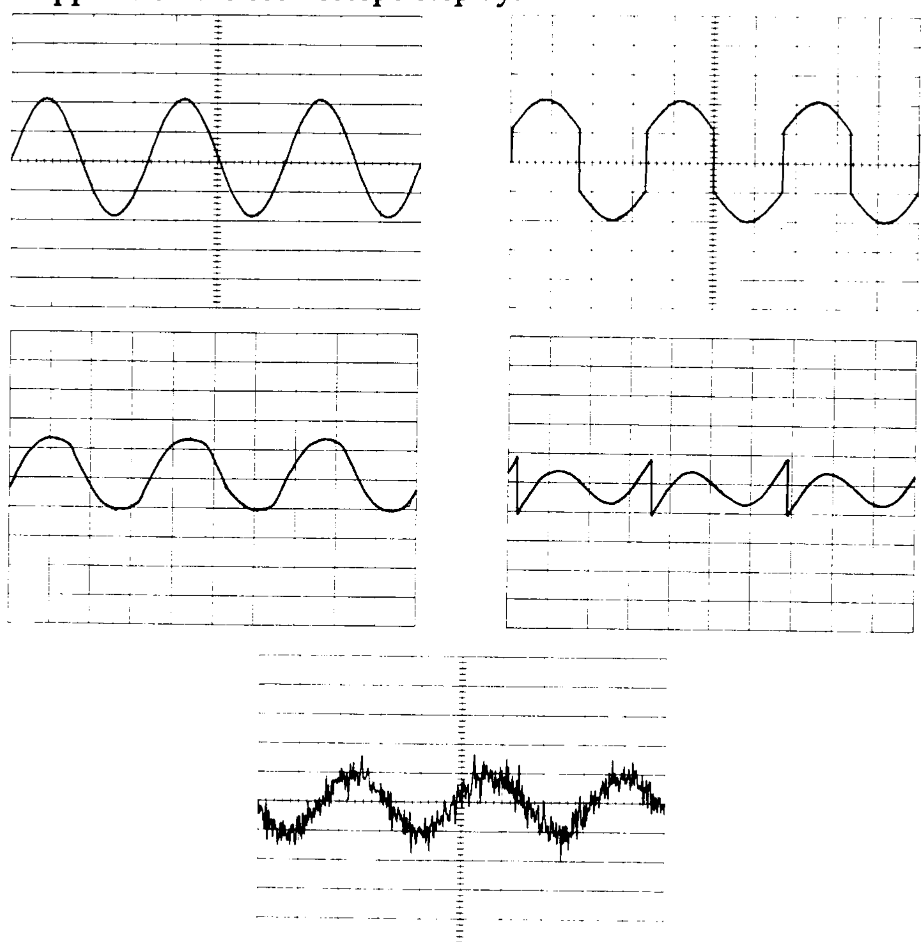
9. **Press the ON key, and then adjust the audio source of Channel 2 to a frequency of 1 kHz.** A 1 kHz sine wave 2 Vpk should appear on the oscilloscope display. The 2 Vpk signal is the result of Channel 1 and Channel 2 being summed together.

Observe and Modify the Results

10. **Press the SPECIAL key, number "135", and press the ON key.** The Signal Generator should now show the following in the FREQUENCY/STATUS display:

```
135:Aud2 Wave Sine
```

11. **Turn the knob. For each waveform, a different composite signal appears on the oscilloscope display:**

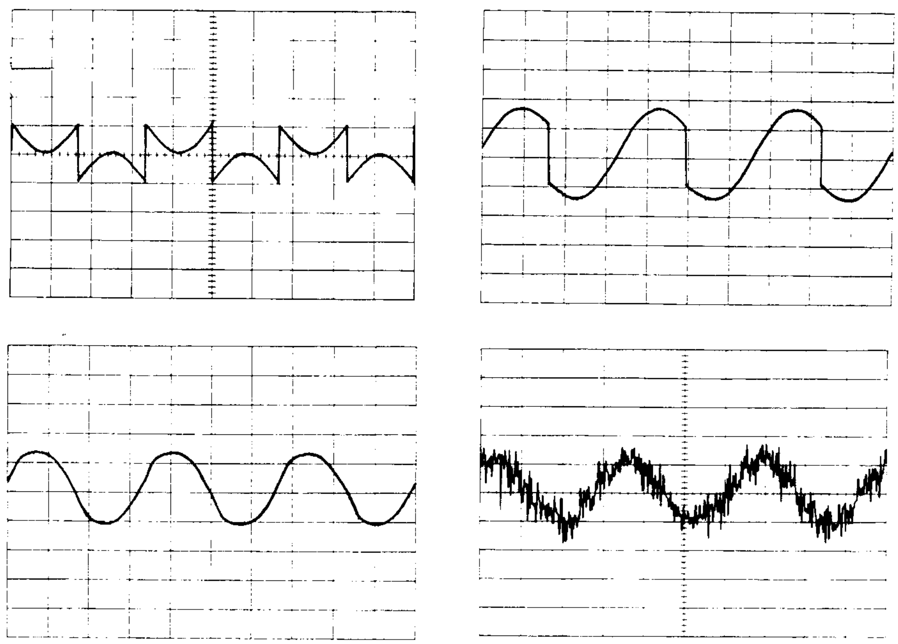


Remember

The signal from the Internal Audio Source can be used to modulate the RF carrier. The same signal taken from the AUDIO *connector may also be used for external applications (for example, on an external speaker).*

12. **Turn the knob to display the sine wave on the oscilloscope.**

13. **Press the SPECIAL key, number "136", and press the ON key.**
14. **Turn the knob to adjust the audio source in Channel 2 to be +180° out of phase with the audio source in Channel 1.** Notice the sine wave shown in the oscilloscope display decreases in amplitude until 0 V dc is left.
15. **Press the SPECIAL key, number "135", and press the ON key.** Turn the knob. For each waveform, a different composite signal appears on the oscilloscope display (the Volts/Division setting on your oscilloscope may need to be changed to get the same displays shown below):



Note

The subcarrier waveforms shown above do not refer to a specific application. They are simply shown to provide you with an example of the multifunction synthesis that takes place. Refer to "Typical Applications" for specific application examples.

An Explanation of Internal Audio Source

If You Need to Know:	Refer to:
• *the basic functional circuitry of the Signal Generator*	*Block Diagrams – An Introduction (5–8)*
• *how many subcarrier sources can be active at any time*	*Subcarrier Sources – Maximum that may be Active (5–10)*
• *what is the maximum output voltage from the Internal Audio Source*	*Subcarrier Sources – Maximum Voltage Levels (5–10)*
• *about the main audio source*	*Audio Source: Channel 1 (5–11)*
• *about the second audio source*	*Audio Source: Channel 2 (5–12)*
• *how to modulate the main audio source*	*Subcarrier Modulation Sources in Channel 1 (5–14)*
• *how the internal audio source affects the modulated RF carrier*	*Modulating the RF Carrier with the internal audio source (5–19)*
• *how to set increment and decrement values*	*Increment/Decrement the Internal Audio Source (5–21)*
• *how to save and recall storage registers*	*Save and Recall Settings (5–21)*

Block Diagrams – An Introduction

The Signal Generator is depicted by the simplified block diagram shown in figure 5-2.

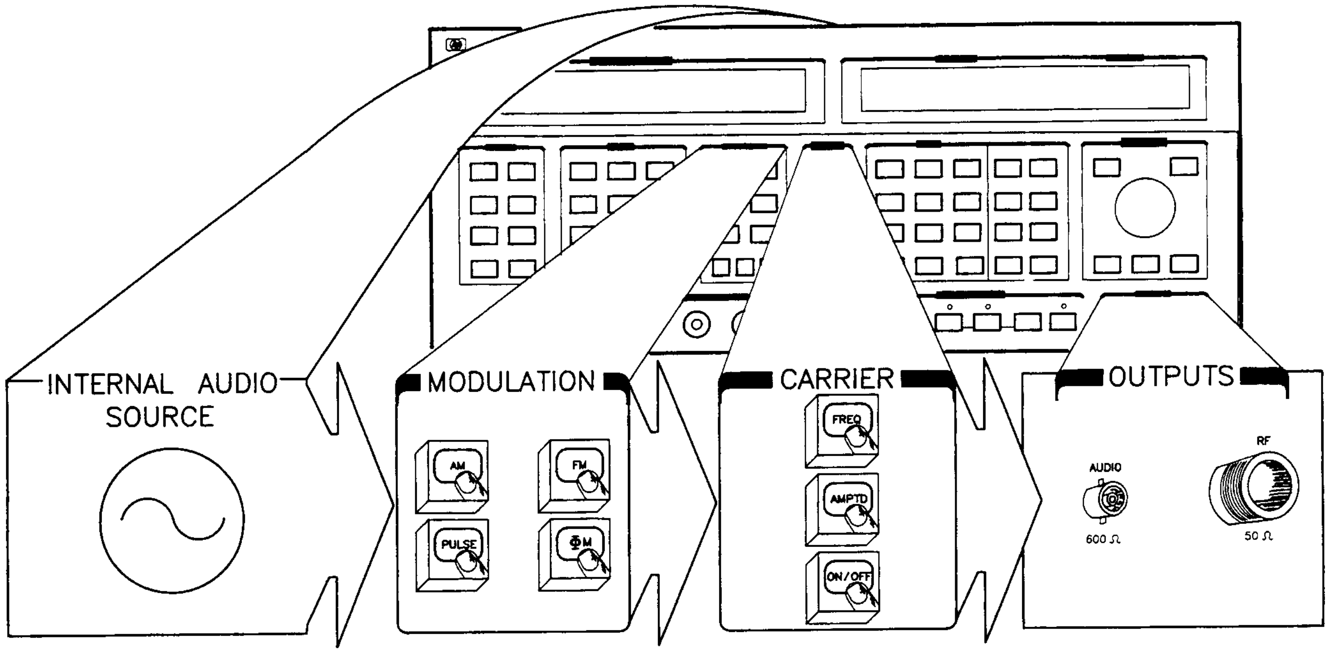


Figure 5-2. Simplified Overall Block Diagram

Using the internal audio source, the audio source in Channel 1 may be modulated; AM, FM, ΦM, and Pulse subcarrier modulation are available.

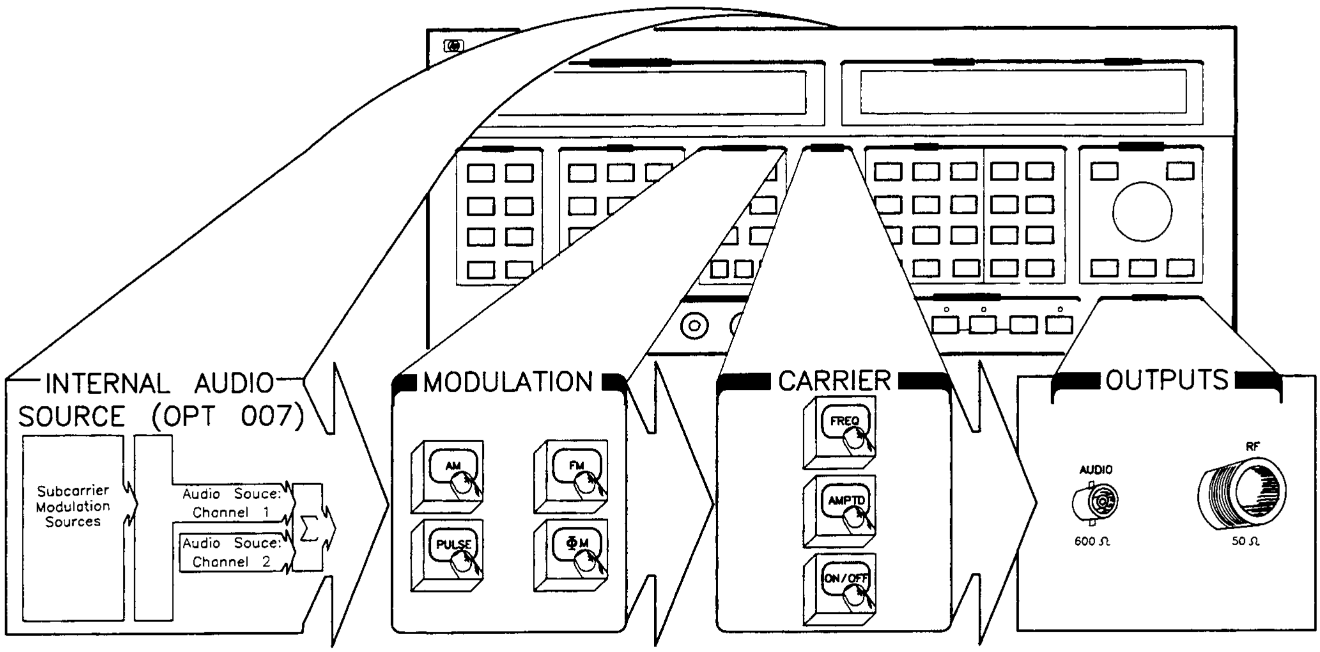


Figure 5-3. The Internal Audio Source

Subcarrier Sources – Maximum that may be Active

It is not permissible to turn **ON** all the subcarrier sources at once. The following rule applies to the maximum allowed **ON** at any time:

> **Rule:** The audio source in Channel 1 may be turned **ON** in combination with any **three** other sources.

Besides the audio source in Channel 1, there are five other sources, as follows:

- Audio Source: Channel 2
- Subcarrier AM Source
- Subcarrier FM Source
- Subcarrier ΦM Source
- Subcarrier Pulse Source

Note

The error message "`Too many audio sources`*" appears if you exceed the maximum limit described above.*

Subcarrier Sources – Maximum Voltage Levels

The Internal Audio Source may have a maximum of 2 Vpk summed (Σ) together from the audio sources in Channels 1 and 2. The preset condition of the Signal Generator sets the **AUDIO LEVEL** of the audio source in Channel 1 to 2 Vpk into 600 Ω. You must reduce this level before turning **ON** any one of the other five sources.

Note

The error message "`Audio level conflict`*" appears if you attempt to exceed the maximum summed limit of 2 Vpk for Channels 1 and 2.*

Also, the error message "`Audio level/AM conflict`*" appears if you attempt to exceed the maximum summed limit of 2 Vpk for Channels 1 and 2 with the subcarrier AM source in Channel 1 turned* **ON**.

Audio Source: Channel 1

The *Quick Demonstration* showed that frequency, level, and on/off state are controlled by keys on the front panel; whereas, waveform is controlled only after Special Function 130 is activated. As shown in figure 5-4, the audio source in Channel 1 has four parts:

- Audio Frequency
- Audio Level
- Waveform
- On/Off State

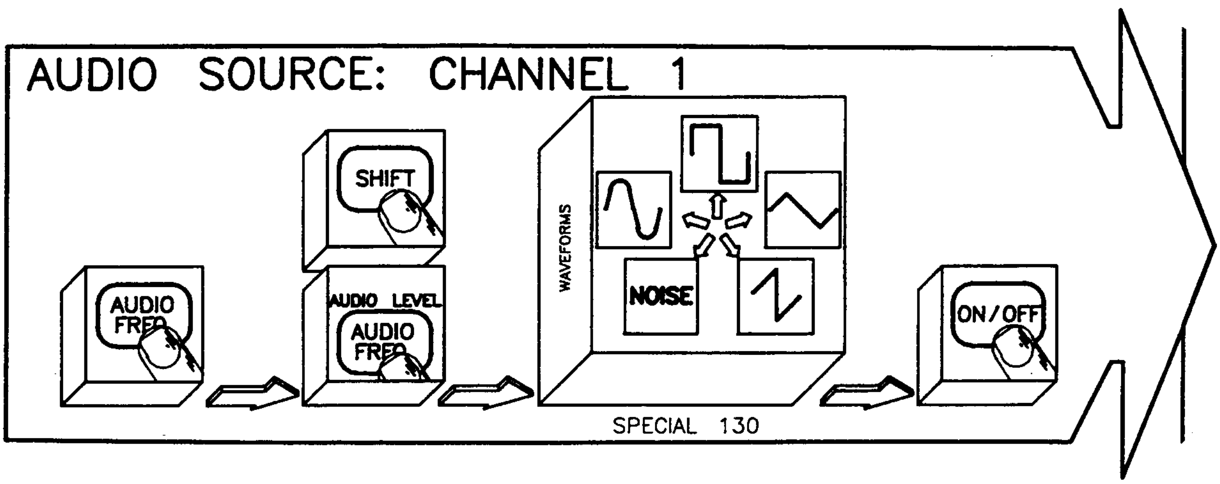


Figure 5-4. Block Diagram of the Audio Source in Channel 1.

Note *The audio source in Channel 1 is the reference to which the phase of the other sources is relative to.*

The audio source in Channel 1 operates within the limits shown in table 5-1. You'll receive an appropriate error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Table 5-1. Limits for the Audio Source in Channel 1.

Limits	Frequency	Level
Minimum	0.1 Hz	0 Vpk
Maximum	400 kHz*	2 Vpk
Resolution	4 digits	0.001 Vpk

* The **AUDIO** output has a typical bandwidth of 400 kHz for all waveforms. This affects complex waveforms with frequency components greater than 400 kHz.

Audio Source: Channel 2

The *Quick Demonstration* showed that special functions are used to control the audio source in Channel 2. As shown in figure 5-5, the audio source in Channel 2 has five parts:

- On/Off State
- Frequency
- Level
- Waveform
- Phase

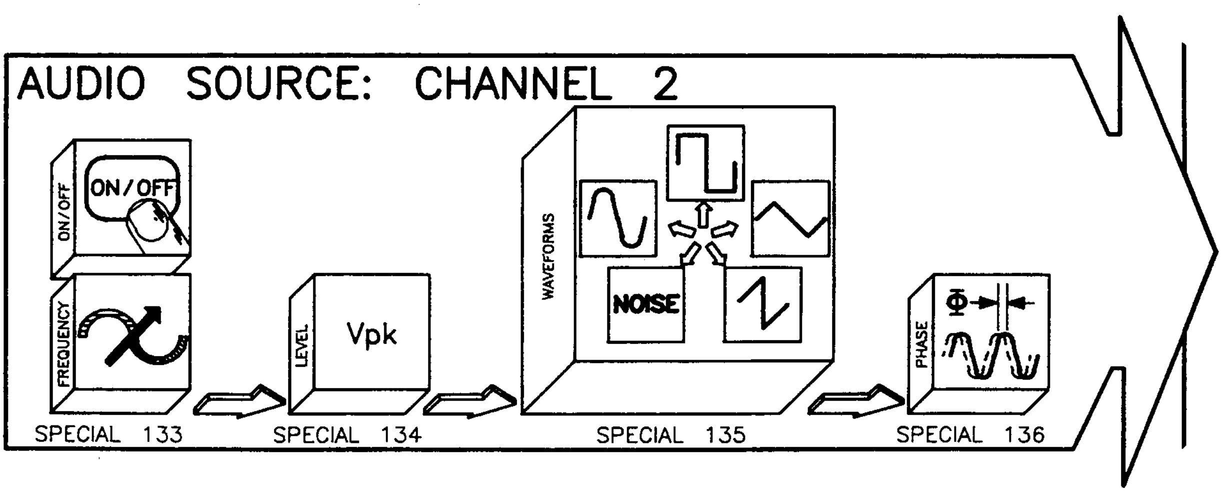


Figure 5-5. Block Diagram of the Audio Source in Channel 2.

Remember

The phase of the audio source in Channel 2 is relative to the phase of the audio source in Channel 1.

The audio source in Channel 2 operates within the limits shown in table 5-2. You'll receive an appropriate error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Table 5–2. Limits for the Audio Source in Channel 2.

Limits	Frequency	Level	Phase**
Minimum	0.1 Hz	0 Vpk	−179.9°
Maximum	400 kHz*	2 Vpk	+180°
Resolution	4 digits	0.001 Vpk	0.1°

* The **AUDIO** output has a typical bandwidth of 400 kHz for all waveforms. This affects complex waveforms with frequency components greater than 400 kHz.

** Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond the maximum and minimum limits will be scaled. For example, entering 560° would yield −160°.

Subcarrier Modulation Sources in Channel 1

Four subcarrier sources (AM, FM, ΦM, and Pulse) are available to modulate the audio source in Channel 1. Each subcarrier modulation source may be modified to control frequency, phase, level, depth, or deviation; also, each may be turned **ON** and **OFF**.

AM Modulating the Audio Source in Channel 1.

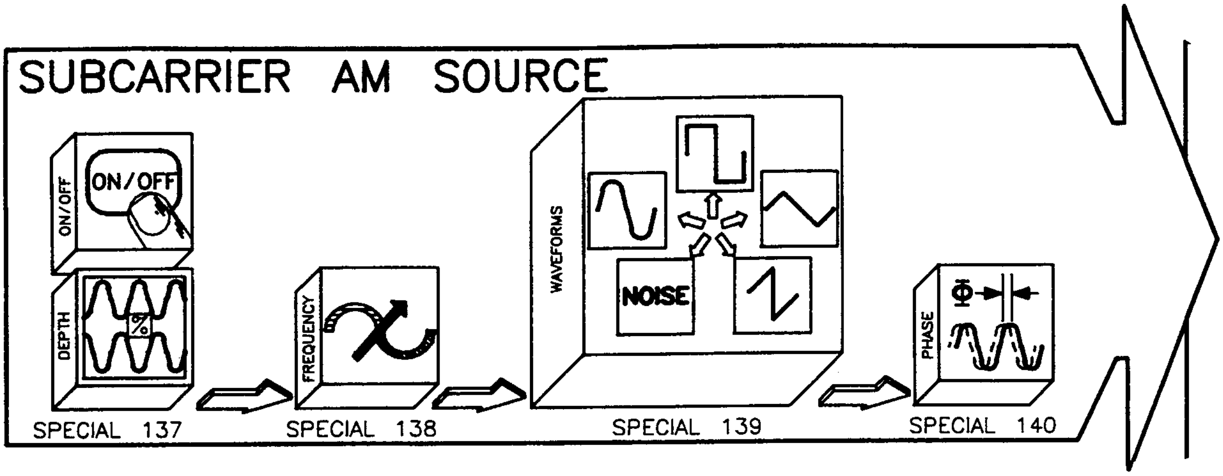


Figure 5–6. Block Diagram of the Subcarrier AM Source

Remember *The phase of each subcarrier modulation source is relative to the phase of the audio source in Channel 1.*

The on/off state, depth, frequency, waveform, and phase of the subcarrier AM source in Channel 1 is controlled by special functions as shown in figure 5-6. The subcarrier AM source operates within the limits shown in table 5-3. You'll receive an appropriate error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Note

A common operator's mistake occurs when the subcarrier AM source is turned **ON** *with the* **AUDIO LEVEL** *of the audio source in Channel 1 set to 2 Vpk (the preset condition), or to a value greater than the amount allowed for the desired AM depth. The error message* `Audio level/AM conflict` *will then appear. Simply reduce the* **AUDIO LEVEL** *to an appropriate value for the amount of subcarrier AM depth selected.*

Table 5-3. Limits for the Subcarrier AM Source.

Limits	Depth	Frequency	Phase**
Minimum	0 %	0.1 Hz	−179.9°
Maximum	100 %	400 kHz*	+180°
Resolution	0.1 %	4 digits	0.1°

* The **AUDIO** output has a typical bandwidth of 400 kHz for all waveforms. This affects complex waveforms with frequency components greater than 400 kHz.

** Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond the maximum and minimum limits will be scaled. For example, entering 560° would yield −160°.

FM Modulating the Audio Source in Channel 1

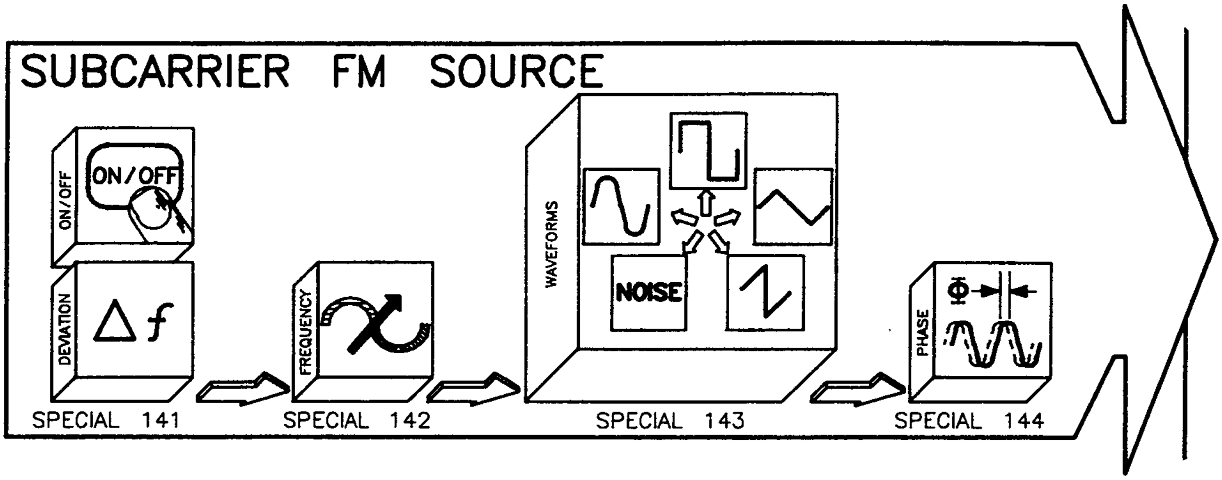


Figure 5-7. Block Diagram of the Subcarrier FM Source.

The on/off state, deviation, frequency, waveform, and phase of the subcarrier FM source in Channel 1 is controlled by Special Functions as shown in figure 5-7. The subcarrier FM source operates within the limits shown in table 5-4. You'll receive an error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Table 5-4. Limits for the Subcarrier FM Source.

Limits	Deviation	Frequency	Phase**
Minimum	0 Hz	0.1 Hz	−179.9°
Maximum	400 kHz	400 kHz*	+180°
Resolution	0.001 Hz	4 digits	0.1°

* The **AUDIO** output has a typical bandwidth of 400 kHz for all waveforms. This affects complex waveforms with frequency components greater than 400 kHz.

** Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond the maximum and minimum limits will be scaled. For example, entering 560° would yield −160°.

ΦM Modulating the Audio Source in Channel 1

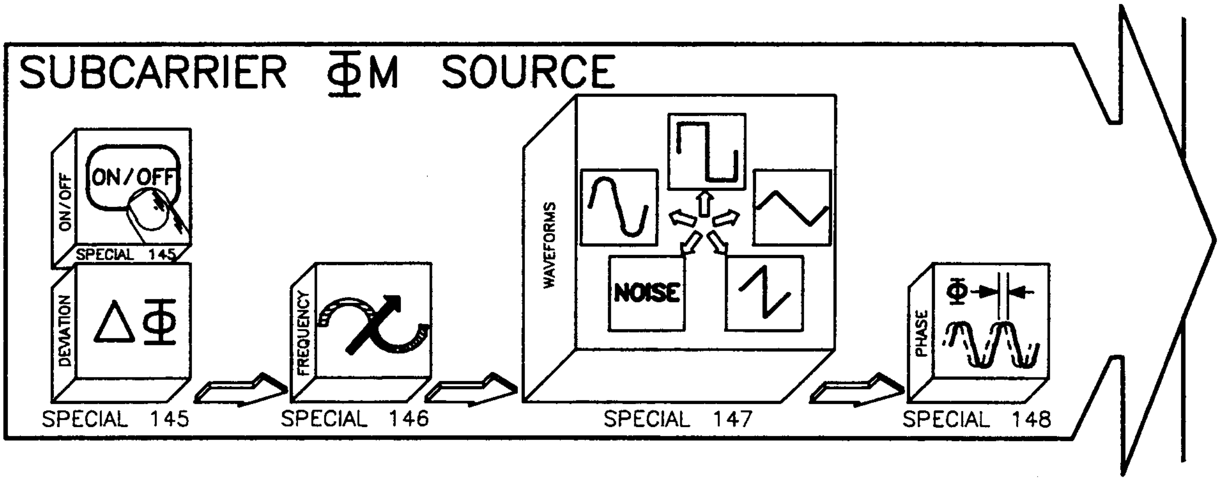


Figure 5–8. Block Diagram of the Subcarrier ΦM Source.

The on/off state, deviation, frequency, waveform, and phase of the subcarrier ΦM source in Channel 1 is controlled by Special Functions as shown in figure 5-8. The subcarrier ΦM source operates within the limits shown in table 5-5. You'll receive an error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Table 5–5. Limits for the Subcarrier ΦM Source.

Limits	Deviation	Frequency	Phase**
Minimum	0°	0.1 Hz	−179.9°
Maximum	+179.9°	400 kHz*	+180°
Resolution	0.1°	4 digits	0.1°

* The **AUDIO** output has a typical bandwidth of 400 kHz for all waveforms. This affects complex waveforms with frequency components greater than 400 kHz.

** Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond the maximum and minimum limits will be scaled. For example, entering 560° would yield −160°.

Pulse Modulating the Audio Source in Channel 1

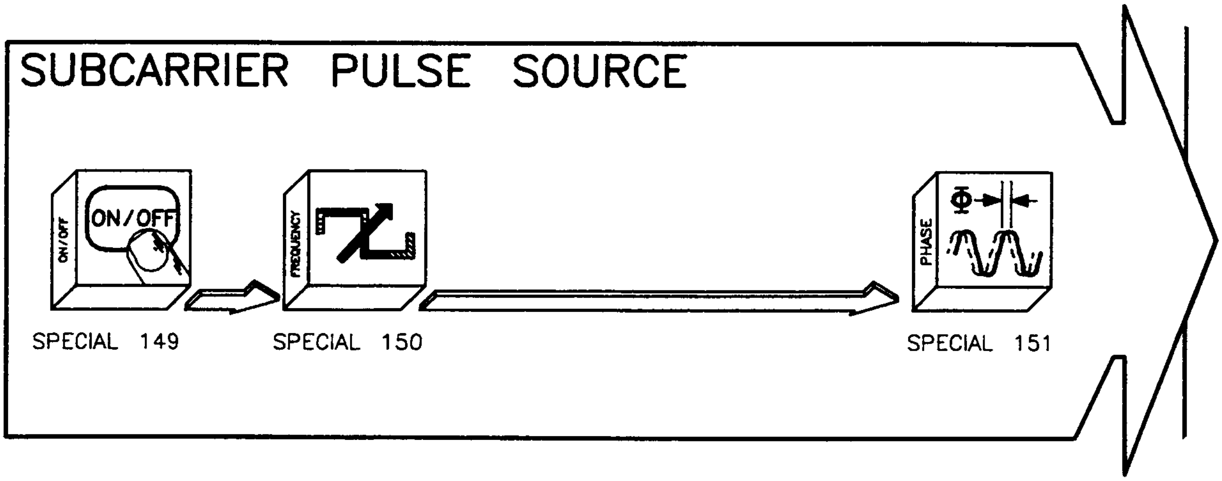


Figure 5–9. Block Diagram of the Subcarrier Pulse Source.

The on/off state, frequency, and phase of the subcarrier Pulse source in Channel 1 is controlled by Special Functions as shown in figure 5-9. The subcarrier Pulse source operates within the limits shown in table 5-6. You'll receive an error message if the limits are exceeded. (Chapter 7 provides error message descriptions.)

Table 5–6. Limits for the Subcarrier Pulse Source.

Limits	Frequency	Phase*
Minimum	0.1 Hz	−179.9°
Maximum	50 kHz	+180°
Resolution	4 digits	0.1°

* Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond the maximum and minimum limits will be scaled. For example, entering 560° would yield −160°.

Modulating with the Internal Audio Source

The **AUDIO LEVEL** affecting the audio source in Channel 1 may be reduced to a value between 2 Vpk and 0 Vpk. Reducing the **AUDIO LEVEL** allows you to turn **ON** the audio source in Channel 2, and to set depth for the subcarrier AM source.

As shown in figure 5-10, the Signal Generator requires a 1 Vpk signal from an external audio source, and/or a 2 Vpk signal from the internal audio source to provide calibrated operation when the RF carrier is being modulated. Voltage levels less than these reduce the amount of modulation on the RF carrier.

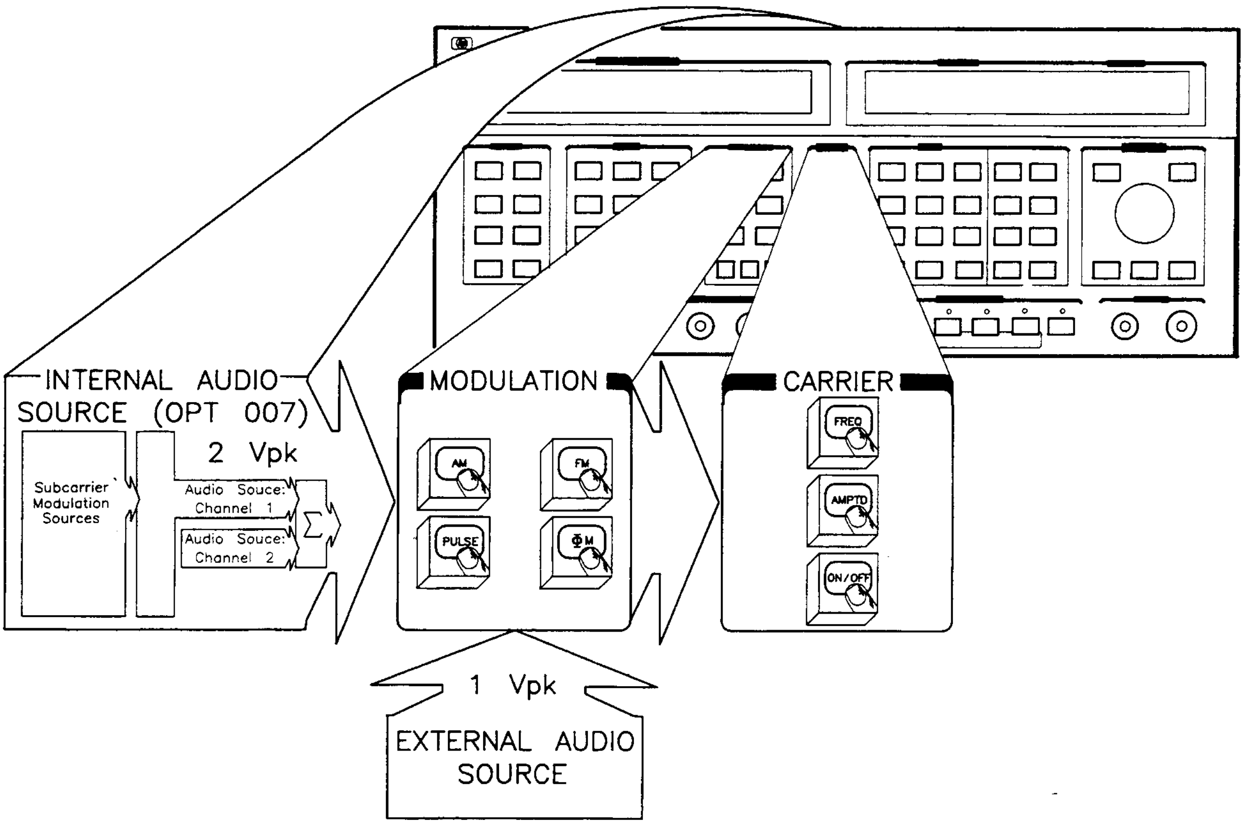


Figure 5–10. Voltage Levels to Produce a Calibrated RF Output.

Internal Audio Source voltage originates from:

- Channel 1 only, or
- summing Channel 1 with any of the other subcarrier modulation sources, or
- summing Channels 1 and 2, or
- summing Channels 1 and 2 with any of the other subcarrier modulation sources.

If you use the Internal Audio Source, you can calculate the amount of modulation on the RF carrier by using the following formulas:

$$\begin{aligned} \%\ Depth &= (Vpk\ from\ Int.\ Aud.\ Source \bullet displayed\ AM\ depth)/2 \\ FM\ Deviation &= (Vpk\ from\ Int.\ Aud.\ Source \bullet displayed\ FM\ deviation)/2 \\ \Phi M\ Deviation &= (Vpk\ from\ Int.\ Aud.\ Source \bullet displayed\ \Phi M\ deviation)/2 \end{aligned}$$

For example, if you FM the RF carrier with the Internal Audio Source at an audio level of 1 Vpk (Channel 1 only), you will get half the specified amount of deviation shown in the **MODULATION** display. However, if you also turn on the audio source in Channel 2 and set its level to 1 Vpk (summing Channels 1 and 2 to get 2 Vpk), the Signal Generator will output the full amount of deviation.

Audio frequency rates up to 400 kHz are allowed, which is also the typical bandwidth of the audio output circuitry. This bandwidth affects complex waveforms with frequency components greater than 400 kHz, causing waveform degradation.

When the Internal Audio Source is used, the maximum bandwidth is specified as the maximum rate (AM bandwidth is a function of the carrier frequency). Refer to the specification table in the *Calibration Manual* for maximum rates. If higher FM bandwidths are required than those specified, see Special Function 124 in chapter 4.

Increment/Decrement the Internal Audio Source

The **INCR SET** key allows you to change increment and decrement values for frequency, level, phase, depth, and deviation of the Internal Audio Source. Use the following procedure:

1. **Select the special function.** For example, after an instrument preset, if Special Function 138 is active, you would then see the following in the FREQUENCY/STATUS display:

```
138:Aud AM Freq  100 Hz
```

2. **Press the INCR SET key.** With Special Function 138 active, you would see the following:

```
Audio Freq Incr  100 Hz
```

3. **Change the increment value.** If you want the Audio Frequency Increment to be 10 Hz instead of 100 Hz, simply press the **1**, **0**, and **Hz** keys. You can then verify that the new increment value is 10 Hz by pressing the **INCR SET** key once again.

Increment values can have a global affect. In the previous example, the new increment value of 10 Hz for Special Function 138 would be effective whenever frequency is incremented or decremented for any audio source. Increment values for phase exhibit the same global affect in the Internal Audio Source.

Save and Recall Settings

The Signal Generator has 50 available storage registers. The first 10, Registers 0-9, accepts all front panel settings for special functions. The remaining 40, Registers 10-49, accepts only RF frequency and output amplitude settings.

Performing an Instrument Preset, or unplugging the Signal Generator does not alter the contents of the 50 storage registers.

Typical Applications

The multifunction synthesis capabilities of the Signal Generator's internal audio source creates complex signals for:

1. VHF omnidirectional range (VOR),
2. ILS two-tone signaling,
3. dual-tone modulation,
4. audio-tone sweep,
5. AM radio testing,
6. amplitude sweep,
7. modem testing,
8. AM noise generation,

   and more...

The following collection of waveforms present a sample of the many different waveforms possible using the Signal Generator's internal audio source. The collection is intended to give you an indication of the capabilities of the instrument and to stimulate ideas for creating other waveforms. In most cases, the waveforms may be altered to match your specific application by changing frequency, phase, waveforms, or their amplitudes.

Each waveform in the collection is numerically organized by the list shown above. Use the foldout in figure 5-11, and the list of special functions in table 5-7 to assist you in generating waveforms with your Signal Generator's internal audio source.

Note

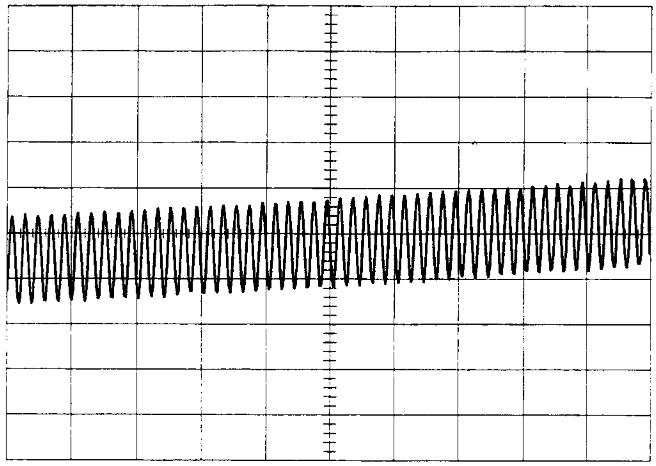
Waveforms in the collection are output at the **AUDIO** *connector (600 Ω), and viewed on an oscilloscope. If the waveform is designated as being applied to an RF carrier, the display is output from the* **RF OUTPUT** *connector (50 Ω), and viewed on a spectrum analyzer.*

Table 5-7. Special Functions 130 to 151

SPECIAL FUNCTIONS					
Number	**Name (Abbreviated)**	**Limits**	**Number**	**Name (Abbreviated)**	**Limits**
130	Audio Wave	5 Waveforms	141	Aud FM Dev	0 Hz to 400 kHz
131	Audio Triggered	ON/OFF	142	Aud FM Freq	0.1 Hz to 400 kHz
132	Trig Audio	Press ON	143	Aud FM Wave	5 Waveforms
133	Aud2 Freq	0.1 Hz to 400 kHz	144	Aud FM Φ	* −179.9° to +180°
134	Aud2 Level	0 V to 2 V	145	Aud ΦM Dev	0°to +179.9°
135	Aud2 Wave	5 Waveforms	146	Aud ΦM Freq	0.1 Hz to 400 kHz
136	Aud2 Φ	* −179.9° to +180°	147	Aud ΦM Wave	5 Waveforms
137	Aud AM Depth	0 to 100%	148	Aud ΦM Φ	* −179.9° to +180°
138	Aud AM Freq	0.1 Hz to 400 kHz	149	Aud Pulse	ON/OFF
139	Aud AM Wave	5 Waveforms	150	Aud Pulse Freq	0.1 Hz to 50 kHz
140	Aud AM Φ	* −179.9° to +180°	151	Aud Pulse Φ	* −179.9° to +180°

* Phase may also be expressed in terms of radians by pressing the front panel **rad** key. Any entry beyond these limits will be scaled. For example, entering 560° would yield −160°.

No. 1. Internal Audio Source Waveform



Waveform Name/Description: VHF omnidirectional range (VOR) composite signal.

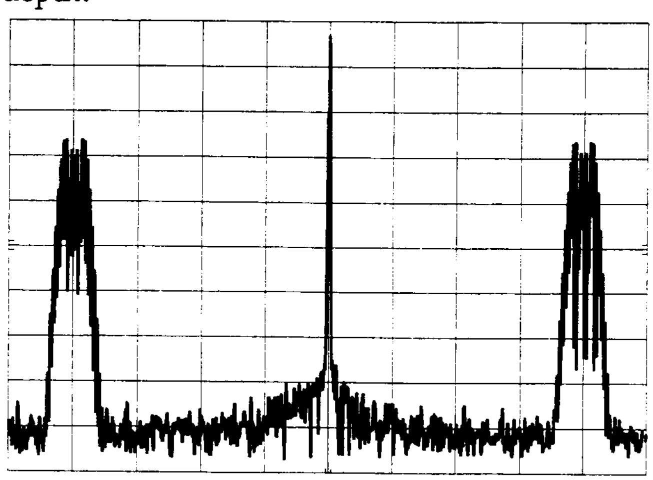
Waveform Application: Avionics receiver test and metrology for VOR test equipment.

Instrument Settings

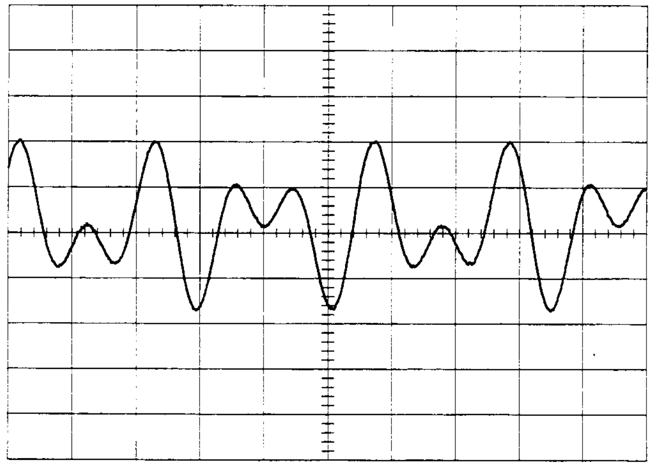
Source	Frequency	Phase	Waveform	Amplitude	Deviation
Audio-Channel 1	9960 Hz	0°	Sine	1 V	–
Audio-Channel 2	30 Hz	0°	Sine	1 V	–
FM	30 Hz	0°(1)	Sine	–	480 Hz

(1) The phase of the FM Source sets the bearing direction.

Waveform Applied to an RF Carrier: The RF carrier has AM at a 90% depth.



No. 2. Internal Audio Source Waveform



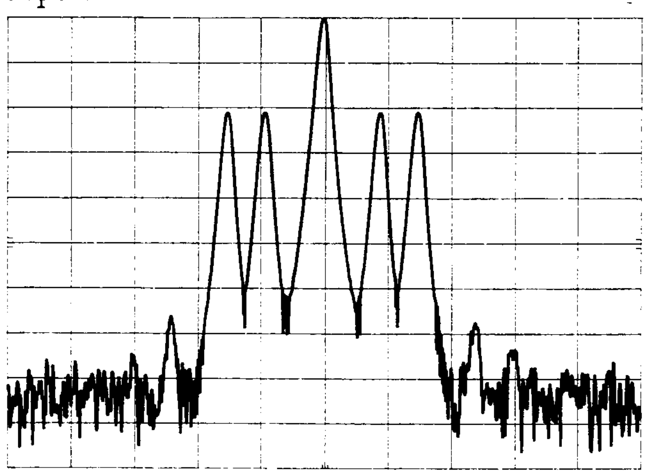
Waveform Name/Description: ILS two-tone composite signal.

Waveform Application: ILS receiver testing.

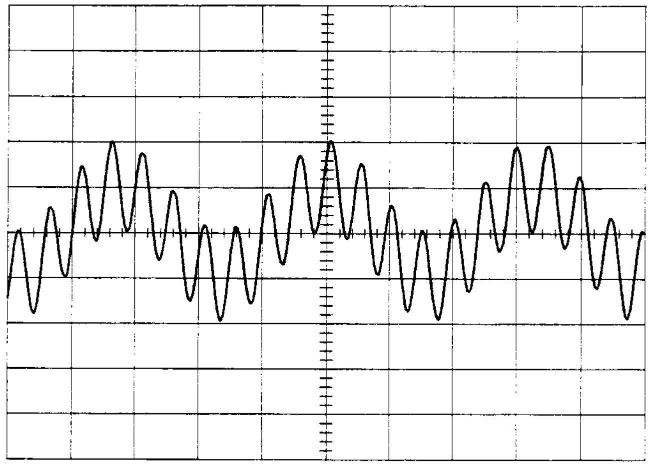
Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude
Audio-Channel 1	90 Hz	0°	Sine	1 V
Audio-Channel 2	150 Hz	0°	Sine	1 V
Comments: Difference in depth of modulation is set by the relative amplitudes of Channels 1 & 2.				

Waveform Applied to an RF Carrier: The RF carrier has AM at a 50% depth.



No. 3. Internal Audio Source Waveform



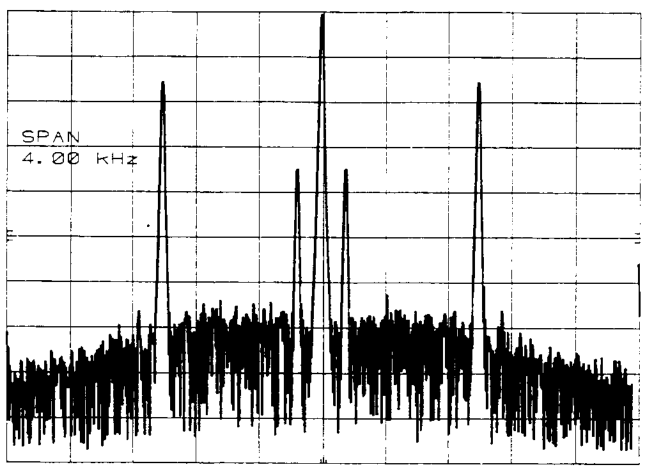
Waveform Name/Description: Dual-tone modulation.

Waveform Application: Sub-audible squelch testing, pocket pagers.

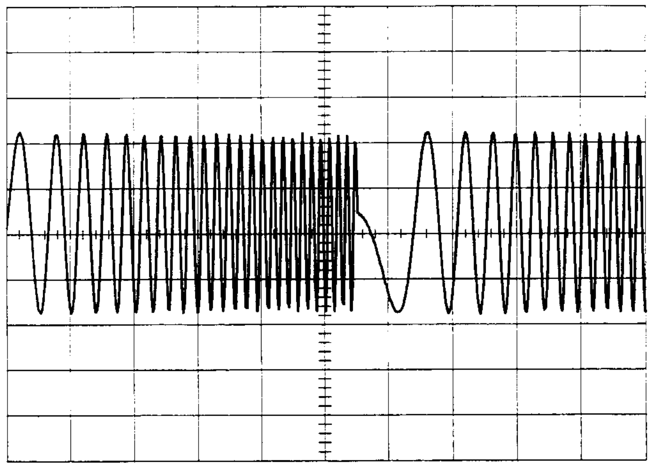
Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude
Audio-Channel 1	1 kHz	0°	Sine	1 V
Audio-Channel 2	150 Hz	0°	Sine	1 V

Waveform Applied to an RF Carrier: The RF carrier has AM at a 50% depth.



No. 4. Internal Audio Source Waveform



Waveform Name/Description: Audio-tone sweep.

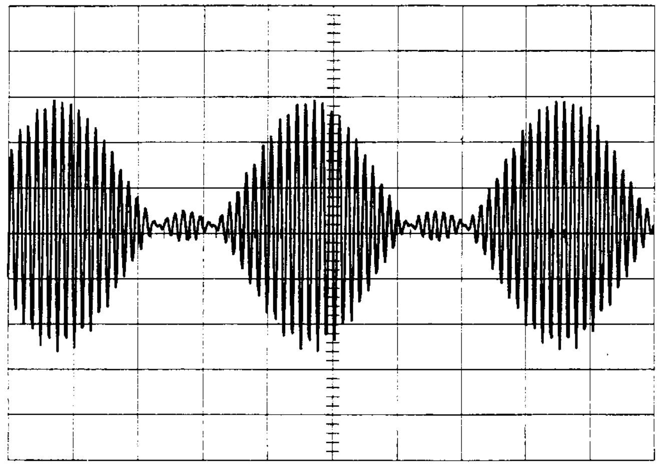
Waveform Application: Audio response of FM receiver.

Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude	Deviation
Audio-Channel 1	2.5 kHz	0°	Sine	2 V	–
FM	150 Hz[1]	0°	Sawtooth	–	2.5 kHz

(1) Change the FM Source frequency to vary rate for the audio-tone sweep.

No. 5. Internal Audio Source Waveform



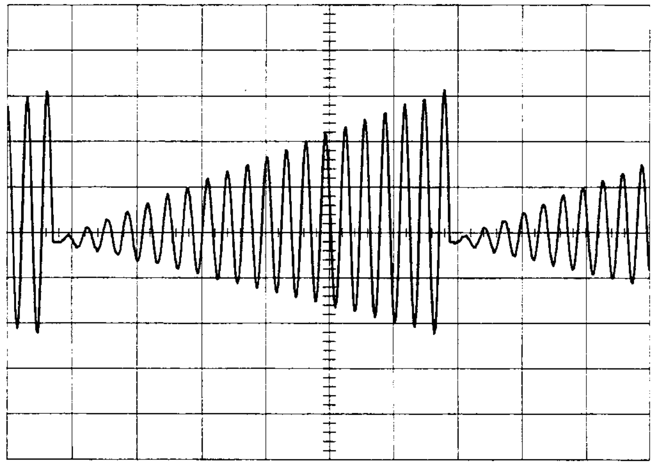
Waveform Name/Description: AM signal with over 100% negative peak modulation.

Waveform Application: AM radio testing.

Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude	Depth
Audio-Channel 1	50 kHz	0°	Sine	900 mV	–
Audio-Channel 2	50 kHz	180°	Sine	200 mV	–
AM	1 kHz	0°	Sine	–	100%
Comments: A 180°phase inversion of the carrier occurs at the trough of the modulating waveform.					

No. 6. Internal Audio Source Waveform



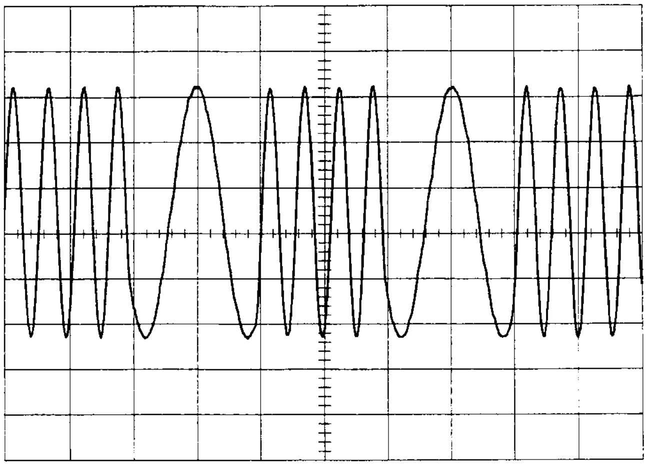
Waveform Name/Description: Amplitude sweeps.

Waveform Application: Receiver testing.

Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude	Depth
Audio-Channel 1	1 kHz	0°	Sine	900 mV	–
AM	50 Hz	0°	Sawtooth	–	100%

No. 7. Internal Audio Source Waveform



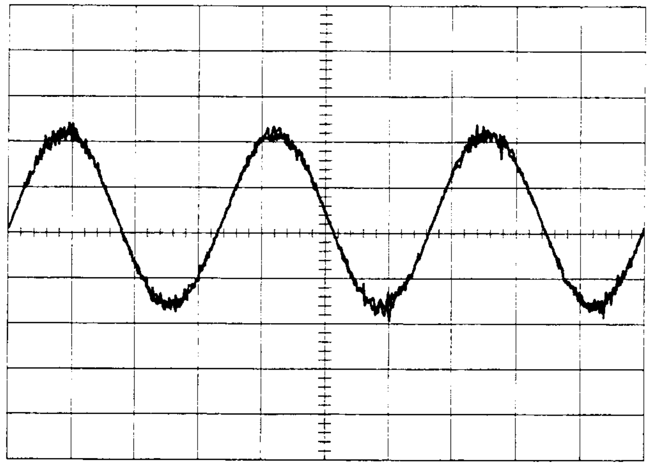
Waveform Name/Description: Two-tone FSK with 50% duty cycle.

Waveform Application: Modem testing.

Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude
Audio-Channel 1	10 kHz	0°	Sine	2 V
FM	2 kHz	0°	Square	5 kHz
Comments: The frequencies of the two tones are the frequency of Audio-Channel 1 plus or minus the amplitude of the FM Source. The data rate is set by the frequency of the FM Source.				

No. 8. Internal Audio Source Waveform



Waveform Name/Description: Sine wave with AM noise.

Waveform Application: Receiver rejection of AM noise.

Instrument Settings

Source	Frequency	Phase	Waveform	Amplitude
Audio-Channel 1	1 kHz	0°	Sine	1.6 V
AM	100 Hz	0°	Noise	20%

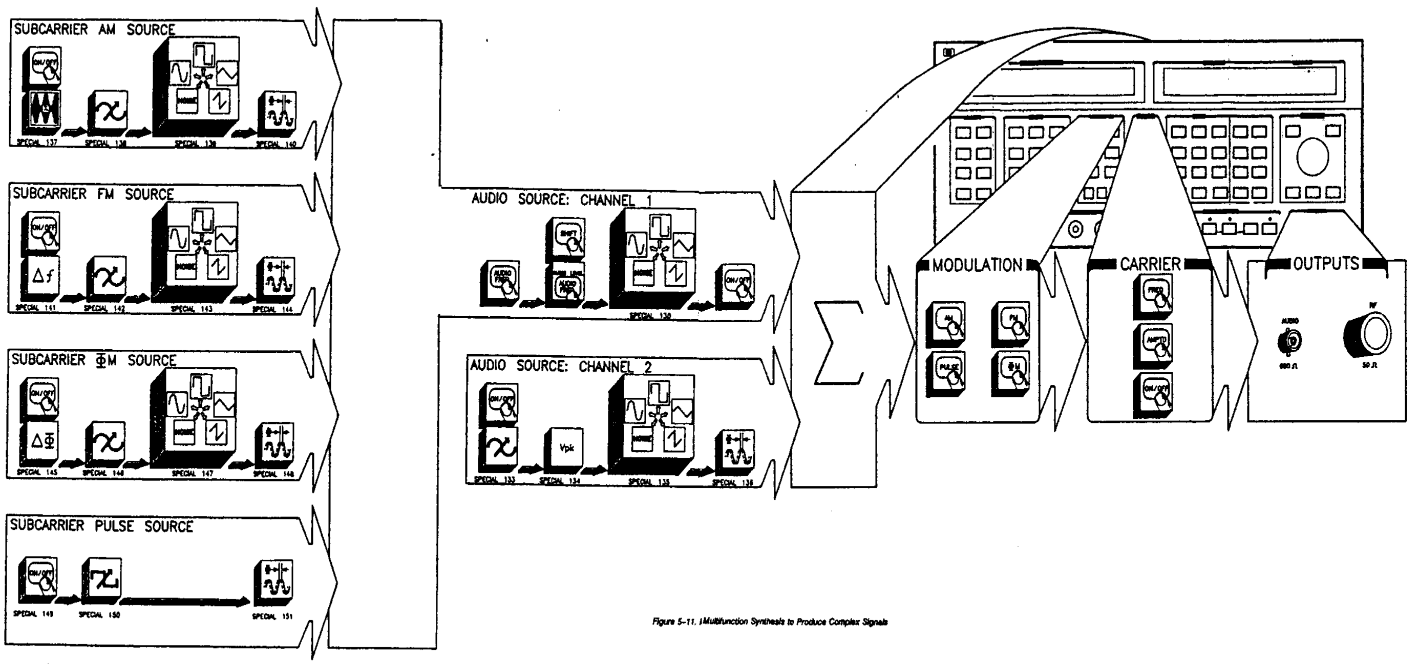


Figure 5-11. Multifunction Synthesis to Produce Complex Signals

6 Remote Operation

Hewlett-Packard Systems Language (HP-SL) is the new programming language for instrumentation adopted by Hewlett-Packard. This language uses standard HP-IB hardware and will be used in many new Hewlett-Packard products. HP-SL uses easy to learn, self-explanatory commands, and is flexible for beginning and advanced programmers. Many commands used in HP-SL are compatible with other instruments to minimize software modifications when hardware is upgraded or replaced.

Hewlett-Packard develop HP-SL to conform to the new IEEE 488.2 standard. The advantage of this new IEEE standard is that it provides common commands, in addition to hardware and protocol that is compatible with previous standards. System commands such as instrument reset, save/recall functions and error codes will be common among all HP-SL instruments. This should greatly reduce software development and shorten the learning time required to program new instruments. The short-term benefit of HP-SL is that it is easy to learn and is self-documenting. In the long term, HP-SL provides a common format and many common commands to reduce the effort required for hardware upgrades and software modifications.

The purpose of this chapter is to help new HP-SL users be successful writing programs in the shortest possible time. The programming format presented here applies to all HP-SL programs, but the commands are particular to the PSG series only.

This chapter is divided into three sections.

- Getting Started
- Advanced Operation
- Programming Reference

The Getting Started section provides enough information to control functions such as frequency, modulation, and amplitude. Also included in this section is an explanation of basic HP-SL format and command statements.

The Advanced Operation section provides information and examples to use more features of the Signal Generator. This section also explains the use of punctuation to combine command statements and avoid instrument settings that are not allowed.

The Programming Reference Section allows users familiar with HP-SL to quickly write programs or modify code written by others. This section provides a listing of the most common HP-SL commands used with the PSG signal generators.

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Getting Started

The examples shown below allow a user to quickly write HP-SL code to set up the Signal Generator. A listing of the most common commands is included in the Programming Reference section and should be used with this section for access to more of the Signal Generator features.

These examples assume that the Signal Generator is at address 719 and the output statements are executed as part of a BASIC program. Examples are given to show how to set up the main features of the Signal Generator. Comments are included where clarification of the code may be needed.

Example 1: Reset, Frequency, Amplitude

Reset the Signal Generator, set the RF freqeuncy to 500 MHz, the amplitude to 10 dBm, and turn the RF amplitude on.

```
100 OUTPUT 719;''*RST''
200 OUTPUT 719;''FREQuency:CW 500 MHZ''
300 OUTPUT 719;''AMPLitude:LEVel 10 DBM''
400 OUTPUT 719;''AMPLitude:STATe ON''
```

Comments

A reset "*RST" in line 100 assures that instrument is in a known state. Line 400 is necessary to turn the amplitude on, since the default state from a reset is off.

Example 2: Frequency Modulation, Amplitude in Volts

Reset the Signal Generator, set FM deviation to 10 kHz at a 1 kHz rate, set the output level at 1 V rms.

```
100 OUTPUT 719;''*RST''
200 OUTPUT 719;''FM:DEViation 10 KHZ''
300 OUTPUT 719;''FM:FREQuency 1 KHZ''
400 OUTPUT 719;''FM:STATe ON''
500 OUTPUT 719;''AMPLitude:LEVel 1 V''
600 OUTPUT 719;''AMPLitude:STATe ON''
```

Comments

Line 400 turns on the selected modulation since the default value for all modulation is off. Internal modulation is implied since none is specified.

Example 3: Amplitude Modulation, External Modulation

Reset the Signal Generator, set the Signal Generator for 50% AM from an external source, ac coupled.

```
100 OUTPUT 719;''*RST''
200 OUTPUT 719;''AM:DEPTh 50%''
300 OUTPUT 719;''AM:SOURce EXTernal''
400 OUTPUT 719;''AM:COUPling AC''
500 OUTPUT 719;''AM:STATe ON''
```

Comments

This example uses external modulation, so external must be specified as the modulation source.

Example 4: Recall Register, Pulse

Reset the Signal Generator, recall register 10 and turn pulse modulation on.

```
100 OUTPUT 719;''*RST''
200 OUTPUT 719;''*RCL 10''
300 OUTPUT 719;''PULSe:STATe ON''
```

Comments

Recall ("*RCL") is similar to reset because it is a root command and has no sub-branches after it.

HP-SL commands are organized in a "tree" structure. Graphically, the trees can be visualizes as shown in figure 1—1. The command statements to execute the branches are also shown. A colon (:) is used to separate branches from the root and sub-branches from branches. The example command statements correspond to the example programs 1 through 4 and show the use of the colon separator. Spaces should not be left after the colon.

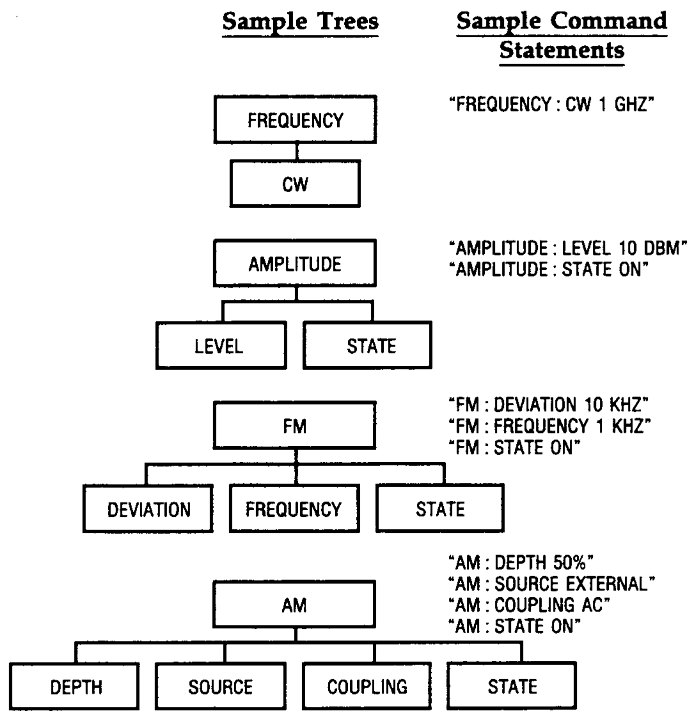

Figure 6–1. HP-SL Tree Structure

A listing of many subsystems and command statements is in the Programming Reference section. This information can be used along with the colon to execute any command. For advanced operation, the semicolon (;) is used to execute multiple command statements in a single output message. This is explained in the Advanced Programming section and is one of the major advantages of HP-SL.

Advanced Programming

A major advantage of HP-SL is that it allows complete instrument settings to be programmed in a single output statement, without regard for invalid instrument states in between. An example of an invalid state would be to increase FM deviation before increasing the carrier frequency. In HP-SL this is allowed so long as the carrier frequency and deviation are increased in the same command message.

The colon (:) and semicolon (;) are used to string together HP-SL commands. The colon is used to indicate the root or to separate branches and sub-branches. The semicolon is used to separate multiple command statements in a single command message.

The basic rules are as follows:

1. A semicolon is used to separate command statements in a single message.

   ``FM:DEV 10 KHZ;:FM:STEP 1 KHZ''

2. When sending more than one command statement in a message, the second and subsequent commands implicitly begin after the last colon in the previous command.

   ``FM:DEV 10 KHZ;STEP 1 KHZ''

3. To restart commands from the root, subsequent commands must be separated by a semicolon and a colon.

   ``FM:DEV 1KHZ;:AMPL 1 DBM''

4. Letter case (upper and lower) is ignored.
5. Spaces must not be left after colons or semicolons.
6. Commands that begin with an asterisk (*) implicitly start at the root.

   ``FM:DEV 1 KHZ;*RCL 35''

7. The commands can be completely spelled out or abbreviated. Certain commands are implied if no command is given. The reference section shows which abbreviations are allowed.

   ``FM:DEViation 10 KHZ'' = ``FM:DEV 10 KHZ'' = ``FM 10000''

8. To query the generator, the command header should be followed with a question mark (?).

   ``FREQ:CW?''

Programming Reference

The remaining part of this chapter provides you with detailed reference information for programming the Signal Generator with HP-SL. HP-IB addressing, HP-IB capabilities, and data input/output information is available for all of your remote operating needs.

All data input/output operations are described in the *HP-IB Control Language Dictionary* and the *HP-IB Device Status Dictionary* sections. Helpful example programs are provided for your use at the end of these sections.

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Note

Refer to HP-SL Syntax Drawings once you become familiar with the information in the "HP-IB Control Language Dictionary".

Also, you may want to refer to the document "Tutorial Description of the Hewlett-Packard Interface Bus" HP Part Number 5952-0156 for detailed information about the HP-IB bus.

HP-IB Address

The Signal Generator's HP-IB address is set at the factory to 19. You can display or change the HP-IB address at any time from the front panel. Any HP-IB address from 00 to 30 can be assigned.

The HP-IB address is stored in non-volatile memory, and remains valid through switching the Power from Standby to On and unplugging the ac power cord; performing a RAM wipe (Special Function 172) does not change the HP-IB address.

How to Display or Change the HP-IB Address

Display the HP-IB address:

1. If the yellow **REM** (remote) annunciator is turned on, press the **LOCAL** key to put the Signal Generator into Local operation. All front panel keys (except for the Power switch and the **LOCAL** key) are inoperative when the Signal Generator is in Remote operation.
2. Press the blue **SHIFT** key, and then the **ADRS** key. You will see the following in the FREQUENCY/STATUS display:

HP-IB Address = 19

Change the HP-IB address:

3. Select a new HP-IB address from 00 to 30, and press the **ENTER** key. The new HP-IB address should then be displayed.
4. Press the **FREQ** key to clear the HP-IB address off of the front-panel display. Then, re-display the HP-IB address to verify the new HP-IB address.

HP-IB Capabilities

The Signal Generator is designed to be compatible with a controller that interfaces in terms of the 14 bus messages summarized in table 6–1. This table describes each of the interface functions available as defined by the IEEE Standard 488 and the identical ANSI Standard MC1.1.

When the Signal Generator is in the remote mode (the front-panel **REM** annunciator lights up), all front-panel controls are disabled except the **POWER** switch, and the **LOCAL** key (the **LOCAL** key can be disabled by configuring the Signal Generator in Local Lockout over HP-IB).

Table 6–1. HP-IB Capability Reference Table. (1 of 2)

HP-IB Capability	Applicable	Response	Related Commands and Controls*	Interface Functions*
Talker/ Listener	Yes	All Signal Generator functions with the exception of Knob control are programmable over HP-IB. The Signal Generator can send query responses and status information. The front-panel annunciators (TALK, REM, LSTN, SRQ) show the Signal Generator's current HP-IB state.	MLA MTA EOI	AH1 SH1 T6 L4
Trigger	No	The Signal Generator does not have a device trigger capability.	GET	DT0
Clear	Yes	The Signal Generator responds equally to DCL and SDC bus commands. The Clear capability does not reset instrument parameters.	DCL SDC	DC1
Remote	Yes	The Signal Generator's remote mode is enabled when the REN bus line is true. However, it remains in local (that is, the keyboard is active) until it is first addressed to listen. The output signal is unchanged when the Signal Generator enters remote mode. The front-panel RMT annunciator turns on when in remote mode.	REN MLA	RL1
Local	Yes	The Signal Generator returns to front-panel control when it enters local mode. The output signal is unchanged. Responds either to the GTL bus command or the front-panel Local key. The LOCAL key will not work if the instrument is in the LOCAL LOCKOUT state.	GTL	RL1

* Commands, Control Lines, and Interface Functions are defined in IEEE Std 488 (and the identical ANSI Standard MC1.1). Knowledge of these might not be necessary if your controller's manual describes programming in terms of the fourteen HP-IB messages shown in the left column.

Table 6–1. HP-IB Capability Reference Table. (2 of 2)

HP-IB Capability	Applicable	Response	Related Commands and Controls*	Interface Functions*
Local Lockout	Yes	The LOCAL key is disabled during Local Lockout so that only the controller or the POWER switch can return the Signal Generator to Local.	LLO	RL1
Clear Lockout/ Set Local	Yes	The Signal Generator returns to Local and Local Lockout is no longer true when the REN bus line goes false.	$\overline{\text{REN}}$	RL1
Pass Control/ Take Control	No	The Signal Generator cannot take control of HP-IB.	ATN IFC	C0
Request Service	Yes	The Signal Generator sets the SRQ bus line true if there is an unmasked bit in the status byte.	SRQ	SR1
Abort	Yes	The Signal Generator stops talking or listening.	IFC	T6 L4
Status Byte	Yes	The Signal Generator responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. Bit 6 (RQS bit) is true if the Signal Generator has sent the Service Request Message. Each bit requires different conditions for clearing.	SPE SPD MTA	T6
Status Bit	No	The Signal Generator does not respond to a parallel poll.	ATN EOI	PP0
Extended Talker/ Listener	No	The Signal Generator does not have secondary addressing capabilities for talking or listening.	MSA	TE0 LE0
Driver Electronics	Yes	The Signal Generator uses tri-state electrical drivers.	None	E2

* Commands, Control Lines, and Interface Functions are defined in IEEE Std 488 (and the identical ANSI Standard MC1.1). Knowledge of these might not be necessary if your controller's manual describes programming in terms of the fourteen HP-IB messages shown in the left column.

HP-IB Control Language Dictionary

All IEEE 488.2 common commands, and HP-SL commands are contained in the control language dictionary. All devices that comply with the IEEE 488.2 standard must have a set of common commands. The requirement of having common commands guarantees that all devices will have a minimum set of capabilities to permit programmers to write code that will work with all devices.

Before you proceed to use the dictionary, please read the HP-SL notes starting on the next page. The notes provide you with essential information and directions for using the dictionary.

The dictionary is alphabetically arranged by subsystems. A table of contents for all subsystems is as follows:

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HP-SL Notes

- The entire dictionary is for use with the IEEE 488.2 standard.

- All HP-SL entries in the dictionary are written in either uppercase or lowercase letters. Also, all entries are shown in either **bold** or *italics* typeface. The following notes explain why.

- Any HP-SL entries in the dictionary that are written in *italics* are commands which allow you to set or query parameters which have only one accepted value, or are commands that cause an event which has no useful effect on the Signal Generator, or are commands that are aliases to another. In any case, the commands are accepted for purposes of HP-SL compatibility.

- All HP-SL entries in the dictionary show the "short form" of the command in uppercase letters. The "long form" of the command includes both the uppercase and lowercase letters. For example, the keyword "frequency" is listed as "FREQuency". This indicates that "FREQ" is all that is required to execute this command. You could even have "FrEq" as the command since case is ignored.

- Command messages sent to the Signal Generator must be terminated by a linefeed character (ASCII character 10) or EOI on the last character.

- Commands statements must be separated by a semicolon. The keywords within the command message are separated by colons. Refer to the first part of this chapter for details about the HP-SL colon and semicolon.

- All HP-SL entries in the dictionary that are enclosed in square brackets " [ ] "are considered optional keywords. The optional keywords are assumed by default and may be omitted.

- Command parameters that you may choose between are separated by a vertical bar " | ". Parameters available with the commands in the dictionary include frequency ranges, amplitude ranges, On state, Off state, ac coupling, dc coupling, and so forth.

- When the command parameter is acting like a switch, "ON", "OFF", "1", or "0" may be sent (ON=1 and OFF=0). But when responding to a query, either a "1" or a "0" will be sent.

HP-SL Notes (Continued)

• Where MINimum and MAXimum are listed as command parameters, they will set that function to its specified minimum or maximum value. For example, the command statement "FREQ MAX" will set the standard Signal Generator to 1030 MHz. MINimum and MAXimum may also be coupled to a subsystem state. For example, if FM is off, FM? MAX is not limited by the RF Frequency and would be 10 MHz. But if FM is on, FM? MAX is reduced by the active synthesis mode and may be less than 10 MHz.

• All HP-SL entries in the dictionary are arranged in a manner that explicitly defines its hierarchy in the tree structure. The keyword at the root is located at the extreme left, branching from the root is indicated by indentation. For example, a portion of the FM subsystem command tree is as follows:

```
FM
    [:DEViation]
        :STEP
            [:INCRement]
    :STATe
    :COUPling
```

The following command statements and messages can be derived from this portion of the FM subsystem command tree. You will notice that several of the command statements are aliases for each other due to implicit couplings of optional keywords.

```
FM
FM:DEViation
FM:DEViation:STEP
FM:DEViation:STEP:INCRement
FM:STEP
FM:STEP:INCRement
FM:STATe
FM:COUPling
```

• Any command message whose first character is an asterisk (such as *CLS) is treated as though the leading asterisk were a colon. For example, "FM:SOURce EXTernal;*CLS" is interpreted as "FM:SOURce EXTernal" and "*CLS".

HP-SL Notes (Continued)

• When you query a command which has mnemonic settings, like GROund or INTernal, the shortform version will be returned. For example, after setting "AM:COUPling" to "GRO","GROUND", or "GND" the response from a query would always be "GRO".

• To read instrument settings over HP-IB, send the query form of the command statement with the correct syntax as specified with a "?" in the dictionary, and address the Signal Generator to talk.

• Phase Modulation "ΦM" will be referred to as PM in the dictionary.

<AM term>	When found in the dictionary, indicates that a "%" or "PCT" termination is required in the command statement. If no termination is specified, then a "% " value is assumed.
<ampl step term>	When found in the dictionary, indicates that a "dB", "V", "mV", "uV" termination is required in the command statement. If no termination is specified, then a "dB" value is assumed.
<ampl step unit>	When found in the dictionary, indicates that a "dB", or "V" termination must be specified in the command statement.
<ampl term>	When found in the dictionary, indicates that "dBm", "dBmW" ("dBmW" is alias for "dBm"), "dBuV", "V", "mV", "uV", or no termination is required in the command statement. If the command statement is not terminated, then "AMPLitude:UNIT" is assumed, except on "STEP" in which case "AMPLitude:STEP:UNIT" is assumed.
<ampl unit term>	When found in the dictionary, indicates that a "dBm", "dBmW", "V", or "dBuV" termination must be specified in the command statement.
<angle term>	When found in the dictionary, indicates that a "DEG", "RAD", or no termination must be specified in the command statement. If no termination is specified, then a "RAD" (radian) value is assumed.
<coupling type>	When found in the dictionary, indicates that sources "AC", "DC", "GROund", or "GND" are available.

HP-SL Notes (Continued)

<freq term>	When found in the dictionary, indicates that "HZ", "KHZ", "MHZ", "MAHZ", "GHZ", or no termination is required in the command statement. If the command statement is not terminated, then "HZ" is assumed.
<lin ampl term>	When found in the dictionary, indicates that "V", "mV", "uV", or no termination is required in the command statement. If the command statement is not terminated, then "V" is assumed.
<mod_type>	When found in the dictionary, indicates that "AM", "FM", "PM", or "PULSe" is required in the command statement.
<non-decimal numeric program data>	When found in the dictionary, indicates that the pound symbol "#" should be followed by either a "B" and a binary representation of a number, or "Q" and a octal representation of a number, or "H" and a hexadecimal representation of a number. For example, the number 943 could be represented as "B1110101111", or "Q1657", or "H3AF".
<nrf>	When found in the dictionary, indicates that an ASCII representation of a number is required in the command statement. The number may be integer or floating-point, and may include a decimal exponent. (nrf stands for – flexible numeric representation – for further information, refer to the IEEE 488.2 standard.)
<ohms term>	When found in the dictionary, indicates that an "OHM", "KOHM", "MOHM" or no termination is required in the command statement. If the command statement is not terminated, "OHM" is assumed.
<source list>	When found in the dictionary, indicates that "INTernal", or "EXTernal", or more than one source separated by commas is required in the command statement. For example: "INTernal,EXTernal" or "EXTernal,INTernal".
<time term>	When found in the dictionary, indicates that "S", "mS", "uS", "nS" or no termination is required in the command statement. If the command statement does not have a termination "S" (seconds) is assumed.

AM Subsystem

AM

[:DEPTh]? [MINimum | MAXimum]

[:DEPTh] <nrf> [<AM term>] | UP | DOWN | MINimum | MAXimum
Sets AM depth in percent. *RST value is 0%.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<AM term>] | MINimum | MAXimum

Sets AM depth step size in percent. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1% .

:STATe?

:STATe ON | OFF | 1 | 0
Turns AM modulation ON or OFF. AM is not turned ON by just setting AM:DEPth. *RST value is OFF.

:SOURce?

:SOURce <source list>
Selects AM source: "EXTernal" or "INTernal". *RST value is INTernal.

:COUPling?

:COUPling <coupling type>
Set source coupling for AM. GROund coupling is equivalent to having NONE displayed on the front panel; it does not turn AM OFF, but all sources are disconnected. *RST value is DC.

:FREQuency? [MINimum | MAXimum]

:FREQuency <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum
Alias to LFSource:FREQuency.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Alias to LFSource:FREQuency:STEP.

Amplitude Subsystem

POWer may be used in place of AMPLitude as an alias. AMPLitude:OUT may be used in place of AMPLitude to specify front-panel output. AMPLitude:SOURce may be used in place of AMPLitude to refer to driving source voltage (EMF).

AMPLitude or POWer

[:OUT] or :SOURce

[:LEVel]? [MINimum | MAXimum]

[:LEVel] <nrf> [<ampl term>] | UP | DOWN | MINimum | MAXimum

Sets CW AMPLitude. LEVel is assumed if omitted in the command statement. *RST value is -137.0 dBm.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<ampl step term>] | MINimum | MAXimum

Sets or queries the AMPLitude step size. MINimum/MAXimum refers to the smallest/largest programmable step size, not the allowed change. *RST value is 10 dB.

:UNIT?

:UNIT <ampl step unit>

Sets or queries the UNIT for amplitude steps. Allowable values of UNIT are V and dB.

If STEP:UNIT is specified as volts, an AMPLitude increment causes the amplitude to be stepped in volts regardless of AMPLitude:UNIT.

If STEP:UNIT is specified as dB, an AMPLitude increment causes the amplitude to be stepped in dB regardless of AMPLitude:UNIT. This allows operations such as setting level in volts and changing it in dB steps.

Setting AMPLitude:STEP with a UNIT suffix causes AMPLitude:STEP:UNIT to be set to dB or V based on the units sent. *RST value is dB.

:STATe?

:STATe ON | OFF | 1 | 0

Turns RF output ON or OFF. OFF disables the output. Setting LEVel does not turn this ON implicitly. *RST value is OFF.

:UNIT?

:UNIT **<ampl unit term>**
Specifies the units of AMPLitude for the Signal Generator. This command sets the implied UNIT for all parameters which have units of power or amplitude (except when the AMPLitude:STEP:UNIT command is sent). It is also used in a query response for these parameters.
If AMPLitude is set with a units suffix different than AMPLitude:UNIT, that UNIT is used in the command, but AMPLitude:UNIT is not changed. *RST is dBm.

:ULIMit? **[MINimum | MAXimum]**

:ULIMit <nrf> **[<ampl term>] | MINimum | MAXimum**
Sets MAXimum upper limit for AMPLitude. This command is equivalent to activating Special Function 103 from the front panel.
ULIMit is affected by POWer:GAIN in the same way as AMPLitude. If AMPLitude:ULIMit is set to less than AMPLitude, then AMPLitude is set to AMPLitude:ULIMit and an error is issued.
The MINimum value that can be set is 1 dB more than the minimum allowable amplitude setting. *RST value is 19.9 dBm.

:ATTenuation? **[MINimum | MAXimum]**

:ATTenuation <nrf> **[dB] | UP | DOWN | MINimum | MAXimum**
Sets or reads the value of the attenuator. This command is equivalent to activating Special Function 101 from the front panel.
Units are in dB of attenuation. Setting attenuation in dB sets POW:ATT:AUTO to OFF. Changing attenuation in dB changes the output level. *RST value is dependent on the option configuration, and is coupled to POWer:LEVel.

:STEP

[:INCRement]?

Reads the attenuator step size.

:AUTO?

:AUTO **ON | OFF | 1 | 0**

When set ON, the firmware will control the attenuators.

Turning it OFF, causes the attenuator range to hold to its present setting. This command is equivalent to activating Special Function 100 from the front panel. *RST value is ON.

:GAIN? **[MINimum | MAXimum]**

:GAIN <nrf> **[dB] | MINimum | MAXimum**

Adjusts displayed/entered power level. Changing the GAIN does not change the actual output level, but it does change the displayed values shown on the front panel. This command is equivalent to setting the amplitude offset, **AMPTD OFS**, from the front panel. *RST value is 0 dB.

:ALC

:BANDwidth

:AUTO?

:AUTO **ON | OFF | 1 | 0**

Enables or disables automatic selection of ALC bandwidth based on frequency and modulation. When OFF the widest ALC BANDwidth is forced. This command is equivalent to activating Special Function 104 from the front panel (in which case, off = narrowband and on = wideband). *RST value is ON.

:MUTing?

:MUTing **ON | OFF | 1 | 0**

The muting command is equivalent to activating Special Function 105 from the front panel.

Calibration Subsystem

CALibration

[:ALL]?

Performs an instrument self-calibration, and then returns an error code (an error code of "0" indicates no failures). Alias to *CAL?

:AMPLitude

:STATe?

:STATe ON | OFF | 1 | 0

Enables or disables the use of AMPLitude correction data. This command is equivalent to activating Special Function 102 from the front panel. *RST value is ON.

Diagnostic Subsystem

These command descriptions are detailed in the Service Diagnostics Manual (part number 08645-90024).

Display Subsystem

Front Panel display and annunciators may be blanked completely or in selective function groups.

DISPlay

:STATe?

:STATe ON | OFF | 1 | 0

:ANNotation

[:ALL]?

[:ALL] ON | OFF | 1 | 0

Enables or disables the front-panel display. This command is equivalent to activating Special Function 191 from the front panel. *RST value is ON.

:FREQuency?

:FREQuency ON | OFF | 1 | 0

Enables or disables front-panel display of RF output frequency. This command is equivalent to activating Special Function 192 from the front panel. *RST value is ON.

:MODulation?

:MODulation ON | OFF | 1 | 0

Enables or disables front-panel display of modulation. This command is equivalent to activating Special Function 193 from the front panel. *RST value is ON.

:AMPLitude?

:AMPLitude ON | OFF | 1 | 0
Enables or disables front-panel display of amplitude. This command is equivalent to activating Special Function 195 from the front panel. *RST value is ON.

:LFSource?

:LFSource ON | OFF | 1 | 0
Enables or disables front-panel display of audio source. This command is equivalent to activating Special Function 194 from the front panel. *RST value is ON.

:RADix?

:RADix US | EURopean
When US (United States) is active, numbers shown on the front panel use a decimal to indicate the "ones" digit position. Commas are used to indicate thousands, millions, and so forth, positions.
When EURopean is active, the commas and decimals shown on the front panel are reversed. For example 123456789 Hz would be shown as 123,456,789.00 Hz in US mode and 123.456.789,00 Hz in EURopean.
This command affects the front-panel display only, all numbers sent over HP-IB must be sent in the US radix.
This command is equivalent to activating Special Function 196 from the front panel. *RST value is US.

FM Subsystem

The Signal Generator cannot do simultaneous FM and PM. If PM is on, and someone requests FM, the following will happen: FM is turned on, PM is turned off, and an error is displayed on the front panel.

FM

[:DEViation]? [MINimum | MAXimum]

[:DEViation] <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum
Set or query FM deviation. *RST value is 1 kHz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Set or query the step size for FM. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1 kHz.

:STATe?

:STATe ON | OFF | 1 | 0
Queries or turns FM ON or OFF. *RST value is OFF.

:SOURce?

:SOURce <source list>
Selects FM source: "INTernal", "EXTernal", or "INTernal,EXTernal". *RST value is INTernal.

:COUPling?

:COUPling <coupling type>
Sets or queries coupling for FM. GROund coupling is equivalent to having NONE displayed on the front panel; it does not turn FM OFF but disconnects all sources. *RST value is DC.

:PREemphasis

:STATe?

:STATe ON | OFF | 1 | 0
Enables or disables the use of a 750 μsec pre-emphasis on the FM modulating signals. This command is equivalent to activating Special Function 122 from the front panel. *RST value is ON.

:MODE?

:MODE LINear | DIGitized
Sets or queries true (LINear) or synthesized (DIGitized) FM. This command is equivalent to activating Special Function 120 from the front panel. *RST value is DIGitized.

:FREQuency? [MINimum | MAXimum]

:FREQuency <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum
Alias to LFSource:FREQuency.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Alias to LFSource:FREQuency:STEP.

:DELay?

:DELay ON | OFF | 1 | 0
Enables or disables the FM Delay Equalizer circuitry. This command is equivalent to activating Special Function 124 from the front panel. *RST value is ON.

Frequency Subsystem

FREQuency

[:CW]? [MINimum | MAXimum]

[:CW] <nrf> **[<freq term>] | UP | DOWN | MINimum | MAXimum**

Set or query non-swept frequency. Does not disable SWEep. *RST value is 100 MHz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> **[<freq term>] | MINimum | MAXimum**

Sets STEP size for RF output frequency related commands (FREQuency, FREQuency:STARt, FREQuency:STOP, CENTer, SPAN, MARKer, MARKer2, MARKer3).

MINimum/MAXimum refers to the smallest/ largest programmable step size, not the smallest/largest allowed change. *RST value is 10 MHz.

:STARt? [MINimum | MAXimum]

:STARt <nrf> **[<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets STARt frequency for a sweep. Does not enable SWEep. May change other SWEep parameters as listed in the following *"Rules for Couplings Between:"*. *RST value is 251,464.85 Hz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Alias to FREQuency:STEP.

:STOP? [MINimum | MAXimum]

:STOP <nrf> **[<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets STOP frequency for a sweep. Does not enable SWEep. May change other SWEep parameters as listed in the following *"Rules for Couplings Between:"*. *RST value is 1030 MHz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINIMUM | MAXIMUM

Alias to FREQuency:STEP.

:CENTer? [MINimum | MAXimum]

:CENTer <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum

Sets CENTer frequency for a sweep. Does not enable SWEep. May change other SWEep parameters as listed in the following *"Rules for Couplings Between:"*.
*RST value is (STARt+STOP)/2.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Alias to FREQuency:STEP.

:SPAN? [MINimum | MAXimum]

:SPAN <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum

Sets frequency SPAN for a sweep. Does not enable SWEep. May change other SWEep parameters as listed in the following *"Rules for Couplings Between:"* . *RST value is STOP-STARt.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Alias to FREQuency:STEP.

Rules for Couplings Between: FREQuency:STARt, FREQuency:STOP, FREQuency:CENTer, and FREQuency:SPAN

If only STARt is sent in the command message:

STOP	is unchanged
CENTer	is set to (STARt + STOP)/2
SPAN	is set to (STOP - STARt)

If only STOP is sent in the command message:

STARt	is unchanged
CENTer	is set to (STARt + STOP)/2
SPAN	is set to (STOP - STARt)

If only CENTer is set in the command message:

SPAN	is unchanged
STARt	is set to (CENTer - (SPAN/2))
STOP	is set to (CENTer + (SPAN/2))

If only SPAN is set in the command message:
CENTer is unchanged
STARt is set to (CENTer - (SPAN/2))
STOP is set to (CENTer + (SPAN/2))

If STARt and STOP are set in the same command message:
CENTer is set to (STARt + STOP)/2
SPAN is set to (STOP - STARt)

If STARt and CENTer are set in the same command message:
STOP is set to (STARt + 2(CENTer-STARt))
SPAN is set to 2(CENTer-STARt)

If STARt and SPAN are set in the same command message:
STOP is set to (STARt + SPAN)
CENTer is set to (STARt + (SPAN/2))

If STOP and CENTer are set in the same command message:
STARt is set to (STOP - 2(STOP-CENTer))
SPAN is set to 2(STOP-CENTer))

If STOP and SPAN are set in the same command message:
STARt is set to (STOP - SPAN)
CENTer is set to (STOP - (SPAN/2))

If CENTer and SPAN are set in the same command message:
STARt is set to (CENTer - (SPAN/2))
STOP is set to (CENTer + (SPAN/2))

If more than two of STARt, STOP, CENTer SPAN commands are sent in one statement, the last two sweep parameters modified will be used, as previously described in the *"Rules for Couplings Between:"* shown above. All changes to the other parameters will be ignored.

:MANual? [MINimum | MAXimum]

:MANual <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum

Controls frequency during a manual sweep. Limits are FREQuency:STARt to FREQuency:STOP. *RST value is the same as FREQuency:STARt.

:OFFSet? [MINimum | MAXimum]

:OFFSet <nrf> [<freq term>] | MINimum | MAXimum

Sets a reference frequency for other absolute frequency settings in the Signal Generator (CW, STARt, STOP, but not FM or SPAN).
Changes the entered or displayed values, but does not change RF output frequency. *RST value is 0 Hz. The coupling equation is as follows:

Entered/Displayed Frequency = (Hardware Freq × Multiplier) + Offset

:MULTiplier? **[MINimum | MAXimum]**

:MULTiplier **<nrf> | MINimum | MAXimum**

Sets a reference multiplier for other frequency settings in the Signal Generator (CW, STARt, STOP, as well as FM and SPAN). This command is equivalent to activating Special Function 111 from the front panel.

This command changes the entered/displayed values, but does not actually change the RF output frequency.

Resolution for this command is integer values, or one over integer values (1/2, 1/3, 1/4 ...). *RST value is 1.

The coupling equation is as follows:

Entered/Displayed Frequency = (Hardware Freq × Multiplier) + Offset

OR

Entered/Displayed Frequency = (Hardware Freq × Multiplier) in cases where offset is not to be used.

:SYNThesis?

:SYNThesis **<nrf>**

Sets synthesis mode for the Signal Generator. For the HP 8644B, this command is equivalent to pressing one of the Synthesis Mode keys on the front panel. For the HP 8643A, selecting Synthesis Mode 1 is equivalent to activating Special Function 125 from the front panel. Selecting Synthesis Mode 2 returns an HP 8643A to its default operating.

Setting this value sets FREQuency:SYNThesis:AUTO to OFF. *RST value is dependent on the hardware configuration and Options installed.

:AUTO?

:AUTO **ON | OFF | 1 | 0**

Turning AUTO to ON, allows the firmware to select the synthesis mode. This command is equivalent to pressing the Synthesis Mode key AUTO on the front panel.

Turning AUTO to OFF, leaves the Signal Generator in its current synthesis mode. *RST value is ON.

:MODE?

:MODE **CW | SWEep**

Determines which commands control the frequency subsystem. If SWEep is selected, then the commands FREQ:STARt, STOP, CENTer, SPAN, and MANual control the frequency subsystem. *RST value is CW.

:INSTantaneous?

Returns the instantaneous RF output frequency during DIGitized FM. This command is equivalent to activating Special Function 121 from the front panel.

Frequency Counter Subsystem

COUNter

:[FREQuency]?
Query for the currently measured frequency.

:RANGe?
Query for the currently set frequency range.

:RANGe <nrf> | **UP** | **DOWN** | **MINimum** | **MAXimum**
Sets the counter to a specific frequency measurement range where the entered "nrf" value is the upper limit of the selected range. The three ranges are:
20 Hz to 10 MHz, nrf value must be 10 MHz;
10 MHz to 640 MHz, nrf value must be 640 MHz;
640 MHz to 2 GHz, nrf value must be 2 GHz.
For example, for measuring frequencies between 20 Hz and 10 MHz, you must enter 10 MHz as the counter range value (nrf), otherwise the error message "Counter setting too low" is displayed.

:TIME?
Query for the currently set gate time.

:TIME <nrf> | **UP** | **DOWN** | **MINimum** | **MAXimum**
Sets the counter to measure frequencies within a specific, selectable "gate" time between .1 and 1.0 seconds.

:TRIGger?
Query to see if the trigger is busy. 0 = NO, 1 = YES.

:TRIGger
Activates the Frequency Counter to make a measurement. Every time you want a new frequency measurement, you must trigger and query the instrument using the following commands:

COUNter:TRIGger
COUNter:[FREQuency]?

HP-SL System Commands

SYSTem

:ERRor? [NUMeric | STRing]

Reads an error from the system error queue. Returns a zero if the queue is empty. If SYSTem:ERRor? or SYSTem:ERRor? NUMeric is used, the Signal Generator returns only a number as described in the table shown below. If SYSTem:ERRor? STRing is used, the Signal Generator returns a number followed by a comma, and a quoted string containing a standard generic error message, a colon, and a specific error message.

Numeric	Error Message	Numeric	Error Message
100	Command Error	211	Legal Command but Settings Conflict
101	Invalid Character Received	212	Argument out of Range
110	Command Header Error	222	Insufficient Capability or Configuration
111	Header Delimiter Error	232	Output Buffer Full or Overflow
120	Numeric Argument Error	300	Device Failure
121	Wrong Data Type (Numeric Expected)	310	RAM Error
123	Numeric Overflow	311	RAM Failure
129	Missing Numeric Argument	312	RAM Data Loss
130	Non Numeric Argument Error	313	Calibration Data Loss
131	Wrong Data Type (Char Expected)	320	ROM Error
132	Wrong Data Type (String Expected)	321	ROM Checksum
133	Wrong Data Type (Block Type #D Required)	322	Hardware and Firmware Incompatible
139	Missing Non Numeric Argument	330	Power on Test Failed
142	Too Many Arguments	340	Self Test Failed
143	Argument Delimiter Error	400	Query Error
144	Invalid Message Unit Delimiter	410	Query Interrupted
200	No Can Do	420	Query Unterminated
201	Not Executable in Local Mode	422	Addressed to Talk with Nothing to Say
202	Settings Lost Due to RTL* or PON*	430	Query Deadlocked

* Return to Local (RTL) or Power On (PON).

For example, if an attempt is made to set the frequency to a value higher than is possible, SYSTem:ERRor? would return: –212 which is an argument out of range error. Under the same conditions a SYSTem:ERRor? STRing query would return: –212,"ARGUMENT OUT OF RANGE:FREQUENCY TOO HIGH" Refer to chapter 7 for a descriptive list of all error messages.

:STATe

:CALL

This event causes all save/recall registers to be cleared.

:SECurity?

:SECurity ON | OFF | 1 | 0

Controls the security mode of the Signal Generator. This command is equivalent to activating Special Function 173 from the front panel. When in the secure mode, any display annunciators which have been disabled cannot be re-enabled. This value is not affected by *RST or *RCL. This value is not effected by power cycles unless memory is lost during power down. When this value is switched from ON to OFF, all memory in the Signal Generator is erased when the equivalent of Special Function 172 (RAM Wipe) is performed.

IEEE 488.2 Common commands

***CAL? Self calibration query**

Causes the Signal Generator to perform an internal self-calibration and returns an integer error code. An error code of zero indicates no failures, other numbers indicate some error. A list of specific error codes are defined in the Service Diagnostics Manual (part number 08645-90024). This command is equivalent to activating Special Function 171 from the front panel.

***CLS Clear status command**

Clears the status register and associated status data structures summarized in the Status Byte, such as the Event Status Register. Clears output and error queues. Clears all event registers.

***ESE <nrf> <non-decimal numeric program data> Event status enable command**

Sets the Standard Event Status Enable Register. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

***ESE? Event status enable query**

Queries the Standard Event Status Enable Register. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

***ESR? Event status register query**

Queries the Standard Event Status Register. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

∗IDN? Identification query

Returns an identification string which is 4 fields separated by commas.

Field 1 : Is always HEWLETT-PACKARD.

Field 2 : Is model number like 8643A.

Field 3 : Is a serial number in HP format e.g. 2419A00873 or a 0 if the serial number is unknown (Equivalent to activating Special Function 190).

Field 4 : Is the firmware version number.

For example: HEWLETT-PACKARD,8643A,2813A09875,REV 1.0.0

∗OPC Operation complete command

Will cause the OPC bit to be set in the standard event status register when a sweep or learn operation is complete. Since the bus is released before a sweep or learn is completed, you may re-synchronize after these operations are complete.

∗OPC? Operation complete query

Will cause an ASCII 1 to be returned when a sweep or learn operation is complete. Since the bus is released before a sweep or learn is completed, you may re-synchronize after these operations are complete.

∗OPT? Option query

Identifies reportable options in current instrument configuration. Each option is indicated by a mnemonic and multiple reportable options are separated by commas. If the Signal Generator has no reportable options in place, the option query returns a zero. For example, "DOUBLER" refers to Option 002, 2 GHz Doubled Output; "COMM_DISCR" refers to Option 004, Enhanced Spectral Purity; "SYNTH_AUDIO" refers to the Synthesized Audio Oscillator; "ELEC_ATTEN" refers to Option 005, Electronic Attenuator.

∗RST Reset command

Causes the Signal Generator to do an instrument preset. Sets all operating parameters to the known states listed in this Dictionary. It does not effect the status reporting information, nor does it clear the error or message queue, and does not affect the contents of the 50 storage registers.

The ∗RST command must be put on a separate line of code.

∗SAV <nrf> Save instrument state

Saves the instrument state in the specified register number. The Signal Generator has 50 available storage registers. The first ten registers (0–9) accepts all front panel settings (except for some Special Functions). The next forty registers (10–49) accepts only frequency and amplitude settings.

∗SRE <nrf> <non-decimal numeric program data> Service request enable command

Sets the Service Request Enable Register. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

∗SRE? Service request enable query

Queries the Service Request Enable Register. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

∗STB? Read status byte query

Sets or queries the HP-IB Status Byte. A more detailed description of the status reporting is included in the *"HP-IB Device Status Dictionary"*.

∗RCL <nrf> Recall instrument state

Recalls the instrument state which was stored in the specified register number. The Signal Generator has 50 available storage registers. The first ten registers (0–9) accepts all front panel settings (except for some Special Functions). The next forty registers (10–49) accepts only frequency and amplitude settings.

∗TST? Self-test query

Causes the Signal Generator to perform internal instrument level diagnostics and returns an integer error code. An error code of zero indicates no failures, other numbers indicate some error. A list of specific error codes are defined in the Service Diagnostics Manual (part number 08645-90024). This command is equivalent to activating Special Function 170 from the front panel.

∗WAI Wait-to-continue command

Causes the Signal Generator to not accept any further input or output between the end of the message containing ∗WAI, and the completion of all command processing for that message.

Initialize Subsystem

INITialize

:STATe?

:STATe PAUSe | RUN

Returns PAUSe or RUN to determines if the Signal Generator is actually sweeping or idle. This parameter only has meaning when FREQuency:MODE is SWEep, and when SWEep:MODE is AUTO. *RST value is PAUSe.

:MODE?

:MODE CONTinuous | SINGle

Determines if the Signal Generator is performing single sweep or continuous sweep. After a single SWEep is done, INITialize:STATe becomes PAUSe, and an INITialize command is required to restart the SWEep. *RST value is CONTinuous.

:ABORt

Aborts any current sweep. Sets INITialize:STATe to PAUSe.

[:IMMediate]

Sets INITialize:STATe to RUN, and starts a single SWEep or a continuous SWEep. If a SWEep is already in progress, it is aborted and restarted.

LF Source Subsystem (Synthesized Audio Oscillator)

LFSource

[:FREQuency]? [MINimum | MAXimum]

[:FREQuency] <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum

Sets frequency of the audio source. This command is equivalent to the command <mod_type>:FREQ. *RST value is 1 kHz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Sets the step size for the audio source. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns the LF source ON or OFF. Setting the frequency or level for the LF does not by itself turn the source ON.

Any attempt to turn LFSource:STATe OFF while any <mod_type>'s STATe is ON, and its SOURce includes INTernal will result in an error. In other words, the Signal Generator will not turn off the LFSource while it is being used for modulation. *RST value is OFF.

:WAVeform?

:WAVeform **SINe | SQUare | TRIangle | SAWTooth | WGNoise**

Selects a waveform for the LF Source: SINe, SQUare, TRIangle, SAWTooth or White Gaussian Noise (WGNoise) is available. This command is equivalent to activating Special Function 130 from the front panel. *RST value is SINe.

:LEVel? **[MINimum | MAXimum]**

:LEVel **<nrf> [<lin ampl term>] | UP | DOWN | MINimum | MAXimum**

Sets level of the audio source in volts. *RST value is 2 V.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<lin ampl term>] | MINimum | MAXimum**

Sets the LFSource:LEVel step size. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/ largest allowed change. *RST value is 0.1 V.

:TRIGger

[:IMMediate]

Causes a one-shot trigger of the LFSource if SOURce is set to EXT. This command is equivalent to activating Special Function 132 with 131 turned ON, from the front panel.

:SOURce?

:SOURce **EXTernal | CONTinuous**

Defines whether the LFSource is continuous or triggered by an external transition. This command is equivalent to activating Special Function 131 from the front panel. In which case, ON would be EXTernal and OFF would be CONTinuous. *RST value is CONTinuous.

:FREQuency2? **[MINimum | MAXimum]**

:FREQuency2 <**nrf**> **[**<**freq term**>**] | UP | DOWN | MINimum | MAXimum**

Sets the frequency of the audio source in Channel 2. This command is equivalent to setting frequency for the second audio source with Special Function 133 turned ON. *RST value is 400 Hz.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] <**nrf**> **[**<**freq term**>**] | MINimum | MAXimum**

Sets the LFSource:FREQuency2 step size for the audio source in Channel 2. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:WAVeform2?

:WAVeform2 **SIN | SQUare | TRIangle | SAWTooth | WGNoise**

Selects a waveform for the audio source in Channel 2: SINe, SQUare, TRIangle, SAWTooth or White Gaussian Noise (WGNoise) is available. This command is equivalent to activating Special Function 135 from the front panel. *RST value is SINe.

:STATe2?

:STATe2 **ON | OFF | 1 | 0**

Turns the audio source in Channel 2 either ON or OFF. Setting the frequency or level does not by itself turn the audio source in Channel 2 ON. This command is equivalent to activating Special Function 133 from the front panel. *RST value is OFF.

:LEVel2? **[MINimum | MAXimum]**

:LEVel2 <**nrf**> **[**<**lin ampl term**>**] | UP | DOWN | MINimum | MAXimum**

Sets the level of the audio source in Channel 2. This command is equivalent to activating Special Function 134 from the front panel. *RST value is 100 mV.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] <**nrf**> **[**<**lin ampl term**>**] | MINimum | MAXimum**

Sets the LFSource:LEVel2 step size for the audio source in Channel 2. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 mV.

:PHASe2

[:ADJust]? **[MINimum | MAXimum]**

[:ADJust] **<nrf> [<angle term>] | UP | DOWN | MINimum | MAXimum**

Adjusts the phase of the audio source in Channel 2 in terms of degrees or radians. This command is equivalent to activating Special Function 136 from the front panel. *RST value is 0°.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<angle term>] | MINimum | MAXimum**

Sets the LFSource:PHASe2 step size for the audio source in Channel 2. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:AM

[:DEPTh]? **[MINimum | MAXimum]**

[:DEPTh] **<nrf> [<am term>] | UP | DOWN | MINimum | MAXimum**

Sets the percentage of AM depth applied to the audio source in Channel 1. This command is equivalent to setting AM depth on the sub-carrier with Special Function 137 turned ON. *RST value is 0%.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<am term>] | MINimum | MAXimum**

Sets the LFSource:AM:DEPTh step size for the AM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1%.

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns the AM source in Channel 1 either ON or OFF. Setting AM frequency or depth does not by itself turn the AM source in Channel 1 ON. This command is equivalent to activating Special Function 137 from the front panel. *RST value is OFF.

:FREQuency? **[MINimum | MAXimum]**

:FREQuency <nrf> **[<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets the frequency rate for the AM source in Channel 1. This command is equivalent to activating Special Function 138 from the front panel. *RST value is 100 Hz.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] <nrf> **[<freq term>] | MINimum | MAXimum**

Sets the LFSource:AM:FREQuency step size for the AM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:WAVeform?

:WAVeform **SIN | SQUare | TRIangle | SAWTooth | WGNoise**

Selects a waveform for the AM source in Channel 1: SINe, SQUare, TRIangle, SAWTooth or White Gaussian Noise (WGNoise) is available. This command is equivalent to activating Special Function 139 from the front panel. *RST value is SINe.

:PHASe

[:ADJust]? **[MINimum | MAXimum]**

[:ADJust] <nrf> **[<angle term>] | UP | DOWN | MINimum | MAXimum**

Adjusts the phase of the AM source in Channel 1 in terms of degrees or radians. This command is equivalent to activating Special Function 140 from the front panel. *RST value is 0°.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] <nrf> **[<angle term>] | MINimum | MAXimum**

Sets the LFSource:AM:PHASe step size for the AM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:FM

[:DEViation]? **[MINimum | MAXimum]**

[:DEViation] **<nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets the percentage of FM deviation applied to the audio source in Channel 1. This command is equivalent to setting FM deviation on the sub-carrier with Special Function 141 turned ON. *RST value is 0 Hz.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<freq term>] | MINimum | MAXimum**

Sets the LFSource:FM:DEViation step size for the FM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 10 Hz.

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns the FM source in Channel 1 either ON or OFF. Setting FM frequency or deviation does not by itself turn the FM source in Channel 1 ON. This command is equivalent to activating Special Function 141 from the front panel. *RST value is OFF.

:FREQuency? **[MINimum | MAXimum]**

:FREQuency **<nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets the frequency rate for the FM source in Channel 1. This command is equivalent to activating Special Function 142 from the front panel. *RST value is 100 Hz.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<freq term>] | MINimum | MAXimum**

Sets the LFSource:FM:FREQuency step size for the FM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:WAVeform?

:WAVeform **SIN | SQUare | TRIangle | SAWTooth | WGNoise**

Selects a waveform for the FM source in Channel 1: SINe, SQUare, TRIangle, SAWTooth or White Gaussian Noise (WGNoise) is available. This command is equivalent to activating Special Function 143 from the front panel. *RST value is SINe.

:PHASe

[:ADJust]? **[MINimum | MAXimum]**

[:ADJust] **<nrf> [<angle term>] | UP | DOWN | MINimum | MAXimum**

Adjusts the phase of the FM source in Channel 1 in terms of degrees or radians. This command is equivalent to activating Special Function 144 from the front panel. *RST value is 0°.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<angle term>] | MINimum | MAXimum**

Sets the LFSource:FM:PHASe step size for the FM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:PM

[:DEViation]? **[MINimum | MAXimum]**

[:DEViation] **<nrf> [<angle term>] | UP | DOWN | MINimum | MAXimum**

Sets the percentage of ΦM deviation applied to the audio source in Channel 1. This command is equivalent to setting ΦM deviation on the sub-carrier with Special Function 145 turned ON. *RST value is 0°.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<angle term>] | MINimum | MAXimum**

Sets the LFSource:PM:DEViation step size for the ΦM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:STATe?

:STATe ON | OFF | 1 | 0

Turns the ΦM source in Channel 1 either ON or OFF. Setting ΦM frequency or deviation does not by itself turn the ΦM source in Channel 1 ON. This command is equivalent to activating Special Function 145 from the front panel. *RST value is OFF.

:FREQuency? [MINimum | MAXimum]

:FREQuency <nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum

Sets the frequency rate for the ΦM source in Channel 1. This command is equivalent to activating Special Function 146 from the front panel. *RST value is 100 Hz.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<freq term>] | MINimum | MAXimum

Sets the LFSource:PM:FREQuency step size for the ΦM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:WAVeform?

:WAVeform SIN | SQUare | TRIangle | SAWTooth | WGNoise

Selects a waveform for the ΦM source in Channel 1: SINe, SQUare, TRIangle, SAWTooth or White Gaussian Noise (WGNoise) is available. This command is equivalent to activating Special Function 147 from the front panel. *RST value is SINe.

:PHASe

[:ADJust]? [MINimum | MAXimum]

[:ADJust] <nrf> [<angle term>] | UP | DOWN | MINimum | MAXimum

Adjusts the phase of the ΦM source in Channel 1 in terms of degrees or radians. This command is equivalent to activating Special Function 148 from the front panel. *RST value is 0°.

:STEP

[:INCRement]? [MINimum | MAXimum]

[:INCRement] <nrf> [<angle term>] | MINimum | MAXimum

Sets the LFSource:PM:PHASe step size for the ΦM source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:PULSe

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns the Pulse source in Channel 1 either ON or OFF. Setting Pulse frequency does not by itself turn the Pulse source in Channel 1 ON. This command is equivalent to activating Special Function 149 from the front panel. *RST value is OFF.

:FREQuency? **[MINimum | MAXimum]**

:FREQuency **<nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets the frequency rate for the Pulse source in Channel 1. This command is equivalent to activating Special Function 150 from the front panel. *RST value is 100 Hz.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<freq term>] | MINimum | MAXimum**

Sets the LFSource:PULSe:FREQuency step size for the Pulse source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 100 Hz.

:PHASe

[:ADJust]? **[MINimum | MAXimum]**

[:ADJust] **<nrf> [<angle term>] | UP | DOWN | MINimum | MAXimum**

Adjusts the phase of the Pulse source in Channel 1 in terms of degrees or radians. This command is equivalent to activating Special Function 151 from the front panel. *RST value is 0°.

:STEP

[:INCRement]? **[MINimum | MAXimum]**

[:INCRement] **<nrf> [<angle term>] | MINimum | MAXimum**

Sets the LFSource:PULSe:PHASe step size for the Pulse source in Channel 1. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians).

:AVIonics

:SETup

:VOR

Configures the instrument for VOR receiver testing. This command is equivalent to activating Special Function 220 from the front panel.

:LOCalizer

Configures the instrument for Localizer receiver testing. This command is equivalent to activating Special Function 221 from the front panel.

:GSLope

Configures the instrument for Guideslope receiver testing. This command is equivalent to activating Special Function 222 from the front panel.

:OMBeacon

Configures the instrument for Outer Marker (OM) beacon testing. This command is equivalent to activating Special Function 223 from the front panel.

:MMBeacon

Configures the instrument for Middle (MM) beacon testing. This command is equivalent to activating Special Function 224 from the front panel.

:IMBeacon

Configures the instrument for Inner Marker (IM) beacon testing. This command is equivalent to activating Special Function 225 from the front panel.

Marker Subsystem

The marker subsystem contains three markers. The behavior of each marker is identical, however, MARKer 1 has two references (that is, MARKer or MARKer1, MARKer2, and MARKer3).

MARKer or MARKer1 or MARKer2 or MARKer3

[:FREQuency]? **[MINimum | MAXimum]**

[:FREQuency] **<nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum**

Sets frequency of selected marker. The marker may be set outside of the START and STOP frequency range, if so, the marker is not shown but is still considered active.

The markers will have the same offset and multiplier values as determined by FREQ:OFFSet and FREQ:MULT. *RST value is 251,464.85 Hz.

:STEP

Step size for the markers will always be in increments equal to FREQ:CW:STEP.

[:INCRement]? *[MINimum | MAXimum]*

[:INCRement] *<nrf> [<freq term>] | MINimum | MAXimum*

Alias to FREQuency:STEP.

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns the specified marker ON or OFF. Marker state is not turned ON when the marker frequency is set. *RST condition is OFF.

:AOFF

Turns off all markers (this is the *RST condition). This command is accepted for any specific marker (MARK2:AOFF) but will still turns off all the markers. This command cannot be queried.

Modulation Subsystem

MODulation

:STATe?

:STATe ON | OFF | 1 | 0

The MODulation:STATe ON and MODulation:STATe OFF commands toggle on and off the modulation type (<mod_type>) that was previously selected. If the modulation is already on when the MODulation:STATe ON command is received, the command has no effect.

The command MODulation:STATe OFF turns off all modulation types, and turns LF-Source:STATe OFF.

The command MOD:STATe? will give the response "1" if any modulation state is on, and will give the response "0" if all modulation states are off. *RST causes the list of "previously active modulation types" to be FM.

Phase Modulation Subsystem

The Signal Generator cannot do simultaneous FM and PM. If FM is on, and someone requests PM, the following will happen: PM is turned on, FM is turned off, and an error displayed on the front panel.

PM

:STATe?

:STATe **ON | OFF | 1 | 0**

Turns PM ON or OFF. *RST value is OFF.

:SOURce?

:SOURce **<source list>**

Selects PM source: "INTernal", "EXTernal", or "INTernal,EXTernal". *RST value is INTernal.

:COUPling?

:COUPling **<coupling type>**

Set source coupling for FM. GROund coupling is equivalent to having NONE displayed on the front panel, it does not turn FM off, but disconnects all sources. *RST value is DC.

:FREQuency? *[MINimum | MAXimum]*

:FREQuency *<nrf> [<freq term>] | UP | DOWN | MINimum | MAXimum*

Alias to LFSource:FREQuency.

:STEP

[:INCRement]? *[MINimum | MAXimum]*

[:INCRement] *<nrf> [<freq term>] | MINimum | MAXimum*

Alias to LFSource:FREQuency:STEP.

Phase Subsystem

This subsystem allows you to increment or decrement the phase of the RF output signal in steps relative to the present frequency reference.

PHASe

[:ADJust]? **[MINimum | MAXimum]**

[:ADJust] **<nrf> [<angle term>] | UP | DOWN |MINimum | MAXimum**

Controls the phase offset value relative to the reference. This command is equivalent to activating Special Function 110 from the front panel. *RST value is 0.

:STEP

[INCRement]? **[MINimum | MAXimum]**

[INCRement] **<nrf> [<angle term>] | MINimum | MAXimum**

Controls the step size in degrees. MINimum/MAXimum refers to the smallest/largest programmable step size, not the smallest/largest allowed change. *RST value is 1°(0.017 radians). (NOTE - base unit for angle measurements is radians. All queries will be returned in radians).

:REFerence

This event resets the PHASe value to 0 without changing the actual PHASe of the Signal Generator. This means that any further references to PHASe will be considered to be relative to the PHASe at the time this command was last issued.

Power Meter Subsystem

PMETer

[:POWer]?

Queries the internal power meter. This command is equivalent to activating Special Function 182 from the front panel.

Pulse Subsystem

PULSe

[:STATe]?

[:STATe] **ON | OFF | 1 | 0**

Turns PULSe ON or OFF. *RST value is OFF.

:SOURce?

:SOURce **<source list>**

Selects the PULSe source. The only allowable value for the Signal Generator is EXTernal. INTernal,EXTernal or INTernal will cause execution errors. *RST value is EXTernal.

Reference Oscillator Subsystem

ROSCillator

:SOURce?

A SOURCe? query returns the status of the current reference source (INT or EXT). The query command is equivalent to activating Special Function 161 from the front panel.

Sequence Subsystem

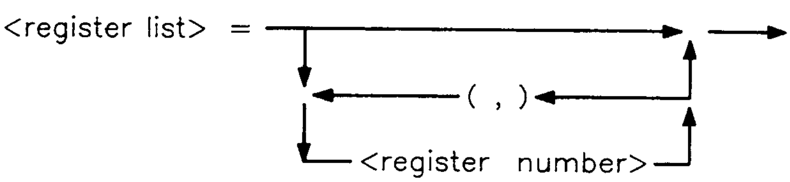
SEQuence

:REGister?

:REGister <register list>

Sets up a list of save/recall registers to step through. All registers are cleared from memory when you send the null list SEQuence:REGister. The REGister command sets up registers 0–9 only. The maximum sequence length is 10 registers. Sending any command statement or message over HP-IB aborts the Auto Sequence state.

The syntax used to generate a <register list> is:



<register number> = number of save/recall register

[:IMMediate]

Causes a step to the next register in the sequence list.

:STATe?

:STATe ON | OFF | 1 | 0

When ON, the Signal Generator automatically steps through the registers in the sequence list. The step time for each register is 1 second, except if a sweep sequence occurs (in which case the step time lasts for the duration of the sweep).

Status Subsystem

STATus

[:DEVice]

[:EVENt]?

Queries the Device Dependent Event Status Register.

:CONDition?

Queries the Device Dependent Condition Status Register.

:ENABle <nrf> | **<non-decimal numeric program data>**

:ENABle?

Sets or queries the Device Dependent Event Enable Register.

:PTRansition?

Queries the Device Dependent Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the Device Dependent Negative Transition Filter.
Always returns 0.

:DQUestionable

[:EVENt]?

Queries the HP-SL Signal Integrity Event Status Register.

:CONDition?

Queries the HP-SL Signal Integrity Condition Status Register.

:ENABle <nrf> | **<non-decimal numeric program data>**

:ENABle?

Sets or queries the HP-SL Signal Integrity Event Enable Register.

:PTRansition?

Queries the HP-SL Signal Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the HP-SL Signal Integrity Negative Transition Filter. Always returns 0.

:SINTegrity

[:EVENt]?

Queries the Signal Generator Signal Integrity Event Status Register.

:CONDition?

Queries the Signal Generator Signal Integrity Condition Status Register.

:ENABle <nrf> | <non-decimal numeric program data>

:ENABle?

Sets or queries the Signal Generator Signal Integrity Event Enable Register.

:PTRansition?

Queries the Signal Generator Signal Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the Signal Generator Signal Integrity Negative Transition Filter. Always returns 0.

:HARDware

[:EVENt]?

Queries the Signal Generator HARDware Integrity Event Status Register.

:CONDition?

Queries the Signal Generator HARDware Integrity Condition Status Register.

:ENABle <nrf> | <non-decimal numeric program data>

:ENABle?

Sets or queries the Signal Generator HARDware Integrity Event Enable Register.

:PTRansition?

Queries the Signal Generator HARDware Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the Signal Generator HARDware Integrity Negative Transition Filter. Always returns 0.

:AMPLitude

[:EVENt]?

Queries the AMPLitude Integrity Event Status Register.

:CONDition?

Queries the AMPLitude Integrity Condition Status Register.

:ENABle <nrf> | **<non-decimal numeric program data>**

:ENABle?

Sets or queries the AMPLitude Integrity Event Enable Register.

:PTRansition?

Queries the AMPLitude Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the AMPLitude Integrity Negative Transition Filter. Always returns 0.

:FREQuency

[:EVENt]?

Queries the FREQuency Integrity Event Status Register.

:CONDition?

Queries the FREQuency Integrity Condition Status Register.

:ENABle <nrf> | **<non-decimal numeric program data>**

:ENABle?

Sets or queries the FREQuency Integrity Event Enable Register.

:PTRansition?

Queries the FREQuency Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the FREQuency Integrity Negative Transition Filter. Always returns 0.

:REFerence

[:EVENt]?

Queries the REFerence Integrity Event Status Register.

:CONDition?

Queries the REFerence Integrity Condition Status Register.

:ENABle **<nrf> | <non-decimal numeric program data>**

:ENABle?

Sets or queries the REFerence Integrity Event Enable Register.

:PTRansition?

Queries the REFerence Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the REFerence Integrity Negative Transition Filter. Always returns 0.

:MODulation

[:EVENt]?

Queries the MODulation Integrity Event Status Register.

:CONDition?

Queries the MODulation Integrity Condition Status Register.

:ENABle **<nrf> | <non-decimal numeric program data>**

:ENABle?

Sets or queries the MODulation Integrity Event Enable Register.

:PTRansition?

Queries the MODulation Integrity Positive Transition Filter. Always returns 65535.

:NTRansition?

Queries the MODulation Integrity Negative Transition Filter. Always returns 0.

Sweep Subsystem

Other commands used with the sweep function are found in the Initialize Subsystem.

SWEep

[:FREQuency]

:TIME? **[MINimum | MAXimum]**

:TIME **<nrf> [<time term>] | UP | DOWN | MINimum | MAXimum**

Sets the sweep time. The commands UP and DOWN will step to the next/previous valid setting since the Signal Generator has 1, 2, 5, 10, 20, 50 ... steps on sweep time.

This command does not turn the SWEep ON. The command statements FREQ:MODE SWEep or INITialize:STATe RUN activate the SWEep. *RST value is 1 second.

:STEP

[:INCRement]?

Always returns 3. This indicates that the step on the sweep time is 3 steps per decade.

:MODE?

Always returns LOG. This indicates that the sweep time is stepped logarithmically.

:MODE?

:MODE **AUTO | MANual**

Selects sweep type. AUTO allows single or continuous sweeps, MANual allows control of frequency with FREQuency:MANual. *RST value is AUTO.

:SPACing?

:SPACing **LINear | LOGarithmic**

Selects LINear or LOGarithmic sweep. *RST value is LINear.

:GENeration?

:GENeration **STEPped | ANALog**

Selects STEPped, or phase continuous (ANALog) SWEep. This command is equivalent to activating Special Function 112 from the front panel. *RST value is STEPped.

Take Sweep Subsystem

TSWeep

Has the same effect as:

INIT:ABORt
SWE:MODE AUTO
FREQ:MODE SWEEP
INIT:MODE SINgle
INIT:IMMediate

This causes any sweep action to stop and a single sweep to take place.

Voltmeter Subsystem

VMETer

[:VOLTage]?

Uses the internal voltmeter to measure voltage at the rear panel voltmeter port.

:MODE?

:MODE AC | DC

Selects DC or AC (rms) measurement for voltmeter. This command is equivalent to activating Special Functions 180 or 181 from the front panel. *RST is DC.

HP-IB Device Status Dictionary

The Signal Generator has a great amount of status information available for your needs through the HP-IB bus. Unfortunately, the single 8 bit status byte register defined in the IEEE.488 standard is not large enough or flexible enough to contain the necessary information for an instrument with the complexity of the Synthesized Signal Generator. Consequently, the Signal Generator contains different levels of registers to overcome this limitation.

The new IEEE 488.2 standard, does however, expand the status byte definition to provide an extremely flexible mechanism for organizing status information. In addition, Hewlett Packard Systems Language (HP-SL) defines a portion of the 488.2 device status model in order to promote as much commonality as possible within various HP instruments. The *HP-IB Device Status Dictionary* describes in detail the Signal Generator implementation of the IEEE 488.2 standard, and HP-SL device status models.

To use the *HP-IB Device Status Dictionary*, refer to the table of contents shown below. All entries in the table of contents are arranged in an order of progressive dependency.

Figure 6-3 helps you understand how each set of registers are progressively dependent upon each other. For example, a bit in the HP-IB Status Byte Register "DEV" is dependent upon the status of bits in the Device Dependent Condition/Event Status Register, and so forth.

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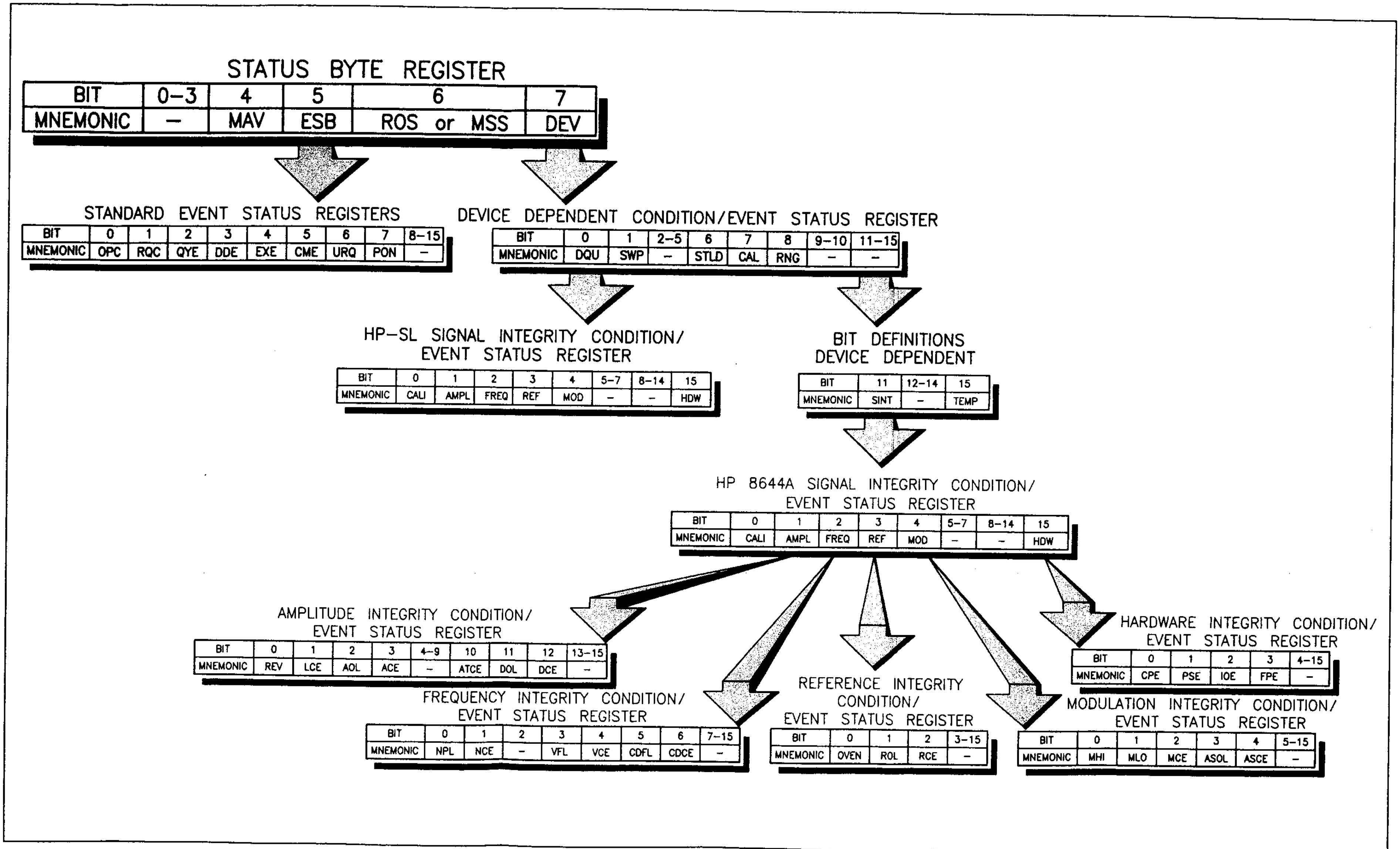

Figure 6–1. Register Map for the HP-SL Device Status Dictionary.

IEEE 488.2 Definitions

The full IEEE 488.2 and HP-SL specifications for device status reporting are beyond the scope of this document, but the following definitions taken from the IEEE 488.2 standard will be sufficient to explain the Signal Generator implementation.

Condition Register

A condition is a device state which is either TRUE or FALSE. A condition register reflects these states in its condition bits. A condition register may range from 1 to 16 bits in length and may contain unused bits. All unused bits are read as a value of zero. A condition bit may also be a summary bit, in which case it represents the status of an event register or a queue.

Event Register

An event register captures changes in conditions. Each bit in an event register corresponds to a condition bit in an associated condition register (or a device condition if there is no condition register).

An event becomes TRUE when there is a certain transition of the associated device condition. Event bits are "sticky" bits; they cannot be cleared (even if they no longer reflect the associated condition) until the event register is read by a user application.

An event register may range from 1 to 16 bits in length and may contain unused bits. All unused bits are read as a value of zero. An event register is cleared after it has been read by a user application and may also be cleared by the IEEE 488.2 *CLS common command.

Transition Filter

A transition filter defines the condition bit changes that set the associated event bit. There are two transition filters for every event register, a positive filter and a negative filter.

When a bit is set in a transition filter, the associated event bit is set after a FALSE to TRUE (positive filter) or TRUE to FALSE (negative filter) transition in the associated condition bit. If a bit is set in both transition filters then the event bit is set after any transition of the condition bit.

Transition filters may or may not be programmable, depending on the implementation. A transition register may range from 1 to 16 bits in length and may contain unused bits. All unused bits are read as a value of zero. A *RST command will reset programmable transition filters to their device dependent default values.

Event Enable Register

Event enable registers select which event bits in the corresponding event register will cause a TRUE summary message when set. Each event bit will have a corresponding enable bit in the event enable register. Each event enable register will be the same length as the corresponding event status register.

All unused bits are read as a value of zero and cannot be written to by the associated event enable command. Any time a bit in the event status register or the event enable register changes, a logical AND is performed on all bits of the event status register and the event enable register. If the result is not zero then the associated summary message is set TRUE.

Queue

A queue is a data structure containing a sequential list of data. Data may be placed in the queue in any order and a single item of data is removed every time the queue is read. A queue has a summary message that is TRUE whenever there is data in the queue and FALSE when the queue is empty.

The data in a queue may be in any format, but all data items must be in that same format. A queue may be cleared using the *CLS command (except for the IEEE 488.2 output queue).

Summary Bit

A summary bit is a condition bit that reflects the current status of the associated summary message. The summary message may be generated by the current values of an event status register and an event enable register or the contents of a queue.

Status Register Model

The diagram in figure 6-2 shows the relationship between the various components of a status register.

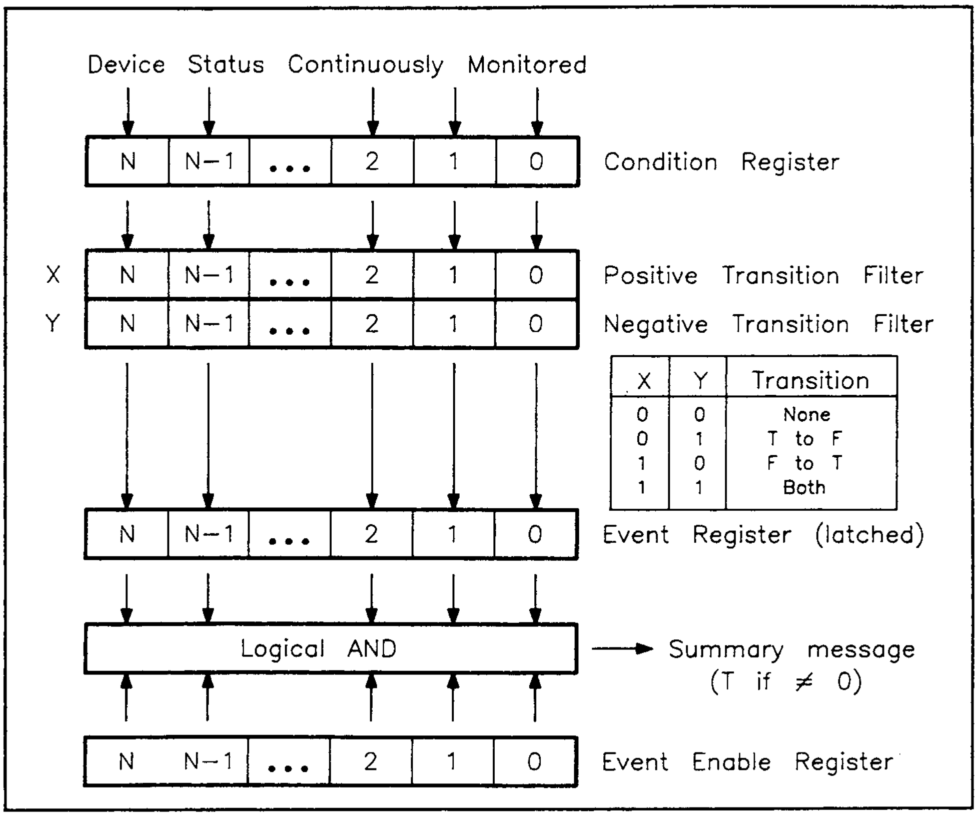

Figure 6–2. Status Register Map.

IEEE 488.2 HP-IB Status Byte Register

The IEEE 488.2 standard and HP-SL defines the 8 bit HP-IB status byte register as follows :

Table 6-1. Status Byte Register.

Bit #	Mnemonic	Definition
7	DEV	HP-SL device dependent event status register summary bit.
6	RQS or MSS	IEEE 488.2 master status summary bit.
5	ESB	IEEE 488.2 standard event status register summary bit.
4	MAV	IEEE 488.2 output queue summary bit.
0–3	–	Device dependent summary bits.

Device Dependent Summary Bits

Bits 0 through 3 are not defined in IEEE 488.2 or HP-SL and may be used as the device designer sees fit, as long as their use does not violate the IEEE 488.2 rules for summary bits. Bits 0 through 3 are not used in the Signal Generator implementation and will always be read as zero.

The status byte register is accessed using the *STB common command and *STB? common query or by performing a HP-IB serial poll operation.

MAV Summary Bit

Bit 4, the MAV (message available) summary bit indicates that there are characters in the instrument output queue. The output queue is read by addressing the instrument to talk and reading data bytes until a line feed character is sent with the EOI control line asserted.

A complete description of the behavior of the output queue is beyond the scope of the *HP-IB Device Status Dictionary*. Interested readers should refer to IEEE 488.2 for the complete definition and behavior of the output queue.

RQS and MSS Summary Bits

Bit 6 of the HP-IB status register has two definitions, depending on the method used to access the status register.

If the register is accessed via the HP-IB serial poll mechanism, then the bit is called the RQS (request service) bit and indicates to the active controller that the instrument is asserting the service request control line (SRQ). The RQS bit is cleared after the active controller performs a serial poll operation.

When the register is accessed via the IEEE 488.2 *STB? common query, the bit is called the MSS (master status summary) bit and indicates that the device has at least one reason for requesting service. Unlike the RQS bit, the MSS bit is not cleared as a result of a serial poll and will always reflect the current status of all of the instrument status registers.

IEEE 488.2 Service Request Enable Register

The service request enable register is an 8 bit register that enables corresponding summary bits in the status byte register. When a status bit is enabled and makes a FALSE to TRUE transition, the instrument will generate a service request.

A service request will also be generated when a status bit is enabled and the bit is already set. The service request enable register is accessed using the *SRE common command and the *SRE? common query. Bit 6 of the service request enable register is unused and will always be read as a zero. The service request enable register may be cleared when the instrument is turned on.

IEEE 488.2 Standard Event Status Register

The standard event status register is a 16 bit event register with the following bit definitions :

Table 6–2. Standard Event Status Register.

Bit #	Mnemonic	Definition
8–15	–	Reserved for future use by IEEE.
7	PON	Power on.
6	URQ	User request.
5	CME	Command error.
4	EXE	Execution error.
3	DDE	Device dependent error.
2	QYE	Query error.
1	RQC	Request control.
0	OPC	Operation complete.

The standard event status register is accessed using the *ESR common command and the *ESR? common query. Because this is an event register, the register is cleared after it is read.

Power On Bit

The power on event bit 7 is set TRUE whenever there has been an OFF to ON transition of the instrument power supply.

User Request Bit

The user request bit 6 is set whenever one of a set of device dependent local instrument controls is activated. At present this feature is not implemented in the Signal Generator firmware and the bit will always be read as a zero.

Command Error Bit

The command error bit 5 is set whenever the parser detects an error in the format or contents of a program message. The Signal Generator implementation will place an HP-SL defined error code in the HP-SL error queue that may specify the exact error (bad header, missing argument, wrong data type, etc.).

Execution Error Bit

The execution error bit 4 is set whenever the current command cannot be processed due to an out of range parameter, conflicting settings, etc. The Signal Generator implementation will place an HP-SL defined error code in the HP-SL error queue.

Device Dependent Error Bit

The device dependent error bit 3 is used to indicate an error that is neither a command error or an execution error. The Signal Generator implementation uses this bit to indicate a hardware failure. An HP-SL defined error code will be placed in the HP-SL error queue that may specify the exact error (self test failure, ROM CRC error, etc.).

Query Error Bit

The query error bit 2 indicates that there is a problem with the output queue. Either there has been an attempt to read the queue when it was empty or the output data has been lost. For a complete description of query errors consult the IEEE 488.2 standard.

Request Control Bit

The request control bit 1 is used to initiate the IEEE 488.2 pass control protocol. The feature is not implemented in the Signal Generator firmware and the bit will always be read as a zero.

Operation Complete Bit

The operation complete bit 0 is set in response to the *OPC common command and indicates that all overlapped commands have completed execution. The Signal Generator firmware supports frequency sweeping as an overlapped operation. For a complete description of the 'operation complete flag', consult the IEEE 488.2 standard.

Standard Event Status Enable Register

The standard event status enable register is a 16 bit register that allows one or more event bits in the standard event status register to be reflected in the ESB summary message in the HP-IB status byte. This register follows all the rules of an event enable register. The standard event status enable register is accessed using the *ESE common command and the *ESE? common query. The standard event status enable register may be cleared when the instrument is turned on.

HP-SL Device Dependent Condition/Event Status Registers

HP-SL defines a group of status registers used to contain device dependent status information. These registers include a condition register, an event register, two transition filters, and an enable register. Each register has the following bit definitions :

Table 6-3. Device Dependent Condition/Event Status Registers.

Bit #	Mnemonic	Definition
11-15	-	Device dependent.
9-10	-	Reserved for use by HP-SL language subset.
8	RNG	Autorange operation in progress.
7	CAL	Calibration in progress.
6	STLD	Signal is settled.
2-5	-	Reserved for future use by HP-SL.
1	SWP	A sweep cycle is in progress.
0	DQU	HP-SL signal integrity summary bit.

The commands used to access these registers are too complex to explain in the *HP-IB Device Status Dictionary*. Refer to *IEEE 488.2 and HP-SL Status Register Syntax* found later on in this chapter for a complete description of the status register syntax.

Device Dependent Bit Definitions.

The Signal Generator firmware defines the device dependent bits 11-15 in the *Device Dependent Condition/Event Status Register* as follows :

Table 6-4. Device Dependent Bit 11-15 Definitions.

Bit #	Mnemonic	Definition
15	TEMP	Temperature drift.
12-14	-	Reserved.
11	SINT	Signal integrity summary bit.

Note

The programmer should be aware that in order to write fully transportable device status routines, only HP-SL mnemonics that do not use any device dependent status bits should be used.

Temperature Drift Bit

The temperature drift bit 15 is set when the internal instrument temperature has changed by more that 10°C since the last time the instrument was calibrated.

Signal Integrity Bit

The signal integrity summary bit 11 is described in detail later on in this chapter in the section titled *Signal Generator Signal Integrity Condition/Event Status Registers.*

Autorange Bit

The autorange bit 8 is set whenever the instrument halts the current measurement in order to automatically select the proper range. The Signal Generator firmware does not support any autorange operations and this bit will always be read as a zero.

Calibration Bit

The calibration bit 7 is set whenever the instrument is performing a calibration operation. Because the Signal Generator calibration is not an overlapped command, the condition register bit will always be read as a zero but the event register bit may be used to see if the instrument has been calibrated since the last time the event register was read.

Signal Settled Bit

The signal settled bit 6 is set when the output signal has settled to its final value. The Signal Generator firmware does not currently support this feature and this bit will always be read as a one.

Sweep in Progress Bit

The sweep in progress bit 1 is set whenever the instrument is in the sweep active state.

Data Questionable Bit

The data questionable bit 0 refers to the HP-SL signal integrity status registers in the following ways.

The HP-SL signal integrity status registers have the same bit definitions as the device dependent signal integrity registers with the following critical difference.

The HP-SL signal integrity condition status register bits are current device conditions, not summary bits. These device conditions are derived from the condition and enable registers associated with the corresponding summary bits in the device dependent signal integrity condition status register.

The Signal Generator firmware provides these two redundant registers so that novice programmers can follow the exact HP-SL model while expert programmers can expand the signal integrity condition bits to the full resolution of the instrument.

Signal Integrity Condition/Event Status Registers

The Signal Generator firmware defines a group of status registers used to contain information about the integrity of the output signal. These registers include a condition register, an event register, two transition filters, and an enable register. Each register has the following bit definitions :

Table 6-5. Signal Integrity Condition/Event Status Registers.

Bit #	Mnemonic	Definition
15	HDW	Misc. hardware integrity summary bit.
8–14	–	Reserved for future use.
5–7	–	Reserved for future use by HP-SL.
4	MOD	Modulation integrity summary bit.
3	REF	Reference integrity summary bit.
2	FREQ	Frequency integrity summary bit.
1	AMPL	Amplitude integrity summary bit.
0	CALI	Calibration integrity condition bit.

Note

Each of the summary bits in these registers refer to other groups of condition/event registers whose format is device dependent.

Hardware Integrity Summary Bit

The hardware integrity summary bit 15 indicates that there is some reason to suspect that the miscellaneous support hardware is not performing correctly. The Signal Generator firmware defines the hardware integrity condition/event register bits as follows :

Table 6-6. Hardware Integrity Summary Bit.

Bit #	Mnemonic	Definition
4–15	–	Reserved for future use.
3	FPE	Front panel hardware error.
2	IOE	I/O board hardware error.
1	PSE	Power supply error.
0	CPE	CPU hardware error.

Modulation Integrity Summary Bit

The modulation integrity summary bit 4 indicates that there is some reason to suspect that the modulation performance of the instrument is not correct. The Signal Generator firmware defines the modulation integrity condition/event register bits as follows:

Table 6–7. Modulation Integrity Summary Bit.

Bit #	Mnemonic	Definition
5–15	–	Reserved for future use.
4	ASCE	Audio source calibration error.
3	ASOL	Audio source PLL out of lock.
2	MCE	Mod distribution calibration error.
1	MLO	External modulation too low.
0	MHI	External modulation too high.

Reference Integrity Summary Bit

The reference integrity summary bit 3 indicates that there is some reason to suspect that the instrument reference frequency is not correct. The Signal Generator firmware defines the reference integrity condition/event register bits as follows:

Table 6–8. Reference Integrity Summary Bit.

Bit #	Mnemonic	Definition
3–15	–	Reserved for future use.
2	RCE	Reference calibration error.
1	ROL	Reference out of lock.
0	OVEN	10811 crystal reference oven cold.

Frequency Integrity Summary Bit

The frequency integrity summary bit 2 indicates that there is some reason to suspect that the output frequency performance of the instrument is not correct. The Signal Generator firmware defines the frequency integrity condition/event register bits as follows :

Table 6-9. Frequency Integrity Summary Bit.

Bit #	Mnemonic	Definition
7–15	-	Reserved for future use.
6	CDCE	140 nS coax FLL calibration error.
5	CDFL	140 nS coax FLL out of lock.
4	VCE	VCO calibration error.
3	VFL	VCO 70 nS FLL out of lock.
2	-	Reserved.
1	NCE	NF calibration error.
0	NPL	NF PLL out of lock.

Amplitude Integrity Summary Bit

The amplitude integrity summary bit 1 indicates that there is some reason to suspect that the output amplitude of the instrument is not correct. The Signal Generator firmware defines the amplitude integrity condition/event register bits as follows :

Table 6-10. Amplitude Integrity Summary Bit.

Bit #	Mnemonic	Definition
13–15	-	Reserved for future use.
12	DCE	Freq doubler calibration error.
11	DOL	Freq doubler ALC out of lock.
10	ATCE	Attenuator calibration error.
4-9	-	Reserved.
3	ACE	ALC calibration error.
2	AOL	ALC out of lock.
1	LCE	Level calibration error.
0	REV	Reverse power detected.

Calibration Integrity Condition Bit

The calibration integrity condition bit 0 indicates that an error has occurred during a calibration or diagnostic operation. This bit will remain set until the entire instrument has been re-calibrated with no errors using the *CAL? query.

IEEE 488.2 and HP-SL Status Register Syntax

All of the status registers defined in the previous sections may be accessed using the following commands :

Table 6–11. IEEE 488.2 and HP-SL Status Register Syntax. (1 of 2)

Command syntax	Definition
*CLS	Clears all event registers and queues.
*STB?	HP-IB status byte register.
*SRE <nrf>|?	HP-IB service request enable register.
*ESR?	IEEE 488.2 standard event status register.
*ESE <nrf>|?	IEEE 488.2 standard event status enable register.
STATus	
[:DEVICE]	
[:EVENt]?	HP-SL device dependent event status register.
:CONDition?	HP-SL device dependent condition status register.
:PTRansition[1] ?	HP-SL device dependent positive transition filter.
:NTRansition[1] ?	HP-SL device dependent negative transition filter.
:ENABle <nrf>|?	HP-SL device dependent event enable register.
:DQUestionable	
[:EVENt]?	HP-SL signal integrity event status register.
:CONDition?	HP-SL signal integrity condition status register.
:PTRansition[1] ?	HP-SL signal integrity positive transition filter.
:NTRansition[1] ?	HP-SL signal integrity negative transition filter.
:ENABle[2] <nrf>|?	HP-SL signal integrity event enable register.
:SINTegrity	
[:EVENt]?	Signal integrity event status register.
:CONDition?	Signal integrity condition status register.
:PTRansition[1] ?	Signal integrity positive transition filter.
:NTRansition[1] ?	Signal integrity negative transition filter.
:ENABle[2] <nrf>|?	Signal integrity event enable register.
:HARDware	
[:EVENt]?	Hardware integrity event status register.
:CONDition?	Hardware integrity condition status register.
:PTRansition[1] ?	Hardware integrity positive transition filter.
:NTRansition[1] ?	Hardware integrity negative transition filter.
:ENABle[2] <nrf>|?	Hardware integrity event enable register.

(1) The firmware does not implement programmable transition filters. All positive transition filters will be fixed at all ones and all negative transition filters will be fixed at all zeros.

(2) The firmware will set the default value of these event enable registers to all ones.

Table 6–11. IEEE 488.2 and HP-SL Status Register Syntax. (2 of 2)

<table>
<tr><th>Command syntax</th><th>Definition</th></tr>
<tr><td>:MODulation</td><td></td></tr>
<tr><td>[:EVENt]?</td><td>Modulation integrity event status register.</td></tr>
<tr><td>:CONDition?</td><td>Modulation integrity condition status register.</td></tr>
<tr><td>:PTRansition[3] ?</td><td>Modulation integrity positive transition filter.</td></tr>
<tr><td>:NTRansition[3] ?</td><td>Modulation integrity negative transition filter.</td></tr>
<tr><td>:ENABle[4] <nrf>|?</td><td>Modulation integrity event enable register.</td></tr>
<tr><td>:REFerence</td><td></td></tr>
<tr><td>[:EVENt]?</td><td>Reference integrity event status register.</td></tr>
<tr><td>:CONDition?</td><td>Reference integrity condition status register.</td></tr>
<tr><td>:PTRansition[3] ?</td><td>Reference integrity positive transition filter.</td></tr>
<tr><td>:NTRansition[3] ?</td><td>Reference integrity negative transition filter.</td></tr>
<tr><td>:ENABle[4] <nrf>|?</td><td>Reference integrity event enable register.</td></tr>
<tr><td>:FREQuency</td><td></td></tr>
<tr><td>[:EVENt]?</td><td>Frequency integrity event status register.</td></tr>
<tr><td>:CONDition?</td><td>Frequency integrity condition status register.</td></tr>
<tr><td>:PTRansition[3] ?</td><td>Frequency integrity positive transition filter.</td></tr>
<tr><td>:NTRansition[3] ?</td><td>Frequency integrity negative transition filter.</td></tr>
<tr><td>:ENABle[4] <nrf>|?</td><td>Frequency integrity event enable register.</td></tr>
<tr><td>:AMPLitude</td><td></td></tr>
<tr><td>[:EVENt]?</td><td>Amplitude integrity event status register.</td></tr>
<tr><td>:CONDition?</td><td>Amplitude integrity condition status register.</td></tr>
<tr><td>:PTRansition[3] ?</td><td>Amplitude integrity positive transition filter.</td></tr>
<tr><td>:NTRansition[3] ?</td><td>Amplitude integrity negative transition filter.</td></tr>
<tr><td>:ENABle[4] <nrf>|?</td><td>Amplitude integrity event enable register.</td></tr>
</table>

(3) The firmware does not implement programmable transition filters. All positive transition filters will be fixed at all ones and all negative transition filters will be fixed at all zeros.

(4) The firmware will set the default value of these event enable registers to all ones.

Example HP-SL Programs

All of the following examples have been written in BASIC Programming Language, however, you may convert the examples into PASCAL or into any other language.

The example HP-SL programs are alphabetically arranged. A table of contents for all examples is as follows:

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Initialize Example 6–78
Modulation Example 6–78
Phase Examples 6–79

A Tool for Developing HP-SL Programs

Programs written in HP-SL are not instrument dependent; that is, HP-SL has removed the one-to-one correspondence between front-panel keystrokes and HP-IB codes. In previous instruments, development of controller programs could be done by trying out functions on the front panel, and then converting the keystrokes into HP-IB codes to send to the instrument.

The following program, written in BASIC, allows you to send command statements and messages to test their effect. In addition, the program traps error conditions and reads the error messages back to the controller in an underlined format.

The program is written for instruments with an HP-IB address of 19. You may modify the program to have any HP-IB address.

When you run the program, type in the command statement or message and press the **ENTER** key. For example, the command statement:

```
FREQ 1.234 MHz
```

will set an RF output frequency of 1.234 MHz. If the command statement or message contains a query "?", the program will generate a response in an inverse video window.

A Tool for Developing HP-SL Programs

```
100  DIM A$[255],L$[255],E$[255]
200  PRINT "ENTER MESSAGE STRING TO SEND TO 8643. REPLIES ARE SHOWN IN INVERSE"
300  PRINT "AND ERROR MESSAGES ARE UNDERLINED."
400  PRINT "################################################################################"
500  ON KBD GOSUB 1100
600  CLEAR 719
700  OUTPUT 719;"*ESE 60;*SRE 48"
800  GOSUB 1600
900  ON INTR 7 GOSUB 1600
1000 GOTO 1000
1100 OUTPUT 2;KBD$;
1200 INPUT "ENTER MESSAGE STRING TO SEND TO 8643:",A$
1300 PRINT A$
1400 OUTPUT 719;A$
1500 RETURN
1600 Z=SPOLL(719)
1700 IF BIT(Z,4)=0 THEN GOTO 2000
1800 ENTER 719;L$
1900 PRINT CHR$(129);L$;CHR$(128)
2000 OUTPUT 719;"*ESR?"
2100 ENTER 719;Z
2200 OUTPUT 719;"SYST:ERR? STR"
2300 ENTER 719;E$
2400 IF E$[1;1]="0" THEN GOTO 2700
2500 PRINT CHR$(132);E$;CHR$(128)
2600 GOTO 2200
2700 ENABLE INTR 7;2
2800 RETURN
2900 END
```

AM Examples

Set the AM depth to a value of 57% and select External AC, AM.

```
100  ! Set the Source to external and the coupling to AC.
200  OUTPUT  719;"AM:SOUR EXT;COUP AC"
300  ! Set the AM depth to a value of 57% and turn AM on.
400  OUTPUT  719;"AM:DEPT 57%;STATE ON"
```

Set the AM depth to 73% with internal AM at 2.5 kHz modulation frequency.

```
100  ! Set the Source to internal and no coupling.
200  OUTPUT  719;"AM:SOUR INT"
300  ! Set the AM depth to a value of 73%.
400  OUTPUT  719;"AM 73 %"
500  ! Set the LFSource Frequency to 3 kHz.
600  OUTPUT  719;"LFS:FREQ 3 KHZ"
```

Amplitude Examples

Set amplitude to 100 mV, increment in 0.1 dB steps until some other measurement returns proper reading. Query amplitude in volts.

```
 100  ! Set output level to 100 mV and enable RF output
 200  OUTPUT  719;"AMPL 100mV;AMPL:STATE ON"
 300  ! Set default instrument amplitude units to return volts
 400  ! and default instrument amplitude step to dB this allows
 500  ! logarithmic stepping of the amplitude in volts.
 600  OUTPUT  719;"AMPL:UNIT V;STEP:UNIT DB"
 700  ! Set increment to 0.1 dB.
 800  OUTPUT  719;"AMPL:STEP:INCR 0.1"
 900  ! Loop testing value and incrementing output level by 0.1 dB
1000    ! Make what ever tests are required here, if proper level
1100    ! has been reached, goto line 1700
1200  ! Increase source amplitude by 0.1 dB.
1300  OUTPUT  719;"AMPL UP"
1400  ! Jump back to test.
1500  GOTO 1000
1600  ! Read current amplitude back from source.
1700  OUTPUT  719;"AMPL?"
1800  ENTER   719;Level
1900  PRINT   "Level required was ";Level;" Volts."
```

FM Example

Set the FM deviation to a value read in from controller keyboard. Also set the FM Source to external.

```
100  ! Set the Source to external and the coupling to DC.
200  OUTPUT  719;"FM:SOUR EXT;COUP DC"
300  ! Input the FM deviation from the console.
400  INPUT  "Enter the FM Deviation in kHz:  ",Fm_deviation
500  ! Set the FM deviation to the value given as input.
600  OUTPUT  719;"FM ";Fm_deviation;"KHZ"
700  ! Now turn FM on.
800  OUTPUT  719;"FM:STATE ON"
```

Frequency Examples

Reset the instrument, then set frequency to 137 MHz, and turn amplitude on at 4.5 dBm:

```
100  ! Set instrument to known state.
200  OUTPUT  719;"*RST"
300  ! Set frequency to 137 MHz
400  OUTPUT  719;"FREQ 137MHZ"
500  ! Set output level to 4.5 dBm and enable RF output
600  OUTPUT  719;"AMPL 4.5DBM;AMPL:STATE ON"
```

Reset the instrument, turn amplitude on and set frequency and amplitude to values read in from controller keyboard:

```
100  ! Set instrument to known state.
200  OUTPUT  719;"*RST"
300  ! Input the Frequency and the Amplitude from the console.
400  INPUT   "Enter frequency in MHz: ",Freq
500  INPUT   "Enter amplitude in dBm: ",Ampl
600  ! Set the Frequency and Amplitude to the input values.
700  OUTPUT  719;"FREQ ";Freq;"MHZ;AMPL ";Ampl;"DBM;AMPL:STATE ON"
```

Reset the instrument, turn amplitude on at 0 dBm and step frequency from 200 to 300 MHz in 1 MHz steps, making some measurement at each frequency:

```
 100  ! Set instrument to known state.
 200  OUTPUT  719;"*RST"
 300  ! Set frequency to 200 MHz and set frequency increment to 1MHz.
 400  OUTPUT  719;"FREQ 200MHZ;FREQ:STEP 1MHZ"
 500  ! Turn RF on at 0 dBm
 600  OUTPUT  719;"AMPL 0;AMPL:STATE ON"
 700  FOR X = 0 TO 100
 800    !  Add code to make whatever
 900    !  measurement is needed here.
1000    !  Increase frequency by 1MHz
1100    OUTPUT  719;"FREQ UP"
1200  NEXT X
```

The instrument is to be used as a local oscillator where it's output frequency will be doubled, and that signal will be mixed with the "frequency of interest" and put through a 10.7 MHz I.F. bandpass filter.

This means (Frequency of interest) = (L.O. Frequency) X 2 - 10.7 MHz. Set up frequency offsets and multipliers to allow the signal generator to be programmed to the frequency of interest, rather than the L.O. frequency.

```
100  ! Set freq multiplier to two and frequency offset to -10.7MHz
200  OUTPUT  719;"FREQ:MULT 2;OFFSET -10.7MHZ"
300  ! Set signal generator so that frequency of interest will be
400  ! 107.7 (actual signal generator output frequency is 59.2 MHz).
500  OUTPUT  719;"FREQ 107.7MHZ"
```

EMF Mode Examples

```
10  ! SAMPLE PROGRAM TO TURN EMF MODE ON AND OFF IN PSG.
20  !
30  Address=719
40  OUTPUT  Address; "AMPLITUDE:SOURCE:UNIT V" ! SETS EMF MODE
50  !
60  OUTPUT  Address; "AMPLITUDE:OUT:UNIT V"    ! SETS NON EMF MODE
70  !
80  END
```

HP-IB Device Status Examples

The following section presents several examples of the use of HP 8644A device status mnemonics.

Example 1:

Configure the instrument to generate a service request whenever an error is placed in the error queue.

```
*ESE 60;*SRE 32
```

Enable the CME, EXE, QYE, and DDE bits in the standard event status register and the ESB summary message in the HP-IB status byte.

Example 2:

Configure the instrument to generate a service request whenever the fractional-N phase locked loop goes out of lock.

```
STAT:ENAB 2048;SINT:ENAB 4;FREQ:ENAB 1;*SRE 128
```

Enable the signal integrity summary message, the frequency integrity summary message, the NPL event bit, and the DEV summary message in the HP-IB status byte.

Example 3:

Respond to a service request and decode the instrument status.

```
*STB?                  Read the HP-IB status byte.
data = 128             The DEV summary message is set.
STAT?                  Read the device dependent event status
                        register.
data = 2048            The HP-SL signal integrity summary bit is set.
STAT:DQU?              Read the HP 8644A signal integrity event
                        status register.
data = 4               The frequency integrity summary bit is
                        set.
STAT:SINT:FREQ?        Read the HP 8644A frequency integrity event
                        status register.
data = 1               The NF PLL has been out of lock.
STAT:SINT:FREQ:COND?   Read the frequency integrity condition
                        status register.
data = 0               The NF PLL is not currently out of lock.
```

It is clear from this dialog that there has been a transient out of lock in the NF PLL.

Initialize Example

Set up a ten second logarithmic sweep. Prompt user for the start frequency and sweep over a 200 MHz span. Put markers at start freq +50 MHz, +100 MHz, and +150 MHz. Make a single sweep.

```
 100  ! Get start frequency from user.
 200  INPUT  "Enter Start Frequency in Hz: ";Startfreq
 300  ! Set start frequency and span for sweep.
 400  OUTPUT  719;"FREQ:START ";Startfreq;";SPAN 200MHZ"
 500  ! Set sweep time to 10 Sec. and select log sweep
 600  OUTPUT  719;"SWEEP:TIME 10;SPACING LOG"
 700  ! Set markers
 800  OUTPUT  719;"MARKER ";Startfreq+50000000;";MARKER:STATE ON"
 900  OUTPUT  719;"MARK2 ";Startfreq+100000000;";MARK2:STATE ON"
1000  OUTPUT  719;"MARK3 ";Startfreq+150000000;";MARK3:STATE ON"
1100  ! Become sweeper, enable auto sweeping and select single.
1200  OUTPUT  719;"FREQ:MODE SWEEP;:SWEEP:MODE AUTO"
1300  OUTPUT  719;"INITialize:MODE SINGle"
1400  ! The next line will cause the sweep to begin.
1500  OUTPUT  719;"INITialize:IMMediate"
```

Modulation Example

If in the middle of some procedure, it may be necessary to make some measurement which require that the HP 8644A be at the current RF output frequency and output amplitude level, but all modulation must be turned off.

The following example will disable all modulation, make necessary measurements, and then turn back on whatever modulation was on before this section of code started. (Note: this section of programming code will work regardless of what modulation(s) were on when it was executed.)

```
        .     .
        .     .
        .     .
7100  ! Shut off all modulation.
7200  OUTPUT  719;"MOD:STATE OFF"
7300  ! Make any necessary tests/measurements ...
7400  !
7500  ! Return modulation to the state it was in before line 7200
7600  OUTPUT  719;"MOD:STATE ON"
        .     .
        .     .
        .     .
```

Phase Examples

Adjust the phase to set the quadrature between two sources.

```
100  ! Set the phase step to 1 degree
200  OUTPUT  719;"PHAS:STEP 1DEG"
300  ! Continue adjusting the Phase by 1 degree until the voltage is
400  ! equal.
450  DONE = 0
500  REPEAT
600    ! Measure mixer voltage using appropriate equipment and store
700    ! the value as "Measurement".
800    ! If measurement is greater than 0.1 V increment phase.
900    IF (Measurement) $>$ 0.1V THEN
1000    OUTPUT  719;"PHAS UP"
1100   ELSE
1200   ! If measurement is less than -0.1 V decrement phase.
1300   IF (Measurement) $<$ -0.1V THEN OUTPUT  719;"PHAS DOWN"
1400   ! If measurement is okay then set done to quit looping.
1500   ELSE
1600     Done = 1
1700 UNTIL (Done  = 1)
```

Shift Carrier Phase by 30°and make a measurement. Then set the Phase back to 0.

```
100  ! Set Phase value to 0.
200  OUTPUT  719,"PHAS:REF"
300  ! Shift Phase by 30 degrees.
400  OUTPUT  719,"PHAS 30DEG"
500  ! Make some appropriate measurement.
600  ! Set Phase back to zero.
700  OUTPUT  719,"PHAS 0DEG"
```

Introduction to HP-SL Syntax Drawings

These syntax drawings provide you with Hewlett-Packard System Language (HP-SL) information for remote operation over the Hewlett-Packard Interface Bus (HP-IB). Use these drawings once you are familiar with the basic structure of HP-SL.

Command Statements

Command statements are used to either modify or query the Signal Generator. A general representation of a command statement is shown in figure 6-3. Keywords are recognized in the command statement as those listed in either the *HP-IB Control Language Dictionary* or the *HP-SL Device Status Dictionary*.

Keywords may be followed by a question mark for a query, or by a space and then a command parameter (as described in the *HP-SL Notes* at the beginning of this chapter).

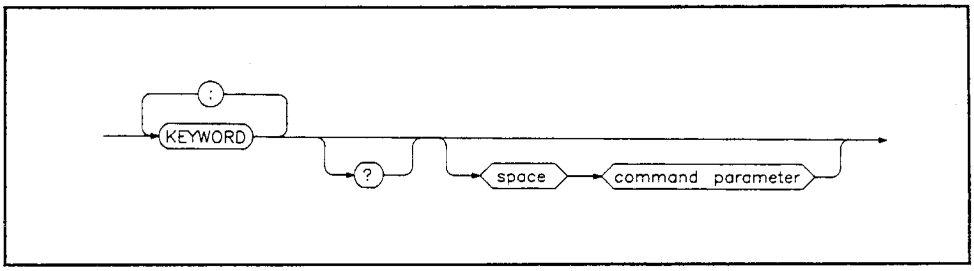


Figure 6-3. Command Statement Syntax Drawing.

Command Message

One or more command statements on a line of programming code make up a command message. A general representation of a command message is shown in figure 6-4. All command messages are terminated by either a new line (ASCII character 10), or an HP-IB end or identify (EOI). (The EOI is not a separate character but is a bus message sent along with a data character "new line" or the last character of the command statement.)

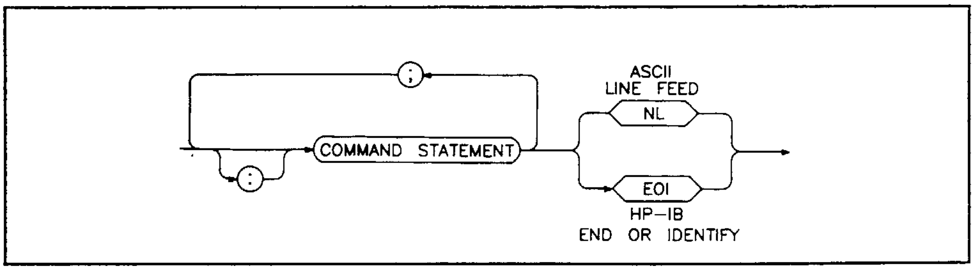
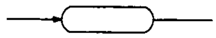


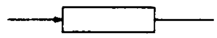
Figure 6-4. Command Message Syntax Drawing.

Subsystem Syntax

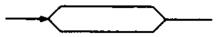
All subsystem syntax drawings are represented pictorially. The following rules apply to all syntax drawings:



- A rounded envelope indicates that the HP-SL command must be included in the command statement.



- A rectangular box indicates an optional HP-SL command which may or may not be included in the command statement.



- A diamond shaped envelope usually indicates a command parameter preceeded by a space, and in some cases the diamond shaped envelope is used to indicate that a "term" (terminator) is required to finish the command statement. Refer to the *HP-SL Notes* shown below for a description of each command parameter.

MINimum

- Any HP-SL command written in *italics* is an alias to another HP-SL command.

HP-SL Notes

<AM term> indicates that a "%" or "PCT" termination is required. " % " is assumed as the default value .

<ampl step term> indicates that a "dB", "V", "mV", "uV" termination is required. "dB" is assumed as the default value.

<ampl step unit> indicates that a "dB", or "V" termination must be specified.

<ampl term> indicates that "dBm", "dBmW" ("dBmW" is alias for "dBm"), "dBuV", "V", "mV", "uV", or no termination is required.

<ampl unit term> indicates that a "dBm", "dBmW", "V", or "dBuV" termination must be specified.

<angle term> indicates that a "DEG", "RAD", or no termination must be specified. "RAD" (radian) is assumed as the default value.

<coupling type> indicates that sources "AC", "DC", "GROund", or "GND" are available.

<freq term> indicates that "HZ", "KHZ", "MHZ", "MAHZ", "GHZ", or no termination is required. "HZ" is assumed as the default value.

<lin ampl term> indicates that "V", "mV", "uV", or no termination is required. "V" is assumed as the default value.

<mod_type> indicates that "AM", "FM", "PM", or "PULSe" is required.

<non-decimal numeric program data> indicates that the pound symbol "#" should be followed by either a "B" and a binary representation of a number, or "Q" and a octal representation of a number, or "H" and a hexadecimal representation of a number.

<nrf> indicates that an ASCII representation of a number is required.

<ohms term> indicates that an "OHM", "KOHM", "MOHM" or no termination is required. "OHM" is assumed as the default value.

<source list> indicates that "INTernal", or "EXTernal", or more than one source separated by commas is required.

<space> indicates an ASCII character in the range of 0 through 9 or 11 through 32 decimal.

<time term> indicates that "S", "mS", "uS", "nS" or no termination is required. "S" (seconds) is assumed as the default value.

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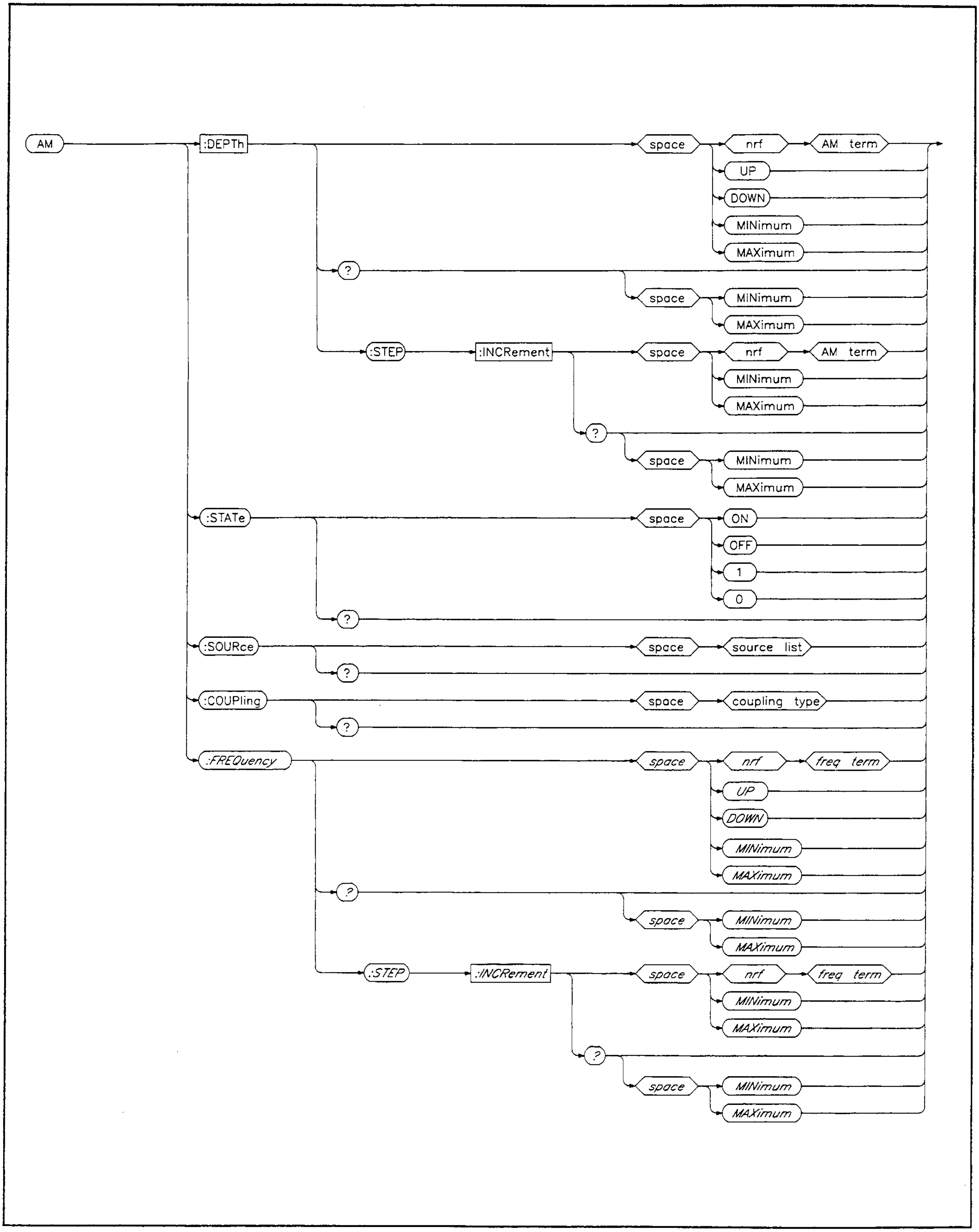


Figure 6-5. AM Subsystem.

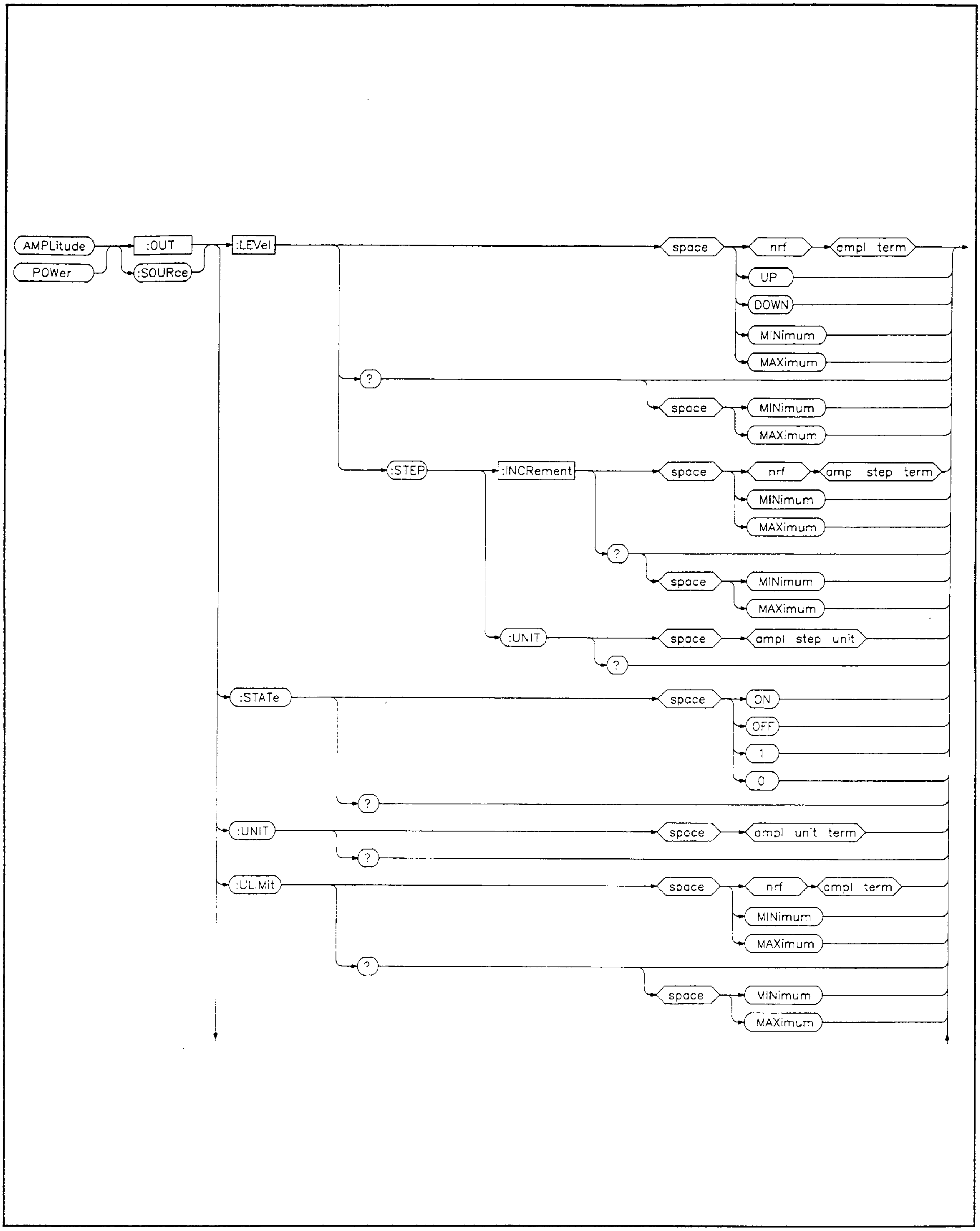


Figure 6–6. Amplitude Subsystem. (1 of 2)

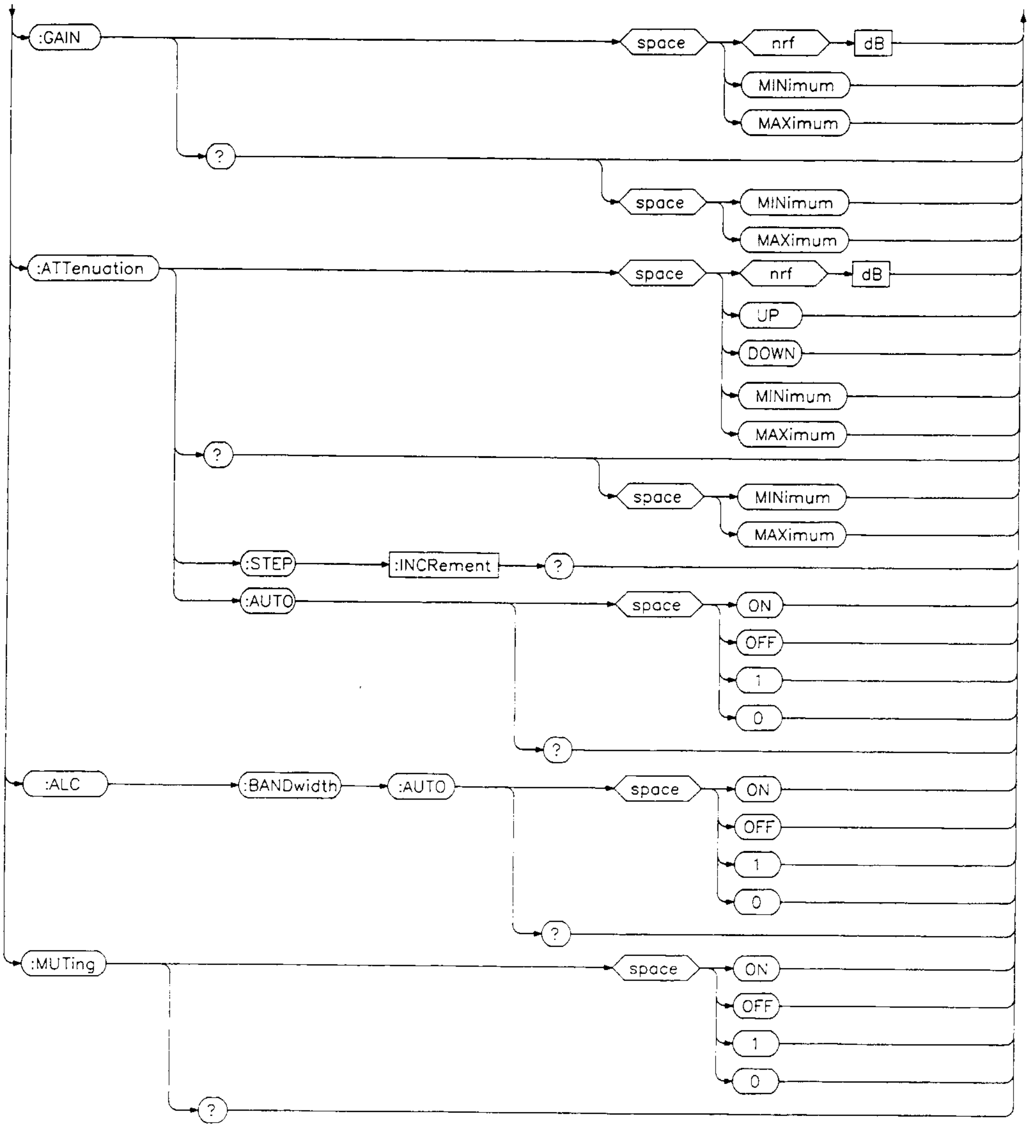


Figure 6–6. Amplitude Subsystem. (2 of 2)

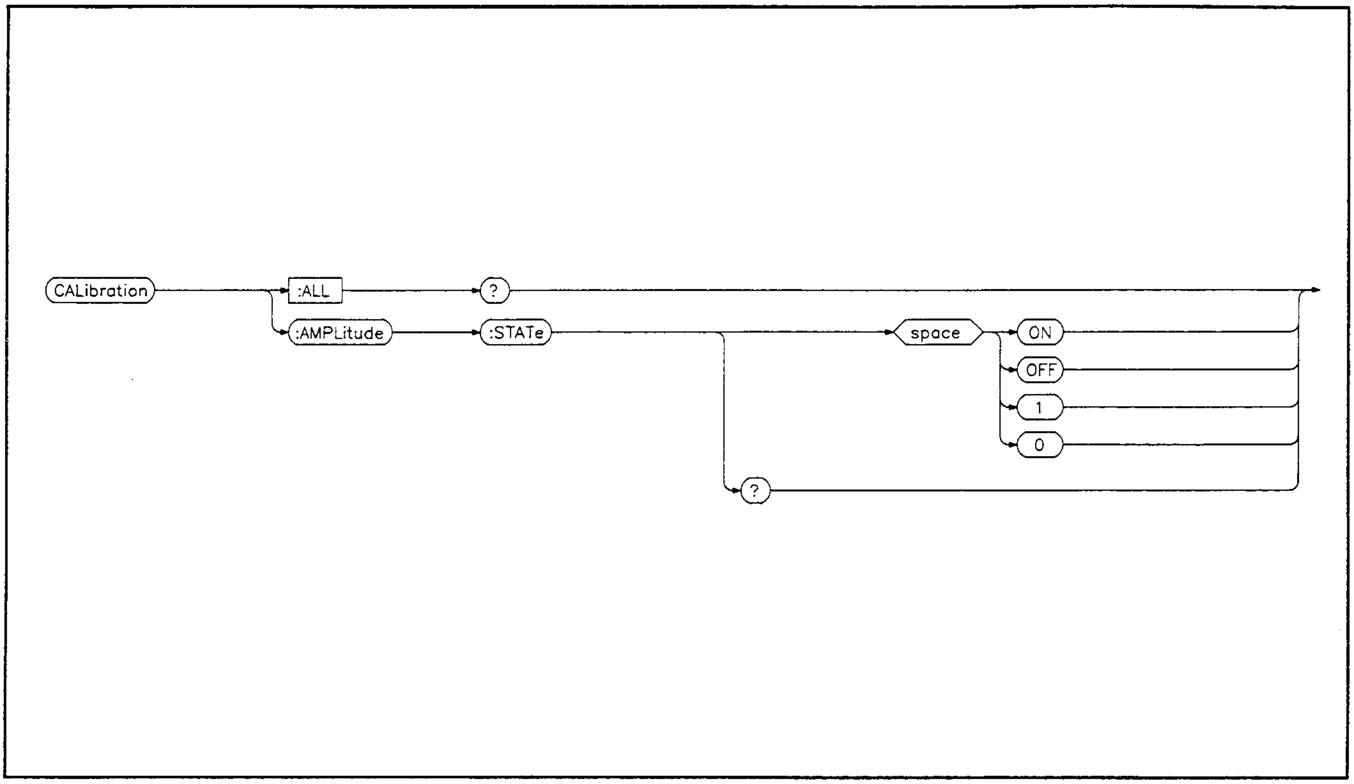


Figure 6-7. Calibration Subsystem.

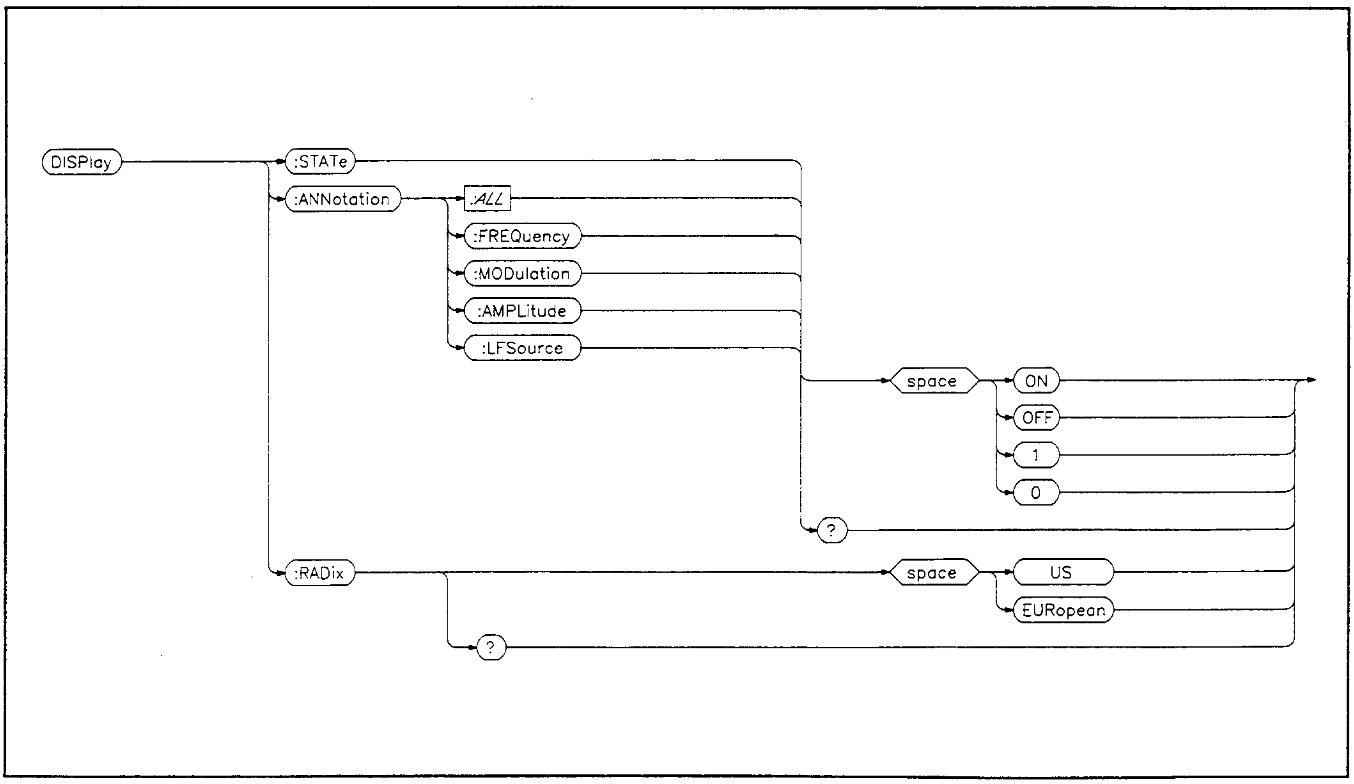


Figure 6-8. Display Subsystem.

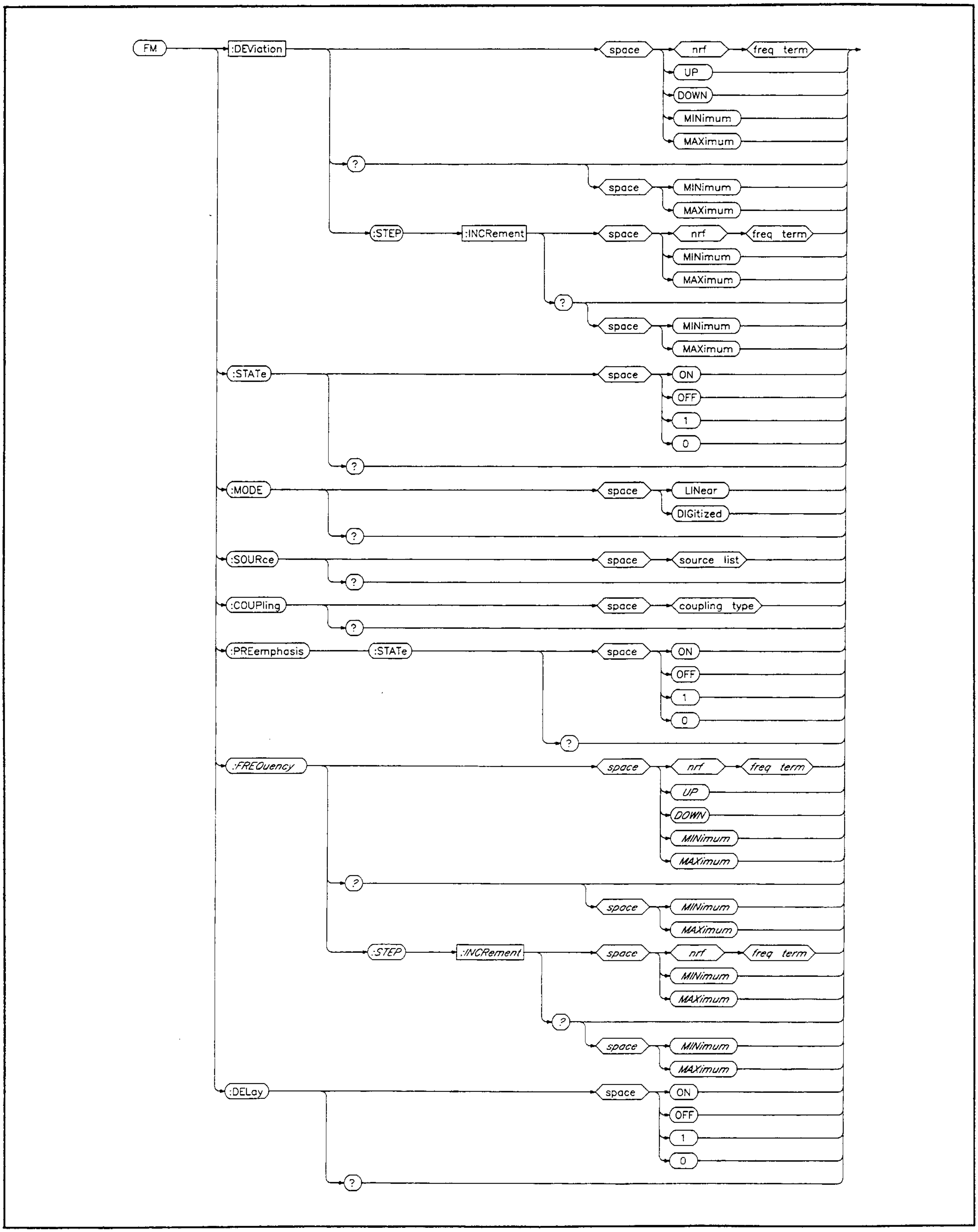


Figure 6-9. FM Subsystem.

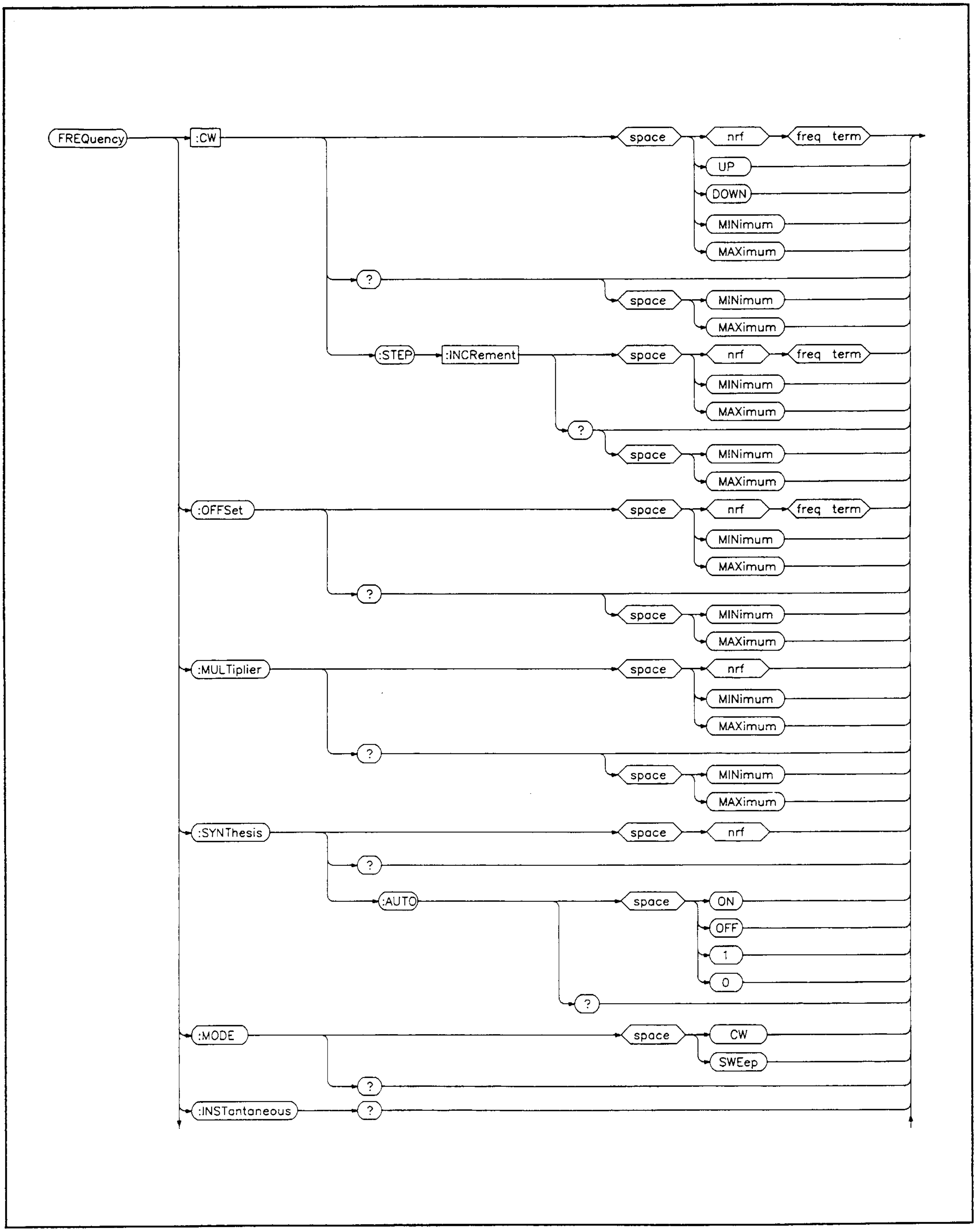


Figure 6-10. Frequency Subsystem. (1 of 2)

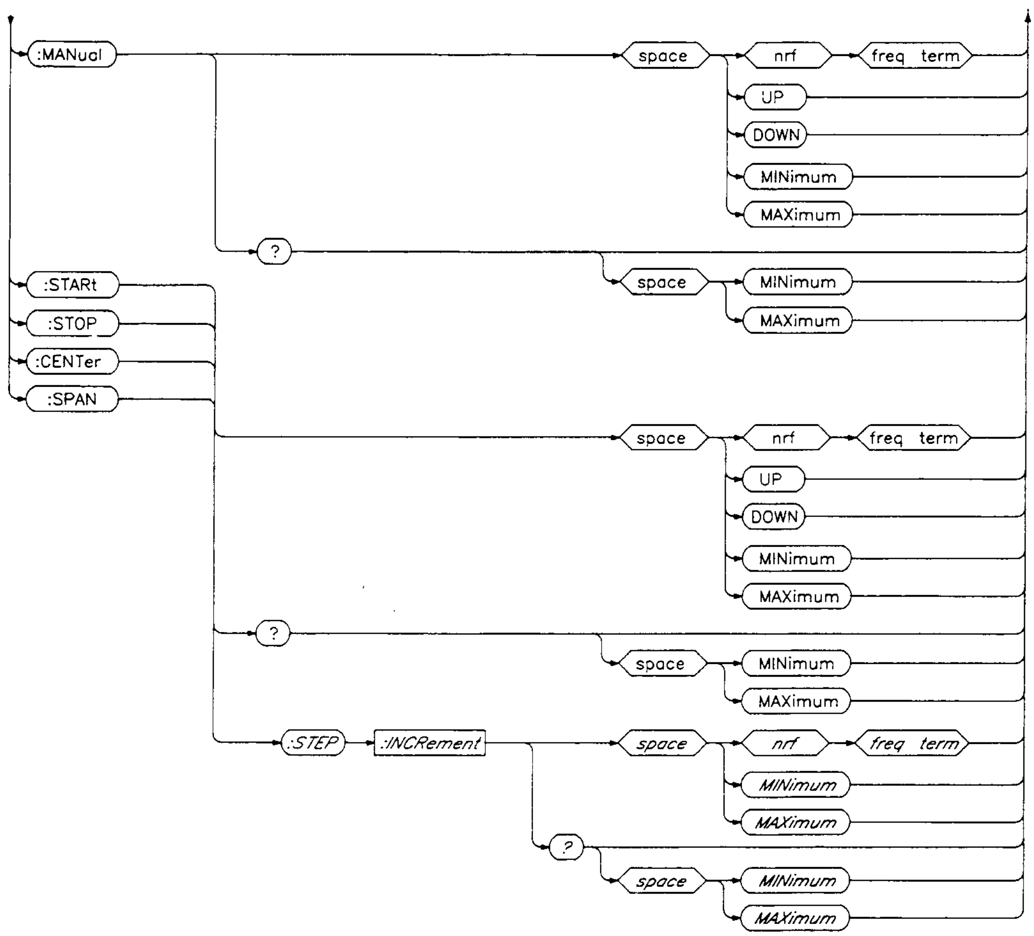


Figure 6-10. Frequency Subsystem. (2 of 2)

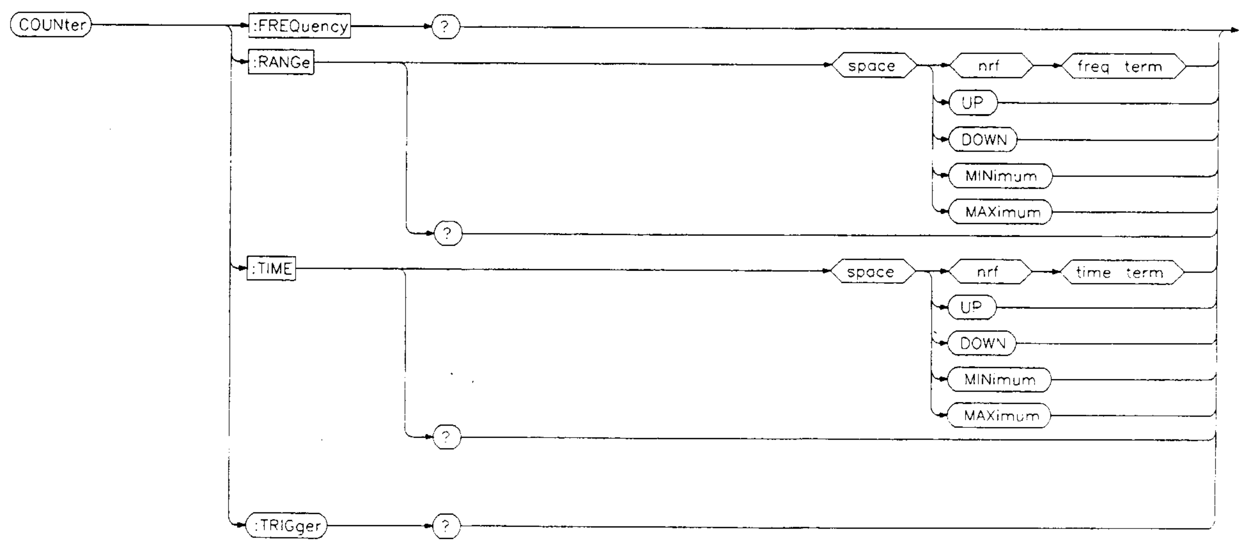


Figure 6-11. Frequency Counter Subsystem.

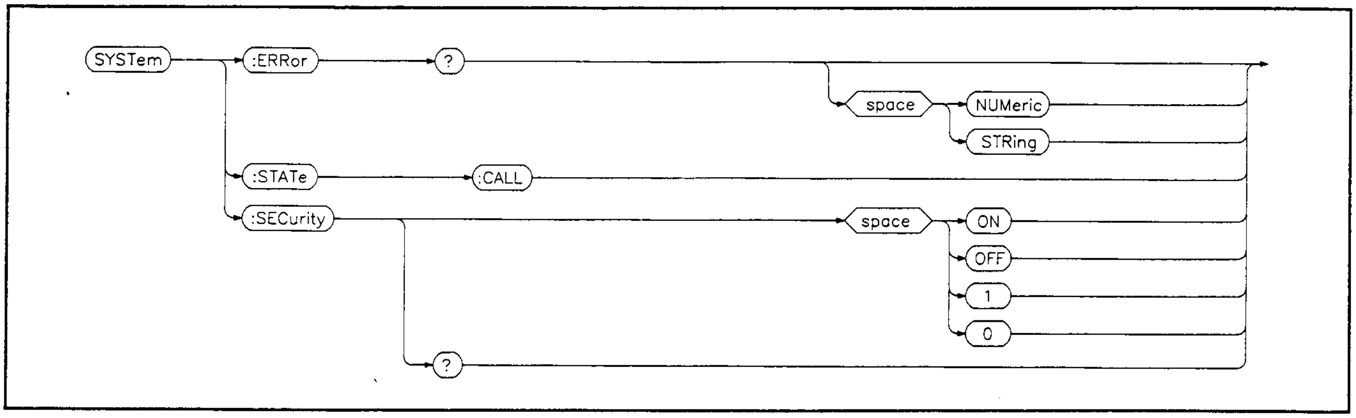


Figure 6-12. HP-SL System Commands.

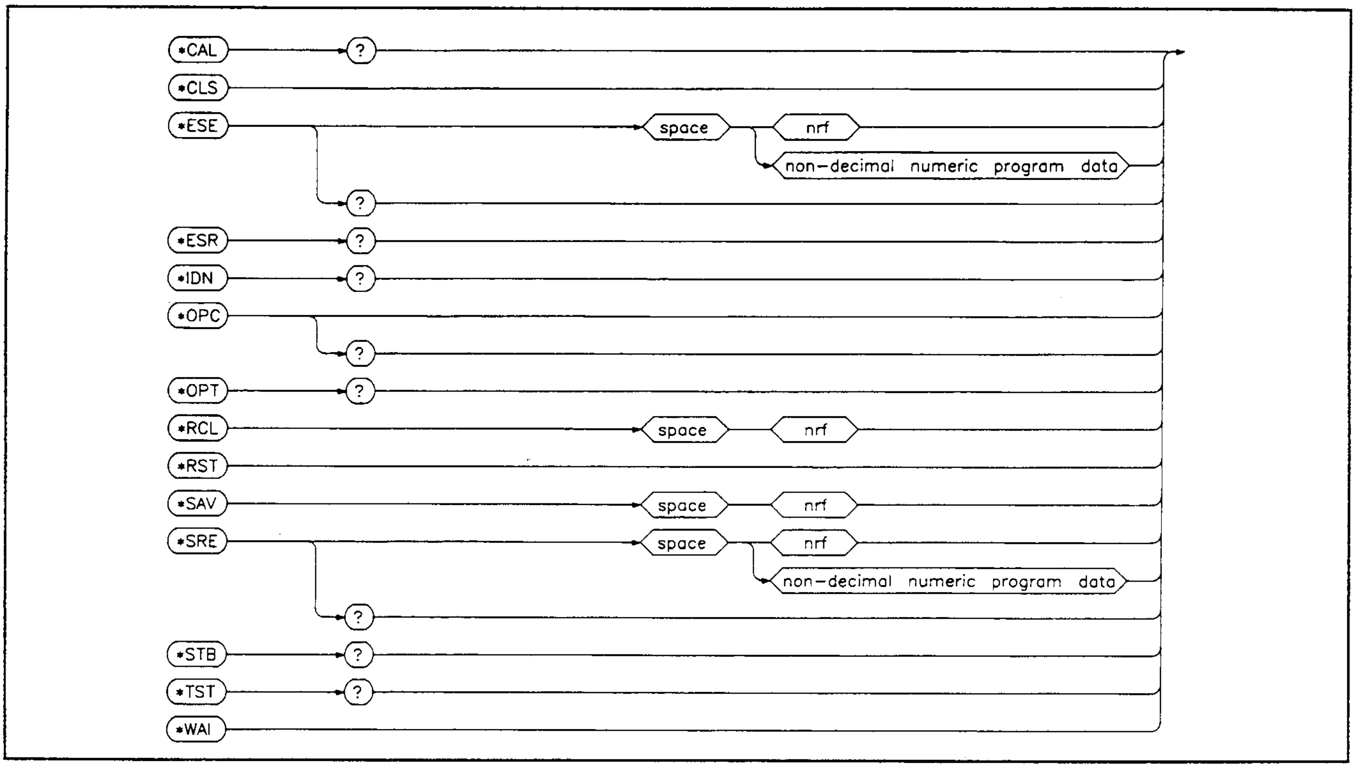


Figure 6-13. IEEE 488.2 Common Commands.

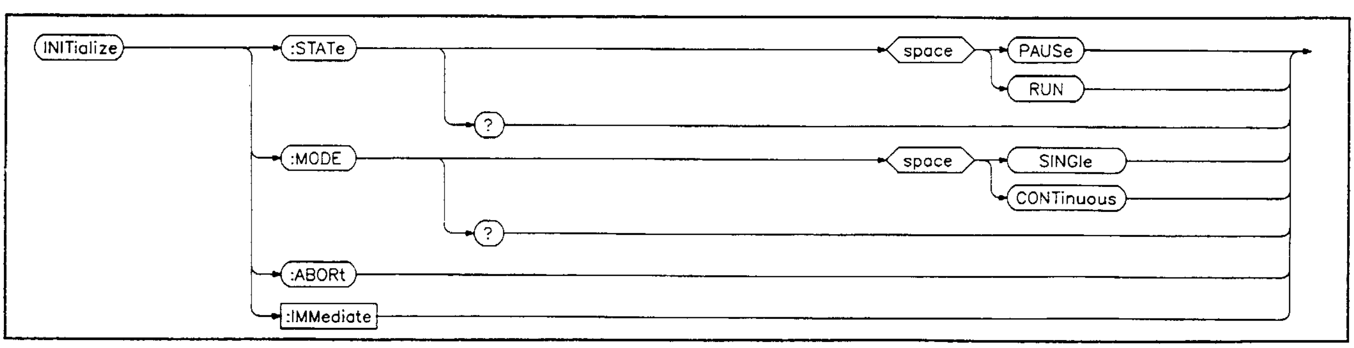


Figure 6-14. Initialize Subsystem.

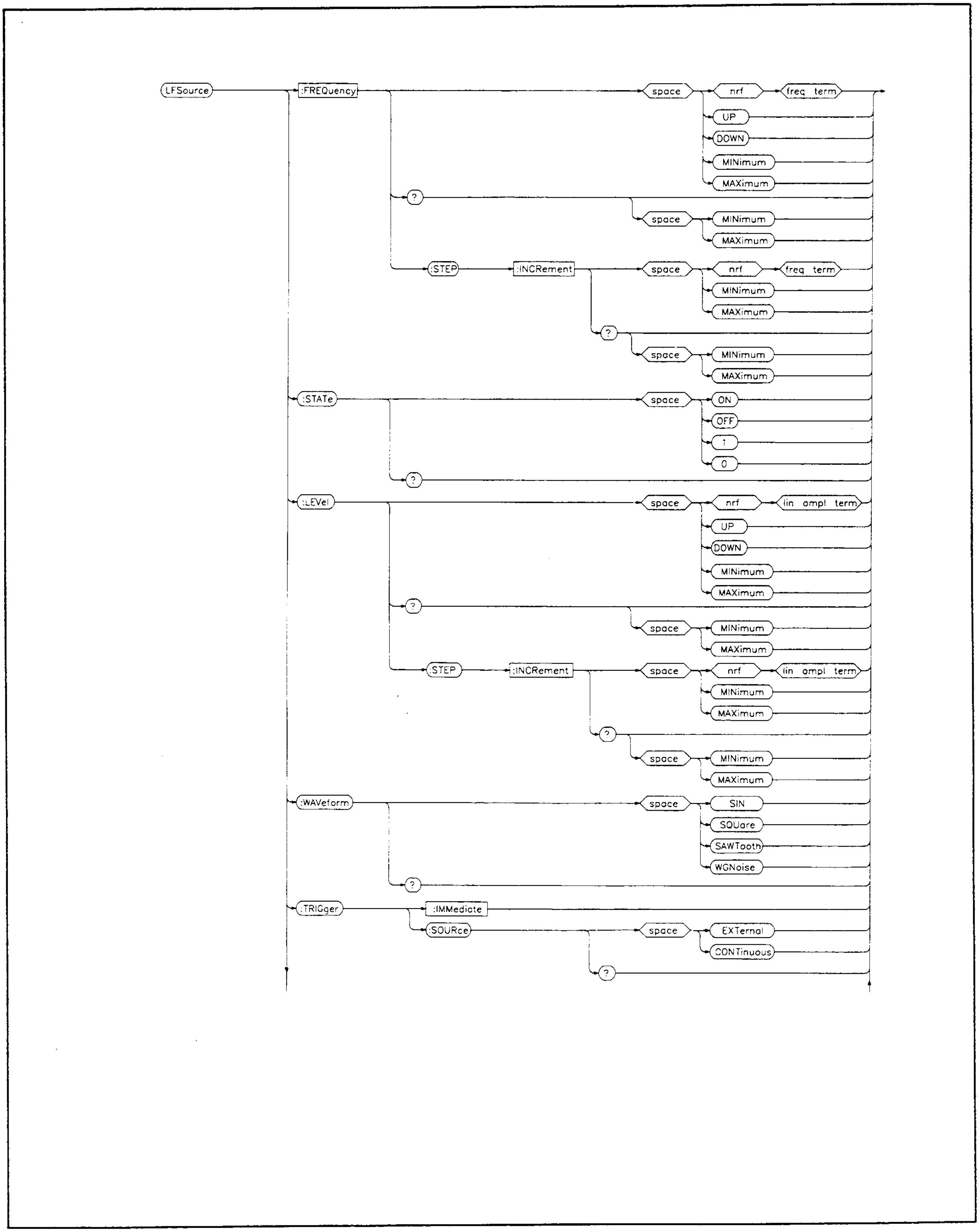


Figure 6–15. LF Source Subsystem. (1 of 6)

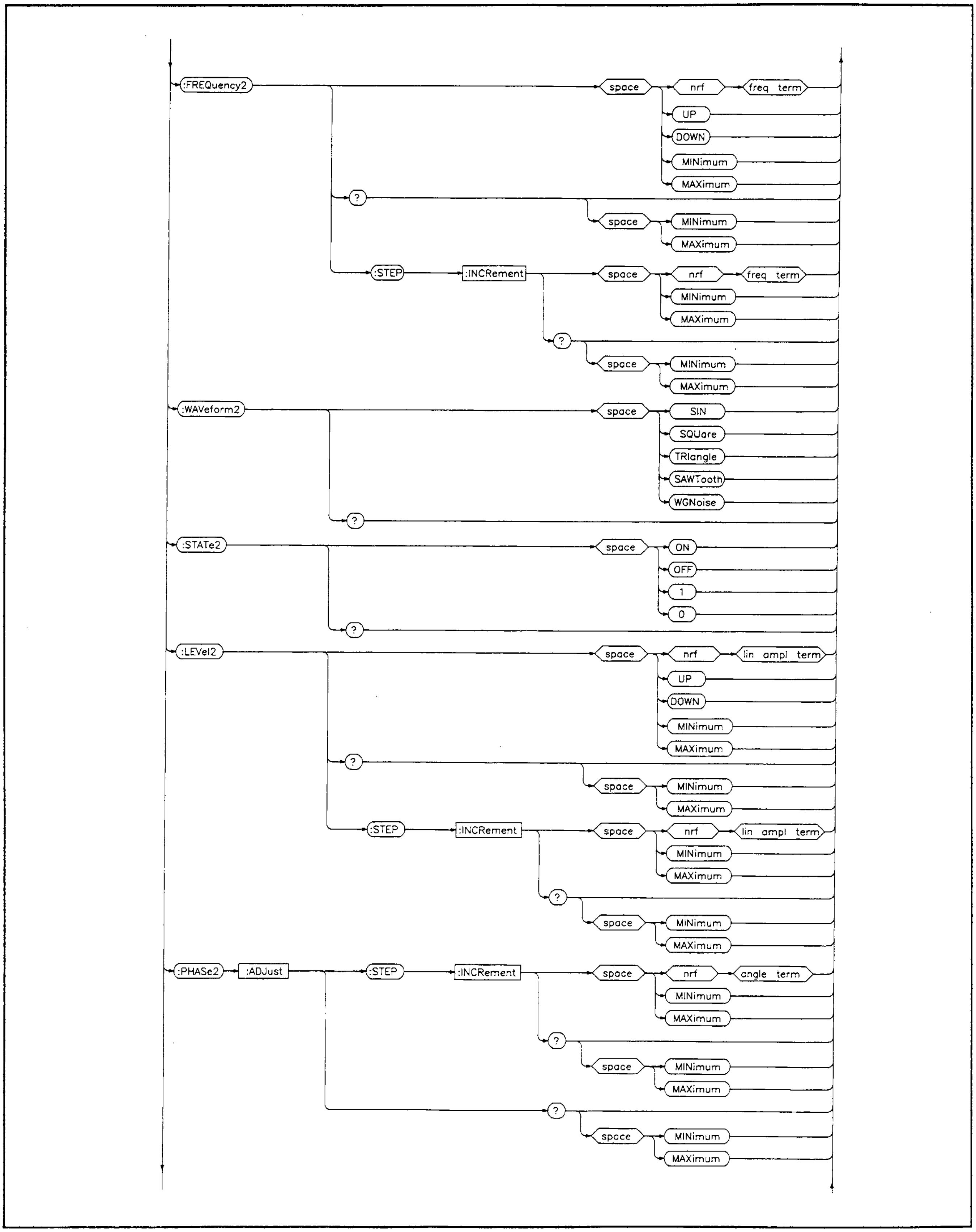


Figure 6–15. LF Source Subsystem. (2 of 6)

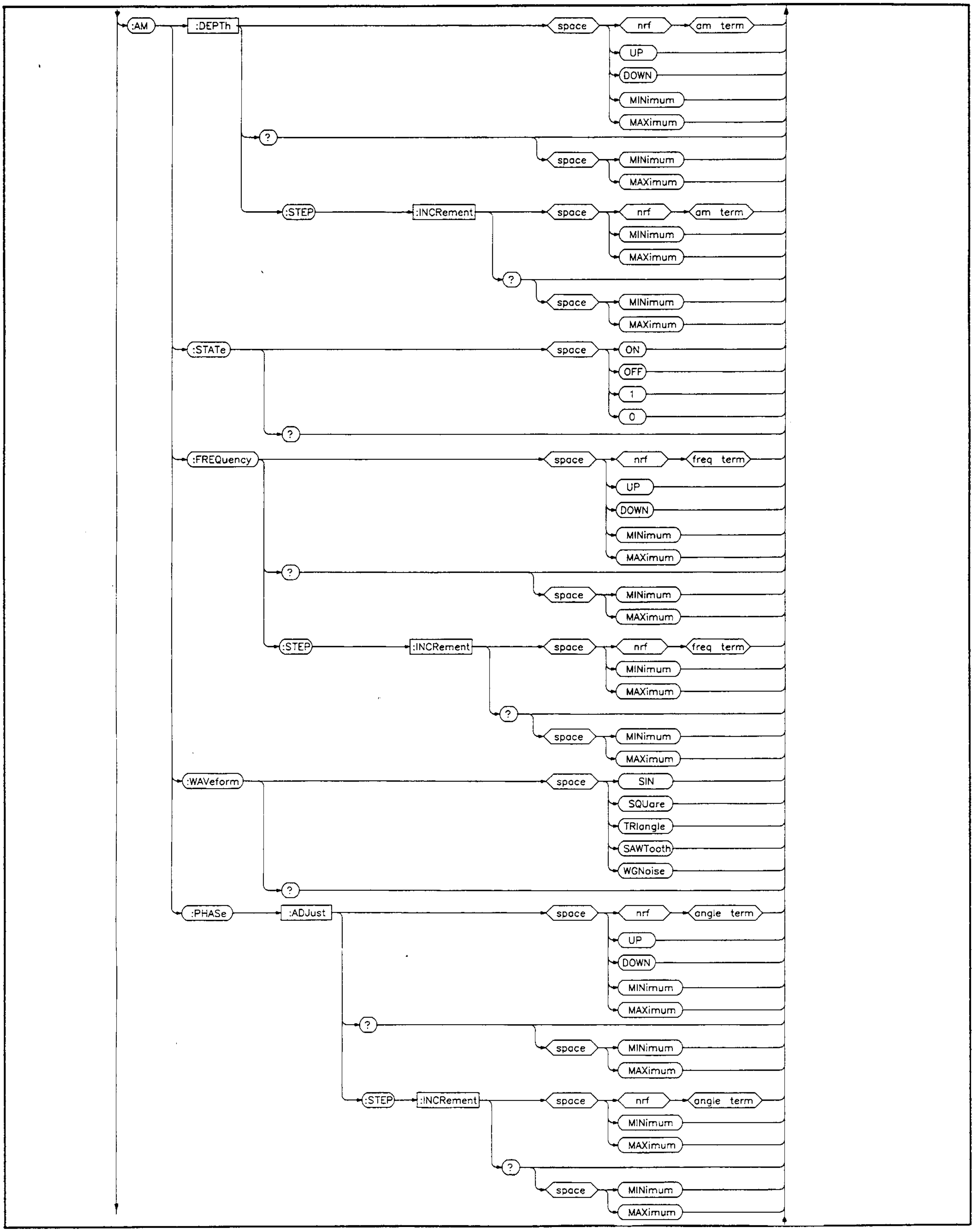


Figure 6–15. LF Source Subsystem. (3 of 6)

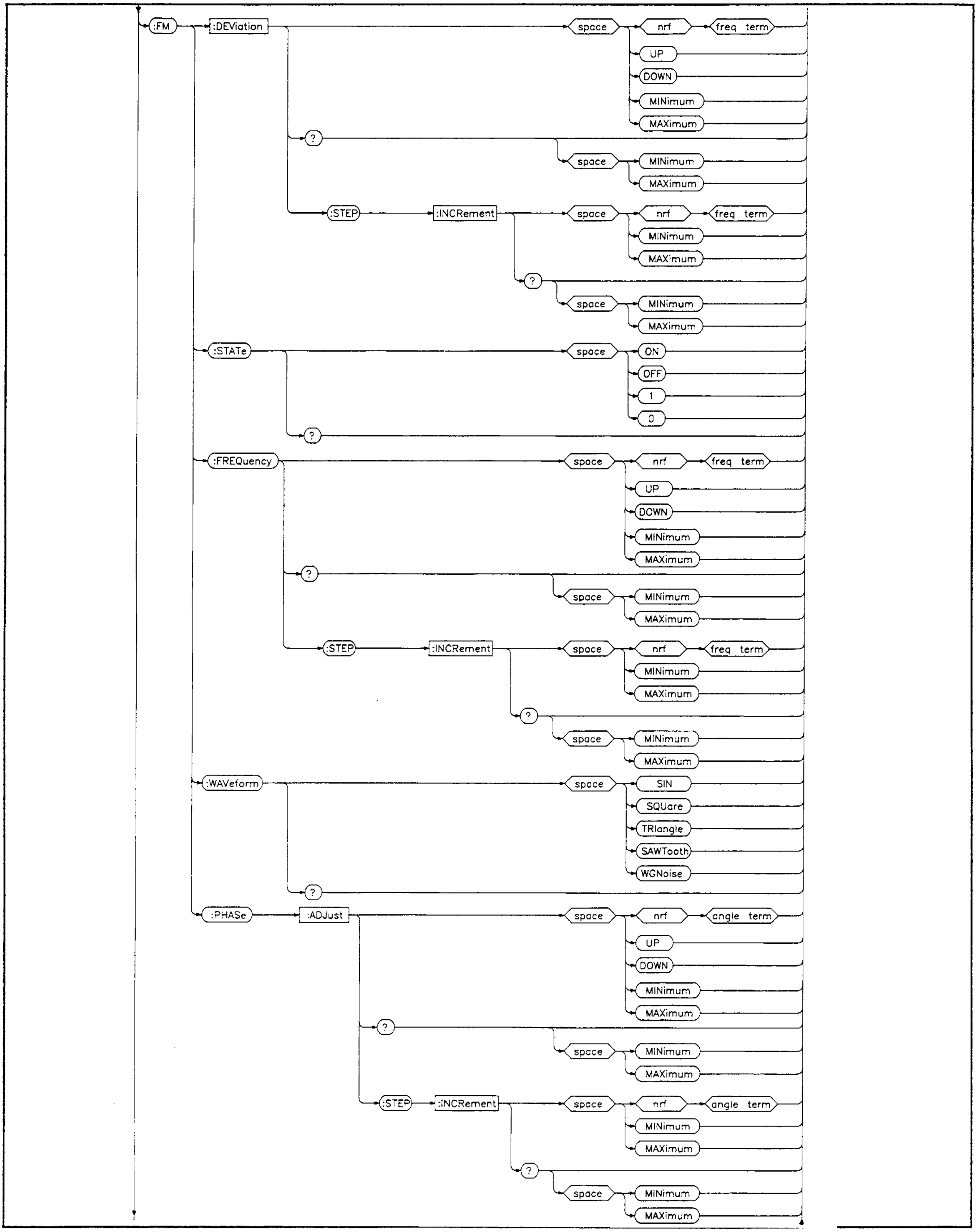


Figure 6-15. LF Source Subsystem. (4 of 6)

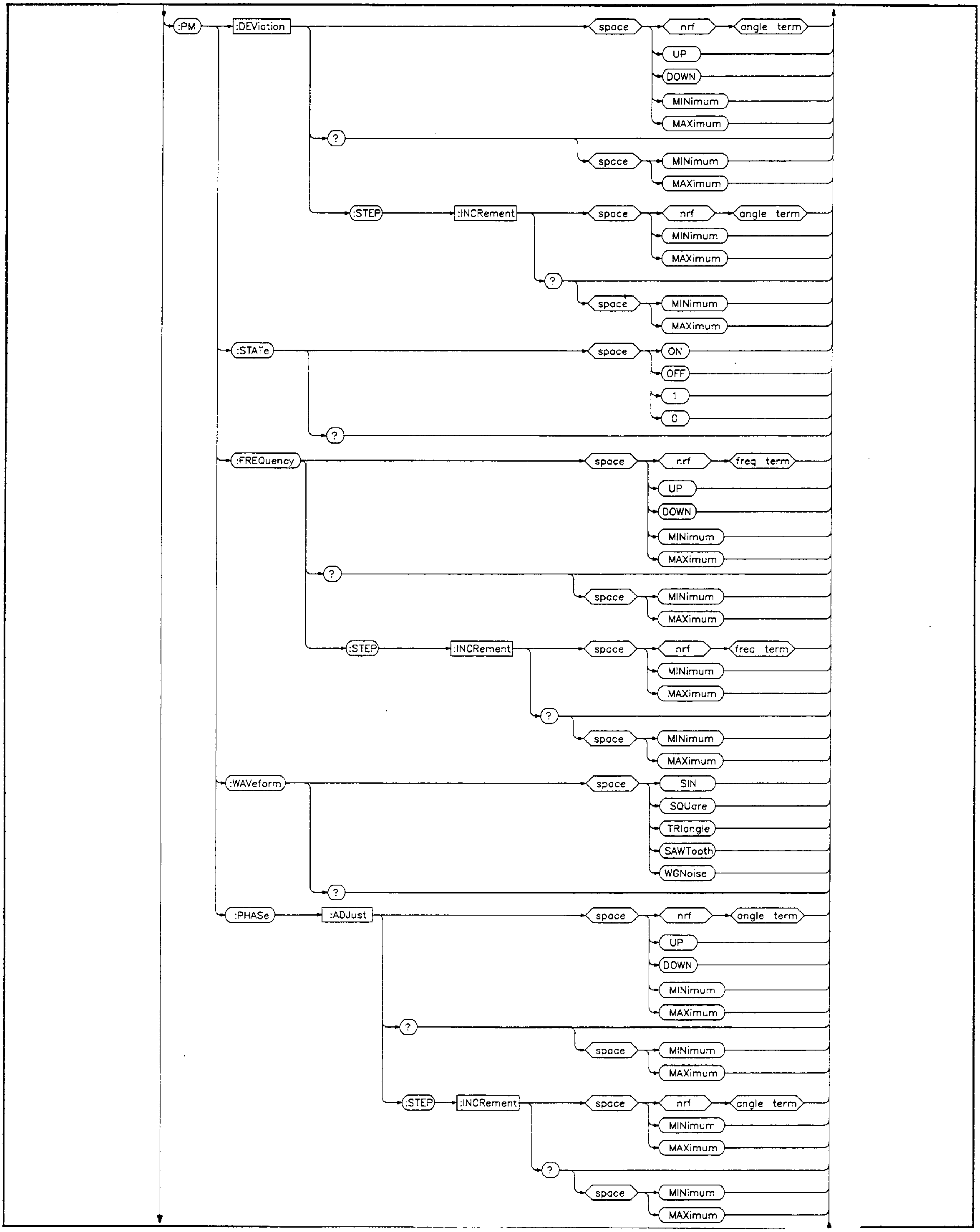


Figure 6-15. LF Source Subsystem. (5 of 6)

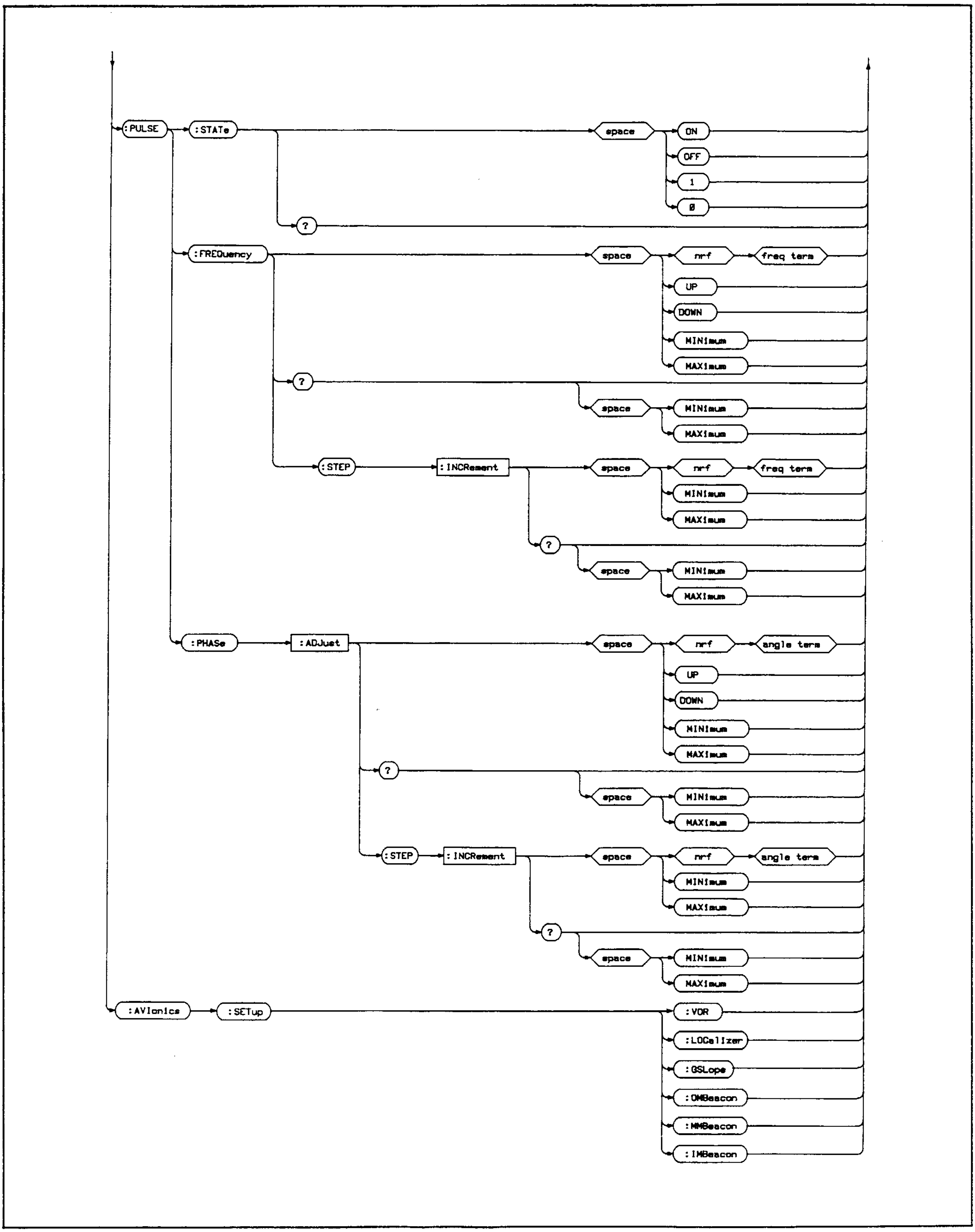


Figure 6-15. LF Source Subsystem. (6 of 6)

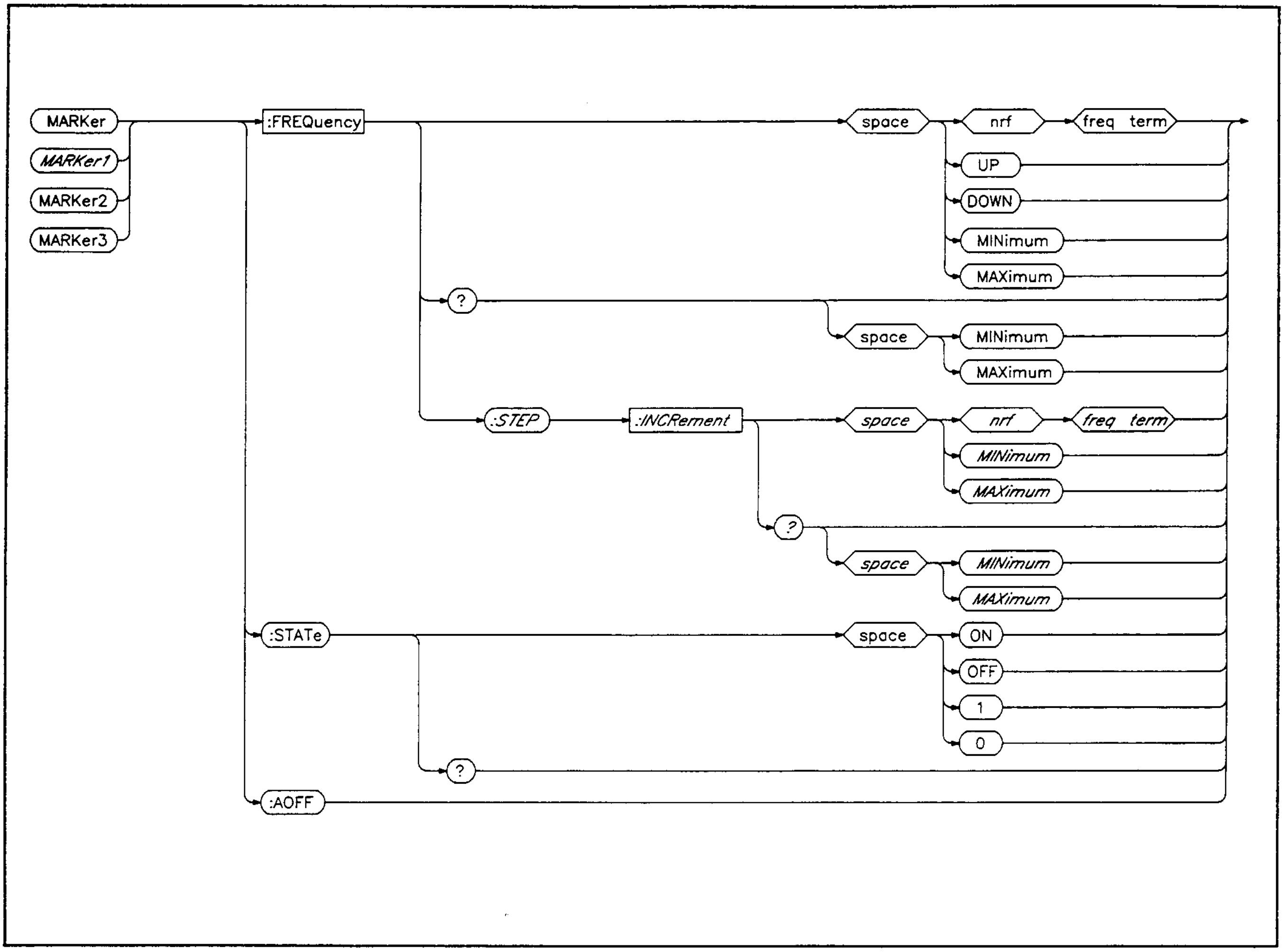


Figure 6-16. Marker Subsystem.

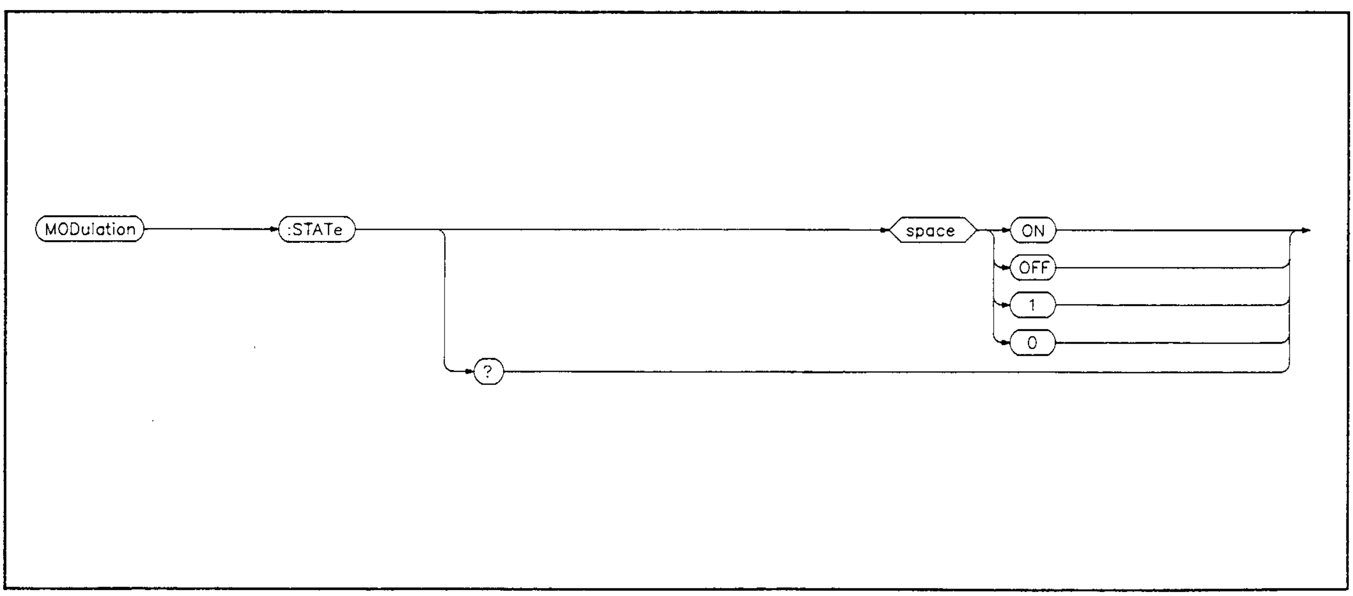


Figure 6-17. Modulation Subsystem.

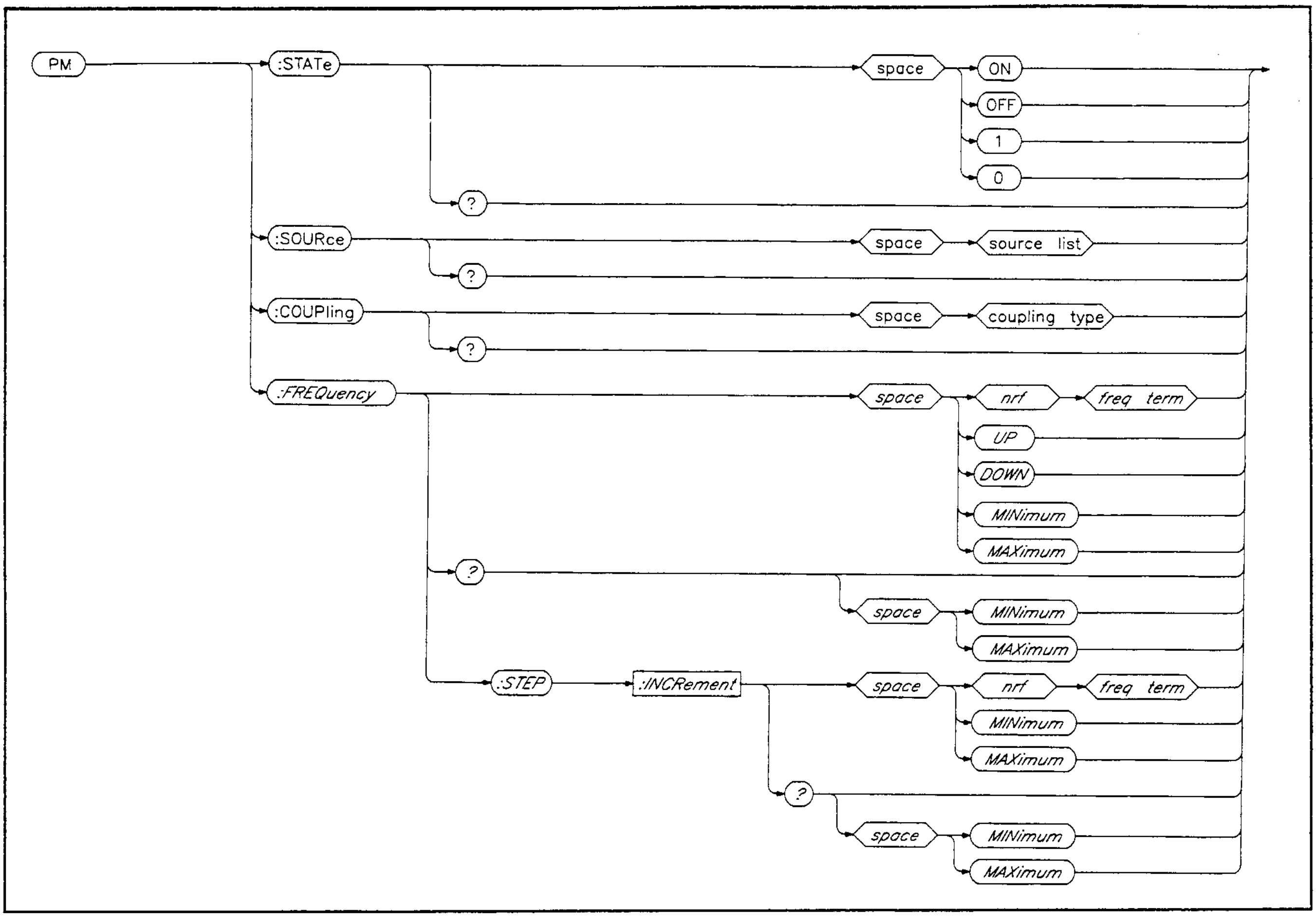


Figure 6-18. Phase Modulation Subsystem.

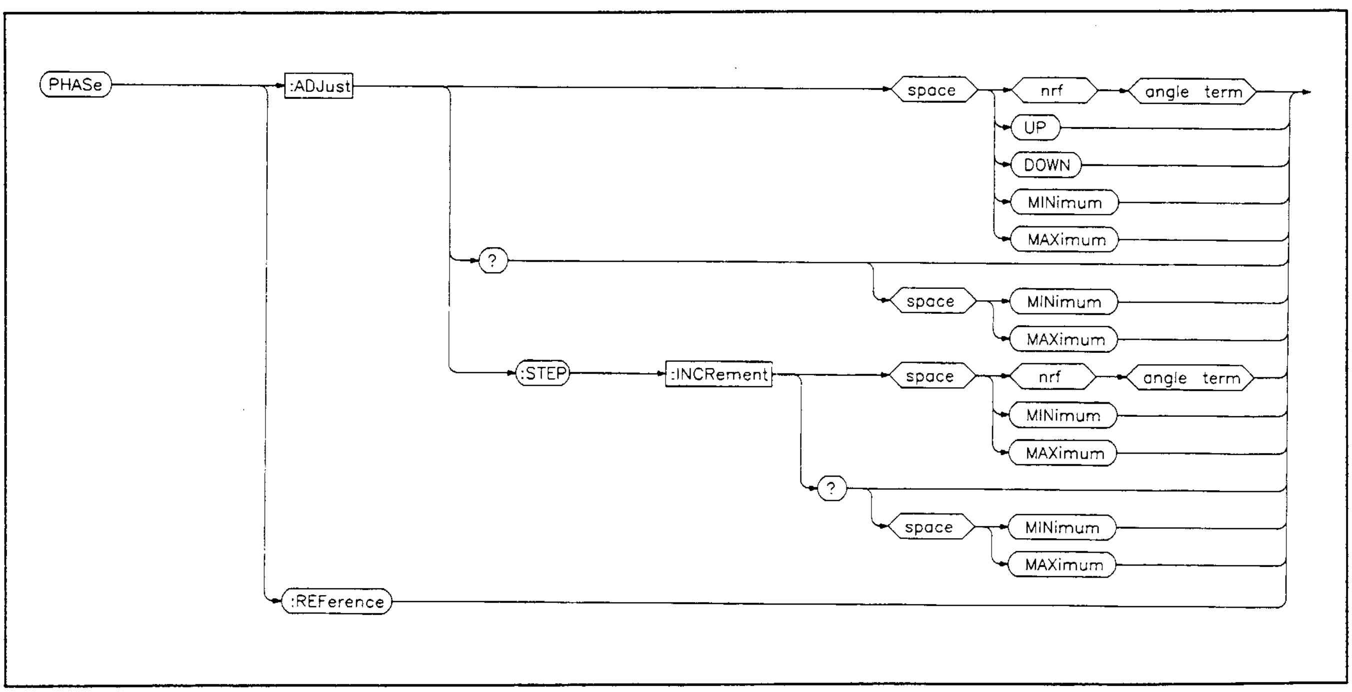


Figure 6-19. Phase Subsystem.

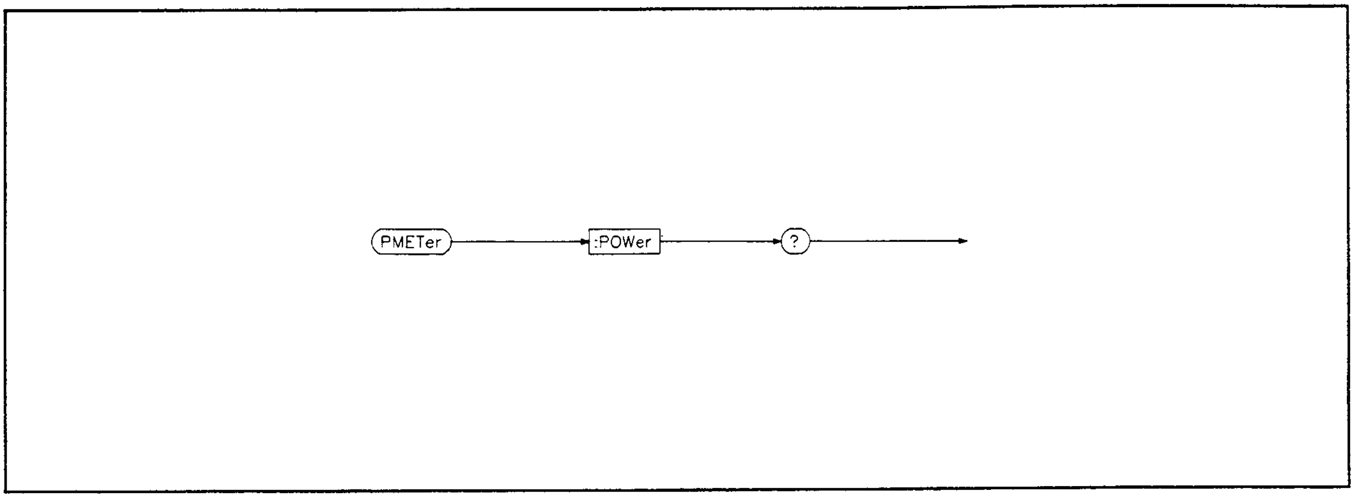


Figure 6-20. Power Meter Subsystem.

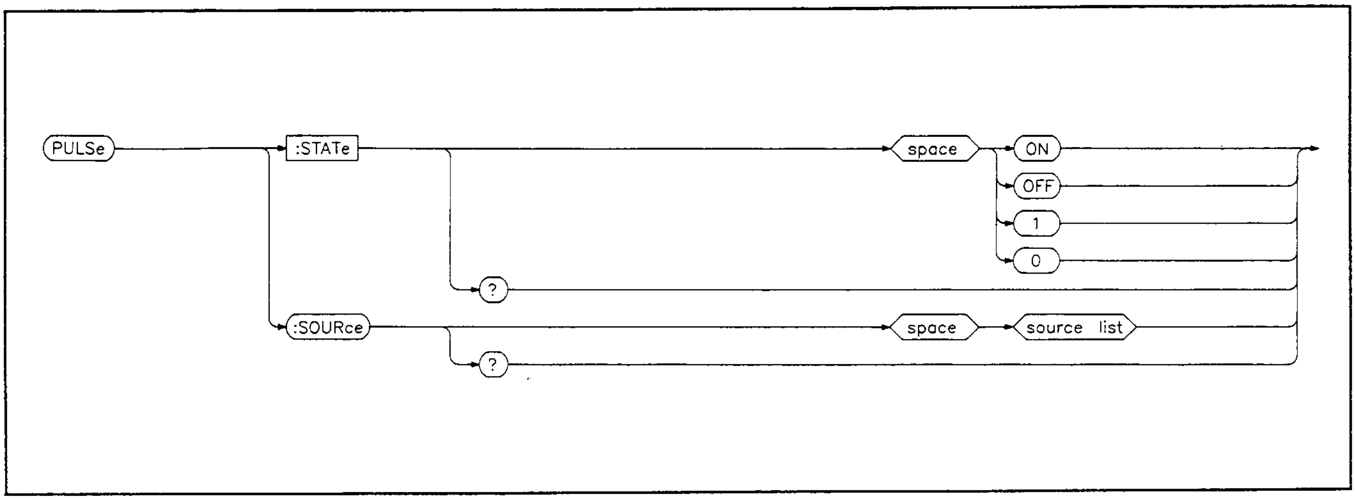


Figure 6-21. Pulse Subsystem.

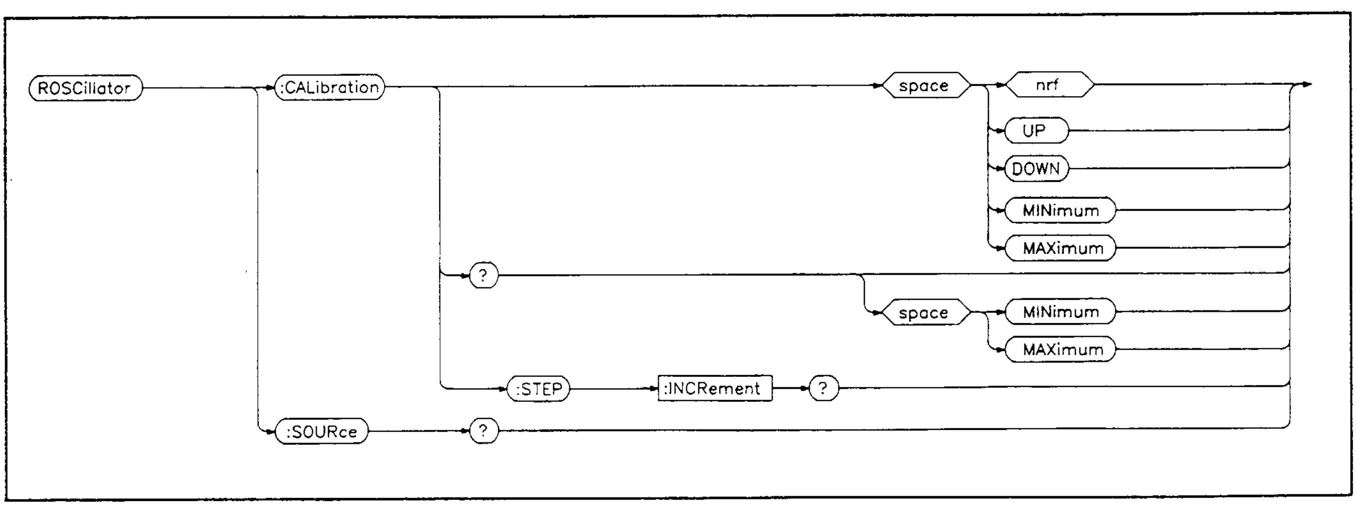


Figure 6-22. Reference Oscillator Subsystem.

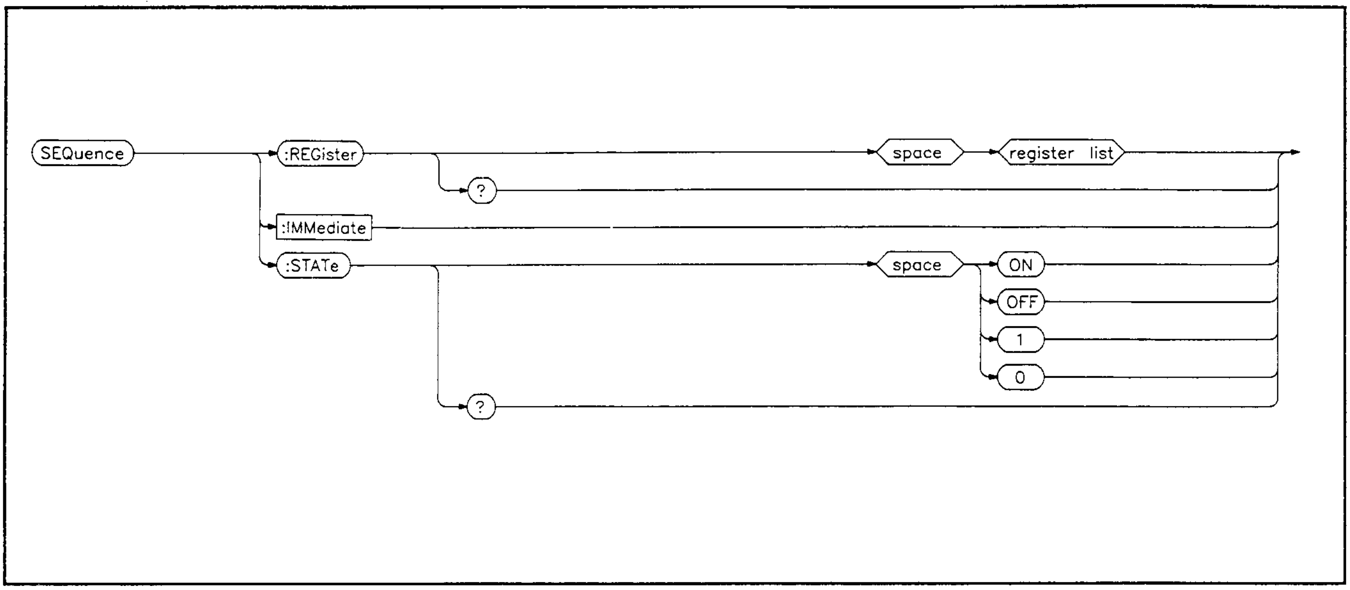


Figure 6-23. Sequence Subsystem.

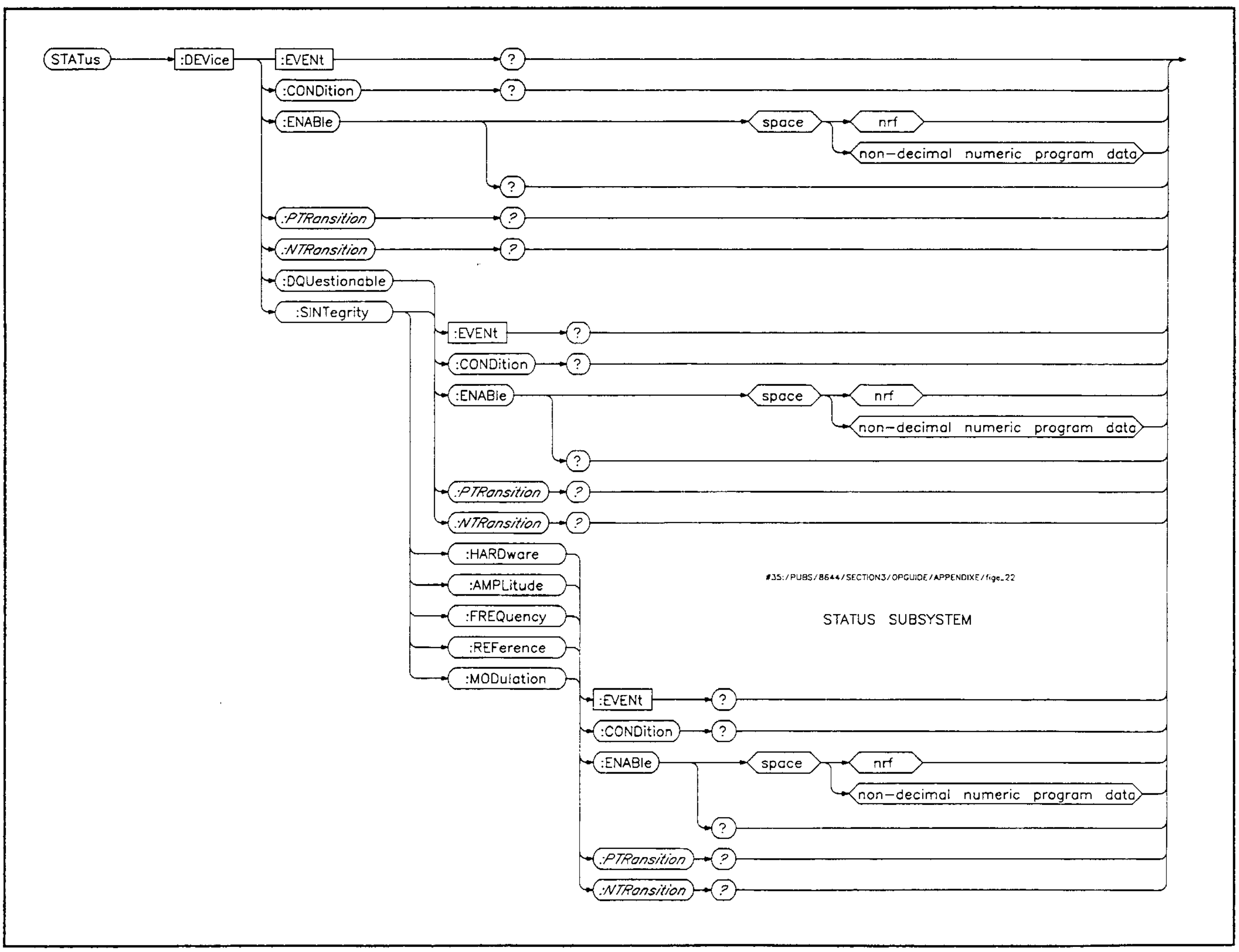


Figure 6-24. Status Subsystem.

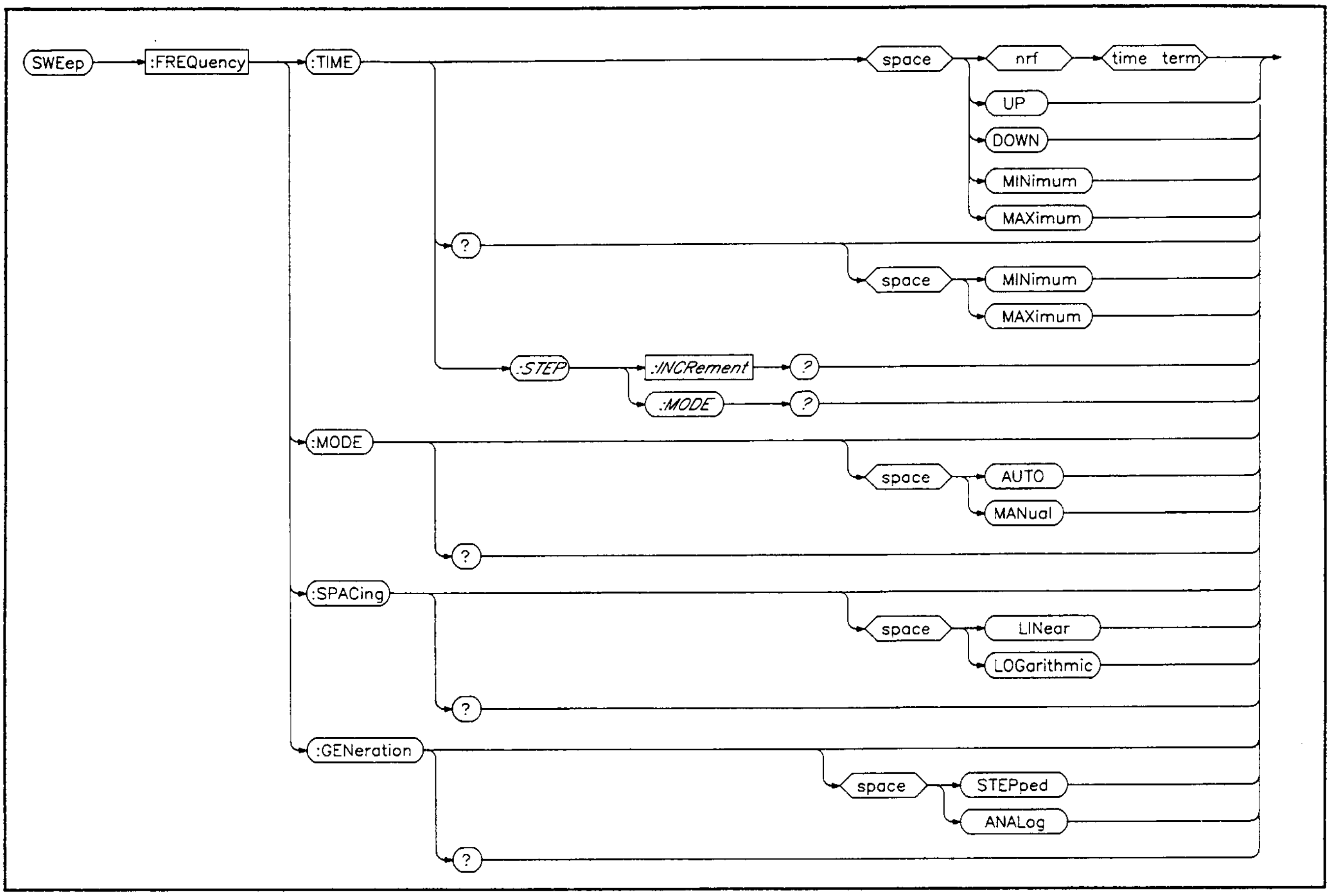


Figure 6-25. Sweep Subsystem.

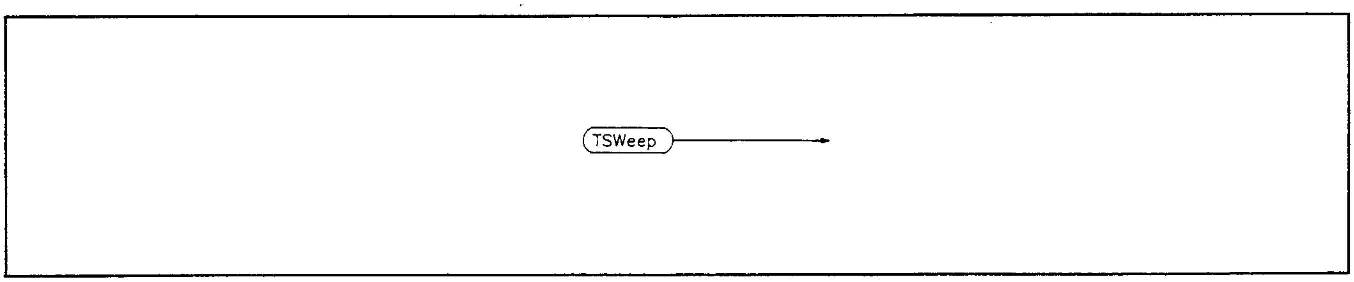


Figure 6-26. Take Sweep Subsystem.

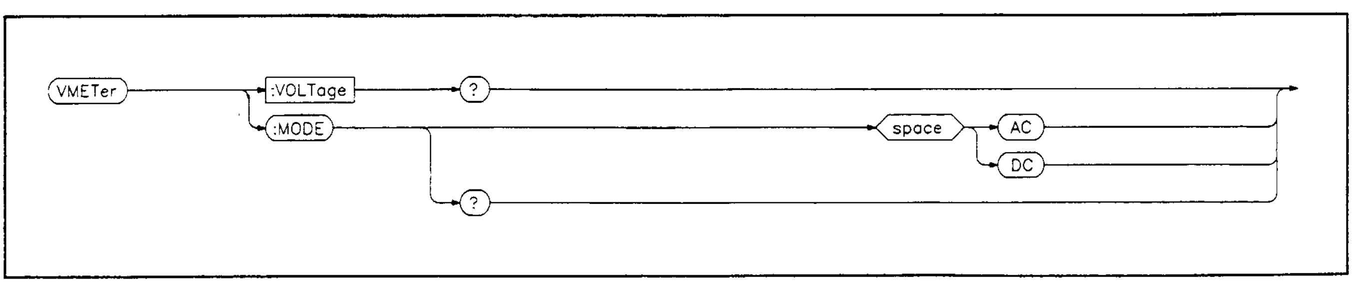


Figure 6-27. Voltmeter Subsystem.

7 Error Messages

What Happens When You Get an Error Message

The Signal Generator interacts with the user to communicate error messages about its operating condition. The error messages suggest or imply that a problem exists either with the instrument or the way in which the user is operating the instrument. Error messages are presented to the user in two ways.

First, if the user attempts to operate the instrument beyond its capabilities, intentionally or not, an error message is immediately shown in the FREQUENCY/STATUS display. Refer to table 7-1 for a description of the error messages that occur under these circumstances.

Second, if the instrument detects a malfunction at power up, or as a result of performing service diagnostics or calibration, an error message is put into the message queue. You will know that this has occurred because the **MSSG** annunciator lights up in the FREQUENCY/STATUS display. Refer to table 7-2 for a description of the error messages that occur under these circumstances.

The error messages in the message queue can then be viewed at the users request by simply pressing the Utility **MSSG** key on the front panel; repetitively pressing the **MSSG** key allows you to view all of the error messages.

To view the error messages again, simply press the blue **SHIFT** key, and then the **MSSG** key. If you have corrected the malfunction shown in the error message list, the message for that error will not reappear.

Note

A hardware failure message does not always indicate that a hardware problem exists. Certain operating conditions may also cause a hardware problem.

Also, if you program the Signal Generator to operate outside of its specified operating ranges a hardware failure may occur. For example, if the current output amplitude and AM depth results in an output signal greater than approximately +16 dBm you may get a hardware failure message.

Table 7-1. Error Messages Immediately Shown to the User. (1 of 8)

Error Message	Description
AM depth too large	The entered amount of AM depth is greater than the maximum permitted (100%). Also, AM depth is limited by the current amplitude setting; Special Function 103 (Amptd Limit) sets the maximum amplitude limit. For example, if the current amplitude setting is +19.9 dBm, the maximum AM depth is 0%.
AM depth too small	The AM depth value entered is less than the minimum permitted (0%).
AM incr too large	The AM increment value entered is greater than the maximum permitted (100%).
AM incr too small	The AM increment value entered is less than the minimum permitted (0.1%).
Amptd incr too large	The amplitude increment value entered is greater than the maximum permitted (100 dB or 1V).
Amptd incr too small	The amplitude increment value entered is less than the minimum permitted (0.1 dB or 0.001 μV).
Amptd limit too high	The Amplitude Limit value entered is greater than the maximum permitted (+19.9 dBm specified by Special Function 103).
Amptd limit too low	The Amplitude Limit value entered is less than the minimum permitted (−137 dBm specified by Special Function 103).
Amptd offset too large	The amplitude offset value entered is greater than the maximum permitted (50 dB).
Amptd offset too small	The amplitude offset value entered is less than the minimum permitted (−50 dB).
Amptd setting too low	The carrier amplitude value entered is less than the minimum permitted (−137 dBm).
Amptd setting too high	The carrier amplitude value entered is greater than the maximum permitted (+19.9 dBm).
Argument out of range	An attempt was made over HP-IB to send an invalid numeral in the command parameter. For example, sending "FM:STATE 2"(there is no STATE 2), or "FREQ:SYNT 6" (there is no Mode 6 synthesis) would give you this error.
Attenuation too large	The attenuation value entered is greater than the maximum permitted (145 dB).
Attenuation too small	The attenuation value entered is less than the minimum permitted (0 dB).
Audio2 freq too high	The frequency of the audio source in Channel 2, entered from Special Function 133, is greater than the maximum permitted (400 kHz).
Audio2 freq too low	The frequency of the audio source in Channel 2, entered from Special Function 133, is less than the minimum permitted (0.1 Hz).

Table 7-1. Error Messages Immediately Shown to the User. (2 of 8)

Error Message	Description
Audio2 level too high	The level of the audio source in Channel 2, entered from Special Function 134, is greater than the maximum permitted (2V).
Audio2 level too low	The level of the audio source in Channel 2, entered from Special Function 134, is less than the minimum permitted (0V).
Audio Φ incr too large	The increment value for phase in the audio source is greater than the maximum permitted (359.9°).
Audio Φ incr too small	The increment value for phase in the audio source is less than the minimum permitted (0.1°).
Audio ΦM dev too large	The ΦM deviation for the audio source in Channel 1, entered from Special Function 145, is greater than the maximum permitted (179.9°).
Audio ΦM dev too small	The ΦM deviation for the audio source in Channel 1, entered from Special Function 145, is less than the minimum permitted (0°).
Audio ΦM freq too high	The ΦM frequency for the audio source in Channel 1, entered from Special Function 146, is greater than the maximum permitted (400 kHz).
Audio ΦM freq too low	The ΦM frequency for the audio source in Channel 1, entered from Special Function 146, is less than the minimum permitted (0.1 Hz).
Audio ΦM incr too large	The increment value of ΦM deviation for the audio source in Channel 1, entered from Special Function 145, is greater than the maximum permitted (179.9°).
Audio ΦM incr too small	The increment value of ΦM deviation for the audio source in Channel 1, entered from Special Function 145, is less than the minimum permitted (0.1°).
Audio AM depth too large	The AM depth for the audio source in Channel 1, entered from Special Function 137, is greater than the maximum permitted (100%).
Audio AM depth too small	The AM depth for the audio source in Channel 1, entered from Special Function 137, is less than the minimum permitted (0%).
Audio AM freq too high	The AM frequency for the audio source in Channel 1, entered from Special Function 138, is greater than the maximum permitted (400 kHz).
Audio AM freq too low	The AM frequency for the audio source in Channel 1, entered from Special Function 138, is less than the minimum permitted (0.1 Hz).
Audio AM incr too large	The increment value of AM depth for the audio source in Channel 1, entered from Special Function 137, is greater than the maximum permitted (100%).
Audio AM incr too small	The increment value of AM depth for the audio source in Channel 1, entered from Special Function 137, is less than the minimum permitted (0.1%).

Table 7-1. Error Messages Immediately Shown to the User. (3 of 8)

Error Message	Description
Audio FM dev too large	The FM deviation for the audio source in Channel 1, entered from Special Function 141, is greater than the maximum permitted (400 kHz).
Audio FM dev too small	The FM deviation for the audio source in Channel 1, entered from Special Function 141, is less than the minimum permitted (0 kHz).
Audio FM freq too high	The FM frequency for the audio source in Channel 1, entered from Special Function 142, is greater than the maximum permitted (400 kHz).
Audio FM freq too low	The FM frequency for the audio source in Channel 1, entered from Special Function 142, is less than the minimum permitted (0.1 Hz).
Audio FM incr too large	The increment value of FM deviation for the audio source in Channel 1, entered from Special Function 141, is greater than the maximum permitted (400 kHz).
Audio FM incr too small	The increment value of FM deviation for the audio source in Channel 1, entered from Special Function 141, is less than the minimum permitted (0.1 Hz).
Audio freq incr too low	The audio frequency increment value entered is less than the minimum permitted (0.1 Hz).
Audio freq incr too high	The audio frequency increment value entered is greater than the maximum permitted (400 kHz).
Audio freq too low	The audio frequency value entered is less than the minimum permitted.
Audio freq too high	The audio frequency value entered is greater than the maximum permitted.
Audio level/AM conflict	The sum of the audio levels in Channels 1 and 2 cannot exceed 2 Vpk with the AM source in Channel 1 ON.
Audio level conflict	The sum of the audio levels in Channels 1 and 2 cannot exceed 2 Vpk.
Audio level incr high	The audio level increment value entered is greater than the maximum permitted (2V).
Audio level incr low	The audio level increment value entered is less than the minimum permitted (1.0 mV).
Audio level too high	The audio level value entered is greater than the maximum permitted (2 V).
Audio level too low	The audio level value entered is less than the minimum permitted (0V).
Aud lev/source conflict	The sum of the audio levels in Channels 1 and 2 cannot exceed 2 Vpk, and too many audio sources are turned ON.

Table 7-1. Error Messages Immediately Shown to the User. (4 of 8)

Error Message	Description
Aud pulse freq too high	The frequency of the audio pulse entered from Special Function 150 is greater than the maximum permitted (50 kHz).
Aud pulse freq too low	The frequency of the audio pulse entered from Special Function 150 is less than the minimum permitted (0.1 Hz).
Bad char during numeric	While the instrument was reading in a numeric argument, a character other than "0" through "9" occurred at a place where it is not valid to end the number.
Bad/missing exponent	After getting a valid mantissa and an "E" (for exponential), a character was found that was not a digit "0" through "9" or a ± sign, or the character was not a digit "0" through "9" after an "E+" or an "E−".
Bad register number	The recalled Save Register does not contain a SAVE setting, or the recalled Save Register is less than 0 or greater than 49.
Bad sequence entry	An attempt was made to enter a register value less than 0 or greater than 9 into the Save/Recall Sequence list.
Cannot continue	An attempt has been made to restart diagnostic testing after altering an internal cable or module without being in the repair mode, or you have come to the point where no additional tests are available or the test sequence has ended.
Center freq too high	The center frequency value entered for the sweep is greater than the maximum permitted.
Center freq too low	The center frequency value entered for the sweep is less than the minimum permitted.
Counter setting too low	With a Signal Generator Option 011, an attempt has been made to set the lower limit of the frequency counter range or gate time to an invalid value over the HP-IB bus.
Counter setting too high	With a Signal Generator Option 011, an attempt has been made to set the upper limit of the frequency counter range or gate time to an invalid value over the HP-IB bus.
Empty sequence list	An attempt was made to sequence through an empty Save/Recall sequence list.
EOC during numeric	While the instrument was reading in a numeric argument, an end-of-command (EOC) condition occurred at a place where it is not valid to end the number (for example, after a ± sign, after a decimal with no leading digits, or after an "E" for exponential).
EOM during numeric	While the instrument was reading in a numeric argument, an end-of-message (EOM) condition occurred at a place where it is not valid to end the number (for example, after a ± sign, after a decimal with no leading digits, or after an "E" for exponential).
EOM in #B/Q/H W/O data	An end-of-message (EOM) was encountered without getting any data in, or without getting the "B" (for binary), "Q" (for octal), or "H" (for hexadecimal) while the instrument was reading in a non-decimal numeric argument.

Table 7–1. Error Messages Immediately Shown to the User. (5 of 8)

Error Message	Description
EOM in arbitrary block	An end-of-message (EOM) was encountered before the end of data while the instrument was reading in an "arbitrary block program data".
Error-EOC after colon	An end-of-command (EOC) was encountered after a colon in the command header. A colon in the command header must always be followed by a keyword mnemonic.
Error-EOC after comma	An end-of-command (EOC) was found after a comma. A comma in the data string must be followed with an additional data item(s).
Error-EOM after colon	An end-of-message (EOM) condition was encountered after a colon in the command header. A colon in the command header must always be followed by a keyword mnemonic.
Error-EOM after comma	An end-of-message (EOM) was found after a comma. A comma in the data string must be followed with an additional data item(s).
Error-Space after colon	A space character was encountered after a colon in the command header. A colon in the command header must always be followed by a keyword mnemonic.
Exponent too big	The numeric exponent was either less than −127 or greater than 127.
FM deviation too large	The FM deviation value entered is greater than the maximum permitted. Refer to the specifications in the technical data sheet or to chapter 2 for FM deviation limits.
FM deviation too small	The FM deviation value entered is less than the minimum permitted. Refer to the specifications in the technical data sheet or to chapter 2 for FM deviation limits.
FM incr too large	The FM increment value entered is greater than the maximum permitted (100 MHz).
FM incr too small	The FM increment value entered is less than the minimum permitted (0.01 Hz).
FM out of range for mode	An attempt was made to change from a Synthesis Mode setting with a higher deviation range, to a Synthesis Mode setting with less deviation range for the set RF output. Push the Synthesis Mode **AUTO** key to let the Signal Generator determine the best mode for the deviation and RF output you have selected.

Table 7-1. Error Messages Immediately Shown to the User. (5 of 8 Cont.)

Error Message	Description
Freq divider too large	The frequency divider value entered is greater than the maximum permitted (−10 from the front panel, 0.1 over HP-IB).
Freq incr too large	The frequency increment value entered is greater than the maximum permitted (10 GHz).
Freq incr too small	The frequency increment value entered is less than the minimum permitted (0.01 Hz).
Freq mult too large	The frequency multiplier value entered is greater than the maximum permitted (10).
Freq offset too large	The frequency offset value entered is greater than the maximum permitted (50 GHz).
Freq offset too small	The frequency offset value entered is less than the minimum permitted (−50 GHz).
Freq setting too high	The frequency value entered is greater than the maximum permitted.
Freq setting too low	The frequency value entered is less than the minimum permitted.

Table 7-1. Error Messages Immediately Shown to the User. (6 of 8)

Error Message	Description
Frequency span too large	The frequency span value entered for the sweep is greater than the maximum permitted.
Frequency span too small	The frequency span value entered for the sweep is less than the minimum permitted.
Hardware not installed	An attempt was made to activate a Synthesis Mode setting presently not installed in the instrument.
HP-IB Command error	This is a generic HP-IB command error. Something is wrong with the command, but the firmware does not recognize the specific problem.
HP-IB No response data	The instrument was given the HP-IB interface command to "talk", but has not been told to "say" anything.
HP-IB Query interrupted	The instrument was given a command to return some data, then given another command before the entire response was read back from the instrument.
HP-IB Query unterminated	The instrument was given the HP-IB interface command to talk, and has received part of a message including a command to return some data, but the message was not terminated (not completely sent, or no end-of-message sent).
Insufficient capability	An attempt has been made to activate a function or feature presently not configured or accessible.
Int modulation enabled	An attempt has been made over HP-IB to turn off the audio source with the internal modulation source turned on.
Invalid char after ''.''	While the instrument was reading in a numeric argument, a character other than "0" through "9", or an "E" (for exponential) with no digits before the decimal occurred.
Invalid char after sign	While the instrument was reading in a numeric argument, a character other than "0" through "9", or a decimal point occurred after the ± sign.
Invalid data mnemonic	A mnemonic was not recognized as the instrument was reading in a non-numeric parameter.
Invalid header mnemonic	A keyword mnemonic in the command header is not recognized as a keyword. Incorrect protocol or a spelling mistake might be the cause.
Invalid suffix	While the instrument was reading in a numeric argument, an invalid suffix occurred after a comma, semicolon, or end-of-command.
Log sweep not allowed	An attempt has been made to do phase continuous log sweep.
Marker freq too high	The marker frequency value entered is greater than the maximum permitted.
Marker freq too low	The marker frequency value entered is less than the minimum permitted (251,464.85 Hz).
Missing space after ''?''	A non-blank character other than a semicolon followed a question mark. The question mark must either be followed by an end-of-message, an end or command, or a space before a parameter.

Table 7-1. Error Messages Immediately Shown to the User. (7 of 8)

Error Message	Description
Mod and sweep conflict	An attempt was made to phase continuous sweep with internal modulation on, or with internal or external FM, ΦM, or the audio source turned on.
Needs space after header	The characters following the command header must have a space or an end-of-command message.
No manual Φ cont. sweep	An attempt was made to do Manual phase continuous sweep.
No such special	An invalid Special Function number was entered. Refer to chapter 4 for a list of available Special Functions.
Not allowed-Security on	An attempt has been made to turn on a "Blanked" display area when the security Special Function 173 is active.
Notice >> FM turned off	An attempt was made to turn on ΦM with FM on, or an attempt was made to go from CW to sweep or from sweep to CW with FM set to a value out of range for the frequency that was entered.
Notice >> ΦM turned off	An attempt was made to turn on FM with ΦM already on.
Notice Aud state changed	A conflict has occured which causes a subcarrier modulation source to be turned off in order to allow modulation on the RF carrier.
Not in service mode	An attempt has been made over HP-IB to access a service Special Function that is not accessible because the service mode switch has been turned off.
Numeric overflow	The number was out of range for the parameter being set.
Reference cal too high	The reference calibration value entered is greater than the maximum permitted (255).
Reference cal too low	The reference calibration value entered is less than the minimum permitted (0).
Reverse power detected	A reverse power condition was detected at either the RF Output. (Disconnect the affected output from any external equipment and re-enter the key sequence that originally resulted in the error. If an error is still detected by the instrument, a reverse power problem still exists.)
Sequence overflow	An attempt was made to enter more than 10 entries into the Save/Recall Sequence list.
Settings conflict	Certain operating conditions are in conflict. For example, an attempt was made over HP-IB to set the Amplitude Limit to a value less than the current amplitude setting.
Start frequency too high	The start frequency value entered for the sweep is greater than the maximum permitted.
Start frequency too low	The start frequency value entered for the sweep is less than the minimum permitted.

Table 7-1. Error Messages Immediately Shown to the User. (8 of 8)

Error Message	Description
Stop frequency too high	The stop frequency value entered for the sweep is greater than the maximum permitted.
Stop frequency too low	The stop frequency value entered for the sweep is less than the minimum permitted.
Sweep settings conflict	An attempt was made over HP-IB to send a command message with conflicting sweep statements.
Sweep time too large	The sweep time value entered is greater than the maximum permitted. Refer to the specifications in the technical data sheet or to chapter 2 for sweep time limits.
Sweep time too small	The sweep time value entered is less than the minimum permitted. Refer to the specifications in the technical data sheet or to chapter 2 for sweep time limits.
Too many audio sources	There cannot be more than three other audio sources turned ON with the audio source in Channel 1 turned ON.
Too many commands	Too many commands were sent in a single message. The message must be broken up into several messages with less commands in each one.
Unexpected ''?''	A question mark was found in the data string. A question mark should only occur immediately after the command header.
Unexpected colon	A colon was found in the command header in an invalid location (for example, after another colon, after a question mark, or found with a command parameter).
Unexpected comma	A comma was found in the command header, before the first argument, or after another comma. Commas are only allowed between certain arguments in the command header or message.
Unexpected EOC	An unexpected end-of-command (EOC) condition was found by the instrument before a valid command was complete. This includes not having a required parameter in a command.
Unexpected EOM	An unexpected end-of-message (EOM) condition was found by the instrument before a valid command was complete. This includes not having a required parameter in a command.
Unrecognized ''#'' format	In a non-decimal numeric argument you must use a binary, octal, hexadecimal, or "arbitrary block program data" format.
Wrong char after suffix	An unexpected character was encountered by the instrument after reading in a numeric suffix. This may indicate a missing comma, semicolon, or an end-of-message.
Wrong position for ''?''	A question mark was found at the start of the message, after a colon or a space, or after an argument or a suffix. Question marks must follow directly after command header mnemonics.

Table 7–2. Error Messages Put In the Message Queue for the User. (1 of 4)

Error Message	Description
Hardware Failure 1	A communications discriminator failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 2	A VCO failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 3	A Fractional-N failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 4	A modulation distribution failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 5	An ALC failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 6	An attenuator failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 7	An audio source failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 8	A reference failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 9	A doubler failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 13	A front panel failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 14	A power supply failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 15	An I/O board failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.

Table 7-2. Error Messages Put In the Message Queue for the User. (2 of 4)

Error Message	Description
Hardware Failure 16	A controller failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7-1 for corrective action.
Hardware Failure 18	A frequency counter failure has been detected at power up. Refer to figure 7-1 for corrective action. Unit should have option 011. If unit was turned off for a long period (ex: 30 days), the instrument will need recalibrated. For option 011, a cable must be attached on the front panel.
Hardware Failure 21	A communications discriminator out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 23	A Fractional-N (NF) phase-locked-loop (PLL) out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 24	A VCO frequency-locked-loop (FLL) out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 25	A VCO phase-locked-loop (PLL) out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 26	A fast controller failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7-1 for corrective action.
Hardware Failure 27	An audio source out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 28	A reference out-of-lock (OOL) condition exists. Refer to figure 7-1 for corrective action.
Hardware Failure 31	A ROM failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7-1 for corrective action.
Hardware Failure 32	A ROM failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7-1 for corrective action.
Hardware Failure 33	A ROM failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7-1 for corrective action.

Table 7–2. Error Messages Put In the Message Queue for the User. (3 of 4)

Error Message	Description
Hardware Failure 34	A ROM failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 35	A voltmeter failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Hardware Failure 36	A RAM failure has been detected at power up, or detected as a result of a self-calibration or self-test. Refer to figure 7–1 for corrective action.
Calibration Error 1	A condition occurred where invalid level calibration data resides in either the Output or the Attenuator modules. Follow the external calibration procedures outlined in figure 7–1 .
Calibration Error 2	At some time during the calibration or self-test, a condition occurred where some hardware was unable to be calibrated. Fix the hardware and re-calibrate. Refer to figure 7–1 for corrective action. This error message will always be accompanied by other error messages.
Calibration Error 3	A sensor indicates that inside temperature has varied $\pm 10°$ Centigrade ($\pm 18°$ Fahrenheit) from where the temperature was when the instrument was last calibrated. A re-calibration by activating Special Function 171 may be necessary for the instrument to maintain its specifications.
Amplitude Error 1	An Automatic-Level-Control (ALC) out-of-lock (OOL) condition exists. An operating condition may have caused the OOL error, or a hardware problem may exist; check out both possibilities.
Amplitude Error 2	A doubler amplitude out-of-lock (OOL) condition exists. An operating condition may have caused the OOL error, or a hardware problem may exist; check out both possibilities.
User Memory Cleared	A memory failure has been detected, all battery backup memory is lost. Refer to figure 7–1 for corrective action.
Reverse power detected	A reverse power condition was detected at the RF Output. (Disconnect the affected output from any external equipment and re-enter the key sequence that originally resulted in the error. If an error is still detected by the instrument, a reverse power problem still exists.)

Note *The "Transient Errors" listed in the following table (4 of 4) will only appear if Special Function 328 is activated. Refer to the Service Documentation for corrective action if you see one of these messages.*

Table 7–2. Error Messages Put In the Message Queue for the User. (4 of 4)

Error Message	Description
Transient Error 1	A transient communications discriminator out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.
Transient Error 3	A transient Fractional-N (NF) phase-locked-loop (PLL) out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.
Transient Error 5	A transient Automatic-Level-Control (ALC) out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.
Transient Error 7	A transient audio source out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.
Transient Error 8	A transient reference out-of-lock (OOL) condition occurred. Refer to figure 7–1 for corrective action.
Transient Error 9	A transient doubler out-of-lock (OOL) condition occurred. Refer to figure 7–1 for corrective action.
Transient Error 24	A transient VCO frequency-locked-loop (FLL) out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.
Transient Error 25	A transient VCO phase-locked-loop (PLL) out-of-lock (OOL) condition occurred. Refer to the service documentation for corrective action.

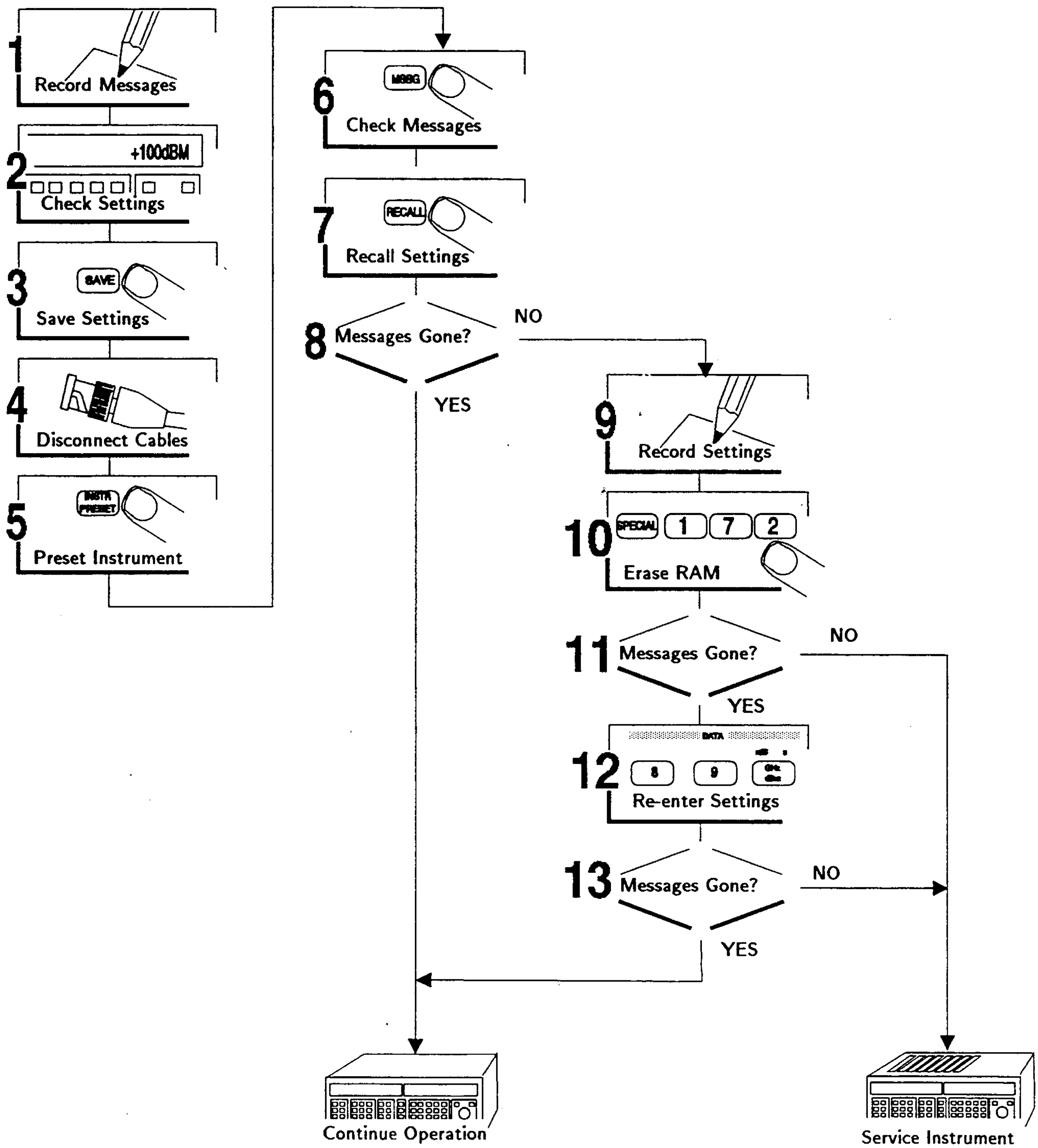
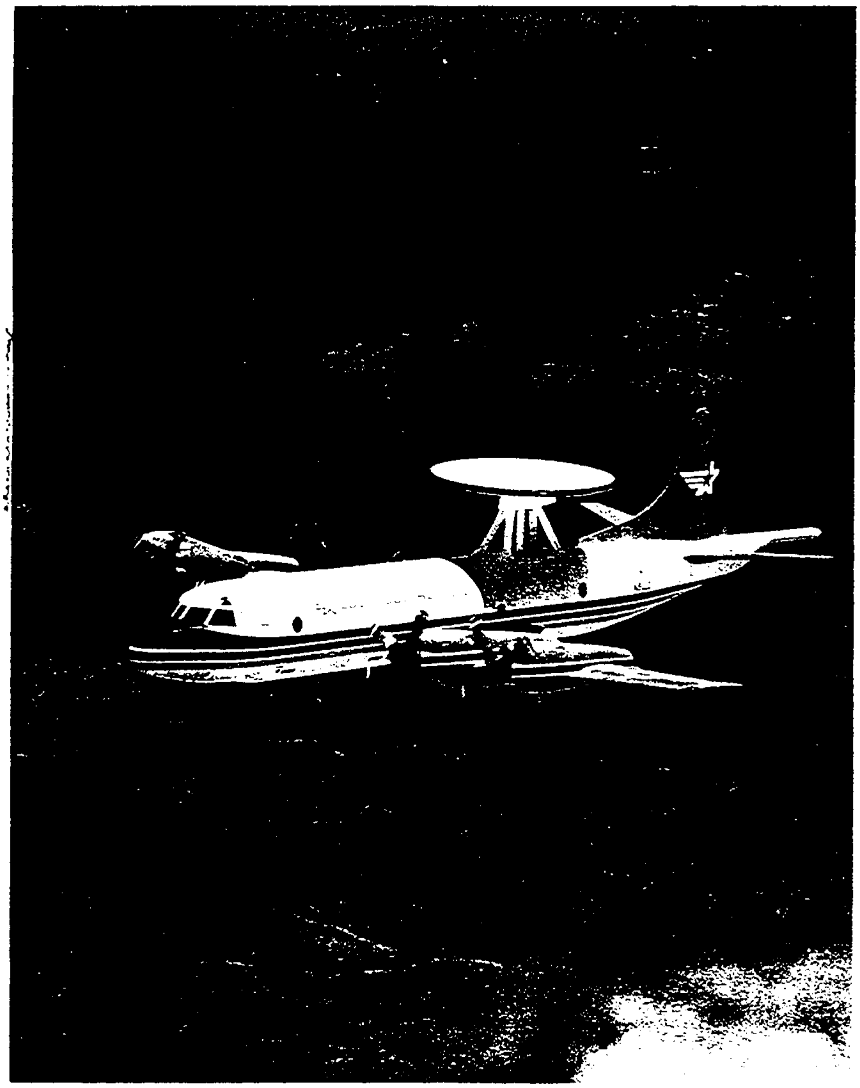


Figure 7–1. Corrective Action for Error Messages

HEWLETT PACKARD

HP 8644A-2 Air Navigation Receiver Testing with the HP 8644A

Application Note



Co-tesy Lockheed

This application note describes the synthesized internal audio source used in the HP 8645A, HP 8665A, and HP 8644A/007 Signal Generators. This flexible source can be used as a modulation source, as an audio function generator, or to extend the frequency range of the signal generator down to 0.1 Hz with complete AM, FM, ϕM and pulse modulation. In addition to general purpose modulation signals, this note describes how the audio source is used in conjunction with the signal generator to create VOR and ILS air navigation waveforms.

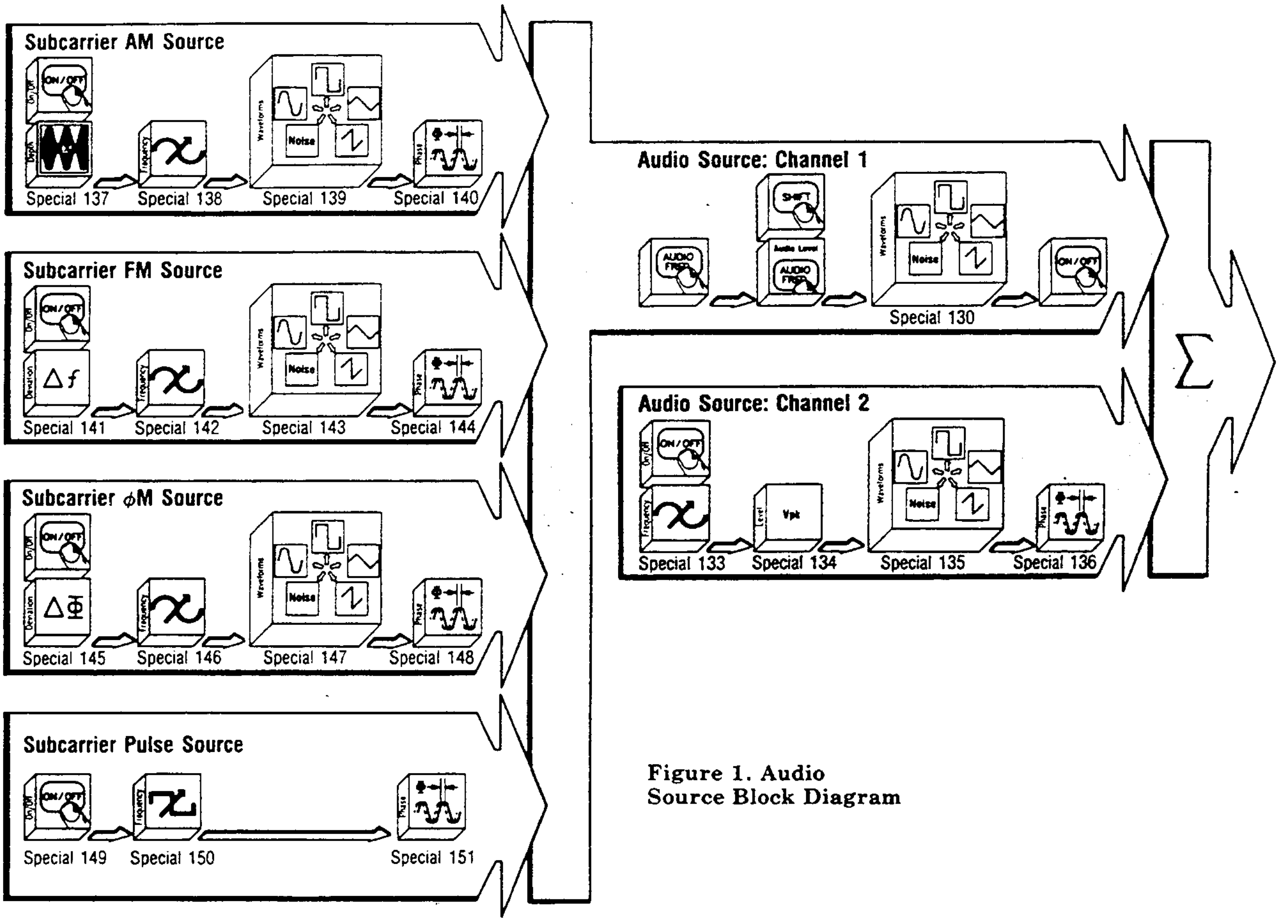


Figure 1. Audio Source Block Diagram

Modulation/Audio Source

The heart of the audio source is a single integrated circuit that uses digital synthesis to "calculate" the proper output and contains a 12 bit D/A converter to generate the analog waveforms. To the user, the audio generator appears as two sources summed together with four other internal sources used for subcarrier modulation only (Figure 1).

The six audio sources are configured as Audio 1, Audio 2, AM subcarrier, FM subcarrier, ϕM subcarrier, and Pulse subcarrier (see Figure 1). Limitations only allow four sources to be used simultaneously, however, each can have independent frequency, amplitude, relative phase, and waveform. Most functions are controlled with the special function menu from the front panel or can be programmed with mnemonics through HP-IB.

Frequency Specifications/Control

Each source has a frequency range of 0.1 Hz to 400 kHz. The audio output circuitry has a 400 kHz bandwidth which will affect complex signals with frequency components above 400 kHz. Square waves and sawtooths should be limited to 50 kHz. The audio frequency of Audio 1 is controlled with the front panel Audio Freq key.

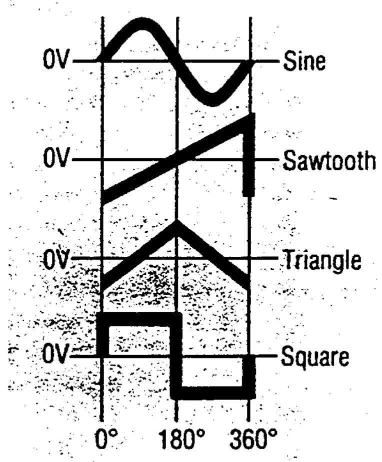


Figure 2. Relative Phase of Audio Waveforms

Amplitude Specifications/Control

The HP 8644A has a maximum peak output voltage of 2 volts and the HP 8645A and HP 8665A have a peak output of 1 volt. The default setting for Audio 1 is the maximum output voltage and must be reduced before using Audio 2 or sub-carrier AM. To calculate the peak voltage of the combination of sources use the formula:

Peak Voltage = Audio 1 + (Audio 1 × depth AM) + Audio 2

This cannot exceed the maximum allowed for the signal generator. To control the level of Audio 1 use the front panel Audio Level key. Audio 2 amplitude and AM depth are controlled with the special functions shown in Figure 1.

Relative Phase Control

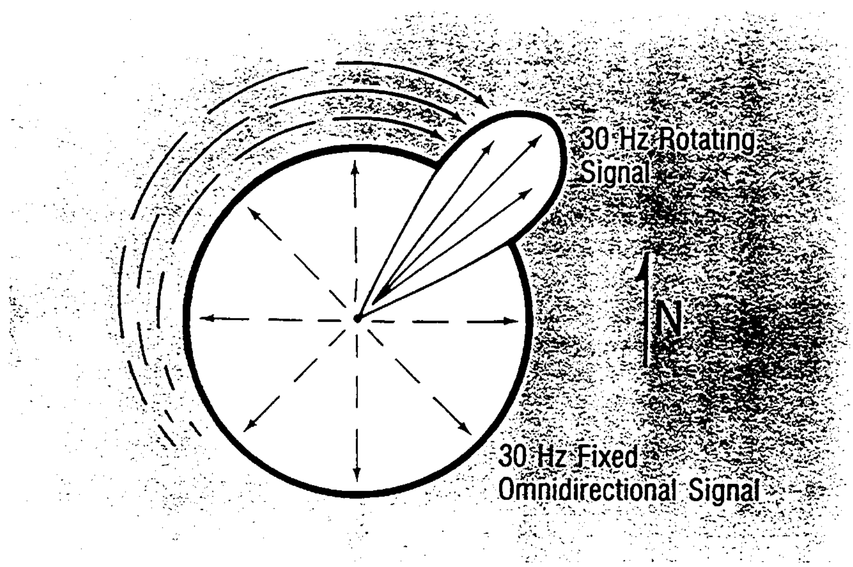
All audio sources have a phase adjustment which sets phase relative to the phase of Audio 1. All phases can be set ±180° with 0.1° resolution. The zero phase reference for the different types of waveforms are shown in Figure 2.

Waveforms

Except for the pulse subcarrier which is square wave only, all source waveforms are set independently and can be either sine, square, triangle, sawtooth, or white Gaussian noise.

Air Navigation Waveforms

The HP 8644A with Option 007—synthesized audio source, and Option 009—specified avionics performance, is an ideal signal generator for VOR (VHF omni-range) and ILS (instrument landing system) receiver testing. The remainder of this application note explains these navigation systems and how the HP 8644A can be used to create the proper test signals.



VOR Antenna Pattern

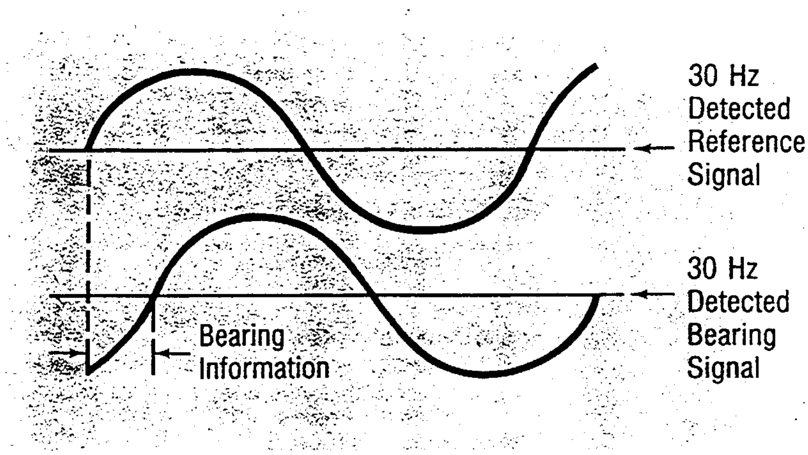
VOR Navigation System Basics

(VHF Omni Range)

The purpose of the VOR system is to provide directional information for aircraft in flight. VOR transmitter stations are strategically located to provide complete coverage for air traffic. Each station radiates a carrier in the 108 to 118 MHz band, which is modulated in a way that provides aircraft bearing information relative to the transmitter location. The modulation is made up of two distinct parts: a 30 Hz reference signal, and a 30 Hz variable phase signal. The reference signal is modulated onto the carrier so that its phase is independent of the bearing at the point of reception. The variable phase signal is modulated so that its phase differs from that of the reference signal by an angle equal to the compass bearing from the point of reception to the VOR station.

By demodulating the transmitted VOR signal, an aircraft receiver can compare the phases of these two 30 Hz signals to determine the compass bearing to the VOR station. By tuning to two or more VOR stations and recording each bearing angle, pilots can determine their exact location on an air chart by triangulation.

In practice, the 30 Hz reference signal is placed on a subcarrier of 9960 Hz using frequency modulation. The peak deviation is set to 480 Hz. This modulated subcarrier is then amplitude modulated onto the VOR carrier in the 108–118 MHz range. This makes the reference signal essentially an FM/AM multiplex signal. The variable phase signal is placed directly on the RF VOR carrier. The modulation and phasing of this signal are produced by a special antenna array which produces a cardioid-shaped antenna pattern which rotates at a 30 Hz rate. This special antenna produces a signal at the aircraft receiver which, in effect, is a 30 Hz amplitude modulated signal with a phase proportional to the bearing of the transmitter.



VOR Signal Seen
at Aircraft Receiver

Generating VOR Test Signals with the HP 8644A

To test a VOR receiver with the HP 8644A, a composite VOR signal is generated with the audio source and AM modulated onto an RF carrier at the proper frequency and amplitude. To configure the signal generator for VOR, execute Special Function 220 (VOR Setup) which configures the signal generator for a VOR signal of 0 degrees "To" the station at a carrier frequency of 108 MHz. To set different bearings use Special Function 144 (Audio FM phase) to enter the radial and use Special Function 136 (Audio 2 phase) to change bearing "To" or "From". Set the Audio 2 phase to 0 degree for "From" setting or to 180 degrees for "To" settings.

To alter the carrier frequency, simply enter the desired frequency using the front panel keys. If other parameters of the modulation signal need adjusted, simply adjust the special function shown in Table 1.

Executing Special 220 (VOR Setup) is similar to individually entering the following list of commands:

1) Instrument Preset

Audio Source 1 – Sets the 9960 Hz carrier
2) Audio freq 9960 Hz
3) Audio level 1 Volt

Audio FM – Modulates the subcarrier with variable 30 signal
4) Special 141, 480 Hz
5) Special 142, 30 Hz
6) Special 143, 0 degrees, This sets variable bearing radial 0.0 to 359.9 degrees

Audio Source 2 – Sets the 30 Hz reference signal
7) Special 133, 30 Hz
8) Special 134, 1 Volt
9) Special 136, 0 degrees for "from" bearings, 180 degrees for "to" bearings

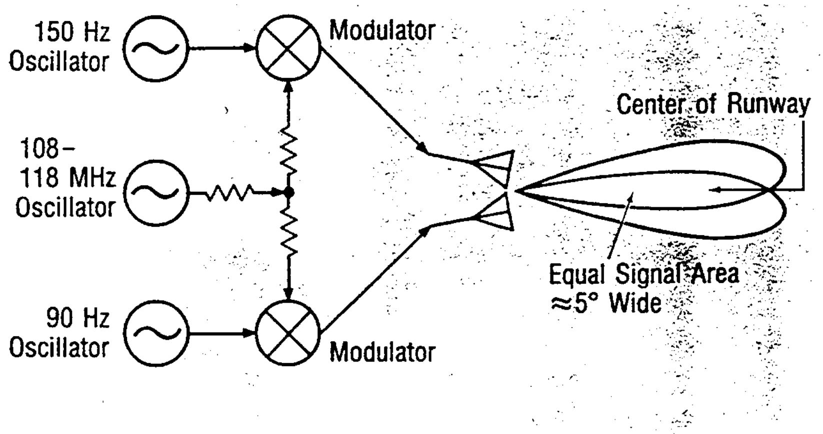
Carrier Modulation Set maximum depth of modulation
10) AM 60%, internal

Carrier Frequency
11) RF frequency 108 MHz

Table 1

ILS System Basics
(Instrument Landing System)

To assist aircraft in landing during periods of poor weather, the ILS or Instrument Landing System was developed. This system is composed of several separate signals, each of which is designed to provide the pilot with specific information relating to the position of the aircraft relative to the runway. These signals are: the Localizer, Glide Slope, Outer Marker, Middle Marker, and the Inner Marker.



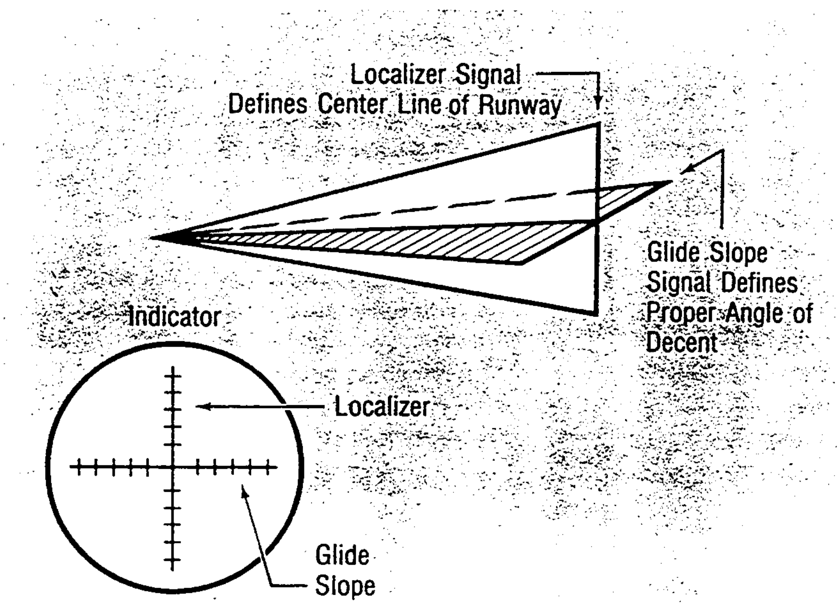
Localizer Transmitter System and Antenna Pattern.

Localizer

The Localizer operates at a carrier frequency from 108 to 112 MHz. This signal provides the pilot with information which indicates whether the aircraft is to the left of, to the right of, or in-line with the runway. The Localizer does this by radiating a directional field pattern directly down the center of the runway. The Localizer's carrier is amplitude modulated by two tones: 90 Hz and 150 Hz. Each of the resulting modulated carriers is sent to a separate directional antenna system. This antenna array is arranged so that the 90 Hz signal is stronger than the 150 Hz signal on the left side of the runway, and the 150 Hz signal is stronger than the 90 Hz signal on the right side of the runway. This equal zone is designed to be approximately 5 degrees wide. This system allows for relatively simple AM demodulators to be built which can recover the 90 Hz and 150 Hz tones and then compare their levels to provide the "localizing" information. The difference in depth of modulation (DDM), is used to provide the pilot with "on course" information. DDM is defined to be the percentage modulation depth of the larger signal *minus* the percent modulation depth of the smaller signal, divided by 100. In addition to the actual localizer signal, an audio Voice/Identity signal is also placed on the localizer carrier. The baseband frequencies from 350 Hz to 2500 Hz are allocated for this purpose.

Glide Slope

The Glide Slope operates with a carrier frequency in the 329.9–335 MHz band and provides signals which indicate whether the aircraft is above, below, or on the glide path. The Glide Slope provides the same type of information as the Localizer, but for a vertical reference as opposed to a horizontal reference (Figure 3). In fact the same modulation and antenna techniques are used, including the use of 90 and 150 Hz modulation tones. The only exception is that no Voice/Ident signal is used with the glide slope signal.



Localizer and Glide Slope Radiation Pattern and Aircraft Indicator Display

Localizer/Glideslope Test Signals

Testing a localizer or glideslope receiver with the HP 8644A Option 007 uses the audio source to simultaneously generate the 90 Hz and 150 Hz test signals. These signal are AM modulated onto the RF carrier at the proper amplitude and frequency. To configure the signal generator for a localizer waveform, execute Special Function 221 (Localizer Setup) for a 0 ddm output at 108.1 MHz. To select different ddm settings, use the formula given at right in Table 2.

Executing Special Function 221 (Localizer Setup) is equivalent to the following commands:

1) Instrument Preset
Audio Source 1 - Sets the 150 Hz signal 2) Audio freq 150 Hz 3) Audio level 1V (see below)
Audio Source 2 - Sets the 90 Hz signal 4) Special 133, 90 Hz 5) Special 134, 1 Volt (see below)
Carrier Modulation - Set maximum depth of modulation 6) AM 40% for localizer
Carrier Frequency 7) RF Frequency 108.1 MHz

Table 2

Executing Special Function 222 (Glideslope Setup) is similar to the preceding setup except AM is set to 80% and RF frequency is set to 334.7 MHz.

Setting both the Audio Level and Special 134 to 1 volt generates localizer and glideslope signals with 0 ddm between the 90 and 150 Hz tones. To test other ddm settings, these voltages must be adjusted according to the formula and examples shown in Table 3 and Table 4.

Localizer

DDM	Audio Level	Aud2 Level (Special 134)
0	1.000V	1.000V
0.046	1.115V	0.885V
0.093	1.232V	0.767V
0.115	1.387V	0.612V
0.200	1.500V	0.500V
Variable	$\frac{20+50*ddm}{20V}$	$\frac{20-50*ddm}{20V}$

Table 3

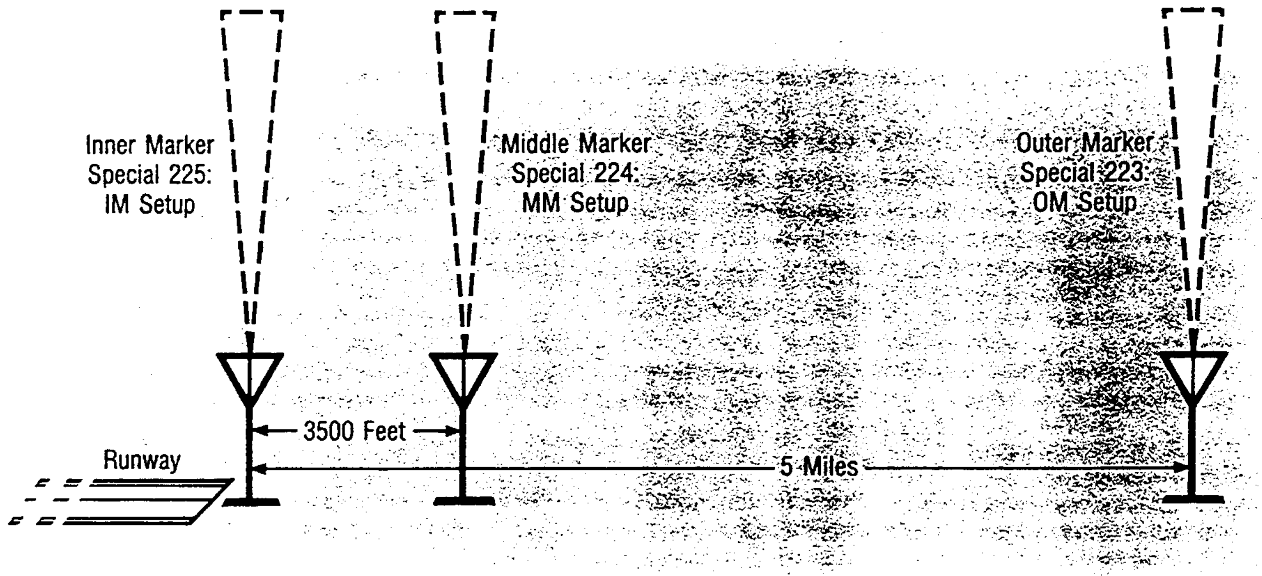
Note: These settings will deflect the localizer indicator left of the central position by the ddm amount shown. Reversing Audio Level and Special 134 level will deflect the indicator right of center. When using calculated voltages, always round the results down to the nearest millivolt. When setting the voltages, the total can never exceed 2 volts.

Glideslope

DDM	Audio Level	Aud2 Level (Special 134)
0	1.000V	1.000V
0.045	1.055V	0.943V
0.091	1.113V	0.886V
0.175	1.218V	0.781V
0.400	1.500V	0.500V
Variable	$\frac{40+50*ddm}{40V}$	$\frac{40-50*ddm}{40V}$

Table 4

Note: These settings will deflect the glideslope indicator up above the central position by the ddm amount shown. Reversing Audio Level and Special 134 level will deflect the indicator down. When using calculates voltages, always round the results down to the nearest millivolt. When setting the voltages, the total can never exceed 2 volts.



Marker Beacon Antenna Locations

Markers

The final components of the ILS system are the three marker beacons. The marker beacons provide the pilot with information which indicates the distance of the aircraft relative to the threshold of the runway. All markers operate at a carrier frequency of 75 MHz and are transmitted through vertical antenna arrays which project a fan-shaped pattern. The outer marker transmitter amplitude modulates the carrier with a 400 Hz tone. The antenna for the outer marker is located approximately five miles from the runway. The middle marker uses a 1300 Hz tone to amplitude modulate the beacon carrier. The antenna for the middle marker is located 3500 feet from the runway. For a normal landing, the aircraft should be at an altitude of 200 feet by the time the middle marker is reached. In addition, the pilot should have the ground in sight at this point. The inner marker uses a 3 kHz tone and is located at the threshold to the runway. All marker beacon tones produce an AM depth of 95% in the RF carrier. Marker beacon receivers illuminate different colored lights as the aircraft passes through each marker beacon signal. For additional aid, the tones used to modulate the carrier are pulsed on and off so as to flash the receiver lights.

Marker Beacons

The HP 8644A can be used to simulate pulsed or non-pulse marker beacon signals. Special Functions 223,224,and 225 configure the signal generator for outer marker, middle marker and inner marker beacon signals respectively.

Executing these Special Functions is similar to entering the following commands.

Audio Source 1 – Sets the tone frequency 1) Audio freq 400 Hz – Outer marker or 1300 Hz – Middle marker or 3000 Hz – Inner marker
Audio Pulse – Pulses the marker tone at a 2 Hz rate 2) Special 149, ON (Turn OFF for nonpulse tests) 3) Special 150, 2 Hz
Carrier Frequency 4) RF Frequency 75 MHz

Table 5

While these avionics waveforms can be simulated with any HP 8644A with Option 007, Option 009 is available for specified performance and includes software drivers that simplify using the signal generator in automatic test systems. These specifications and a summary of the software drivers are shown at right.

Description of Software Subroutines Available for Air Navigation Waveforms on the HP 8644A

These subroutines are intended to be added to a receiver test program to simplify using the HP 8644A audio source for complex air navigation waveforms. These subroutines require that parameters be passed to the sub routine and return string variables that can be directly output to the signal generator.

VOR (VHF omni-range) Subroutines

SUB Vor_setup(Direction$,Bearing,Lfsource$,Modulate$)

Direction$ – This is an input into the sub routine and must contain either "To" or "From" indicating whether the bearing is to or from the transmitter.

Bearing – This is an input corresponding to the radial in degrees either to or from the transmitter.

Lfsource$ – This is a string variable returned from the subroutine that contains the HP-IB command string to set up the Low Frequency Source to generate a VOR waveform with correct bearing and direction information. This can be output directly to the signal generator and assumes that the modulation source was in a state similar to an instrument preset before the command is sent.

**Modulate$** – This is similar the Lfsource$ except that it sets up the correct amplitude modulation for VOR waveforms. This can be output directly to the signal generator and assumes no other modulation is being used before the command is sent.

Example:
Call Vor_setup("From",90.0,Output1$,Output2$)

This sets the string variables output 1 and output 2 to the correct HP-IB commands to simulate a VOR signal 90 degrees from a VOR transmitter.

SUB Vor_bearing(Direction$,Bearing,Lfsource$)

This is similar to Vor_setup except that it only modifies the bearing angle and assumes that the Vor_setup program has already been run. The variable Lfsource$ can be output directly to the signal generator.

Localizer Subroutines

SUB Loc_setup(Direction$,Ddm,Lfsource$,Modulate$)

Direction$ – This is an input into the subroutine and must contain either "Left" or "Right" indicating whether the indicator is left or right of the central position.

Ddm – This is an input that indicates the Difference in Depth of Modulation that the generator will produce to test the receiver.

Lfsource$ – Returns the string variables to set the levels for the 90 Hz and 150 Hz tones for localizer waveforms.

Modulate$ – Returns the HP-IB command to set the proper AM modulation for localizer waveforms.

SUB Loc_offset(Direction$,Ddm,Lfsource$)

This is similar to the Loc_setup subroutine except that is assumes the amplitude modulation has previously been set with the Loc_setup routine.

Glideslope Subroutines

SUB Gs_setup(Direction$,Ddm,Lfsource$,Modulate$)

Direction$ – This is an input into the sub routine and must contain either "Up" or "Down" indicating whether the glideslope display is up or down of the central position.

Ddm – This is an input that indicates the Difference in Depth of Modulation that the generator will produce to test the receiver.

Lfsource$, Modulate$ – These are similar to the variables returned in the localizer setup subroutine except they correspond to glideslope waveforms.

SUB GS_offset(Direction$,Ddm,Lfsource$)

This is similar to the Gs_setup subroutine except that is assumes the amplitude modulation has previously been set with the Gs_setup routine.

Marker Beacon Subroutines

SUB Mb_setup(Marker$,Lfsource$,Modulate$)

Marker$ – This is an input to the subroutine and is either "O", "M", or "I" for outer, middle, or inner marker.

Lfsource$, Modulate$ – These are similar to the string variable returned from the VOR setup routine. These assume that no other modulation has previously been set and can be output directly to the signal generator.

Option 009 Specifications

Option 009 provides specified VOR/ILS performance for the HP 8644A with Option 007. These specifications are in addition to those for the standard HP 8644A. This performance cannot be specified with Option 002 (doubled version) or Option 005 (electronic attenuator).

VOR (108 to 118 MHz)	
Bearing accuracy	0.1 degrees
Frequency accuracy	Set by timebase
AM accuracy	±5% of setting
FM accuracy (480 Hz deviation)	±1.5 Hz
AM distortion	2%
ILS: Localizer/Glide Slope (108 to 112 MHz/ 329.3 to 335 MHz)	
AM accuracy	±5% of setting
AM distortion	2%
DDM resolution	
(Localizer)	0.0004
(Glide Slope)	0.0008
DDM accuracy	
(Localizer)	±0.0006 ±5% of DDM
(Glide Slope)	±0.0012 ±5% of DDM
Marker Beacon (75 MHz)	
AM accuracy (95%)	±5% of setting +1%
AM distortion	5%

Specification Verification

VOR Bearing accuracy is the relative phase accuracy of two 30 Hz signals. One directly AM modulates an RF carrier, the other is first FM modulated onto a 9960 Hz subcarrier which then AM modulates the same RF carrier. Bearing accuracy refers to the relative phase accuracy of the two 30 Hz signals on the RF carrier.

There are two main sources of bearing error in the HP 8644A implementation. The first is from the audio source which generates the composite signals. A complete investigation of this digital source shows this is always <0.044 degrees and has been verified on calibrated test equipment (Arbiter 1070A). Another source of error is the phase shift in the AM path of the 30 Hz reference signal and the 9960 Hz subcarrier which has the 30 Hz variable signal imposed on it. This AM phase shift is measured with calibrated network analyzers to a test line limit of <15 degrees shift of the 9960 Hz signal. This is equal to 0.05 degrees of phase shift of the 30 Hz signal modulated on the 9960 Hz carrier. Summing together this 0.05 degrees error with the 0.044 degree maximum from the digital source gives a maximum error of <0.1 degrees.

Localizer and glideslope ddm is the difference in depth of modulation of a 90 Hz and 150 Hz tone AM modulated on a RF carrier. When setting this difference with the HP 8644A there are three sources of error. First, the audio source which generates these two tones. The digital nature of this audio source guarantees the two tones within one LSB or 2 mV in 1000 mV. For localizer this equates to an uncertainty of 0.0004 ddm since the modulation sensitivity is 0.4 ddm/2000 mV (40% AM). For glideslope the uncertainty is 0.0008 ddm because the sensitivity is 80% AM. The second source of error is from the AM flatness between the two tones. This is verified to be <0.005 dB which has an equivalent difference if depth of modulation of 0.00012 for localizer and 0.00023 ddm for glideslope. AM accuracy is the third contribution to error and is a multiplier on the amount of ddm selected. This final error is measured with a modulation analyzer (HP 8901B). The worst case spec for localizer is 0.0004+0.00012+(AM accuracy*ddm). The guaranteed specification is 0.0006 +5% of ddm selected for localizer, 0.0012 +5% of ddm selected for glideslope.

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Data subject to change
Printed in U.S.A. 9/89
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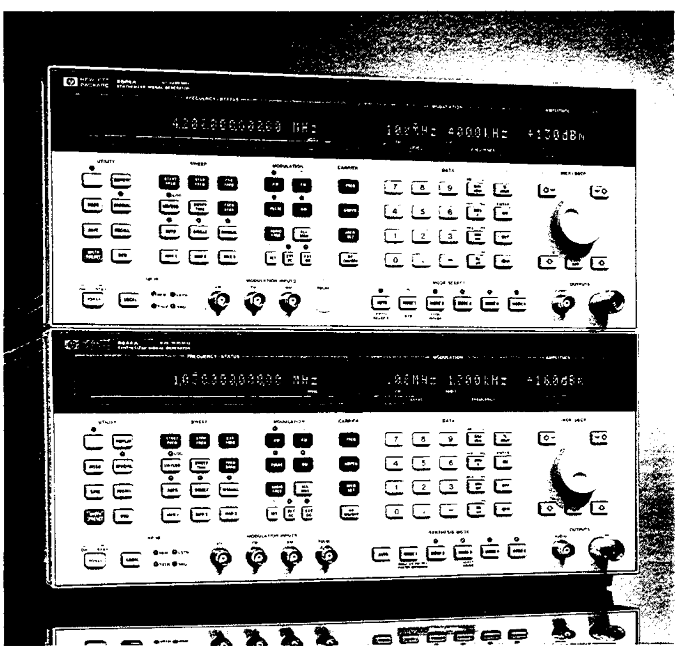
Phase noise test with the HP 8644A and HP 8665A Signal Generators

HP 8644A-1 Product Note

This product note describes the unique characteristics of the FM scheme used in the HP 8644A and HP 8665A and explains how it affects phase noise measurements. Also included is typical performance, limitations, and specific operating instructions when using these generators as the tunable reference in a phase noise measurement.

HP 8644A and HP 8665A Theory of Operation

The HP 8644A and HP 8665A have a unique FM implementation that offers benefits over the classical open loop dc coupled scheme but has inherent characteristics that are different than most other signal generators. The default FM is a digitized scheme that is used for most applications and has benefits such as center frequency accuracy and good close in phase noise. A traditional open loop, non-digitized, linear FM is also available as a special function for applications that need true linear FM with low group delay. Both schemes have advantages and disadvantages that will be explained more thoroughly.



Digitized FM

This is the default FM scheme automatically selected on power-up or instrument preset. This scheme uses a single phase lock loop with a fractional N divider (Figure 1). The modulation signal is applied to the loop at two points, directly to the VCO and indirectly after digitization to the digital divider. Only low rate signals within the PLL bandwidth can cause modulation at the divider, the high rate signals must be applied directly to the VCO input. The benefits of this scheme are good dcFM stability since the loop remains locked to the reference and good close in phase noise because of the clean-up within the phase lock loop bandwidth. The drawback of this scheme in a phase noise measurement, is the group delay and quantization error from the digitization. Group delay varies with modulation rate (Figure 2) and can cause phase shift and possible instability when the generator is used as an element in a phase lock loop. The quantization error is small but can show up when using small input signals < 10 mV. For these very small signals, the generator appears to have a changing FM sensitivity which causes an incorrect phase noise measurement within the loop bandwidth. A true open loop, linear FM, is available for phase noise measurements which use small input signals and are sensitive to group delay.

Linear FM

This FM scheme is true linear FM where the modulating signal is applied directly to the VCO and the feedback path for the phase locked loop is opened. This operation is selected with special function 120. The advantage of this scheme is true linear dcFM with group delay of < 1 μsec. This eliminates the instability caused by large group delay and quantization error from digitization. The disadvantage of this scheme is poor center frequency accuracy and higher close-in phase noise because the loop is no longer locked to the reference and there is no clean up from the PLL.

Operation as a Phase Noise Measurement Reference

The most common technique for measuring the phase noise of a source is to use reference source and demodulate the phase instability using a phase detector. Commonly referred to as the Phase Detector method, this method requires a reference source with equal or better phase noise performance than the source being tested. It is also required that one of the sources have tuning capability, like dcFM in order to maintain phase quadrature at the input of the phase detector. The need for good phase noise performance and dcFM capability often results in a signal generator being used as the reference source of a phase noise measurement system. The remainder of this product note describes how to use and optimize the HP 8644A and HP 8665A as a reference source for phase noise measurements. More information on the measurement technique itself can be found in literature related to products such as the HP 11729C Carrier Noise Test Set (Literature #5954-7362) or HP 3048A Phase Noise Measurement System (#5953-8462).

Several features of these signal generators make them good choices for use as a phase noise measurement source. These include wide carrier frequency range, high output power, good spectral purity, and dcFM. The phase noise of these signal generators is very low at offsets greater than 10 kHz from the carrier as is commonly required for testing channelized communication devices or systems. Both signal generators have very low spurious on the output which simplifies the detection and interpretation of spurs from the test source. The typical phase noise and spurious performance is shown in the graph included in the "Phase Noise Performance" summary of this product note.

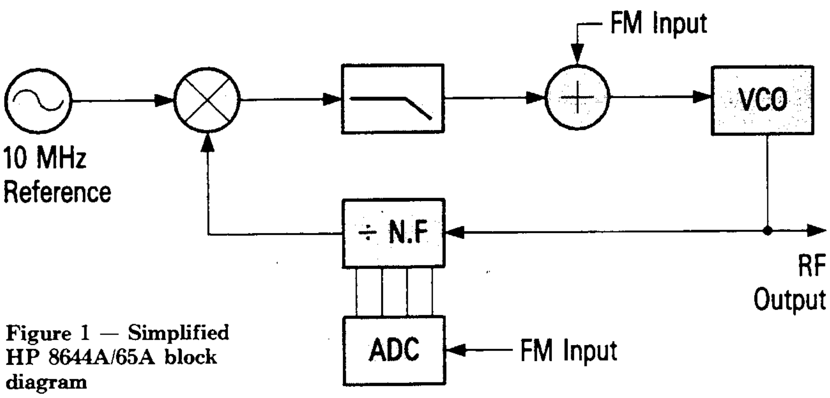


Figure 1 — Simplified HP 8644A/65A block diagram

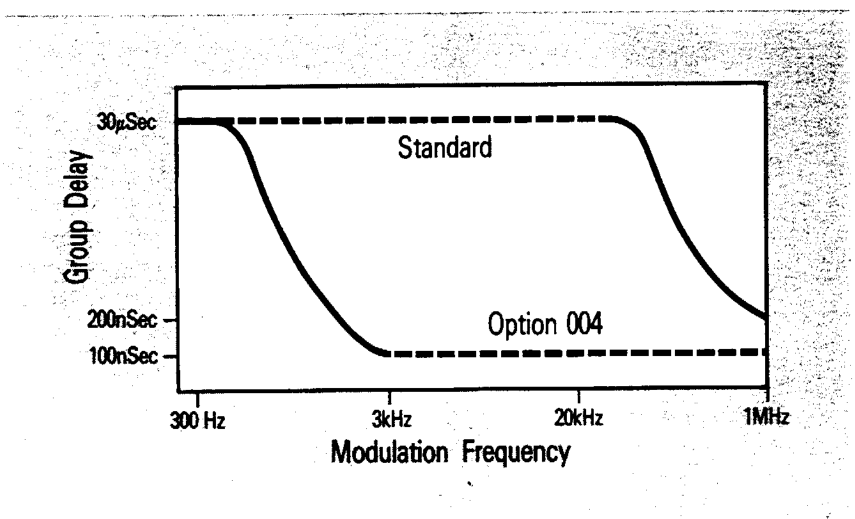


Figure 2 — Group delay for digitized FM synthesis

When using these signal generators as non-tunable references, all modulation should be turned off. This provides good spectral purity and frequency stability. These generators can be used with or without the enhanced spectral purity Option 004.

Application Procedure

When using the HP 8644A or HP 8665A as the tunable reference in a phase noise measurement some special precautions must be taken to ensure the accuracy of the results. This section outlines the procedures and operating modes necessary to make a reliable measurement.

While these signal generators were not specifically designed as a reference for a phase noise measurement, they do have excellent spectral purity and may be useful for certain applications. As will be explained further, the digitized FM scheme must not be used for tuning the signal generator during a phase noise measurement. Currently these generators are not supported by the HP 3048A software and must be manually adjusted when connected to the system.

The first step that is necessary is to select Linear FM with special function 120 and DC coupled FM from the front panel. This dcFM mode eliminates the group delay which can cause instability in the phase lock loop. This FM scheme also avoids the quantization error inherent in the default digitized FM which would be significant because of the small signals presented to the FM input during a phase noise measurement.

Because it is necessary to use linear dcFM, the center frequency accuracy and resolution of these signal generators will be worse. To overcome these problems it is necessary to use at least the minimum amount of FM deviation specified in Tables 1 and 2. This is necessary to ensure that the signal generator and the DUT can be brought into phase quadrature with the feedback tuning control to the dcFM input. Also, on the HP 8665A, it is necessary to have the Option 004 installed and front panel Mode 2 selected. This minimizes the center frequency errors and gives the best possible phase noise performance. For HP 8644A with serial numbers <150, Option 004 is also necessary to eliminate the tuning resolution problem and should only be used with the minimum amount of FM deviation specified in Table 1.

Selecting the FM deviation requires two considerations. First, the deviation must be within that specified in Tables 1 and 2. Secondly, only use the minimum amount of deviation necessary to keep the signal generator locked to the DUT. As a general rule, start with the minimum deviation shown in the table and increase it if the system loses lock during the measurement. Choosing the least amount of deviation necessary gives the signal generator the best possible spectral purity.

One other unique characteristic of these generators is that several circuits internally are calibrated whenever the center frequency setting is changed. The output is decreased by more than 60 dB during these resets so that the unspecified output during the transition will not affect the user's device. This transition period typically lasts 200 msec. This operational characteristic will be apparent when the center frequency of the signal generator is tuned, causing the beatnote to disappear momentarily with each change. Activating special function 105 Amplitude Muting disables this amplitude blanking and is recommended when manual tuning.

Phase Noise Performance Summary

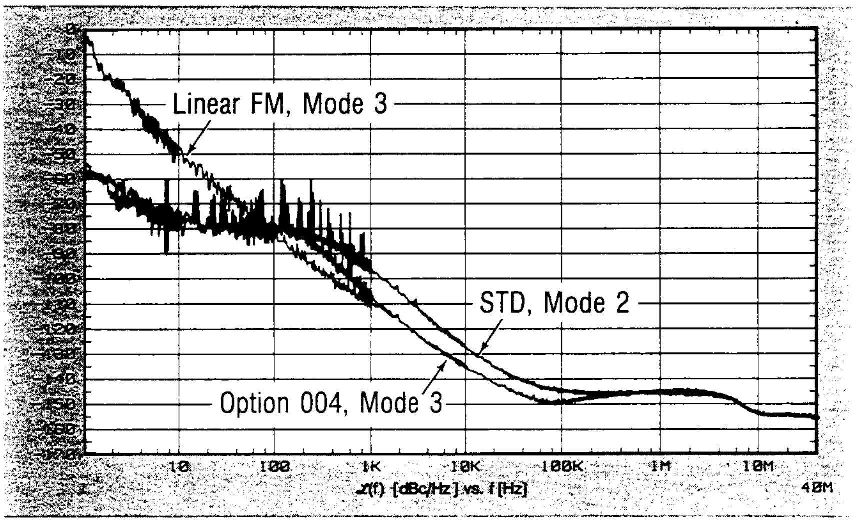
HP 8644A

Necessary conditions:

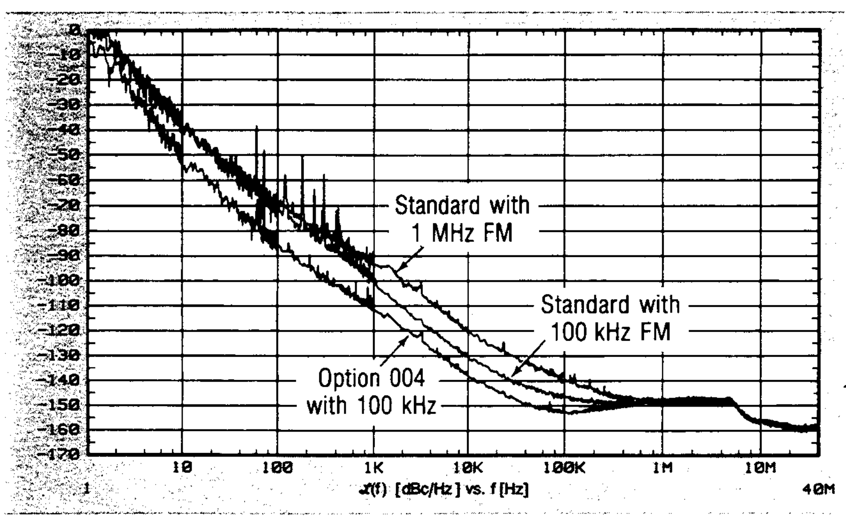
1) Linear FM special 120.
2) FM deviation selected according to Table 1.
3) When using Option 004 the minimum amount of FM deviation should be used. If larger amounts of deviation are selected the signal generator will automatically select standard performance with less spectral purity. This standard performance is shown in the graph below.

Table 1 — HP 8644A frequency/FM deviation settings

Carrier Frequency (MHz)		Recommended FM deviation	Tuning Resolution in Linear FM (kHz)
1030	- 2060	200 kHz - 2 MHz	4 -10
515	- 1029.99999999	100 kHz - 1 MHz	2 - 5
257.5	- 514.99999999	50 kHz - 500 kHz	1 - 2.5
128.75	- 257.49999999	25 kHz - 250 kHz	.5 - 1.25
64.375	- 128.74999999	12.5 kHz - 125 kHz	.25 - .62
32.1875	- 64.37499999	6.25 kHz - 62.5 kHz	.12 - .31
16.09375	- 32.18749999	3.12 kHz - 31.2 kHz	.06 - .15
8.046875	- 16.09374999	1.56 kHz - 15.6 kHz	.03 - .078
4.0234375	- 8.04687499	.781 kHz - 7.81 kHz	.015 - .039
2.01171875	- 4.02343749	.39 kHz - 3.9 kHz	.008 - .019
1.00585937	- 2.01171874	.19 kHz - 1.9 kHz	.004 - .009
0.50292968	- 1.00585937	.097 kHz - .97 kHz	.002 - .004
0.25146485	- 0.50292968	.048 kHz - .48 kHz	.001 - .002



Typical SSB phase noise and spurs at 1 GHz in digitized FM or FM off



Typical SSB phase noise and spurs at 640 MHz in linear FM

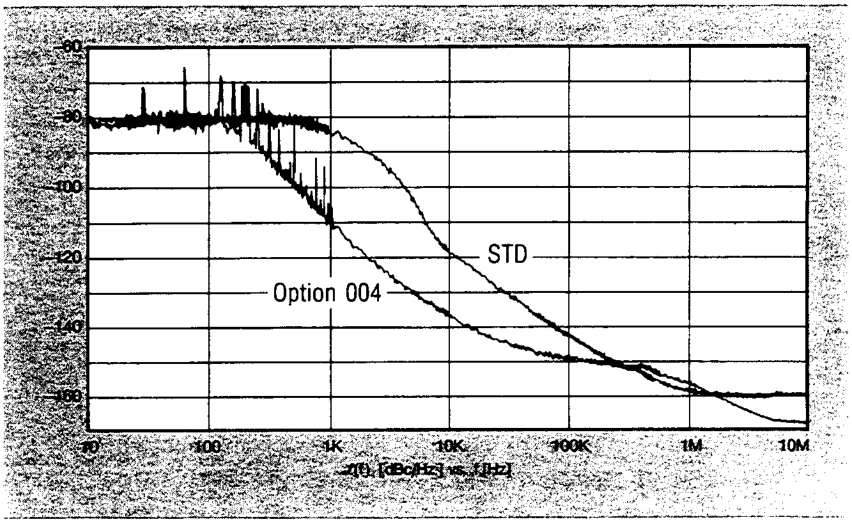
Table 2 — HP 8665A frequency/FM deviation settings

Carrier Frequency (MHz)	FM deviation	Tuning Step Size in Linear FM (kHz)
4120 - 4200	800 kHz	16
2060 - 4119.99999999	400 kHz	8
1030 - 2059.99999999	200 kHz	4
515 - 1029.99999999	100 kHz	2
257.5 - 514.99999999	50 kHz	1
187.5 - 257.49999999	25 kHz	.5
30 - 187.49999999	200 kHz	4
.1 - 29.99999999	100 kHz	2

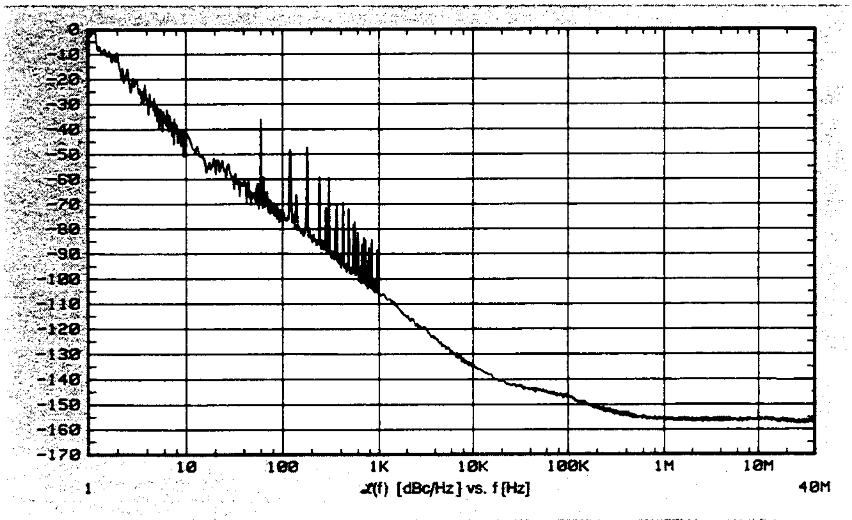
HP 8665A

Necessary conditions:

1) Option 004 installed, front panel Mode 2 selected.
2) Linear FM special 120 selected.
3) FM deviation selected according to Table 2.



Typical SSB phase noise and spurs at 1 GHz in digitized FM



Typical SSB phase noise and spurs at 640 MHz in linear FM

United States:
Hewlett-Packard Company
4 Choke Cherry Road
Rockville, MD 20850

Hewlett-Packard Company
5201 Tollview Drive
Rolling Meadows, IL 60008

Hewlett-Packard Company
5161 Lankershim Blvd.
No. Hollywood, CA 91601

Hewlett-Packard Company
2015 South Park Place
Atlanta, GA 30339

Canada:
Hewlett-Packard Ltd.
6877 Goreway Drive
Mississauga, Ontario L4V1M8

Australia/New Zealand:
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Melbourne, Australia

Europe/Africa/Middle East:
Hewlett-Packard S.A.
Central Mailing Department
P.O. Box 529
1180 AM Amstelveen
The Netherlands

Far East:
Hewlett-Packard Asia Ltd.
22/F Bond Centre
West Tower
89 Queensway
Central, Hong Kong

Japan:
Yokogawa-Hewlett-Packard Ltd.
29-21, Takaido-Higashi 3-chome
Suginami-ku, Tokyo 168

Latin America:
Latin American Region Headquarters
Monte Pelvoux Nbr. 111
Lomas de Chapultepec
11000 Mexico, D.F. Mexico

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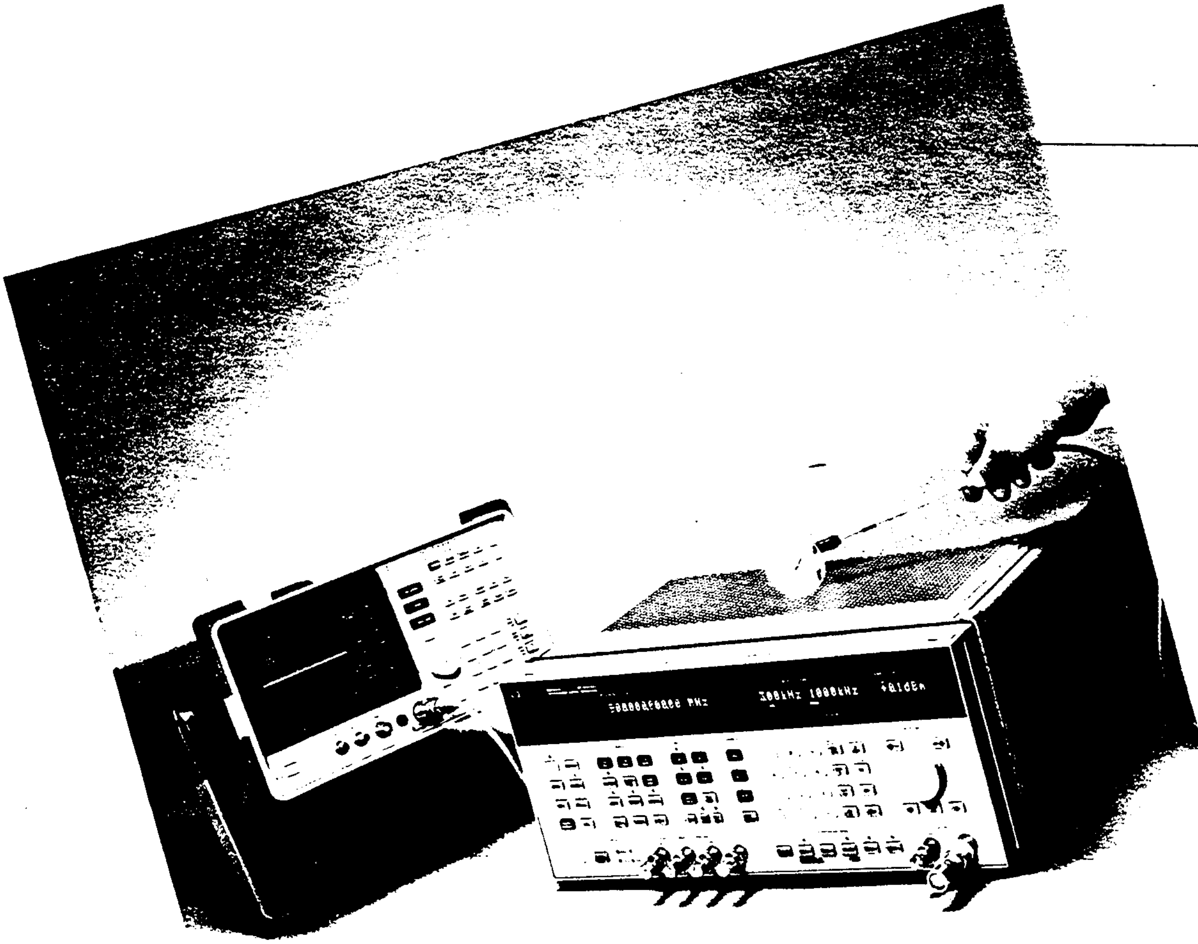
5951-6729

HEWLETT PACKARD

Low-Level RF Leakage Measurement

Application Note 1204



Introduction

There are many advancements in two-way radios and pagers including greater sensitivities, and higher frequencies. A radio or pager which can receive very low level signals far from the transmitter is considered more valuable and can command a higher price. Regulatory agencies are opening channels to higher frequencies. In order to design and produce these new products, component, device and product manufacturers are requiring signal sources which can accurately simulate the low-level signals in the right frequency range which their new products are being designed to work with.

The impact of greater receiver sensitivity is subtle. The obvious need is for sufficient output level attenuation to obtain the new lower test signal levels. The less obvious need is for reduced RF leakage from the signal generator. The test signal should leave the signal generator by the RF output connector only. But the signal may also leave the signal generator by a radiated leakage path. If the radio under test is not well shielded, or if the radio's shielding covers are off for purposes of test, the leakage signal can enter the radio along with desired signal from the RF output connector. The two signals can add either constructively or destructively, resulting in a total signal of unknown amplitude. This reduces the accuracy of the test.

Higher frequencies also demand more of a signal generator. Once again, there is an obvious need—test signals at higher frequencies. But higher frequencies also make leakage from the signal generators worse. For example, a cabinet seam becomes a larger fraction of a wavelength as the frequency increases, and its shielding effectiveness goes down. Thus, increasing leakage with increasing frequency.

The task for the manufacturer of the signal generator is to measure leakage at higher frequencies and lower levels, while improving the accuracy of those measurements. This paper addresses the measurement problems, and briefly discusses some of the work done to reduce leakage from signal generators.

Many are familiar with the problems of radiated RF leakage from computer equipment and its effects on radio and television reception. Reception can be degraded even at some distance away, say 10 meters or more. The radio regulatory agencies in various countries, for example the Federal Communications Commission in the United States, have set limits on the electric field emissions from electronic equipment. HP has generated a field strength specification that assures compliance in practically any country by combining the most stringent requirements of all these countries into one field strength curve.

Hewlett-Packard signal generators have been designed to meet these same regulatory limits. How do these regulatory field strength limits compare to radio sensitivities? Let's look at the portion of the regulatory field strength curves from 100 MHz to 1000 MHz, and compare it to typical VHF and UHF radio sensitivities (.25 μV) in this same frequency range. Assume the radios use a resonant dipole antenna.

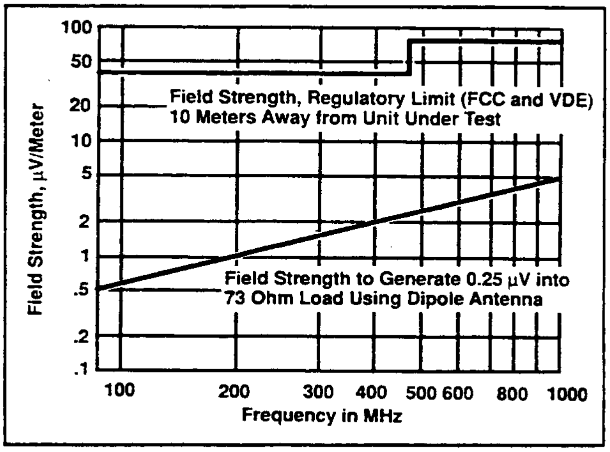


Figure 1. Regulatory field strength limits vs. typical radio sensitivities

Figure 1 shows that even at 10 meters away, emissions from equipment passing the regulatory requirements for RF leakage can be detected by radios quite easily. Typically, radio tests are done at distances much less this, often times within one meter of the signal generator.

What is this field, and how do we compare field strength to radio sensitivity? How do we quantify this?

The electromagnetic fields we are discussing are made up of two components—an electric field (E), and a magnetic field (H). The strength of the E field is measured in volts per meter, and the H field is measured in units of amps per meter. The origin of these fields may be unintentional radiation, such as RF leakage from a signal generator or computer, or may be intentional radiation, such as from a radio transmitter. At a distance of several wavelengths from an electromagnetic field source, perhaps a transmitting antenna, the magnitudes of the E and H fields are found to be in a fixed ratio:

(1) $\frac{|E|}{|H|} = 377$ ohms,

and 377 ohms is defined as the impedance of free space. Multiplying the magnitude of the E field with the magnitude of the H field yields the power flux density in watts/sq. meter:

(2) $P_f = |E|\,|H| \frac{\text{watts}}{\text{meter}^2}$

(3) $= \frac{|E|^2}{377} \frac{\text{watts}}{\text{meter}^2}$

(4) $= 377\,|H|^2 \frac{\text{watts}}{\text{meter}^2}$

These are the fundamental units of electromagnetic fields. They allow us to relate RF leakage, regulatory requirements, and radio sensitivities to each other as we shall see.

Radio sensitivity is often specified as microvolts into a given input impedance, for example .5 μV into 50 ohms. It can also be specified in input power, for example 5 femtowatts. These sensitivity figures are usually given for 12 dB SINAD out of the radio. How do we convert from field strength to radio sensitivity? Antennas convert electromagnetic fields to power (or voltage) into the radio input terminals. Let us review some antenna basics.

Let's start with a transmitting antenna. If we assume an isotropic antenna, power will be radiated uniformly in all directions.
The power flux density (P_f) at a distance r from the antenna is then:

$$(5) \quad P_f = \frac{\text{power to antenna}}{\text{surface area of sphere}} = \frac{P_t}{4\pi r^2} \frac{\text{watts}}{\text{meter}^2}$$

Most antennas are not isotropic, and will radiate more power in some directions then others. The field strength will be increased in those directions by the amount of the gain over isotropic. This number is the antenna gain. The power flux density in the preferred direction will then be:

$$(6) \quad P_f = \frac{G_t P_t}{4\pi r^2} \frac{\text{watts}}{\text{meter}^2}$$

where G_t = transmit antenna gain.

A resonant half wave dipole has a gain of 1.64, or 2.15 dB. This gain factor holds for both transmit and receive antennas. A transmitting dipole will radiate fields in its preferred direction 1.64 time as strong as an isotropic antenna. Similarly, a receiving dipole will provide a signal at its terminals 1.64 times as strong as the signal from an isotropic antenna.

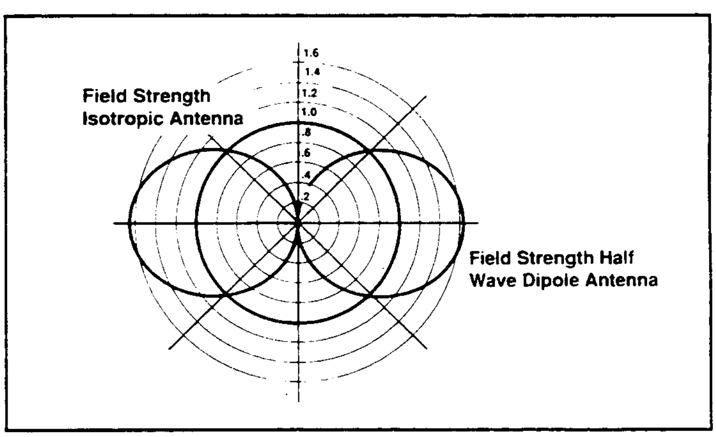


Figure 2. Dipole field strength pattern

To calculate the relationship between field strength and antenna terminal voltage, we use the power flux density equation (6) and the equation for path loss between two antennas. Path loss is the reduction in power of the signal at the receive antenna terminals compared to the transmit antenna terminals. It is due to the spreading of the signal power over a larger area as the distance from the source increases. A given receive antenna will then intercept less power as this distance increases. The equation for path loss is:

$$(7)\quad \frac{P_r}{P_t} = \frac{G_t P_t \lambda^2}{(4\pi r)^2} = \frac{A_{er}\, A_{et}}{(\lambda r)^2}$$

where:

A_{er} = Effective area, receive antenna
λ = Wavelength in meters.
A_{et} = Effective area, transmit antenna
G_r = Receive antenna gain
G_t = Transmit antenna gain
P_f = Power flux density
P_r = Received power
P_t = Power transmitted by transmit antenna

Rearranging equation (7) gives:

$$(8)\quad P_r = \frac{P_t G_r G_t \lambda^2}{16\,(\pi r)^2} \text{ watts}$$

Note that antenna gain and effective area can be related by:

$$(9)\quad G = \frac{4\pi A_e}{\lambda^2}$$

To calculate the amount of power received by the antenna in a field with a given power flux density, we take the ratio of the received power to the power flux density, P_r / P_f [ratio of equation (8) to equation (6)].

Thus:

$$(10)\quad \frac{P_r}{P_f} = \frac{\dfrac{P_t G_r G_t \lambda^2}{16(\pi r)^2}}{\dfrac{P_t G_t}{4\pi r^2}} = \frac{G_r \lambda^2}{4\pi}$$

Or equivalently:

$$(11)\ P_r = P_f \frac{G_r\lambda^2}{4\pi} = \frac{|E|^2}{377}\frac{G_r\lambda^2}{4\pi} \text{ watts}$$

We see that the received power does not depend on the nature of the transmit antenna, but only the field strength. For a resonant half wave dipole, Z_{in} = 73 ohms (pure resistive).

Thus:

$$(12)\ E_r = \sqrt{73P_r}$$

$$= \sqrt{73 \frac{E^2}{377}\frac{G_r\lambda^2}{4\pi}} \text{ volts}$$

$$(13)\ = E\lambda\sqrt{\frac{73G_r}{377\cdot 4\pi}} \text{ volts}$$

For a half wave resonant dipole, G_r = 1.64.

Thus:

$$(14)\ E_r = .159\ |E|\ \lambda$$

assuming a 73 ohm impedance load. We now have a simple conversion between field strength and voltage into a 73 ohms load assuming a dipole antenna.

Well then, are we all ready to go now and make measurements? No! We have to decide at what distance we are going to measure, and what level is acceptable. As discussed earlier, receiver tests are often done close to the signal generator, usually less than one meter away. As equation (5) shows,

$$(5)\ P_f = \frac{\text{power to antenna}}{\text{surface area of sphere}} = \frac{P_t}{4\pi r^2}\ \frac{\text{watts}}{\text{meter}^2}$$

Higher power flux density is found closer to the source. Thus, maximum leakage signal is obtained close to the signal generator. Let us assume that receiver tests are to be conducted as close as 25 mm away from the signal generator. Can we repeat the regulatory requirements tests with a new lower specification line and extrapolate to our 25 mm receiver test position? We might be able to do an extrapolation using equation (3),

$$(3)\ P_f = \frac{|E|^2}{377}\ \frac{\text{watts}}{\text{meter}^2}$$

and equation (6),

$$(6)\quad P_f = \frac{G_t P_t}{4\pi r^2} \ \frac{\text{watts}}{\text{meter}^2}$$

Combining the two, we find:

$$(15)\quad |E|^2 = \frac{377 G_t P_t}{4\pi r^2} \ \text{volts}^2$$

or:

$$(16)\quad |E| = \frac{1}{r}\sqrt{\frac{377 G_t P_t}{4\pi}}$$

This analysis indicates that a magnitude of the electric field strength $|E|$ varies as 1/r. We know from equation (14) that electric field strength and antenna terminal voltage (and thus receiver terminal voltage) vary directly with each other. If we desire no more than .25 μV of antenna terminal voltage at 25 mm away, by our analysis, what must we measure at 10 meters away to insure this? The 1/r electric field strength relationship indicates that we would find .625 nV of signal at the antenna terminals. A very low noise receiver with a bandwidth of less than 1 Hz would be needed for this measurement. To make things easier, why not just make the measurement at 25 mm away?

We must look again at our analysis. The assumptions made for the analysis thus far hold true only at distances several wavelengths from the source of radiation, that is, the far field region. Several nice field properties hold in the far field region:
1. The ratio of $|E|$ to $|H|$ is 377 ohms, independent of source.
2. The magnitude of E and H vary as 1/r along a given radius line where r is the radial distance from the source.
3. The fields are plane waves.

What happens closer in, at distances of a fraction of a wavelength? This region is called the near field region, and things get more complicated. First of all, to simplify the discussion, let us assume that the sources of radiation are point sources. Also we must now be concerned with two types of sources—an electric point source and a magnetic point source.

An infinitesimal dipole is an electric field point source. An infinitesimal loop is a magnetic field point source.

The equations for the fields generated by an electric point source are below:

$(I_m \leftrightarrow I_o)$

$$(-E_\phi)\quad H_\phi = \frac{I_o h}{4\pi}\, e^{-jkr} \left(\frac{jk}{r} + \frac{1}{r^2}\right) \sin\theta$$

$$(H_r)\quad E_r = \frac{I_o h}{4\pi}\, e^{-jkr} \left(\frac{2\eta}{r^2} + \frac{2}{j\omega\varepsilon r^3}\right) \cos\theta$$

$$(H_\theta)\quad E_\theta = \frac{I_o h}{4\pi}\, e^{-jkr} \left(\frac{j\omega\mu}{r} + \frac{1}{j\omega\varepsilon r^3} + \frac{\eta}{r^2}\right) \sin\theta$$

These are the fields generated by the infinitesimal dipole current element I_o. The terms in parentheses are for the fields generated by an infinitesimal current loop. The term I_m is an imaginary magnetic "current" element, perpendicular to the current loop, whose magnitude is proportional to the magnitude of the current times the area of the loop.

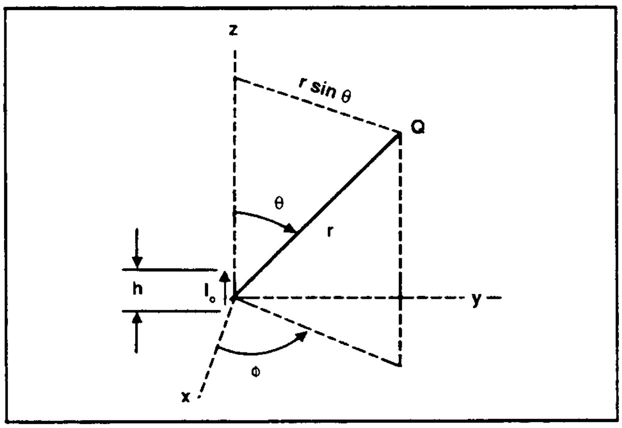


Figure 3. Electrical field source and current system

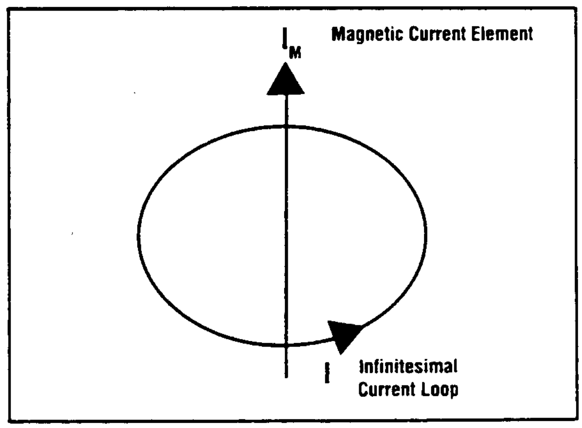


Figure 4. Magnetic current element

Looking at the equations, we now find that the field intensity varies as something other than just 1/r—there are field components which vary as $1/r^2$ and $1/r^2$. We find field components in all three orthogi-nal directions: r, θ, and ϕ.

These equations hold in general, both near field and far field. In the far field, the $1/r^2$ and $1/r^3$ terms become negligible. The radial field component therefore also becomes negligible. Thus, in the far field, the fields vary only as 1/r, and the ratio of $|E| / |H|$ is 377 ohms.

The θ and ϕ terms are perpendicular to the direction of wave travel. The direction of wave travel is along radial lines. At large enough radius, the curvature in the θ and ϕ directions is negligible with respect to a wavelength, and so we have plane waves.

Dipoles are electric field antennas. Loops are magnetic field antennas. In the far field, where the E field and H field are in constant ratio to each other (377 ohms), the relative sensitivity of dipoles versus loops is always the same. In the near field, because of the additional $1/r^2$ and $1/r^3$ terms, this is no longer true. Let us look at the ratio of $|E|$ and $|H|$ in the near field so see what the difference in sensitivity between dipoles and loops would be.

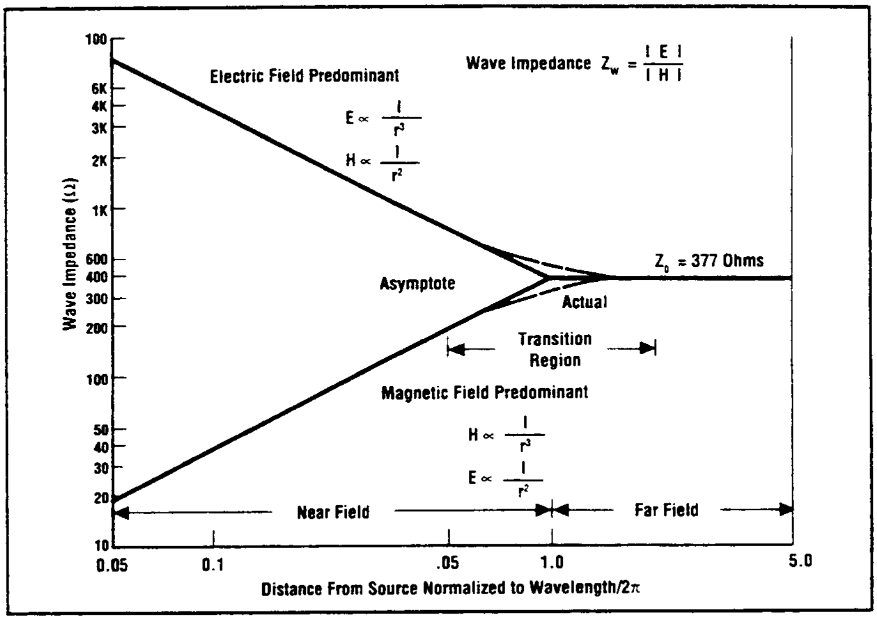


Figure 5. Wave impedance vs. distance from source

The ratio of $|E|$ and $|H|$ is called the wave impedance. This illustration shows how the wave impedance varies as a function of distance and nature of the source, with the radial component neglected. Note that the distance is normalized to the wavelength divided by 2π .

Several other factors complicate near field measurements. As we have just seen, there is no fixed ratio between the E and H fields.

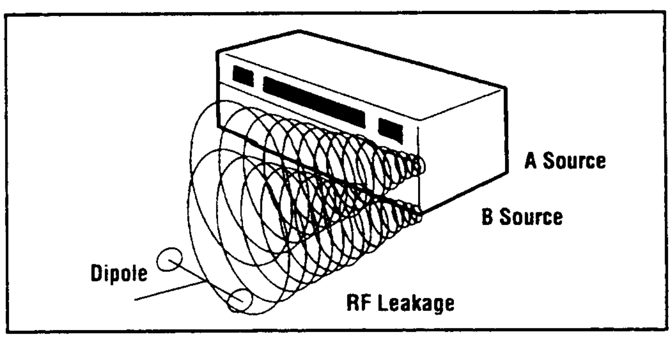


Figure 6. Sources complete measurement

We may measure different field strengths depending on the type of antenna we use. In general, the wave fronts are not plane waves in near field, but are curved. The antenna calibrations which are done in far field, where the wave fronts are plane waves, therefore will not hold. Very small dipoles can be used to make accurate near field measurements. They will minimize the field curvature effect. But they sacrifice a lot of sensitivity due to large mismatch or loss in the matching network. In practical leakage measurements, we have additional complicating factors: The nature of the source, whether electric or magnetic, may be unknown. And most likely there will be multiple sources for the leakage.

Historically, we have used a two turn loop antenna, Hewlett Packard number 08640-60501, to measure rf leakage from our signal generators. Due to radios becoming more sensitive and operating at higher frequencies, it has become inadequate for rf leakage

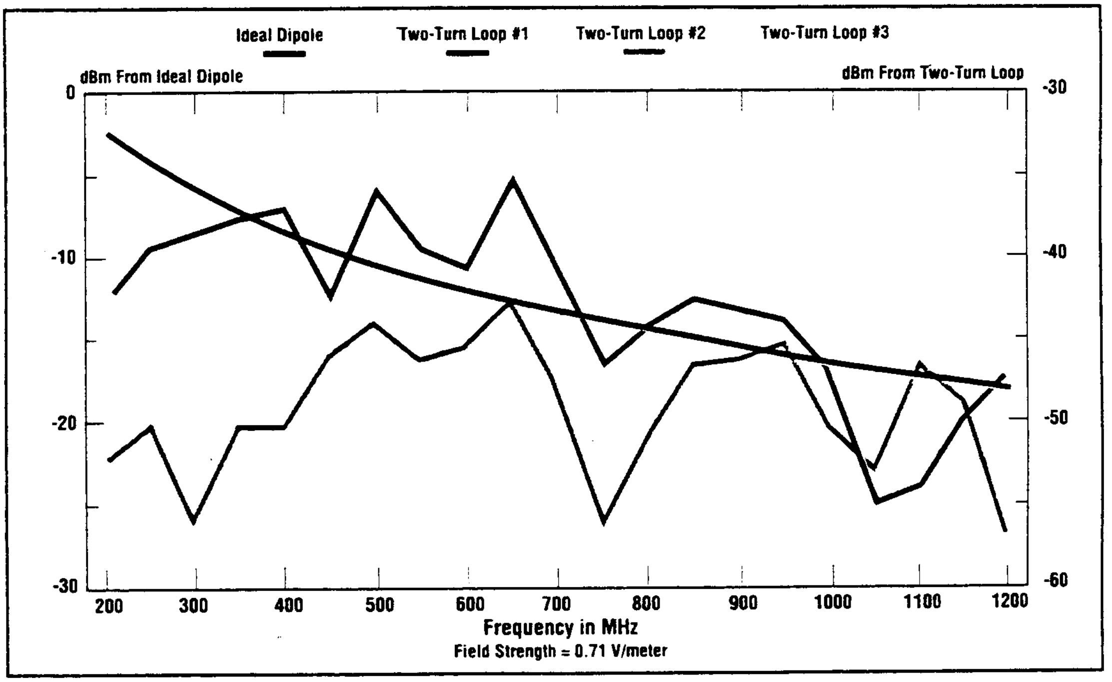


Figure 7. Two turn loop far field responses vs. ideal dipole

measurements. Its sensitivity is no match for a resonant dipole—about 20 to 30 dB less sensitive in far field measurements. It is hard to assign a number for comparative sensitivity due to its unflatness and lack of consistency among units. At frequencies higher than several hundred MHz, the handle has been found to be a better antenna than the loop portion. This make it sensitive to small changes in orientation and hand position. Even reflections off the user's body change the response.

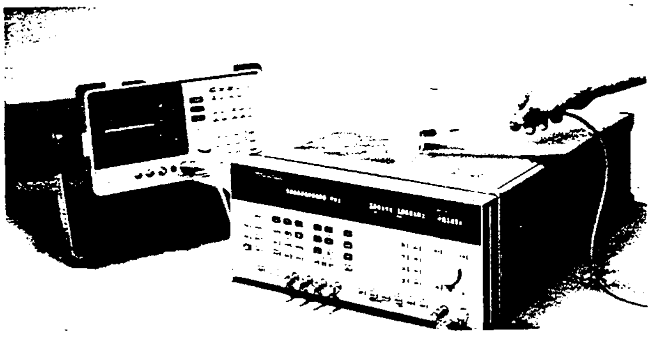


Figure 8. Photo of dipole

To improve our sensitivity and flatness for measuring our low leakage signal generators, we have decided to use resonant dipoles. The dipoles have spacers, 25 mm radius, to set a standard measuring distance. Several tests have shown this to be a good choice as we shall see.

Correlating receivers and dipole antennas

Our goal is to build signal generators with leakage low enough such that it cannot be detected by receivers placed a given distance from the signal generators. The problem is then to generate a field that a receiver can barely detect, and then substitute a resonant dipole in this same field. The signal level out of the dipole is then measured. This is first done in the far field where all the "nice" properties hold. The test is repeated in the near field. The signal levels from the dipole in far field and near field are then compared. If they are equal, we have established equivalency between dipole field strength measurements and radio sensitivities.

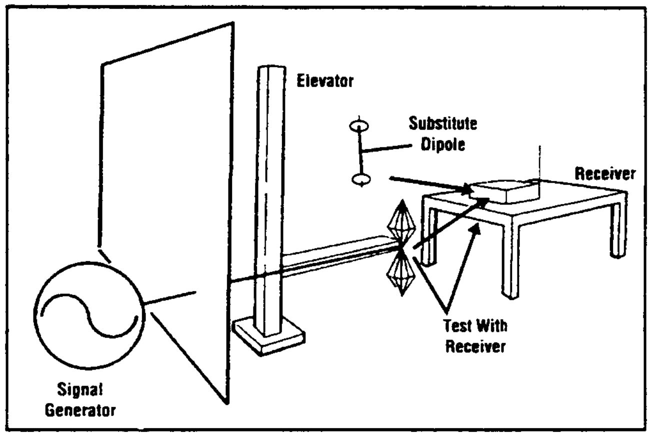


Figure 9. Calibration test between dipole and receiver.

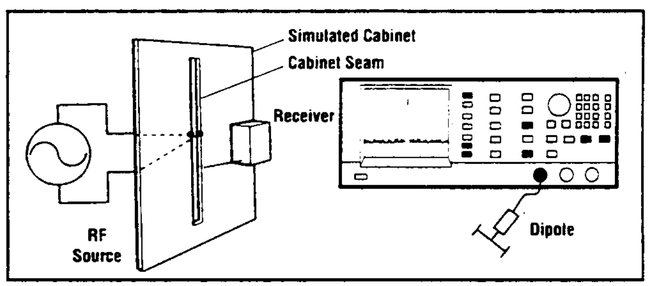


Figure 10. Leakage Simulation of Cabinet with seam

First, the far field tests were carried out. In a semianechoic chamber (all surfaces covered with RF absorber except the floor) a transmit antenna was placed on an elevator mechanism. Various radios and pagers, 146 MHz to 1260 MHz were placed about two meters from the transmit antenna, about 1 meter above the floor. The height of the transmit antenna was adjusted for maximum received signal in the receiver. The signal strength was adjusted at the source so that the modulation tone was just perceptible from the receiver. A dipole was then substituted at the location of the receiver, and the received signal measured.

Next, a circuit fed slot antenna was constructed. A receiver was placed 25 mm from the slot antenna. The receiver was rotated for

maximum signal strength, and the signal strength was again adjusted so the modulation tone was just perceptible from the receiver. A dipole with 25 mm radius spacers was then scanned over the slot antenna. The received signal strength was then compared to that previously found in the earlier test, and was with 2 dB.
The tests so far have compared the relative sensitivity of dipoles versus receivers. While this is sufficient for accurate testing of RF leakage, we wanted to determine the absolute sensitivity of the dipole antennas.

For the far field, this is given by equation 14:

$$(14)\quad E_r = .159\ |E|\lambda$$

How well would the dipole do in absolute terms in measuring the radiation from a slot antenna in the near field? A test was done at 500 MHz to find out. A 500 MHz resonant circuit fed slot antenna was driven with 0 dBm RF power. A resonant dipole was placed across the slot, 25 mm away. The received power was measured. The power was -3 dBm, indicating a rather efficient coupling of power. We believe that this is due to capacitive coupling of the potential difference across the slot to the antenna poles. This unexpected result shows that a dipole, an electric field antenna, is good even for measuring radiation from magnetic sources like a slot antenna.

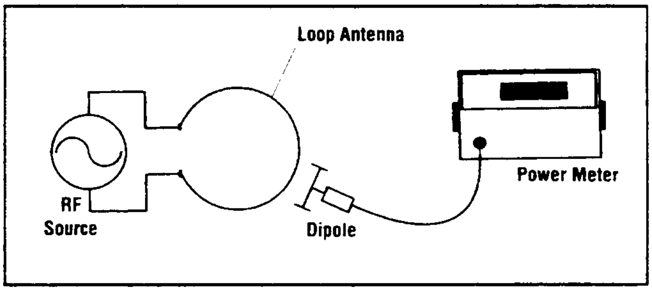


Figure 11. Absolute measurement loss — loop antenna to dipole antenna

This success inspired a similar experiment. A 500 MHz resonant loop was constructed. This too is a magnetic radiator. The loop was driven with 0 dBm RF power. When a dipole was placed 25 mm from the loop, the power received was -6 dBm. In this case, the coupling was not quite as good, but still quite acceptable to indicate when leakage should occur.

Thus, experimentally, the dipole has shown itself to be sensitive, even to magnetic sources which might be found in signal generators.

Sources of leakage from a signal generator

If the cabinet containing a signal generator were a welded metal box, for all practical purposes there would be no leakage. Of course, this is impractical, for we must be able to get signals out of the box, and modulation, control, and power into it. In addition, in order to service it, the covers must be removable, and not welded. These considerations cause us to compromise the ultimate shielded box.

Wires and cables passing through a shielding enclosure are commonly called penetrations. If an insulated wire is simply passed from the inside to the outside of a shielded box through a hole, it will conduct out the rf fields present in the box and then radiate them on the outside. Even a terminated coax cable, if the outer conductor is not grounded at the hole, can conduct out the fields.

For low leakage along seams, the ideal is a continuous low impedance contact. In practice, this is difficult to achieve. The goal can be approached with some reduction in performance by using closely spaced periodic contact points of the sort provided by multiple screws or contact fingers.

In the critical front seam area of our low leakage signal generators, the periodic contact between the instrument cover and a front bulkhead is supplied by screws spaced 25 mm apart. This is about .08 wavelength apart at 1 GHz.

The rear area was deemed less critical for leakage, as it is further away from the area where radio testing would be done. Here, a spiral strip is used to make contact between the instrument cover and rear panel assembly.

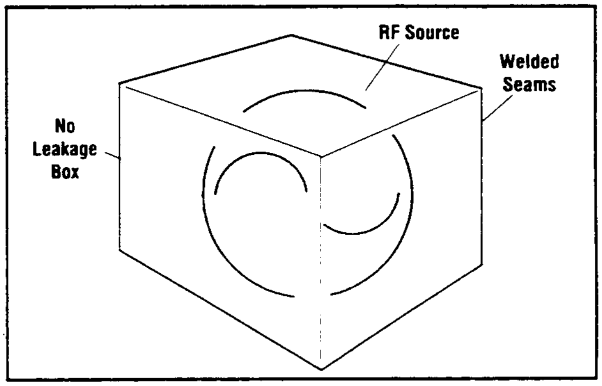


Figure 12. Perfect cabinet

The cover is a one piece sleeve, with a spotwelded seam. The air vent hole area in the cover is backed by aluminum mesh riveted to the cover. The mesh lowers rf leakage through the vent holes.
As mentioned earlier, behind the front panel, there is a bulkhead which supplies the shielding in front. The instrument cover makes contact with this bulkhead, forming a shielded box. Through this bulkhead pass the rf output cable and several modulation input cables. Also passing through the bulkhead is a digital control cable for the front panel keyboard and display.

The solution for coax cables then is to ground the outer conductor at the bulkhead wall. This is done by using a bulkhead connector in the case of the modulation inputs. The rf output cable is soldered to a grounding plate which is then bolted to the bulkhead.

The digital control cable for the front panel keyboard and display is brought through the bulkhead with a shielded connector having an internal low pass filter for each line.

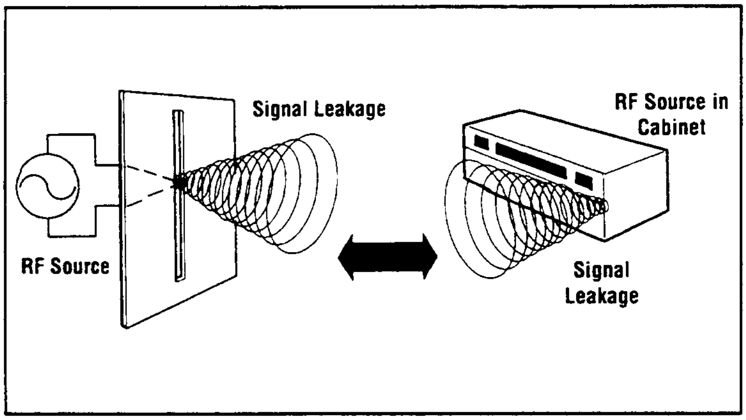


Figure 13. Simulation equivalents to signal generator cabinet

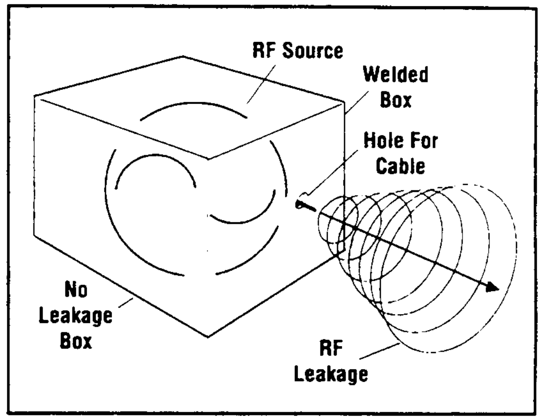


Figure 14. Wire causes cabinet leakage

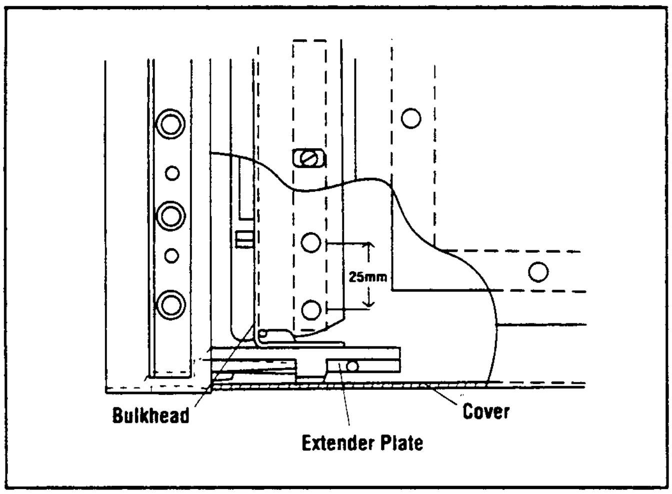


Figure 15. Detail of cabinet option 10

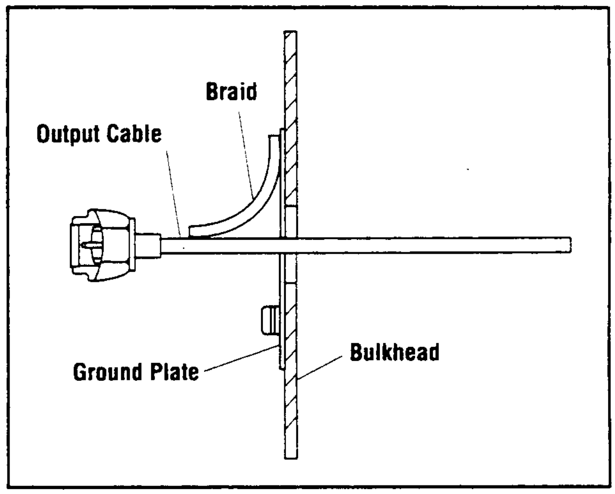


Figure 16. RF leakage wire passage option 10

Dipole Discussion

What are some of the sources of inaccuracy with dipole measurements?

1. If the dipole impedance is not matched to the measurement system impedance, there will be loss due to mismatch. The magnitude of this loss is:

Mismatch loss in dB = $-10 \log (1-\rho^2)$

where: ρ = reflection coefficient magnitude
log = base 10 logarithm

As an example, 73 ohms is the impedance of a dipole in free space, slightly shortened from one half wave length. If this is connected to a 50 system, there will be .15 dB mismatch loss.

2. A more general form of mismatch loss is mismatch uncertainty. This problem is often seen in systems with cables, where the angle of the reflection coefficient will rotate with frequency.
The limits of this uncertainty are:

Mismatch uncertainty = 20 log $(1 \pm \rho_1 \rho_2)$

ρ_1 = reflection coefficient magnitude of source (antenna)
ρ_2 = reflection coefficient magnitude of load (receiver)

Analysis shows that resistive loss in a half wave dipole is negligible. Let the pole elements be made of copper. Assume all the current flows uniformly on the surface of the pole to a thickness of one skin depth. The surface resistivity is:

$$\text{Surface resistivity} = \frac{1}{\sigma\delta}\ \frac{\text{ohms}}{\text{square}}$$

where σ = conductivity
δ = skin depth

Skin depth is as follows:

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

Where: f = frequency
π = permeability

Thus:

$$\text{Surface resistivity} = \sqrt{\frac{\pi f \mu}{\sigma}}\ \frac{\text{ohms}}{\text{square}}$$

For copper, $\mu = 4\pi 10^{-7}$ henry/meter (permeability of free space),
σ = 5.8e7 siemens at room temperature.

$$\text{Surface resistivity} = \sqrt{\frac{3.1416 x 225 x 10^6 x 4 x 3.1416 x 1 x 10^{-7}}{5.8 x 10^7}} = 3.9\ \frac{\text{milliohms}}{\text{square}}$$

Assume the pole diameter is 3.58 mm (.141 inch). The circumference is 11.25 mm. For poles of circumference 11.25 mm:

$$\text{Resistance per mm} = 3.9 x 10^{-3} \frac{1}{11.25} = .35\ \frac{\text{milliohms}}{\text{mm}}$$

The length of a half wave dipole at 225 Mhz is:

$$\text{Antenna length} = \frac{3x10^8 \frac{m}{sec}}{2x225x10^6 \frac{1}{sec}} = .667\ m = 667\ mm$$

Thus, the total pole resistance is:

Pole resistance = 667 mm * .0035 ohm/mm = .23 ohm.
Assume a current of one amp into the dipole. With a 73 ohm input impedance, this would represent 73 watts. Assume a uniform 1 amp current along the length of the dipole. The power dissipated in the pole resistance then is .23 watt. The calculated loss is only about .014 dB. The actual loss is even less, as the current decreases away from the center of the dipole. Interestingly enough, the loss goes down as the frequency increases. While the resistance goes up as square root of frequency, the element lengths go down directly with frequency.

Data subject to change
Printed in U.S.A 2/91
5952-2789

Performance Tests

INTRODUCTION TO PERFORMANCE TESTS

The procedures in this section test the instrument's electrical performance using the specifications in chapter 2 as performance standards. All tests are performed without accessing the interior of the instrument.

NOTE

Before beginning the performance tests, the Signal Generator should be allowed a 24 hour warm-up period after being connected to the ac power line and a 10 minute warm-up period after turn-on. Line voltage must be within ±10% of nominal if the results of the performance tests are to be considered valid.

Unless otherwise stated, the specifications assume the Signal Generator is operating with its Synthesis Modes set to Auto which automatically optimizes the internal hardware configuration for best performance.

PERFORMANCE TEST RECORD

Results of the performance tests may be tabulated on the *Performance Test Record* at the end of the procedures. The *Performance Test Record* lists all of the tested specifications and their acceptable limits. The results, recorded at incoming inspection, can be used for comparison in periodic maintenance and troubleshooting and after repairs or adjustments.

CALIBRATION CYCLE

This instrument requires periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked using the following performance tests every two years.

INTERNAL VOLTMETER VERIFICATION

Internal to the Signal Generator is a precision dc voltmeter. This voltmeter is used to collect calibration correction data when the Recal function is invoked. Recal should be run prior to running the Performance Tests. The accuracy of the voltmeter is not explicitly specified but must be within ±1% of reading ±0.25V for the Recal operation to give valid results.

BASIC FUNCTIONAL CHECKS

If you suspect an instrument failure, test the Signal Generator by activating Special Function 170. Special Function 170 verifies most of the Signal Generator's circuitry. At the conclusion of the test, a result code equal to "0" indicates that the instrument is operating normally. Refer to the *Service Diagnostics Manual* whenever a result code other than "0" appears.

EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in table 8–1, *Recommended Test Equipment.* Any equipment that satisfies the critical specifications provided in the table may be substituted for the recommended model(s).

Table 8–1. *Recommended Test Equipment (1 of 2)*

Instrument Type	Critical Specifications	Recommended Model
Crystal Detector with 600 Ω Feedthru	Frequency: 2060 MHz	HP 423B HP 11095A
Distortion Analyzer	Distortion Range: < 0.1% Range: 20 Hz to 100 kHz	HP 339A, HP 8903B, or HP 8903E
Measuring Receiver and Sensor Module	Frequency Range: 250 kHz to 1300 MHz Input Level: −127 to +17 dBm RF Power: 0.2 dB Tuned RF Level: 0.36 dB RSS Referenced to −10 dBm input Amplitude Modulation: Rates: 20 Hz to 100 kHz Depth: to 90% Accuracy: ±2% at 1 kHz Demodulated Output Distortion: 0.5% for 50% depth; < 1.0% for 90% depth Incidental ΦM: <0.05 radians for 30% depth at 1 kHz rate (50 Hz to 3 kHz bandwidth) Residual AM: < 0.01% rms (0.3 to 3 kHz BW) Frequency Modulation: Rates: 20 Hz to 200 kHz Deviation: to 400 kHz Accuracy: ±3% at 1 kHz Demodulated Output Distortion: <0.3% Incidental AM: 0.2% depth at 20 kHz FM deviation Residual FM: See specifications for External Local Oscillator for Measuring Receiver	HP 8902A and HP 11722A

Table 8-1. Recommended Test Equipment (2 of 2)

Instrument Type	Critical Specifications	Recommended Model
Frequency Standard	Frequency: 10 MHz ±0.5 Hz	HP 5061B
Oscilloscope	Vertical Sensitivity: 0.01 mV/div Bandwidth: 100 MHz Time/Div: 0.05μs Input: Dual Channel	HP 1740A, or Tektronix 2245
Phase Noise Measurement System	The Performance Tests for SSB Phase Noise are complex and the procedure has been written specifically using the HP 3048A, no substitutions are recommended.	HP 3048A Opt. 101
Pulse Generator	Rates: to 1 MHz Pulse Width: 500 ns minimum Output Level: 4 Vpk into 50 ohms	HP 8116A
Reference Signal Generator	Residual FM: Less than or equal to the specification for the HP 8644B.	HP 8644B
Signal Generator	Frequency Range: 100 kHz to 2 GHz Output Amplitude: +20 dBm Range	HP 8642B
Spectrum Analyzer, RF	Frequency Range: 0.1 to 7 GHz Resolution Bandwidth: <1 kHz to 3 kHz	HP 8559A/853A or HP 8562B

Preliminary Test

INTERNAL VOLTMETER VERIFICATION

Specification

The accuracy of the internal voltmeter is not explicitly specified but it should be ±1% of reading ±0.25V for the Recal routine to be valid.

Description

A dc voltage is applied to the voltmeter input of the Signal Generator. The voltage is measured by both the Signal Generator's internal voltmeter and an external voltmeter and the two readings are compared.

NOTE

This test should be run before beginning the Performance Tests.

Equipment

Digital Voltmeter .... HP 3478A
Power Supply .... HP 6218C or HP 6236B

Procedure

1. Remove any connection to the Signal Generator's rear-panel VM IN connector.
2. On the Signal Generator, press INSTR PRESET then key in SPECIAL 180 ENTER to set the internal voltmeter to read the voltage at the Signal Generator's rear-panel VM IN connector. The reading should be between −0.25 and +0.25 Vdc.

   Voltmeter Offset: −0.25 ________ +0.25 Vdc
3. Connect the dc power supply and digital voltmeter to the Signal Generator's rear-panel VM IN connector using a BNC tee. (If a dual power supply is used, stack the + and − outputs to obtain the 40V if needed.)
4. Set the power supply to +40V and set the voltmeter to read +40 Vdc. The Signal Generator should display approximately +40, but more importantly it should agree with the reading of the external voltmeter within ±0.65 Vdc (that is, ±1% of 40V ±0.25V).

   Voltmeter Accuracy at +40V: −0.65 ________ +0.65 Vdc
5. Reverse the power supply leads to produce −40V at the Signal Generator's VM IN connector. The Signal Generator should display approximately −40 and should agree with the reading of the external voltmeter within ±0.65 Vdc (that is, ±1% of 40V ±0.25V).

   Voltmeter Accuracy at −40V: −0.65 ________ +0.65 Vdc

Performance Test 1

CARRIER AMPLITUDE TEST

Specification

Characteristic	Performance Limits	Conditions
Output		
Maximum Level	+13 dBm +16 dBm +13 dBm	HP 8643A HP 8644B, except Option 002 HP 8644B, Option 002
Absolute Accuracy	±1 dB	output ≥ −127 dBm

Description

The carrier amplitude specifications are verified with an HP 8902A Measuring Receiver. The higher amplitudes are measured directly with the measuring receiver's built-in power meter. Lower amplitudes are measured using the very sensitive tuned RF level feature of the measuring receiver. Carrier amplitude is set in the instrument both by switching attenuator pads and also by voltage-variable gain control. Both types of amplitude control are checked.

Equipment

Measuring Receiver .... HP 8902A
Sensor Module .... HP 11722A

Procedure

Initial Setup

1. On the Signal Generator, press INSTR PRESET.
2. Preset the measuring receiver, then select the RF power measurement with units of dBm.

NOTE

Verify that the measuring receiver's calibration factors match the sensor module. Zero the power sensor and calibrate the power measurement using the measuring receiver's built-in power reference.

3. Connect the input of the measuring receiver's sensor module directly to the Signal Generator's OUTPUTS RF connector.

Maximum Level

4. Set the Signal Generator's carrier frequency and amplitude as indicated in the following table. Also, key the frequency into the measuring receiver to invoke the appropriate calibration factor. The carrier amplitude should be within the limits given in the table.

Signal Generator Carrier		Amplitude Limits (dBm)	
Frequency (MHz)	**Amplitude (dBm)**	**Minimum**	**Actual**
HP 8643A			
.25147	+14	+13	________
12.247	+14	+13	________
141.42	+14	+13	________
1029.9	+14	+13	________
HP 8644B			
.25147	+17	+16	________
8.05	+17	+16	________
75	+17	+16	________
1029.9	+17	+16	________
HP 8643A or HP 8644B Option 002			
.25147	+14	+13	________
8.05	+14	+13	________
75	+14	+13	________
1029.9	+14	+13	________
2060	+14	+13	________

High-Amplitude Accuracy

5. Set the Signal Generator's carrier frequency and amplitude as indicated in the following table. Also, key the frequency into the measuring receiver to invoke the appropriate calibration factor. The output power should be within the limits given in the table. There are two tables, one for the HP 8643A and one for the HP 8644B; be sure to use the correct table for the signal generator you are using.

HP 8643A Standard or HP 8644B Opt. 005 Settings and Limits

Signal Generator Carrier		Amplitude Limits (dBm)		
Frequency (MHz)	Amplitude (dBm)	Minimum	Actual	Maximum
141.42	+8	+7	________	+9
7.5	+8	+7	________	+9
3	+8	+7	________	+9
.25147	+8	+7	________	+9
.25147	+3	+2	________	+4
3	+3	+2	________	+4
7.5	+3	+2	________	+4
141.42	+3	+2	________	+4
1015	+3	+2	________	+4

HP 8644B or HP 8643A Opt. 002 Settings and Limits

Signal Generator Carrier		Amplitude Limits (dBm)		
Frequency (MHz)	Amplitude (dBm)	Minimum	Actual	Maximum
1015	+10	+9	________	+11
141	+10	+9	________	+11
15	+10	+9	________	+11
5.1775	+10	+9	________	+11
0.305	+10	+9	________	+11
0.305	+5	+4	________	+6
5.1775	+5	+4	________	+6
15	+5	+4	________	+6
141	+5	+4	________	+6
1015	+5	+4	________	+6
1015	+0	−1	________	+1
141	+0	−1	________	+1
15	+0	−1	________	+1
5.1775	+0	−1	________	+1
3.05	+0	−1	________	+1
Option 002				
2060	+10	+9	________	+11
2060	+5	+4	________	+6
2060	+0	−1	________	+1

Low-Amplitude Accuracy

6. On the Signal Generator key in FREQ 1015 MHz and AMPTD 0 dBm.
7. Set the measuring receiver to the tuned RF level measurement mode and key in automatic operation to tune the measuring receiver to the Signal Generator's output. (If the measuring receiver indicates the need to calibrate, press the calibrate key.)
8. Set the Signal Generator's carrier amplitude as indicated in the following table and note the measured amplitude. The carrier amplitude should be within the limits given in the table.

NOTE

When the recalibration annunciator appears on the measuring receiver's display, press the measuring receiver's CALIBRATE *key, wait for completion of the calibration, then proceed.*

Other frequencies can be tested if they are in the range of the measuring receiver. For high frequencies, a down-converter may be required.

HP 8644B Standard or HP 8643A Option 002

Signal Generator Carrier Amplitude (dBm)	Amplitude Limits (dBm)		
	Minimum	Actual	Maximum
−10	−11	________	−9
−20	−21	________	−19
−30	−31	________	−29
−50	−51	________	−49
−65	−66	________	−64
−70	−71	________	−69
−80	−81	________	−79
−95	−96	________	−94
−105	−106	________	−104
−115	−116	________	−114
−120	−121	________	−119

HP 8643A Standard or HP 8644B Option 005

Signal Generator Carrier Amplitude (dBm)	Amplitude Limits (dBm)		
	Minimum	Actual	Maximum
−7	−8	________	−6
−27	−28	________	−26
−37	−38	________	−36
−47	−48	________	−46
−57	−58	________	−56
−67	−68	________	−66
−77	−78	________	−76
−87	−88	________	−86
−97	−98	________	−96
−107	−108	________	−106
−117	−118	________	−116
−127	−128	________	−126

Performance Test 2

AM TEST

Specification

Characteristic	Performance Limits	Conditions
Spectral Purity		
Residual AM	<0.01% rms	0.3 to 3 kHz post-detection bandwidth
Amplitude Modulation		
Indicator Accuracy	±(7% of setting +1%)	to 80% depth; 1 kHz rate
Distortion		30% depth; 1 kHz rate
	<3%	Not Option 002
	<4%	Option 002
3 dB Bandwidth	>100 kHz	128 to 1030 MHz
	>75 kHz	1030 to 2060 MHz; Option 002
Incidental Phase Modulation	<0.2 rad peak	at 30% depth; 1 kHz rate

Description

The AM specifications are verified directly with an HP 8902A Measuring Receiver.

Equipment

Measuring Receiver .... HP 8902A

Procedure

Initial Setup

NOTE

Verify that the measuring receiver's AM is calibrated using its built-in AM calibrator.

1. Connect the equipment as shown in figure 8–1.

NOTE

Connect the Signal Generator's OUTPUTS RF *directly to the RF input of the measuring receiver or, if a sensor module is being used, connect it to the input of the sensor module.*

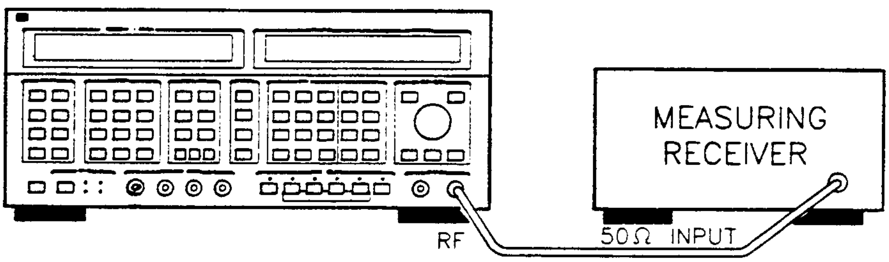


Figure 8–1. AM Test Setup

2. On the Signal Generator, press INSTR PRESET.
3. Preset the measuring receiver, then set it as follows.
    a. Select the AM measurement.
    b. Set the high-pass filter to 300 Hz.
    c. Set the low-pass filter to 3 kHz.
    d. Set the detector to RMS.

Residual AM

4. Set the Signal Generator's carrier frequency and amplitude as indicated in the following table. Allow the measuring receiver to retune. The residual AM should be within the limits given in the table. (Note that the Signal Generator's AM function is off.)

Signal Generator Carrier Settings		Residual AM Limits (%)	
Frequency (MHz)	Amplitude (dBm)	Actual	Maximum
750	+13	________	0.01
1030	+13	________	0.01

Indicator Accuracy

5. Set the measuring receiver as follows.
   a. Set the detector to peak± /2 (that is, to average peak+ and peak−). (To do this press the PEAK + and PEAK − keys simultaneously.)
   b. Set the high-pass filter off.
   c. Set the low-pass filter off.
6. Set the Signal Generator as follows.
   a. Key in FREQ 1 GHz.
   b. Key in AMPTD 0 dBm.
   c. Key in AM ON. (Note that modulation source is set to internal with a modulation rate of 1 kHz.)
7. Set the Signal Generator's AM depth as indicated in the following table. The AM depth, as read on the measuring receiver, should be within the limits shown in the table.

Signal Generator AM Depth (%)	AM Depth Limits (%)		
	Minimum	Actual	Maximum
30	26.9	________	33.1
70	64.1	________	75.9

Distortion

8. Set the measuring receiver to measure the audio distortion on the demodulated 1 kHz AM.
9. Set the Signal Generator's AM depth as indicated in the following table. The AM distortion, as read on the measuring receiver, should be within the limits shown in the table.

Signal Generator AM Depth (%)	AM Distortion Limits (%)			
	Not Option 002		Option 002	
	Actual	Maximum	Actual	Maximum
30	________	3	________	4

10. If the Signal Generator has Option 002, set its carrier frequency to 1390 MHz. Repeat step 9 using the following table.

Signal Generator AM Depth (%) 1390 MHz	AM Distortion Limits (%)	
	Actual	Maximum
30	________	4

Incidental Phase Modulation

11. On the Signal Generator key in FREQ 1029 MHz and AM 30 %. (Carrier amplitude should remain at 0 dBm.)
12. Set the measuring receiver to read phase modulation (ΦM) and set its detector to peak+. (If the phase modulation reading is fluctuating, average several readings.) The phase deviation of the phase modulation should read 0.2 rad peak or less.

Incidental ΦM Limit: ________ 0.2 rad peak

3 dB Bandwidth

13. Set the measuring receiver to measure AM depth.
14. On the Signal Generator, key in AM 80 %, AMPTD 7 dBm.
15. Set the Signal Generator's carrier frequency as indicated in the following table. For each setting perform the following steps.
    a. After setting the Signal Generator's carrier frequency, allow the measuring receiver to retune.
    b. Key in AUDIO FREQ 1 kHz.
    c. Set the measuring receiver ratio display off (if it is on). Then set the ratio back on to establish a new ratio reference. (Also, set the ratio to read in dB, that is, log.)
    d. Set the Signal Generator's audio (modulation) frequency as shown in the table.
    e. Note the dB change in AM depth on the measuring receiver. The depth should be between −3 and +3 dB (relative).

Signal Generator Settings		Relative AM Depth Limits (dB)		
Carrier Frequency (MHz)	Audio Frequency (kHz)	Minimum	Actual	Maximum
516	100	−3	______	+3
1029	100	−3	______	+3
1030 [1]	75	−3	______	+3

[1] Option 002

Performance Test 3

FM TEST

Specification

Characteristic	Performance Limits	Conditions
Spectral Purity		
Residual FM		deviation <0.01% of maximum available
HP 8643A		0.3 to 3 kHz post-detection bandwidth
	<1 Hz rms	0.25 to 257 MHz carrier
	<1.2 Hz rms	257 to 515 MHz carrier
	<2 Hz rms	515 to 1030 MHz carrier
	<4 Hz rms	1030 to 2060 MHz carrier; Option 002
		0.05 to 15 kHz post-detection bandwidth
	<1.2 Hz rms	0.25 to 257 MHz carrier
	<2 Hz rms	257 to 515 MHz carrier
	<4 Hz rms	515 to 1030 MHz carrier
	<8 Hz rms	1030 to 2060 MHz carrier; Option 002
HP 8644B Mode 3		0.3 to 3 kHz post-detection bandwidth;
	<0.5 Hz rms	0.25 to 515 MHz carrier
	<1 Hz rms	515 to 1030 MHz carrier
	<2 Hz rms	1030 to 2060 MHz carrier; Option 002
		0.05 to 15 kHz post-detection bandwidth;
	<0.5 Hz rms	0.25 to 257 MHz carrier
	<1 Hz rms	257 to 515 MHz carrier
	<2 Hz rms	515 to 1030 MHz carrier
	<4 Hz rms	1030 to 2060 MHz carrier; Option 002

(Table continued on next page)

(Table continued from previous page)

Characteristic	Performance Limits	Conditions
Frequency Modulation		
Maximum Peak Deviation		Mode 1
	20 MHz	1030 to 2060 MHz carrier; Option 002
	10 MHz	515 to 1030 MHz carrier
	5 MHz	257 to 515 MHz carrier
	2.5 MHz	128 to 257 MHz carrier
	1.25 MHz	64 to 128 MHz carrier
	625 kHz	32 to 64 MHz carrier
	312 kHz	16 to 32 MHz carrier
	156 kHz	8 to 16 MHz carrier
	78 kHz	4 to 8 MHz carrier
	39 kHz	2 to 4 MHz carrier
	19.5 kHz	1 to 2 MHz carrier
	9.76 kHz	0.5 to 1 MHz carrier
	4.88 kHz	0.25 to 0.5 MHz carrier
	10% of Mode 1 maximum	HP 8643A or HP 8644B Mode 2
	1% of Mode 1 maximum	HP 8644B Mode 3
Maximum Rate	100 kHz	1030 to 2060 MHz carrier; Option 002
	100 kHz	8 to 1030 MHz carrier
	78 kHz	4 to 8 MHz carrier
	39 kHz	2 to 4 MHz carrier
	19.5 kHz	1 to 2 MHz carrier
	9.67 kHz	0.5 to 1 MHz carrier
	4.88 kHz	0.25 to 0.5 MHz carrier
Indicator Accuracy		accuracy at time of setting for rates that do not exceed maximum rate
HP 8643A	5%	30 kHz rate
	10%	100 kHz rate
HP 8644B	6%	30 kHz rate
	15%	100 kHz rate
Distortion	5%	20 Hz to 100 kHz rates
	<1%	HP 8644B Mode 3;
Incidental AM	<0.5% depth	deviation $\leq$ 20 kHz
Carrier Frequency Accuracy in FM	±0.5% of deviation setting	

Description

The FM specifications which can be verified directly with an HP 8902A Measuring Receiver are checked in these tests. The restrictions are that (1) the peak deviation must be less than 400 kHz for carrier frequencies above 10 MHz or 40 kHz below 10 MHz, (2) the modulation rate must be less than 200 kHz for carrier frequencies above 10 MHz or 10 kHz below 10 MHz, and (3) the local oscillator's residual FM must be no more than the HP 8643/8644. This latter restriction can be overcome by choosing an external local oscillator with better or equal performance (such as an HP 8662A or a second HP 8643/8644).

The FM indicator accuracy is checked at the high end, geometric midpoint, and low end of each carrier range. In instrument operation, a low-pass filter switches in or out at the midpoint. Indicator accuracy is checked at the highest frequency where the lower-frequency filter is in.

Equipment

Distortion Analyzer .... HP 8903B or HP 8903E
Measuring Receiver .... HP 8902A Option 003
Reference Signal Generator .... HP 8662A, HP 8663A, or HP 8643/8644

NOTE

If the Signal Generator being tested has Option 002, the reference signal generator must have carrier frequency range of 2060 MHz.

Procedure

Initial Setup

NOTE

Verify that the measuring receiver's FM is calibrated using its built-in FM calibrator.

1. Connect the equipment as shown in figure 8–2 making note of the following details.
   a. If the measuring receiver does not have series 030 options (high selectivity), remove the rear-panel coaxial jumper from the local oscillator's input and output.
   b. Connect the reference signal generator's output to the measuring receiver's rear-panel local oscillator input.
   c. Connect the Signal-Generator-under-test's OUTPUTS RF directly to the RF input of the measuring receiver or, if a sensor module is being used, connect it to the input of the sensor module.

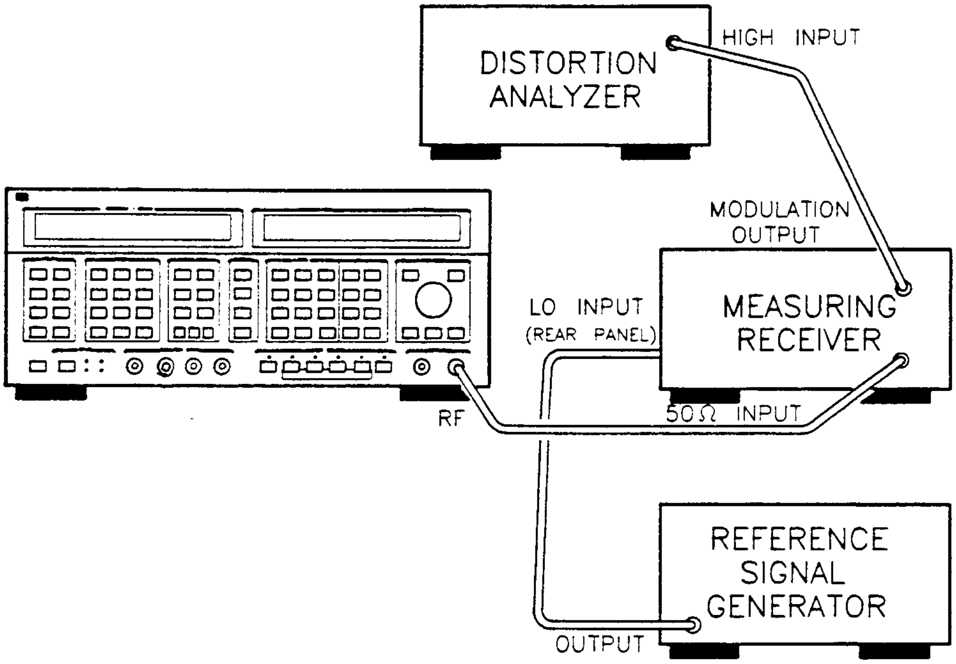


Figure 8-2. FM Test Setup

2. Set the reference signal generator's carrier to 1029.5006 MHz at 0 dBm.
3. On the Signal-Generator-under-test, press INSTR PRESET and key in AMPTD 0 dBm. On the HP 8644B, select Mode 3.
4. Preset the measuring receiver, then set it to read FM with the RMS detector. (If the measuring receiver has series 030 options (high selectivity), invoke special function 23.1 to switch the local oscillator to external.)

Residual FM

5. Set the Signal-Generator-under-test's carrier frequency and synthesis mode, the reference signal generator's carrier frequency, and the measuring receiver's high-pass and low-pass filters as indicated in the following table. For each setting, allow the measuring receiver to retune. The residual FM should be within the limits given in the table.

Signal-Generator-Under-Test		Reference Generator Carrier (MHz)	Measuring Receiver Filter		Residual FM Limits (Hz rms)	
Model	Carrier (MHz)		High-Pass	Low-Pass	Actual	Maximum
HP 8643A	1028.0006	1029.5006	300 Hz	3 kHz	________	2
	1028.0006	1029.5006	50 Hz	15 kHz	________	4
	1030 (1)	1301.5	50 Hz	15 kHz	________	8
	1030 (1)	1301.5	300 Hz	3 kHz	________	4
HP 8644B Mode 3	1028	1029.5	50 Hz	15 kHz	________	2
	1028	1029.5	300 Hz	3 kHz	________	1

(1) Option 002

Indicator Accuracy

6. On the Signal-Generator-under-test, key in FM ON, then key in AUDIO FREQ 40 kHz.
7. If the measuring receiver does not have series 030 options, disconnect the reference generator from the rear panel and re-connect the coaxial jumper. If the measuring receiver has series 030 options, invoke special function 23.0 to switch the local oscillator back to internal.
8. Set the measuring receiver as follows.
   a. Press the automatic operation key.
   b. Set the detector to peak± /2 (that is, to average peak+ and peak−). (To do this press the PEAK + and PEAK − keys simultaneously.)
   c. Set the high-pass filter off.
   d. Set the low-pass filter off.

9. On the Signal-Generator-under-test, set the instrument as indicated in the following table. For each setting, perform the following steps.

   a. Set the carrier frequency, peak FM deviation, and Synthesis Mode as indicated in the table.

      NOTE

      The order in which these settings are made may not necessarily be in the sequence stated. For example, a decrease in carrier frequency may not be possible unless the peak FM deviation is first reduced. Also, low values of FM deviation (such as 0.097 kHz) cannot be entered as shown in the table; enter such values using less-significant units (such as 97 Hz).

   b. Set the FM rate as indicated in the table.

   c. Read the FM peak deviation on the measuring receiver. The FM deviation should be within the limits shown in the table. (There are two tables, one for the HP 8643A and one for the HP 8644B. Be sure to use the correct one for your instrument.)

HP 8643A Settings and Limits

HP 8643A Settings			FM Deviation Limits (kHz peak)		
Carrier Frequency (MHz)	FM Rate (kHz)	FM Deviation (kHz peak)	Minimum	Actual	Maximum
750	50	360	324	______	396
750	70	360	324	______	396
750	100	360	324	______	396
260	20	250	238	______	262
260	100	250	225	______	275
514	20	250	238	______	262
514	100	250	225	______	275

HP 8644B Settings and Limits

HP 8644B Settings			FM Deviation Limits (kHz peak)		
Carrier Frequency (MHz)	FM Rate (kHz)	FM Deviation (kHz peak)	Minimum	Actual	Maximum
260	20	250	235	______	265
260	100	250	213	______	287
514	20	250	235	______	265
514	100	250	213	______	287

Distortion

10. Connect the distortion analyzer to the modulation output of the measuring receiver. (Refer to figure 8–2.)
11. Set the distortion analyzer to measure the distortion on the demodulated FM which will have an audio rate of 100 kHz. (Switch any low-pass filtering off.)
12. Set the frequency of the audio source to 100 kHz.
13. On the Signal-Generator-under-test, set the carrier frequency, and peak FM deviation as indicated in the following table. For each step read the distortion on the distortion analyzer. The distortion should be within the limits shown in the table.

Signal Generator Settings		FM Distortion Limits (%)	
Carrier Frequency (MHz)	FM Deviation (kHz peak)	Actual	Maximum
260	250	______	5
514	250	______	5

Incidental AM

14. On the Signal-Generator-under-test, key in FREQ 516 MHz and FM 20 kHz.
15. Set the measuring receiver to read AM. The AM depth should read 0.5% or less.

Incidental AM Limit: ______ 0.5%

Carrier Frequency Accuracy in FM

16. Set the measuring receiver to measure carrier frequency. Set the counter resolution to 10 Hz (special function 7.1).
17. On the Signal-Generator-under-test, press INT to turn off the internal modulation oscillator.
18. On the Signal-Generator-under-test, set the carrier frequency and the FM peak deviation as indicated in the following table. For each step press FM OFF then press FM ON and note the shift in carrier frequency as read on the measuring receiver. (The frequency error measurement mode in the measuring receiver can also be used to measure carrier shift.) The carrier shift should be within the limits shown in the table.

NOTE

The FM system in the Signal Generator is turned on but no actual FM is generated because the audio source is turned off.

Signal Generator Settings		Carrier Shift Limits (Hz)	
Carrier Frequency (MHz)	FM Deviation (MHz peak)	Actual	Maximum
516	10	______	50,000
1029	10	______	50,000

Performance Test 4

SPECTRAL PURITY TEST (SSB PHASE NOISE)

Specification

Characteristic	Performance Limits	Conditions
Spectral Purity		
SSB Phase Noise		CW, AM, or FM (FM at 1% of maximum specified deviation for offsets >1 kHz, FM at minimum deviation for offsets <1 kHz)
HP 8643A		20 kHz frequency offset
	−124 dBc/Hz	1030 to 2060 MHz carrier; Option 002
	−130 dBc/Hz	515 to 1030 MHz carrier
	−136 dBc/Hz	257 to 515 MHz carrier
	−140 dBc/Hz	128 to 257 MHz carrier
	−142 dBc/Hz	.25 to 128.5 MHz carrier
HP 8644B Mode 3		20 kHz frequency offset
	−130 dBc/Hz	1030 to 2060 MHz carrier; Option 002
	−136 dBc/Hz	515 to 1030 MHz carrier
	−142 dBc/Hz	257 to 515 MHz carrier
	−145 dBc/Hz	0.25 to 257 MHz carrier
Nonharmonic Spurious Signals		
		HP 8643A; >10 kHz offset frequency
	< −100 dBc	0.25 to 1030 MHz carrier
	< −94 dBc	1030 to 2060 MHz carrier; Option 002
		HP 8644B; >10 kHz offset frequency
	< −105 dBc	0.25 to 1030 MHz carrier
	< −100 dBc	1030 to 2060 MHz carrier; Option 002

Description

The single-sideband (SSB) phase noise and non-harmonic spurious signals are measured by a system that is specifically designed to measure these parameters—the HP 3048A Phase Noise Measurement System. Measurements are made using a phase detector in a phase-locked-loop.

This method requires a reference signal generator with lower phase noise than the source being tested. A second HP 8643/8644 can be used as this source (and thus both sources are measured as a pair) but the following considerations apply: (1) If the measured results are within specification, both generators meet the specification individually. (2) If the measured results are out of specification, at least one generator is out of specification and a third source must be measured against the first two to determine which one is faulty.

NOTE

While the HP 8643/8644 is not recommended as a general-purpose, tuneable reference for the HP 3048A system, this particular procedure has been shown to yield accurate results.

Equipment

Phase Noise Measurement System .... HP 3048A
Reference Signal Generator .... HP 8643/8644

NOTE

The HP 8644B for the reference signal generator is needed only if the Signal Generator under test is an HP 8644B. Neither the reference source nor the HP-8643/8644-under-test will be under remote control.

If a suitable reference source is unavailable, the 10 MHz A oscillator in the HP 11848A Phase Noise Interface to the HP 3048A system can be used as reference for a 10 MHz carrier.

Procedure

Initial Setup

1. Connect the equipment as shown in figure 8-5.

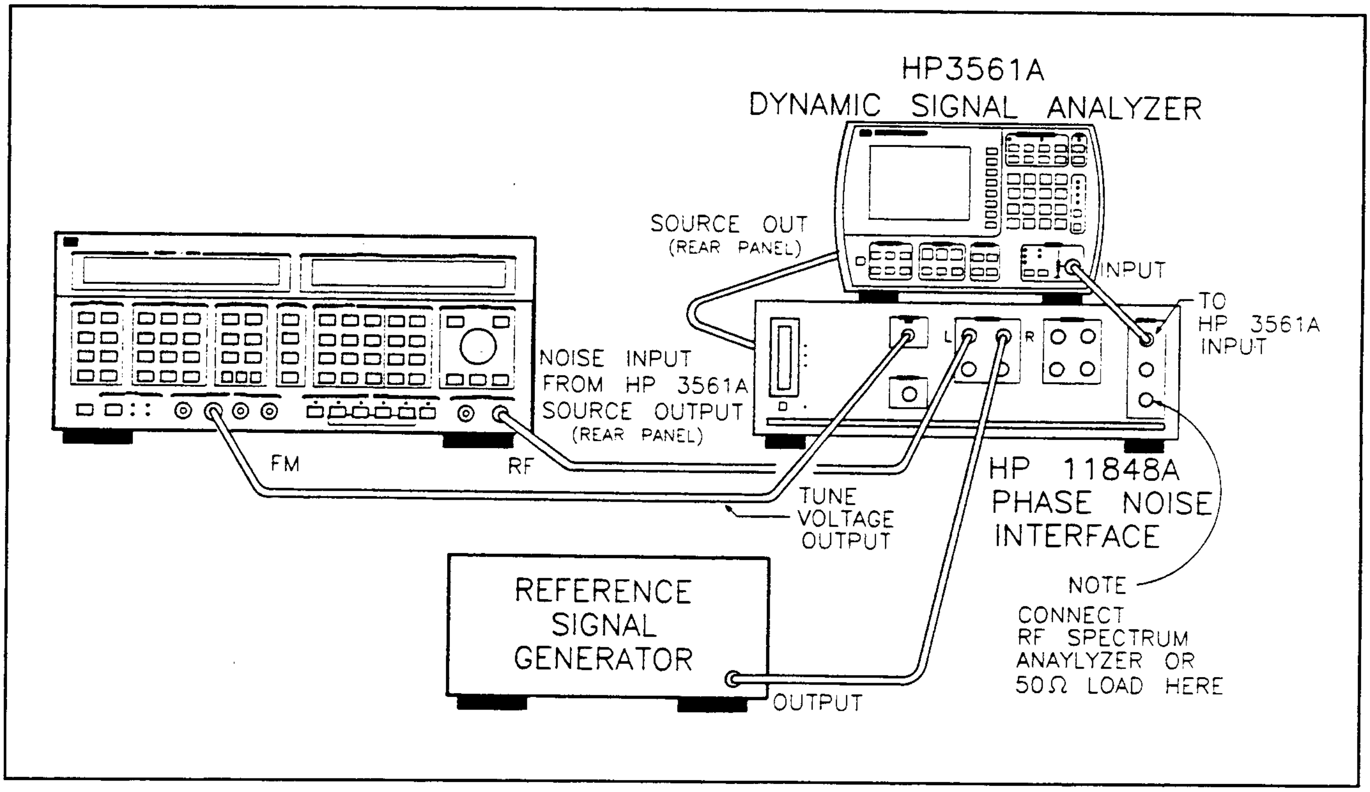


Figure 8-5. SSB Phase Noise Test Setup

2. Set the reference signal generator's carrier to 516 MHz + 2 Hz (that is, 516 000 002 Hz) at 6 dBm.
3. Set the Signal Generator under test as follows.
   a. Press **INSTR PRESET**.
   b. Key in **AMPTD 13 dBm**.
   c. Key in **FREQ 516 MHz**.
   d. Key in **FM 128 Hz**.
   e. Press **INT** in the **MODULATION** key group to turn the internal modulation source off.
   f. Press **EXT DC** in the **MODULATION** key group to enable DC FM.
4. Set the HP 3048A to the Main Software Level menu. Refer to figure 8–6.

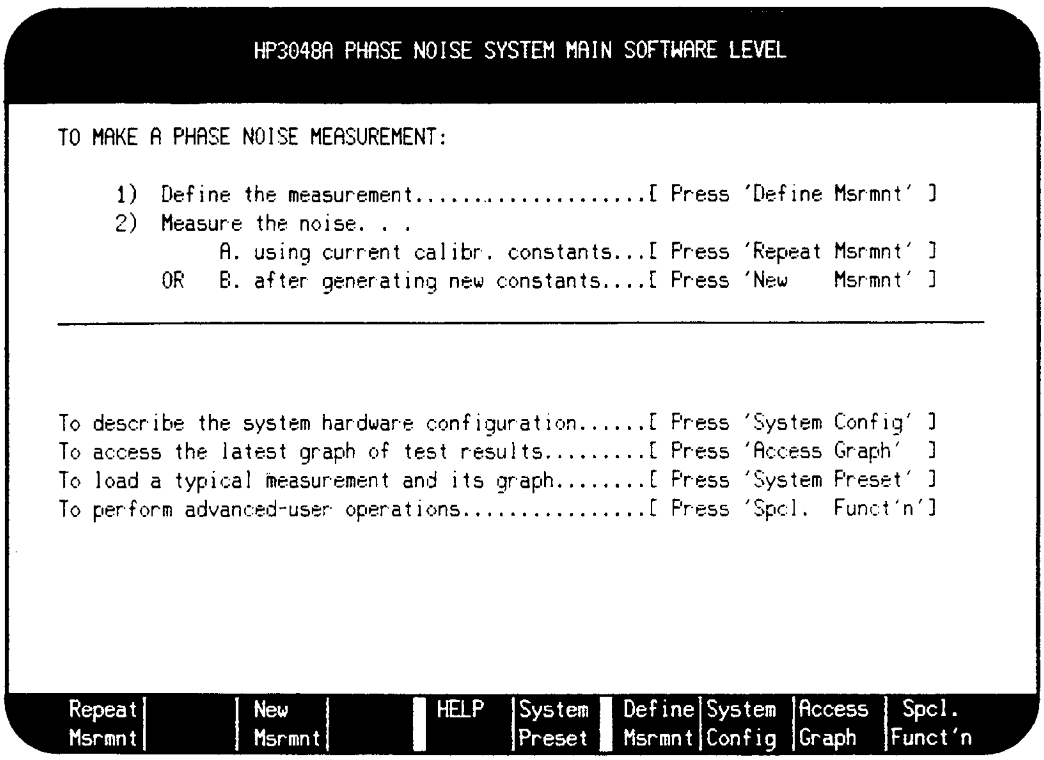


Figure 8–6. Main Software Level Menu

Example Measurement

NOTE

The following steps are the procedure for making a single-sideband phase noise measurement on a 516 MHz carrier. For other carrier frequencies, the procedure is similar. If these measurements are to be repeated in the future for this or other HP 8643/8644 generators, it will be advantageous to record the test file entries for each carrier frequency; these test files can be recalled as needed later on instead of having to re-enter them each time.

5. On the HP 3048A press the `Define Msrmnt` softkey to obtain the Measurement Definition menu. Refer to figure 8–7.

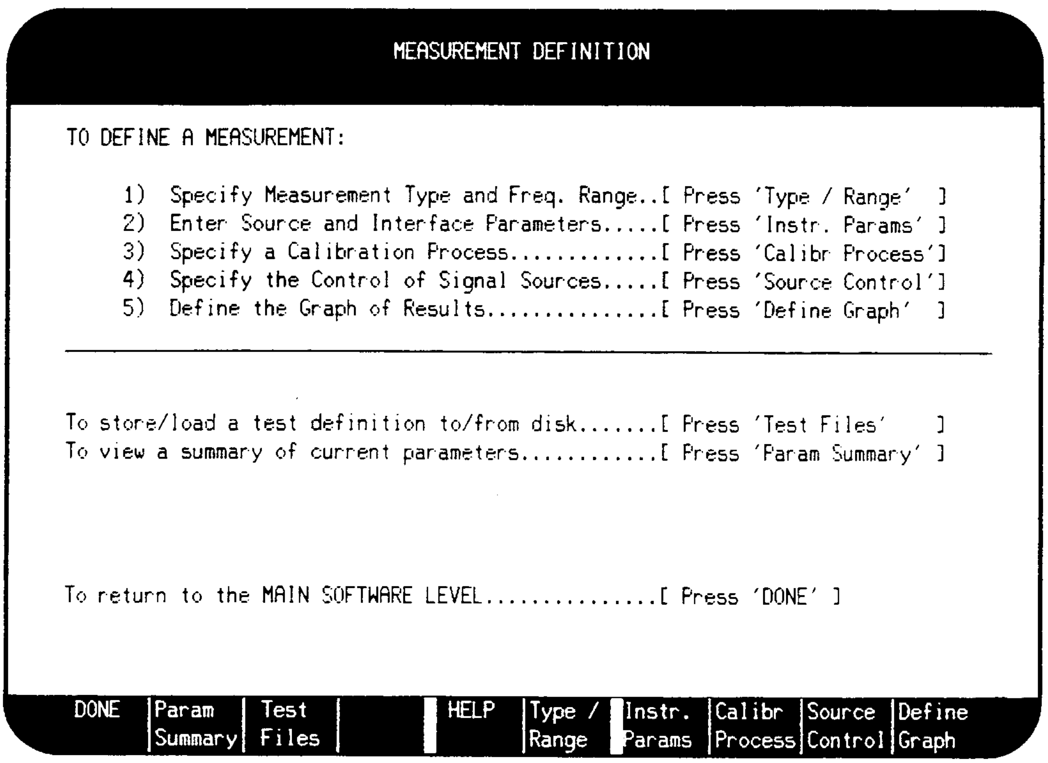


Figure 8–7. Measurement Definition Menu

6. On the HP 3048A press the [Type / Range] softkey to obtain the Measurement Type and Frequency Range Specification menu. Set the measurement type and offset frequency range as shown in figure 8–8. When done, press the [DONE] softkey.

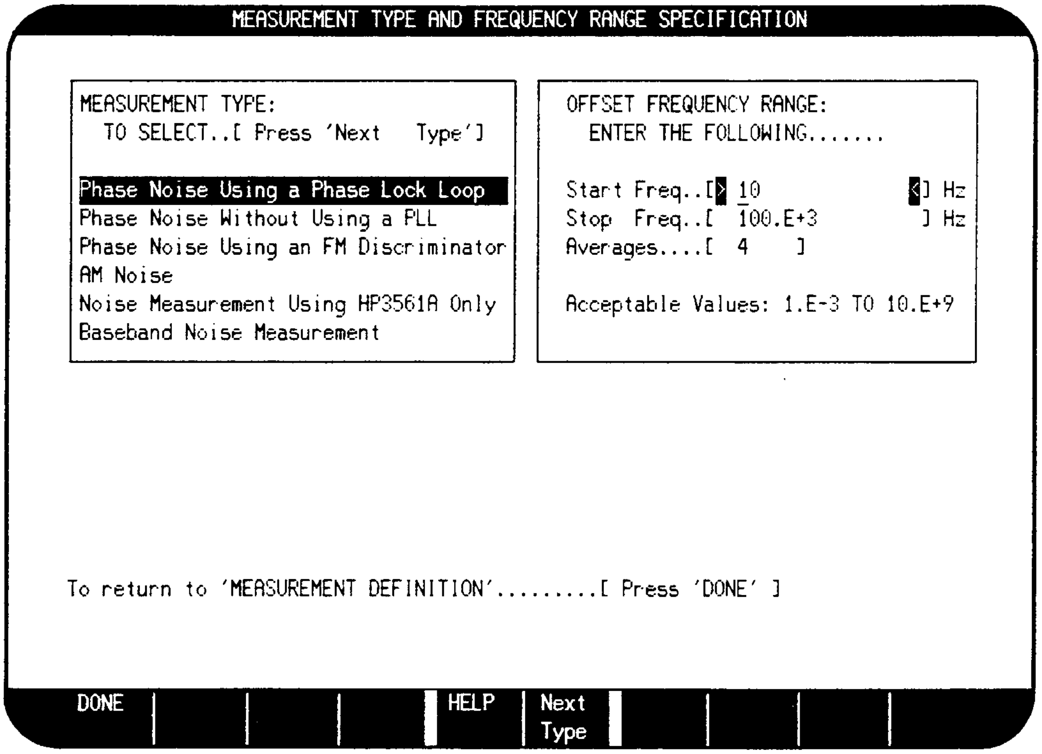


Figure 8–8. Measurement Type and Frequency Range Specification Menu

7. On the HP 3048A press the [Instr. Params] softkey to obtain the Source and Interface Parameter Entry menu. Set the parameters and phase detector as shown in figure 8-9. When done, press the [DONE] softkey.

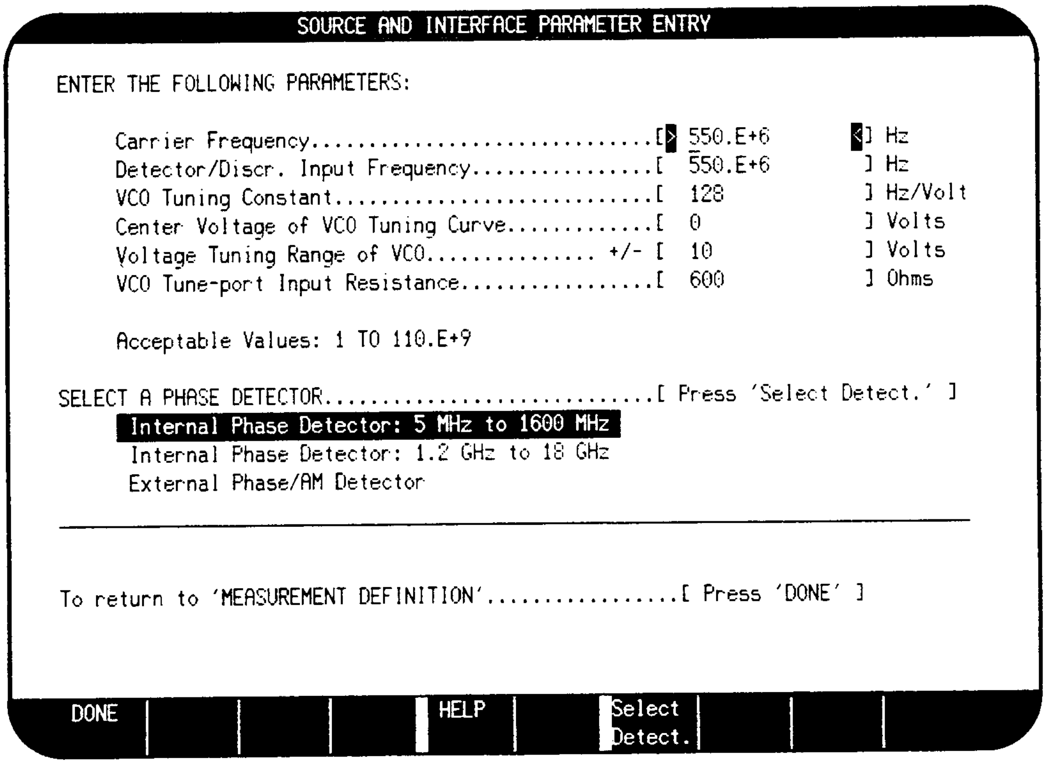


Figure 8-9. Source and Interface Parameter Entry Menu

8. On the HP 3048A press the [Calibr Process] softkey to obtain the Determination of Phase Detector Constant and VCO Tuning Constant menu. Set the method of determining the phase detector and VCO tuning constants and the verification of the phase lock loop suppression as shown in figure 8–10. (The displayed Computed Constant may by be quite different from the one in figure 8–10. It will be updated later.) When done, press the [DONE] softkey.

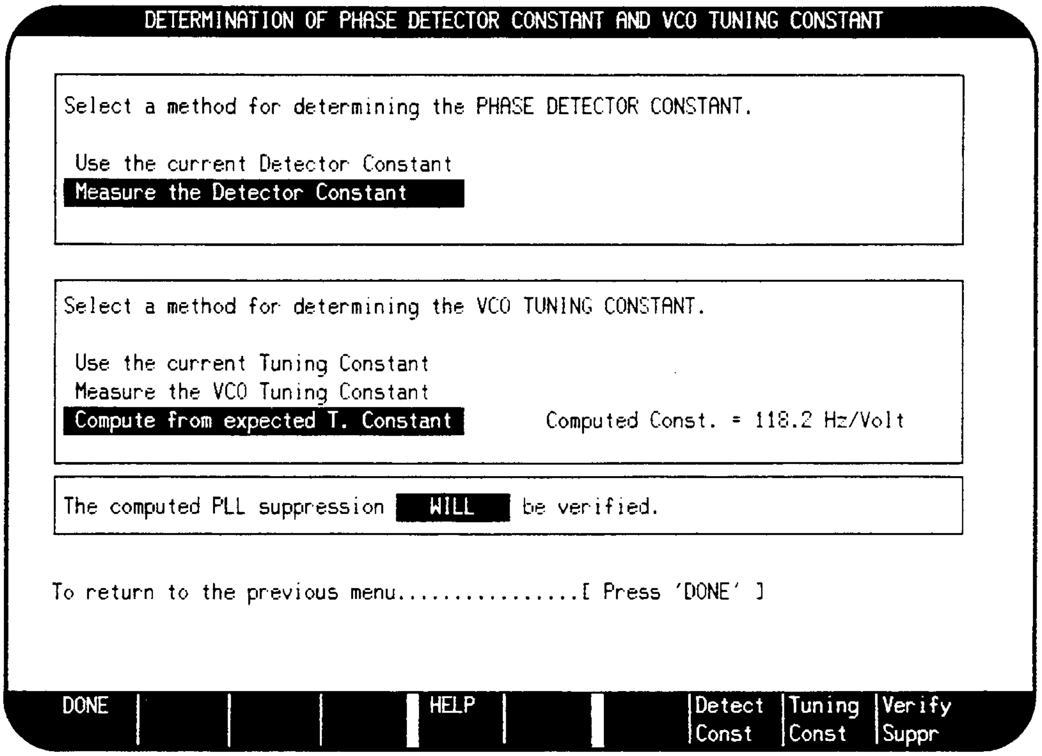


Figure 8–10. Determination of Phase Detector and VCO Tuning Constant Menu

9. On the HP 3048A press the [Source Control] softkey to obtain the Source Control for Measurement Using a Phase Lock Loop menu. Set the various devices in the system as shown in figure 8–11. When done, press the [DONE] softkey.

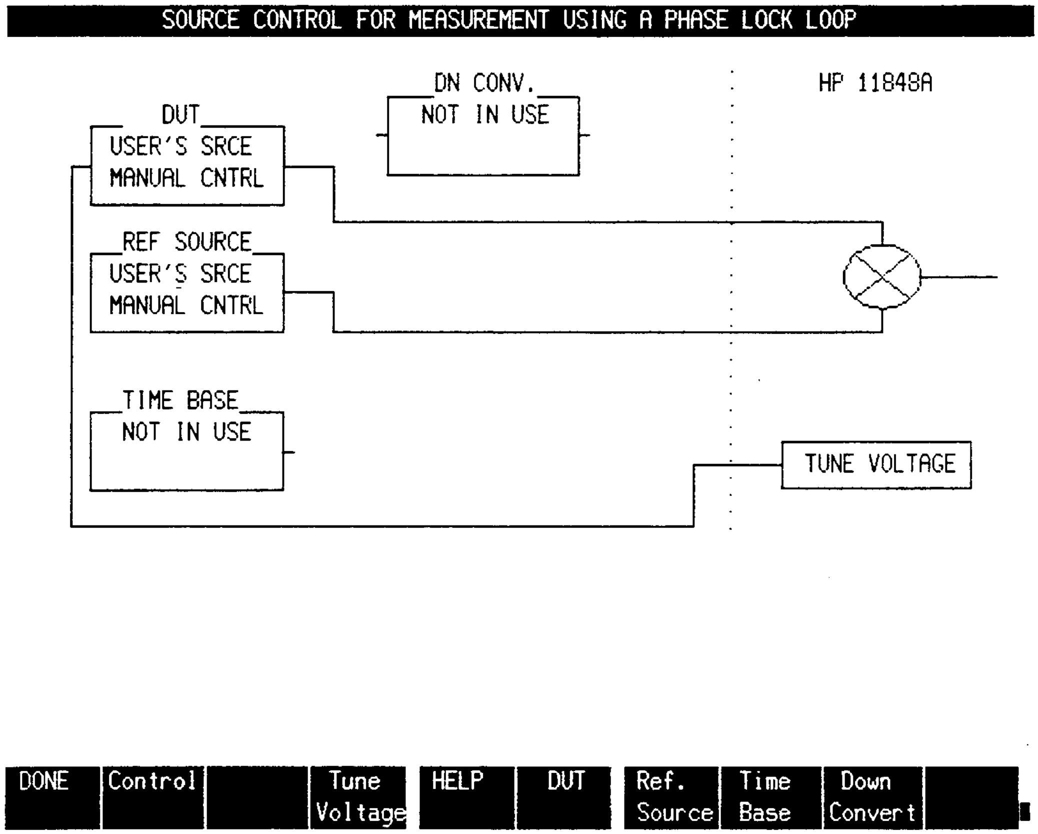


Figure 8–11. *Source Control for Measurement Using a Phase Lock Loop Menu*

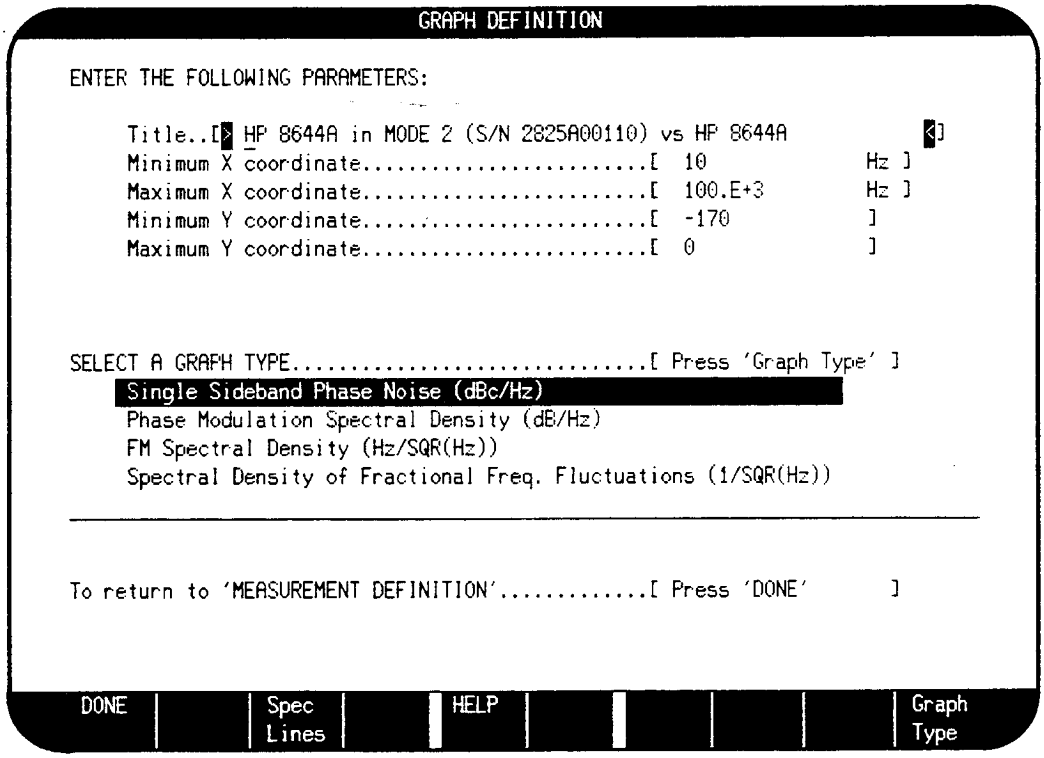


Figure 8-12. Graph Definition Menu

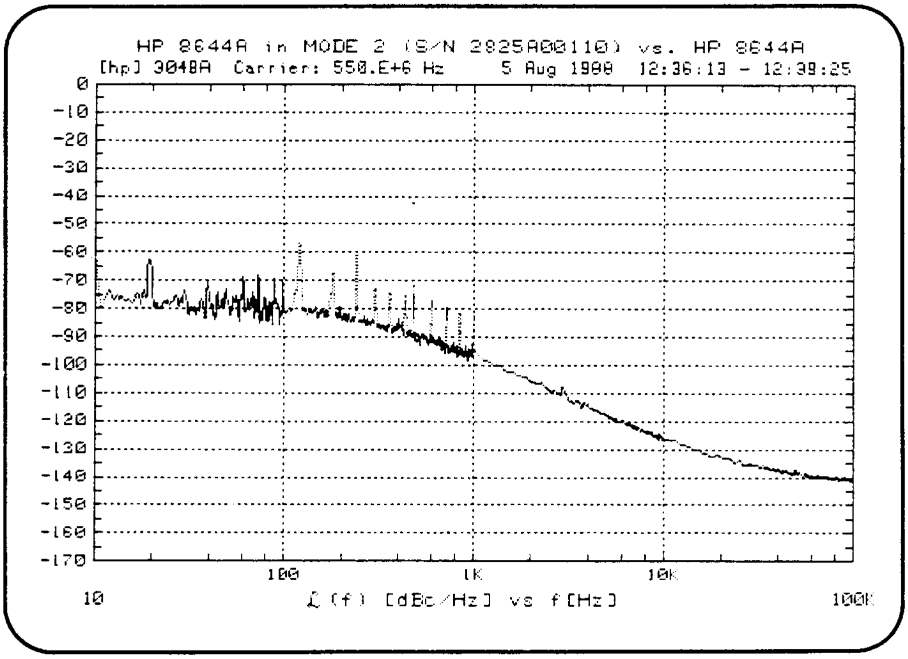
10. On the HP 3048A press the `Define Graph` softkey to obtain the Graph Definition menu. Set the graph parameters and graph type as shown in figure 8-12. Change the title as appropriate for your particular setup. (You may wish to include the serial number of the device under test for example. Note that date, time, and carrier frequency information will automatically appear on the measurement result graph.) When done, press the `DONE` softkey.
11. On the HP 3048A press the `DONE` softkey again to obtain the Main Software Level menu.
12. On the HP 3048A press the `New Msrmnt` softkey then press the `Yes, Proceed` softkey.

13. When the connect diagram appears on the display, verify that the instrument connections are properly made then press the [Proceed] softkey. The phase noise measurement should proceed without error and the phase noise plot should appear as in figure 8–13. Ignoring spurious signals, the phase noise (*ℒ(f)*) should be less than – 130 dBc at 20 kHz for the HP 8643A and less than –136 dBc at 20 kHz offset for the HP 8644B. Spurious signals at offsets > 10 kHz should be < – 100 dBc for the HP 8643A and < – 105 dBc for the HP 8644B.

NOTE

Figure 8–13 also shows a listing of measurement parameters. This listing with the graph itself can be printed by holding down the keyboard's SHIFT *key and pressing the* [Hard Copy] *softkey.*

If you intend to make measurements of this same type frequently, the setup information (carrier frequency, tuning constant, source control, etc.) can be easily stored as test files, then loaded as needed. Refer to the HP 3048A Reference Manual *on storing and loading test files.*



PERTINENT MEASUREMENT PARAMETERS

Measurement Type: PHASE LOCKED
Start Offset Freq: 10 Hz
Stop Offset Freq: 100.E+3 Hz
Minimum Averages: 4

Carrier Frequency: 550.E+6 Hz
Detect. Input Frq: 550.E+6 Hz

Entered K_VCO : 128 Hz/Volt
Center Voltage : 0 Volts
Tune-voltage Rnge: +/- 10 Volts
Phase Detector : 5 TO 1600 MHz

K_Detector Method: MEASURED
Detector Constant: 244.7E-3 V/Rad

K_VCO Method : COMPUTED
Tuneport Resist. : 600 Ohms
VCO Tune Constant: 118.2 Hz/Volt

Loop Suppression : VERIFIED
Closed Pll Bandw.: 229.9 Hz
Peak Tuning Range: 1.181E+3 Hz
Assumed Pole : 2.361E+3 Hz

Dev. Under Test : USER'S SRCE, MAN
Reference Source : USER'S SRCE, MAN, VCO
Ext. Timebase : NOT IN USE
Down Converter : NOT IN USE

HP 11848A LNA : IN

***Figure 8-13.** Phase Noise Plot and Pertinent Measurement Parameters*

Further Measurements

14. To measure single-sideband phase noise for other carrier frequencies, set the signal generators and phase noise measurement system as outlined in the following table. The phase noise should be within the limits indicated in the table.

    Non-harmonic spurious signals for the HP 8643A at offset frequencies greater than 10 kHz should be down more than 100 dBc for carrier frequencies to 1030 MHz and more than 94 dBc at carrier frequencies between 1030 and 2060 MHz (Option 002).

    Non-harmonic spurious signals for the HP 8644B at offset frequencies greater than 10 kHz should be down more than 105 dBc for carrier frequencies to 1030 MHz and more than 100 dBc at carrier frequencies between 1030 and 2060 MHz (Option 002).

Carrier Frequency (MHz) (1)	HP 8643/8644 Settings		HP 3048A VCO Tuning (Hz/V)	Phase Noise Limits (dBc) 20 kHz Offset	
	Model	FM Peak Dev. (Hz)		Actual	Max.
1300 (2)	HP 8643A	256	256	______	−124
1029	HP 8643A	128	128	______	−130
64	HP 8643A	8	8	______	−142
1300 (2)	HP 8644B	256	256	______	−130
516	HP 8644B	128	128	______	−136

(1) Make the carrier frequency change to the following:
a. the HP-8643/8644-under-test,
b. the reference signal generator (then increment the frequency by 2 Hz),
c. the HP 3048A Source and Interface Parameter Entry menu (for Carrier Frequency and Detector/Disc. Input Frequency), and
d. the Graph Definition menu (in the Title).
(2) Option 002

Performance Test 5

SPECTRAL PURITY TEST (HARMONICS)

Specification

Characteristic	Performance Limits	Conditions
Spectral Purity		
Spurious Signals		
Harmonics	< −25 dBc < −25 dBc	output <8 dBm; HP 8643A output <10 dBm; HP 8644B
Subharmonics	none < −60 dBc < −40 dBc	0.25 to 515 MHz carrier 515 to 1030 MHz carrier 1030 to 2060 MHz carrier; Option 002

Description

Harmonics and subharmonics are observed directly on an RF spectrum analyzer while the Signal Generator is swept slowly over its frequency range.

Equipment

RF Spectrum Analyzer .... HP 8562B or HP 8563E

Procedure

Initial Setup

1. Set the Signal Generator as follows.
   a. Press INSTR PRESET.
   b. Key in AMPTD 10 dBm or if the Signal Generator is an HP 8643A, key in AMPTD 8 dBm.
   c. Key in SWEEP TIME 10 s.
   d. Press AUTO (in the SWEEP key group). This initiates a continuous, 10s sweep from 0.25 to 1030 MHz (or 2060 MHz for Option 002).

2. Set the spectrum analyzer as follows.
   a. Set the frequency span 0 to 3 GHz (or for Option 002, 0 to 6 GHz) with compatible resolution bandwidth and display smoothing. (If this span width is not available, use the widest span possible and, as the measurement progresses, retune the center frequency as needed to span the complete range in segments.)
   b. Set the vertical scale to 10 dB per division log.
   c. Set the vertical sensitivity and attenuation to view a 10 dBm signal with at least 40 dB of uncompressed range.
3. Connect the Signal Generator's OUTPUTS RF to the spectrum analyzer's input.

Harmonics

4. Set the spectrum analyzer sensitivity so that the peak of the sweeping fundamental is at a convenient horizontal graticule.
5. Observe the second and third harmonics of the signal as the fundamental sweeps over its range. If necessary, change the spectrum analyzer's center frequency to observe the harmonics at higher frequencies. The harmonics should be down more than 25 dBc over the instrument's entire frequency range.

Harmonics:: ________ −25 dBc

Subharmonics

6. Set the spectrum analyzer to span 0 to 1 GHz (or 0 to 2 GHz for Option 002). Increase the vertical gain, sweep time, resolution bandwidth, and display smoothing as necessary to generate a dynamic range of 70 dB. (A slight compression of the signal is acceptable.)
7. Observe the subharmonics of the signal as the fundamental sweeps over its range. The subharmonics should be unobservable over the fundamental range to 0.25 to 515 MHz, more than 60 dBc from 515 to 1030 MHz range, and, if the instrument has Option 002, more than 40 dBc from 1030 to 2060 MHz.

Subharmonics (515 to 1030 MHz carrier): ________ −52 dBc
Subharmonics (1030 to 2060 MHz carrier, Option 002): ________ −40 dBc

Performance Test 6

PULSE MODULATION TEST

Specification

Characteristic	Performance Limits	Conditions
Pulse Modulation		>10 MHz carrier
On/Off Ratio	< −35 dB < −50 dB < −80 dB	10 to 1030 MHz carrier <1030 MHz, Serial Prefix ≥3302A, HP 8643A only 1030 to 2060 MHz carrier; Option 002
Rise/Fall Time	<100 ns	10% to 90% points
Maximum Pulse Repetition Rate	1 MHz	
Minimum Pulse Width	500 ns	

Description

For low carrier frequencies, the characteristics of the RF pulses are observed directly on an oscilloscope. For high frequencies, a crystal detector is used to peak-detect the pulse envelope which is then viewed on the oscilloscope. The pulse on/off ratio is measured statically on a spectrum analyzer by setting a CW reference then noting how far the amplitude drops when the Signal Generator is switched to the pulse modulation mode with no pulse input.

Equipment

Crystal Detector .... HP 423B
600 Ω Feed Thru Termination .... HP 11095A
Oscilloscope .... HP 1740A or Tektronix 2245
Pulse Generator .... HP 8116A
Spectrum Analyzer .... HP 8562A or HP 8563E

Procedure

Initial Setup

1. Connect the equipment as shown in figure 8–14.
2. Set the oscilloscope as follows.
   a. Set the input coupling to dc with 50 Ω input impedance.
   b. Set the vertical scale to view a 2 V (p-p) signal.
   c. Set the time sweep to 200 ns per division.
   d. Set the triggering to trigger on the rising transition of the pulse generator's trigger output.

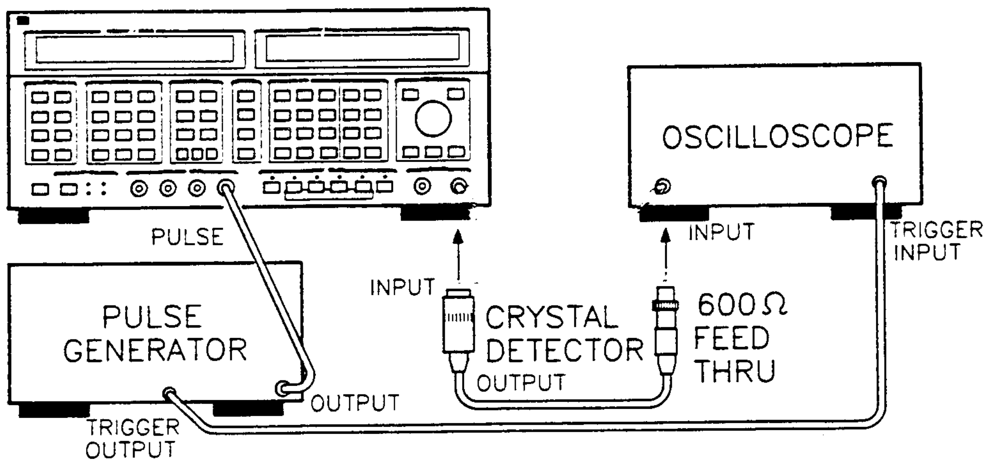


Figure 8–14. Pulse Modulation Test Setup

3. Set the pulse generator as follows.
   a. Set the frequency (rate) to 83.3 kHz.
   b. Set the pulse width to 1 μs.
   c. Set the amplitude to switch from 0 V to 4 V.
4. Set the Signal Generator as follows.
   a. Press INSTR PRESET.
   b. Key in AMPTD 10 dBm.
   c. Key in FREQ 1029 MHz.
   d. Key in PULSE ON.

Risetime (Using a Crystal Detector)

5. Connect the the crystal detector input to the Signal Generator's OUTPUT connector. Connect the feed-thru termination to the output of the detector then connect the output of the 600 Ω feed-thru to the oscilloscope's input. (Refer to figure 8–14.)
6. Set the oscilloscope to high impedance, dc coupled.
7. Set the Signal Generator's carrier frequency as indicated in the following table. For each setting, observe the 10% to 90% risetime and falltime of the RF burst relative to its steady-state value. The risetime and falltime should be within the limits shown in the table.

NOTE

If there is RF feedthrough from the detector, measure the envelope of it.

Carrier Frequency (MHz)	Risetime Limits (ns)		Falltime Limits (ns)	
	Actual	Maximum	Actual	Maximum
1029	________	100	________	100
1030 [1]	________	100	________	100

[1] Option 002

Pulse On/Off Ratio

8. Set the Signal Generator as follows.
   a. Key in AMPTD 0 dBm.
   b. Key in FREQ 100 MHz.
9. Remove the crystal detector from the Signal Generator's OUTPUTS RF and connect the OUTPUTS RF to the spectrum analyzer's input. (The spectrum analyzer is not shown in figure 8–14.)
10. Set the pulse generator to produce a 0.5 Hz squarewave.
11. Set the spectrum analyzer as follows.
    a. Set the center frequency to 900 MHz.
    b. Set the vertical gain and the input attenuation to view the 0 dBm signal without compression.
    c. Set a span suitable for viewing the RF signal which is switching on and off at a 0.5 Hz rate.
12. Set the Signal Generator's carrier frequency and the spectrum analyzer's center frequency as indicated in the following table. For each carrier frequency, observe the change in amplitude as the Signal Generator is pulsed on and off. The amplitude should drop at least 35 dB between pulse on and pulse off (or 80 dB for 2 GHz carrier frequency, Option 002).

Carrier Frequency (MHz)	On/Off Ratio (dB)	
	Minimum	Actual
900	35 (2)	________
1030 (1)	80	________

(1) Option 002

(2) 50 for Serial Prefix ≥3302A on HP 8643A

Performance Test 7

INTERNAL AUDIO OSCILLATOR TEST

Specification

Characteristic	Performance Limits	Conditions
Internal Modulation Source		
Frequency Accuracy	same as reference oscillator	
Distortion	<0.2%	output 2V peak; rate <20 kHz

Description

The frequency and distortion of the internal modulation source are measured directly on a distortion analyzer.

Equipment

Distortion Analyzer .... HP 8903B or HP 8903E

Procedure

1. Connect the input of the distortion analyzer directly to the Signal Generator's OUTPUTS AUDIO connector.
2. Set the distortion analyzer to measure distortion. Set its low-pass filter to 50 kHz or greater.
3. On the Signal Generator press INSTR PRESET.

4. Key in the audio frequency as listed in the following table. For each setting measure the audio distortion. The distortion should be within the limits indicated.

Audio Frequency Setting (Hz)	Distortion Limits (%)	
	Actual	Maximum
300	________	0.2
1 000	________	0.2
20 000	________	0.2

Performance Test 8

FREQUENCY ACCURACY TEST

Specification

Characteristic	Performance Limits	Conditions
Frequency Accuracy 0.375×10^{-6} times carrier in Hz	±375 Hz at 1 GHz	1 hour warmup

Description

A measuring receiver with a high accuracy external timebase is used to measure the frequency accuracy of the Signal Generator at 1 GHz carrier frequency.

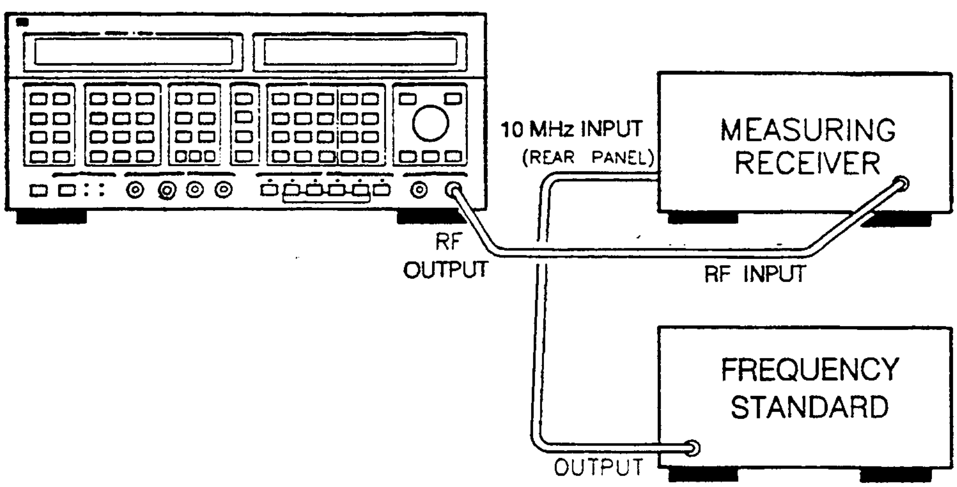


Figure 8-16. Frequency Accuracy Test Setup

Equipment

Frequency Standard .... HP 5061B
Measuring Receiver .... HP 8902A

NOTE

Be sure the signal generator has warmed up at least 1 hour before performing this test.

Procedure

Setup

1. Connect the equipment as shown in figure 8–16.
2. Preset the instruments.

Frequency Accuracy

1. On the signal generator, key in frequency 1 GHz, amplitude 0 dBm.
2. On the measuring receiver, key in 7.1 SPCL (for 10 Hz resolution).
3. Verify that the measuring receiver reading is within the specified range.

Signal Generator Settings	Frequency Limits		
Carrier Frequency (MHz)	Actual	Minimum	Maximum
1000	________	1GHz −375 Hz	1GHz +375 Hz

Performance Test 9

AVIONICS PARAMETERS TEST (OPTION 009)

Specification

Characteristic	Performance Limits	Conditions
VOR		**108 to 118 MHz**
Bearing Accuracy	0.1 degrees	
Frequency Accuracy		Set by timebase
AM		60% AM; 30 Hz and 9960 kHz rates
Accuracy	5% of setting	
Distortion	2%	
FM Accuracy	±1.5 Hz	9960 Hz carrier; 480 Hz Deviation; 30 Hz rate
ILS: Localizer/Glideslope		**108 to 112 MHz/329.3 MHz to 335 MHz**
AM		40 and 80% AM; 90 and 150 Hz rates
Accuracy	±5% of setting	
Distortion	2%	
DDM Resolution		
Localizer	0.0002	
Glideslope	0.0004	
DDM Accuracy		
Localizer	±0.0004 5% of DDM	
Glideslope	±0.0008 5% of DDM	
Marker Beacon		**75 MHz**
AM		95% AM; 400, 1300 and 3000 Hz rates
Accuracy	±5% of setting + 1 %	
Distortion	5%	

Description

The AM accuracy and distortion are measured directly using a modulation analyzer and distortion analyzer. Bearing accuracy is verified by measuring the phase shift of AM modulation at a 10 kHz rate.

Equipment

Modulation Analyzer .... HP 8901A
Audio Analyzer .... HP 8903B
Oscilloscope .... HP 54501A
Detector .... HP 423B

Procedure

1. Connect the equipment as shown in figure 8–17.

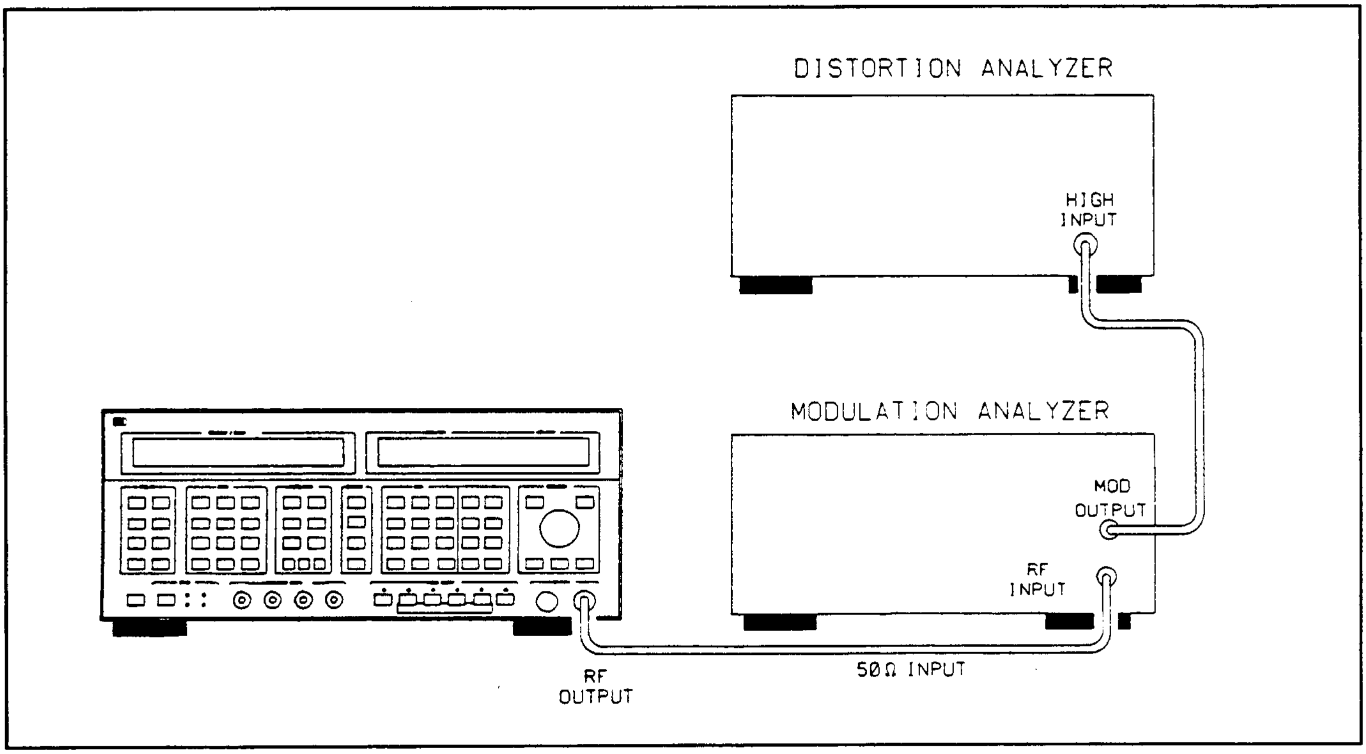


Figure 8–17. AM Test Setup 1

2. Press INSTR PRESET on the Signal Generator. Then set as follows:

   Carrier Frequency .... As shown in table
   Modulation AM .... As shown in table
   Modulation Audio Frequency .... As shown in table
   Amplitude (RF Level) .... As shown in table

3. Set the Modulation Analyzer to measure AM. Set the Distortion analyzer to measure distortion in percent.

4. Set the Signal Generator to the settings specified in the first 3 columns of the table. For each setting enter the AM depth and distortion measurements in the table.

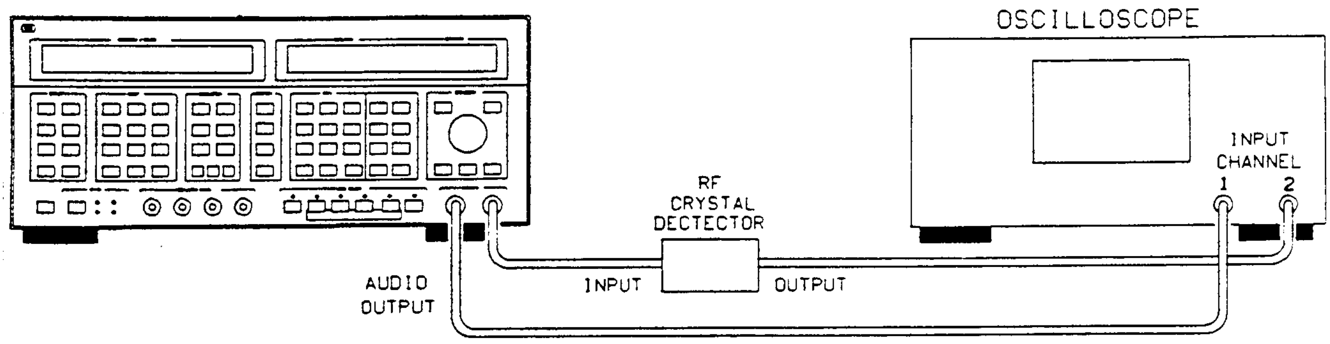


Figure 8–18. AM Test Setup 2

5. Connect the equipment as shown in figure 8–18.
6. Press INSTR PRESET on the Signal Generator. Then set as follows:

   Carrier Freq .... 118.0 MHz
   Modulation AM 60%
   Modulation Audio Frequency .... 10.0 kHz
   Amplitude (RF Level) .... 0 dBm

7. Set the oscilloscope to display both channels. Set as follows:

   CHAN 1

      AC coupling

      2 V/div

   CHAN 2

      AC coupling

      100 mV/div

   TIMEBASE

      10 uS/div

   TRIGGER

      Chan 1

      – slope

      +1.5 V level

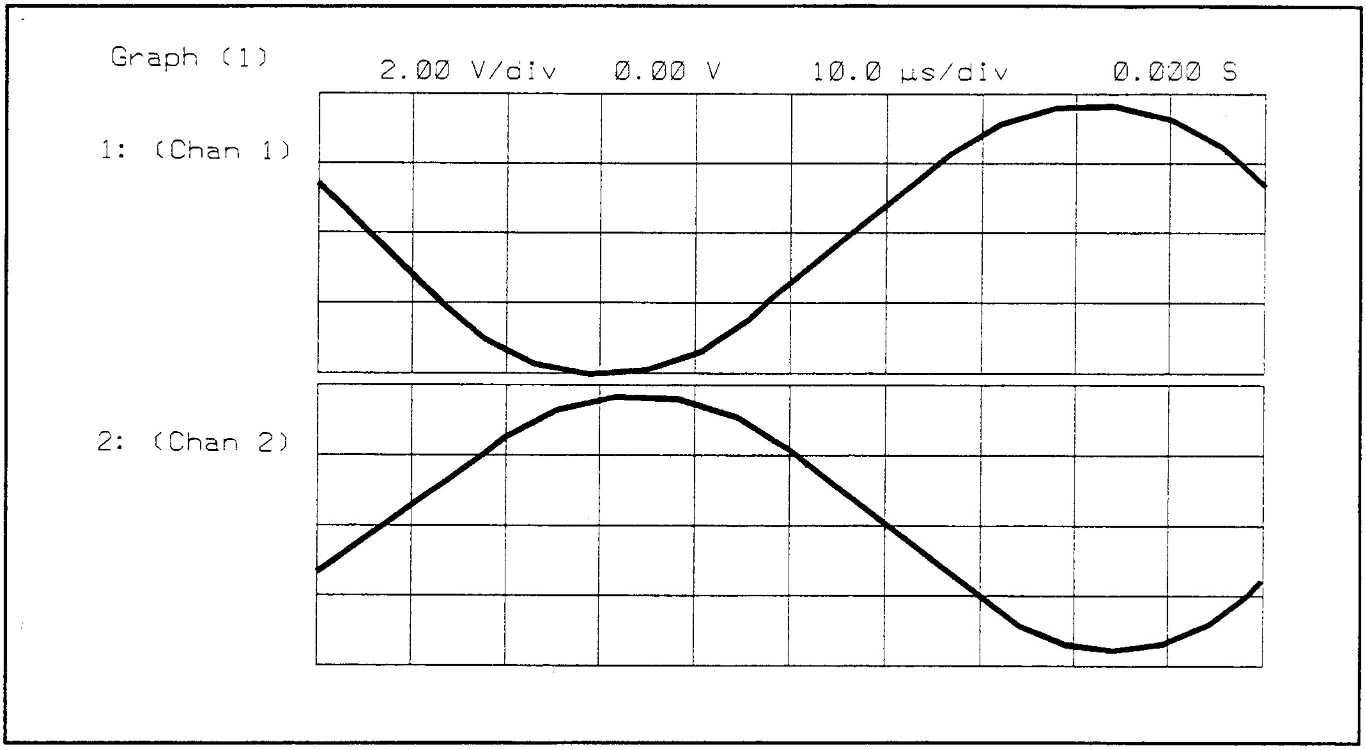


Figure 8–19. Adjusting Channel 1 Zero Crossing

8. Both channels should have a sine wave displayed as shown in figure 8–19. Adjust the trigger level so the zero crossing on channel 1 is approximately in the center of the division on the left edge of the display.
9. Change the oscilloscope timebase to 1 µs/div.
10. Decrease the vertical scale (smaller V/div) until the trace has a steep slope as it passes through the zero level. 100 mV/div is about right for channel 1. The top and bottom of the waveform will be off the screen. We are only concerned with the waveform as it passes through zero. Do this on both channels. Figure 8–20 shows how these waveforms should look. Changing the oscilloscope trigger level will move the waveforms to the right or left.

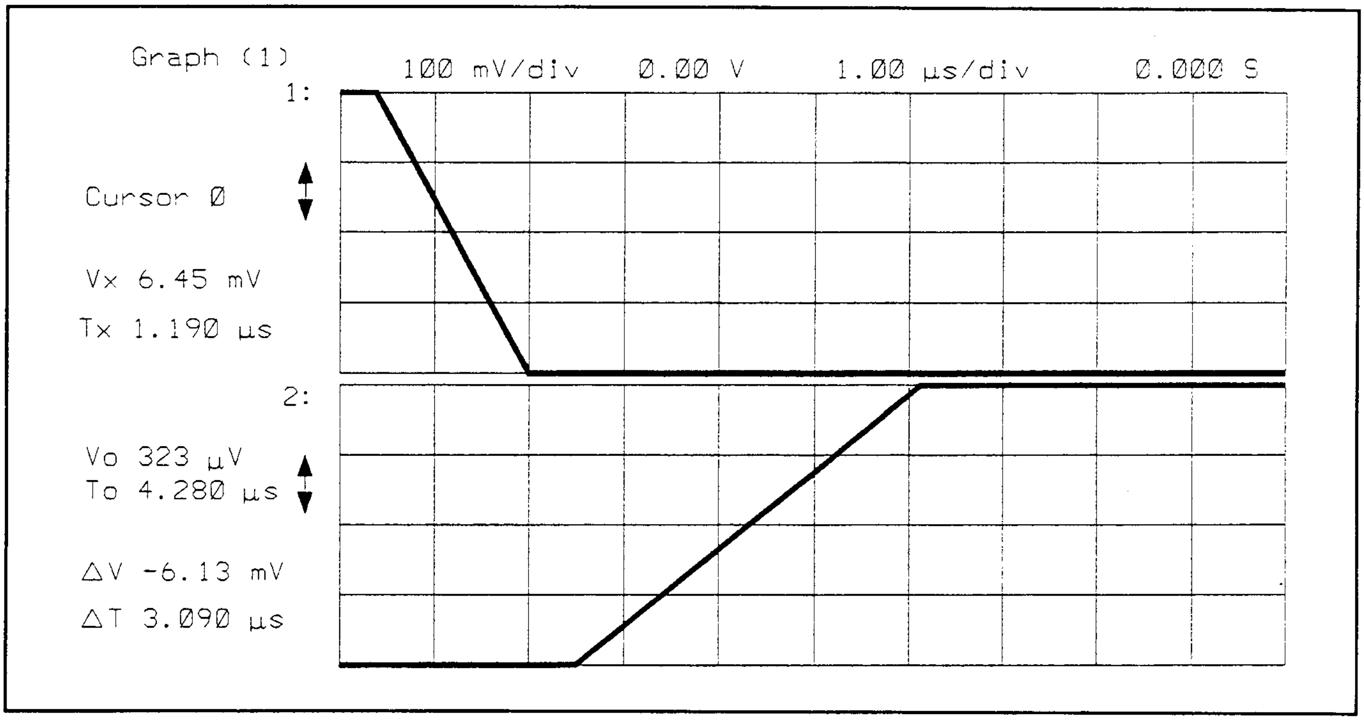


Figure 8-20. Time Difference at Zero Crossing

11. The time between the zero crossing on channel 1 and the zero crossing on channel 2 is the phase shift caused by the AM on the Signal Generator. Measure this time using the oscilloscope markers if available.
12. The upper limit is 15 °. This corresponds to 4.17 µs for a 100.0 kHz sine wave (100 µs period).

Bearing Accuracy Limit: ________ 4.17 µs

Signal Generator Setting			AM Depth Limits (%)			AM Distortion Limits (%)	
Carrier Frequency	Depth AM %	Audio Frequency (Hz)	Minimum	Actual	Maximum	Actual	Maximum
118 MHz	60	30	57	________	63	________	2
		9960	57	________	63	________	2
112 MHz	40	90	38	________	42	________	2
		150	38	________	42	________	2
	80	90	76	________	84	________	2
		150	76	________	84	________	2
334 MHz	40	90	38	________	42	________	2
		150	38	________	42	________	2
	80	90	76	________	84	________	2
		150	76	________	84	________	2
75 MHz	95	400	89.25	________	100.75	________	5
		1300	89.25	________	100.75	________	5
		3000	89.25	________	100.75	________	5

Performance Test 10

OPTION 010 LEAKAGE TEST

Specification

2 μV measured into a resonant dipole 1 inch from the instrument's surface (except rear panel) with output level < 0 dBm and all inputs/outputs properly terminated.

Description

Leakage is measured using a resonate dipole. The output of the antenna is amplified by an RF amplifier and measured on a spectrum analyzer. The calibrated output of the signal generator under test is used to calibrate the amplifier/spectrum analyzer combination.

Equipment

Spectrum Analyzer .... HP 8560A
RF Amplifier .... HP 8447E
Antenna .... HP 8644A/K03
Type N 50 ohm load .... HP 908A
BNC 50 ohm load .... HP 1250-0207

Procedure

Set-Up and Calibration

1. Press the INSTR PRESET key of the signal generator. Then set as follows:

   Frequency .... 1029.1 MHz
   Amplitude .... 2.0 μV

2. Connect the RF Output of the signal generator to the input of the RF Amplifier. Connect the output of the RF Amplifier to the input of the spectrum analyzer.

3. Set the spectrum analyzer center frequency to 1029.1 MHz and input attenuation to 0dB. Set the span so the signal is at least 20 dB above the noise level and the sweep speed is 400 mSec or faster. Try a 100 kHz span as a starting point. Change the reference level so the signal peak in at mid screen. If the spectrum analyzer has display line capability, set a line at the signal peak.

   This line on the spectrum analyzer display represents a 2 μV signal level from the antenna. All leakage picked up by the antenna must be below this level.

4. Disconnect the cable from the RF Output connector of the signal generator, and connect it to the antenna. Put 50 ohm loads on the RF OUTPUT and all the front panel and rear panel BNC connectors of the signal generator. Set the signal generator RF amplitude to −0.1 dBm.

Measurement

Frequency (MHz)	Length Antenna Element	Max Leakage (dB)[1]
1029.1	5.9 cm (2.30 in)	______
975.1	6.1 cm (2.40 in)	______
925.1	6.5 cm (2.56 in)	______
875.1	7.0 cm (2.74 in)	______
825.1	7.5 cm (2.95 in)	______
775.1	8.1 cm (3.18 in)	______
725.1	8.7 cm (3.44 in)	______
454.1	14.9 cm (5.87 in)	______
[1] Upper limit is 0 dB.		

5. For each frequency in the above table do the following:
   - Set the signal generator carrier frequency and the spectrum analyzer center frequency to the frequency in the table.
   - Set the antenna elements length to the value given in the table. Measure from the outside of the center hub to the tip of the dipole.
   - Move the antenna over all the surfaces (except the rear panel) of the signal generator keeping the spacers in contact with the covers. This keeps the actual antenna elements 1 inch away from the surface. Do not allow the antenna elements to get closer than 1 inch to the RF Output connector or any of the front panel BNC connectors.
   - Move the antenna slowly. The antenna should move less than one inch per spectrum analyzer sweep cycle.
   - Monitor the signal level displayed on the spectrum analyzer. The signal level must stay below the reference line set above for the test to pass. For each frequency note the maximum signal level in relation to the reference line. Write this value in the table. For example if the highest signal level was 5 dB below the reference, enter - 5.0 in the table.

6. To measure leakage at other frequencies use the formula below to determine antenna element length and follow the procedure in step 5.

$$\ell = \frac{7500}{f} - 1.6$$

Where:

ℓ = antenna element length in centimeters
f = frequency in MHz.

Performance Test 11

OPTION 011 COUNTER ACCURACY AND SENSITIVITY TEST

Specification

Characteristic	Performance Limits	Conditions
Frequency Range	Selectable: 20 Hz to 10 MHz 10 MHz to 640 MHz 640 MHz to 2 GHz	Option 011
Sensitivity	25 mV_{rms} (1M Ω) −19 dBm (50 Ω) −15 dBm (50 Ω)	10 MHz Range 640 MHz-1.5 GHz Range 1.5 - 2 GHz Range
Maximum Input Level	2.25 V_{rms} (1M Ω) +20 dBm (50 Ω)	10 MHz Range 640 MHz, 2 GHz Range
Measurement Resolution (Hz)	Measurement frequency (in Hz) × 10^{-8} divided by gate time (in seconds), or 0.01 Hz (whichever is greater)	

Description

Frequency accuracy is measured by locking the time base of the Signal Generator with the HP 8643/8644 Frequency Counter, setting Frequency Counter sampling time (gate time) to maximum, and observing the displayed frequency measurement.

Equipment

Signal Generator .... HP 8642B
Adapter, N (m) to BNC (f) .... HP 1250-0780
30 cm (12 in) BNC Cable .... HP 8120-1838

Procedure

Initial Set-up

1. Connect the equipment as shown in figure 8–21.
   a. Connect the HP 8643/8644 10 MHz REF Output to the signal generator EXT REF IN (Time Base Input).
   b. Connect the RF output of the signal generator to the HP 8643/8644 MEAS INPUT connector. (Use the N to BNC adaptor on the signal generator RF output connector if necessary.)
2. Press the INSTR PRESET key on the HP 8643/8644. Set the HP 8643/8644 Frequency Counter Gate Time to 1.00 s using SPECIAL 185.

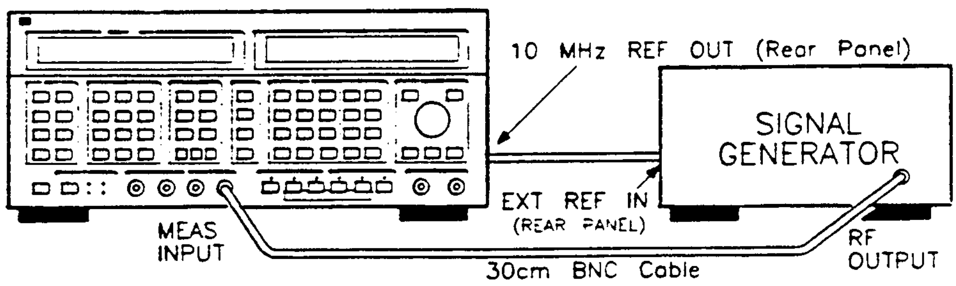


Figure 8-21. *Counter Accuracy and Sensitivity Test Setup*

Frequency Measurement

Sig Gen Freq (MHz)	Sig Gen Level (dBm)	HP 8643/8644 Counter Range	HP 8643/8644 Counter Display (Hz)		
			Minimum	Actual	Maximum
0.10	+20.0	10 MHz	99,999.99	______	100,000.01
10.00	+20.0	10 MHz	9,999,999.90	______	10,000,000.10
100.00	+20.0	640 MHz	99,999,999.00	______	100,000,001.00
1000.00	+20.0	2 GHz	999,999,990.00	______	1,000,000,010.00
2000.00	+20.0	2 GHz	1,999,999,980.00	______	2,000,000,020.00
10.00	−19.0	10 MHz	9,999,999.90	______	10,000,000.10
100.00	−19.0	640 MHz	99,999,999.00	______	100,000,001.00
1000.00	−19.0	2 GHz	999,999,990.00	______	1,000,000,010.00
2000.00	−19.0	2 GHz	1,999,999,980.00	______	2,000,000,020.00

3. For each frequency in the above table perform the following steps:
   a. Set the signal generator carrier frequency and level to the settings as shown in the **SIG GEN Freq** and **SIG GEN level** columns.
   b. Set the Frequency Counter measurement range to the value shown in the **HP 8643/8644 Counter Range** column using SPECIAL 183.
   c. Enable the Frequency Counter using SPECIAL 184, and record the displayed Frequency Counter measurement in the **Actual** column of the table.

Performance Test Record

HP 8643/8644 Synthesized Signal Generator
Tested By ____________________
Serial Number ______________ Date __________

TEST 1. CARRIER AMPLITUDE TEST

Maximum Level

Signal Generator Carrier		Amplitude Limits (dBm)	
Frequency (MHz)	**Amplitude (dBm)**	**Minimum**	**Actual**
HP 8643A			
.25147	+14	+13	______
12.247	+14	+13	______
141.42	+14	+13	______
1029.9	+14	+13	______
HP 8644B			
.25147	+17	+16	______
8.05	+17	+16	______
75	+17	+16	______
1029.9	+17	+16	______
HP 8643A or HP 8644B Option 002			
.25147	+14	+13	______
8.05	+14	+13	______
75	+14	+13	______
1029.9	+14	+13	______
2060	+14	+13	______

TEST 1. CARRIER AMPLITUDE TEST (CONT'D)

High-Amplitude Accuracy for the HP 8643A and the HP 8644B

HP 8643A Standard or HP 8644B Opt. 005 Settings and Limits

Signal Generator Carrier		Amplitude Limits (dBm)		
Frequency (MHz)	Amplitude (dBm)	Minimum	Actual	Maximum
141.42	+8	+7	________	+9
7.5	+8	+7	________	+9
3	+8	+7	________	+9
.25147	+8	+7	________	+9
.25147	+3	+2	________	+4
3	+3	+2	________	+4
7.5	+3	+2	________	+4
141.42	+3	+2	________	+4
1015	+3	+2	________	+4

HP 8644B or HP 8643A Opt. 002 Settings and Limits

Signal Generator Carrier		Amplitude Limits (dBm)		
Frequency (MHz)	Amplitude (dBm)	Minimum	Actual	Maximum
1015	+10	+9	________	+11
141	+10	+9	________	+11
15	+10	+9	________	+11
5.1775	+10	+9	________	+11
0.305	+10	+9	________	+11
0.305	+5	+4	________	+6
5.1775	+5	+4	________	+6
15	+5	+4	________	+6
141	+5	+4	________	+6
1015	+5	+4	________	+6
1015	+0	−1	________	+1
141	+0	−1	________	+1
15	+0	−1	________	+1
5.1775	+0	−1	________	+1
3.05	+0	−1	________	+1
Option 002				
2060	+10	+9	________	+11
2060	+5	+4	________	+6
2060	+0	−1	________	+1

TEST 1. CARRIER AMPLITUDE TEST (CONT'D)

Low-Amplitude Accuracy

HP 8644B Standard or HP 8643A Option 002

Signal Generator Carrier Amplitude (dBm)	Amplitude Limits (dBm)		
	Minimum	Actual	Maximum
−10	−11	________	−9
−20	−21	________	−19
−30	−31	________	−29
−50	−51	________	−49
−65	−66	________	−64
−70	−71	________	−69
−80	−81	________	−79
−95	−96	________	−94
−105	−106	________	−104
−115	−116	________	−114
−120	−121	________	−119

HP 8643A Standard or HP 8644B Option 005

Signal Generator Carrier Amplitude (dBm)	Amplitude Limits (dBm)		
	Minimum	Actual	Maximum
−7	−8	________	−6
−27	−28	________	−26
−37	−38	________	−36
−47	−48	________	−46
−57	−58	________	−56
−67	−68	________	−66
−77	−78	________	−76
−87	−88	________	−86
−97	−98	________	−96
−107	−108	________	−106
−117	−118	________	−116
−127	−128	________	−126

TEST 2. AM TEST

Residual AM

Signal Generator Carrier Settings		Residual AM Limits (%)	
Frequency (MHz)	Amplitude (dBm)	Actual	Maximum
750	+13	_______	0.01
1030	+13	_______	0.01

Indicator Accuracy

Signal Generator AM Depth (%)	AM Depth Limits (%)		
	Minimum	Actual	Maximum
30	26.9	_______	33.1
70	64.1	_______	75.9

Distortion

Signal Generator AM Depth (%)	AM Distortion Limits (%)			
	Not Option 002		Option 002	
	Actual	Maximum	Actual	Maximum
30	_______	3	_______	4

Signal Generator AM Depth (%) 1390 MHz	AM Distortion Limits (%)	
	Actual	Maximum
30	_______	4

TEST 2. AM TEST (CONT'D)

3 dB Bandwidth

Signal Generator Settings		Relative AM Depth Limits (dB)		
Carrier Frequency (MHz)	Audio Frequency (kHz)	Minimum	Actual	Maximum
516	100	−3	________	+3
1029	100	−3	________	+3
1030 (1)	75	−3	________	+3
(1) Option 002				

TEST 3. FM TEST

Residual FM

Signal-Generator-Under-Test		Reference Generator Carrier (MHz)	Measuring Receiver Filter		Residual FM Limits (Hz rms)	
Model	Carrier (MHz)		High-Pass	Low-Pass	Actual	Maximum
HP 8643A	1028.0006	1029.5006	300 Hz	3 kHz	________	2
	1028.0006	1029.5006	50 Hz	15 kHz	________	4
	1030 (1)	1301.5	50 Hz	15 kHz	________	8
	1030 (1)	1301.5	300 Hz	3 kHz	________	4
HP 8644B Mode 3	1028	1029.5	50 Hz	15 kHz	________	2
	1028	1029.5	300 Hz	3 kHz	________	1
(1) Option 002						

TEST 3. FM TEST (CONT'D)

Indicator Accuracy for the HP 8643A and the HP 8644B

HP 8643A Settings and Limits

HP 8643A Settings			FM Deviation Limits (kHz peak)		
Carrier Frequency (MHz)	FM Rate (kHz)	FM Deviation (kHz peak)	Minimum	Actual	Maximum
750	50	360	324	________	396
750	70	360	324	________	396
750	100	360	324	________	396
260	20	250	238	________	262
260	100	250	225	________	275
514	20	250	238	________	262
514	100	250	225	________	275

HP 8644B Settings and Limits

HP 8644B Settings			FM Deviation Limits (kHz peak)		
Carrier Frequency (MHz)	FM Rate (kHz)	FM Deviation (kHz peak)	Minimum	Actual	Maximum
260	20	250	235	________	265
260	100	250	213	________	287
514	20	250	235	________	265
514	100	250	213	________	287

TEST 3. FM TEST (CONT'D)

Distortion

Signal Generator Settings		FM Distortion Limits (%)	
Carrier Frequency (MHz)	FM Deviation (kHz peak)	Actual	Maximum
260	250	________	5
514	250	________	5

Carrier Frequency Accuracy in FM

Signal Generator Settings		Carrier Shift Limits (Hz)	
Carrier Frequency (MHz)	FM Deviation (MHz peak)	Actual	Maximum
516	10	________	50,000
1029	10	________	50,000

TEST 4. SPECTRAL PURITY TEST (SSB PHASE NOISE)

Carrier Frequency (MHz) (1)	HP 8643/8644 Settings		HP 3048A VCO Tuning (Hz/V)	Phase Noise Limits (dBc) 20 kHz Offset	
	Model	FM Peak Dev. (Hz)		Actual	Max.
1300 (2)	HP 8643A	256	256	________	−124
1029	HP 8643A	128	128	________	−130
64	HP 8643A	8	8	________	−142
1300 (2)	HP 8644B	256	256	________	−130
516	HP 8644B	128	128	________	−136

(1) Make the carrier frequency change to the following:
- a. the HP-8643/8644-under-test,
- b. the reference signal generator (then increment the frequency by 2 Hz),
- c. the HP 3048A Source and Interface Parameter Entry menu (for Carrier Frequency and Detector/Disc. Input Frequency), and
- d. the Graph Definition menu (in the Title).

(2) Option 002

TEST 5. SPECTRAL PURITY TEST (HARMONICS)

Harmonics	Actual	Limit
	________	−25 dBc
Sub-Harmonics	**Actual**	**Limit**
515 to 1030 MHz Carrier	________	−52 dBc
1030 to 2060 MHz Carrier (option 002)	________	−40 dBc

TEST 6. PULSE MODULATION TEST

Risetime (Using a Crystal Detector)

Carrier Frequency (MHz)	Risetime Limits (ns)		Falltime Limits (ns)	
	Actual	Maximum	Actual	Maximum
1029 1030 [1]	________ ________	100 100	________ ________	100 100
[1] Option 002				

Pulse On/Off Ratio

Carrier Frequency (MHz)	On/Off Ratio (dB)	
	Minimum	Actual
900 1030 [1]	35 [2] 80	________ ________
[1] Option 002 [2] 50 for Serial Prefix ≥3302A on HP 8643A		

TEST 7. INTERNAL AUDIO OSCILLATOR TEST

Audio Frequency Setting (Hz)	Distortion Limits (%)	
	Actual	Maximum
300 1 000 20 000	________ ________ ________	0.2 0.2 0.2

TEST 8. FREQUENCY ACCURACY TEST

Signal Generator Settings	Frequency Limits		
Carrier Frequency (MHz)	Actual	Minimum	Maximum
1000	______	1GHz −375 Hz	1GHz +375 Hz

TEST 9. AVIONICS PARAMETERS TEST (OPTION 009)

Signal Generator Setting			AM Depth Limits (%)			AM Distortion Limits (%)	
Carrier Frequency	Depth AM %	Audio Frequency (Hz)	Minimum	Actual	Maximum	Actual	Maximum
118 MHz	60	30	57	______	63	______	2
		9960	57	______	63	______	2
112 MHz	40	90	38	______	42	______	2
		150	38	______	42	______	2
	80	90	76	______	84	______	2
		150	76	______	84	______	2
334 MHz	40	90	38	______	42	______	2
		150	38	______	42	______	2
	80	90	76	______	84	______	2
		150	76	______	84	______	2
75 MHz	95	400	89.25	______	100.75	______	5
		1300	89.25	______	100.75	______	5
		3000	89.25	______	100.75	______	5

TEST 10. OPTION 010 LEAKAGE TEST

Frequency (MHz)	Length Antenna Element	Max Leakage (dB)[1]
1029.1	5.9 cm (2.30 in)	______
975.1	6.1 cm (2.40 in)	______
925.1	6.5 cm (2.56 in)	______
875.1	7.0 cm (2.74 in)	______
825.1	7.5 cm (2.95 in)	______
775.1	8.1 cm (3.18 in)	______
725.1	8.7 cm (3.44 in)	______
454.1	14.9 cm (5.87 in)	______

[1] Upper limit is 0 dB.

TEST 11. OPTION 011 COUNTER ACCURACY AND SENSITIVITY TEST
Frequency Measurement

Sig Gen Freq (MHz)	Sig Gen Level (dBm)	HP 8643/8644 Counter Range	HP 8643/8644 Counter Display (Hz)		
			Minimum	Actual	Maximum
0.10	+20.0	10 MHz	99,999.99	______	100,000.01
10.00	+20.0	10 MHz	9,999,999.90	______	10,000,000.10
100.00	+20.0	640 MHz	99,999,999.00	______	100,000,001.00
1000.00	+20.0	2 GHz	999,999,990.00	______	1,000,000,010.00
2000.00	+20.0	2 GHz	1,999,999,980.00	______	2,000,000,020.00
10.00	−19.0	10 MHz	9,999,999.90	______	10,000,000.10
100.00	−19.0	640 MHz	99,999,999.00	______	100,000,001.00
1000.00	−19.0	2 GHz	999,999,990.00	______	1,000,000,010.00
2000.00	−15.0	2 GHz	1,999,999,980.00	______	2,000,000,020.00

Adjustments

INTRODUCTION

The procedures in this section will adjust the instrument's electrical performance.

NOTE

Before beginning the adjustments, the Signal Generator should be allowed a 24 hour warm-up period after being connected to the ac power line and a 10 minute warm-up period after turn-on. Line voltage must be within ±10% of nominal if the results of the adjustments are to be considered valid.

Unless otherwise stated, the specifications assume the Signal Generator is operating with its Synthesis Modes set to Auto which automatically optimizes the internal hardware configuration for best performance.

EQUIPMENT REQUIRED

Equipment required for the Adjustments is listed in table 8–1, *Recommended Test Equipment* in chapter 8 *Performance Tests.* Any equipment that satisfies the critical specifications provided in the table may be substituted for the recommended model(s).

CALIBRATION CYCLE

This instrument requires periodic adjustments. Depending on the use and environmental conditions, the instrument should be checked and adjusted every two years.

Adjustment 1

SPECIAL 171: RECAL

Description

This special function allows you to recalibrate the entire instrument. A recalibration takes about five minutes. The message **Result Code = 0** appears if the recalibration passes. All error codes are defined in the Service Diagnostics Manual.

Equipment: None

Procedure

1. On the Signal Generator, press the [INSTR PRESET] key.
2. Key in the following:

   [SPECIAL] [1] [7] [1] [ENTER] [ON].

   Note: "ENTER" and "ON" are the same key.

Adjustment 2

TIMEBASE ADJUSTMENT

Specification (typical)

	Standard	*Option 001*
Aging:	*± 1.5 × 10^{-8} / day after 10 days*	*± 3 × 10^{-10} / day after 10 days*
Temperature:	*± 7 × 10^{-10}, 0 to 55°C*	*± 3 × 10^{-9}, 0 to 55°C*
Line Voltage:	*± 2 × 10^{-10}, ± 10%*	*± 1 × 10^{-10}, ± 10%*

Description

The OVEN REF OUTPUT from the Signal Generator (rear panel) is compared against a frequency standard with a long term stability greater than 1 × 10^{-10}. The frequency of the reference oscillator is fine tuned for minimum drift using the OVEN REF Adjustment.

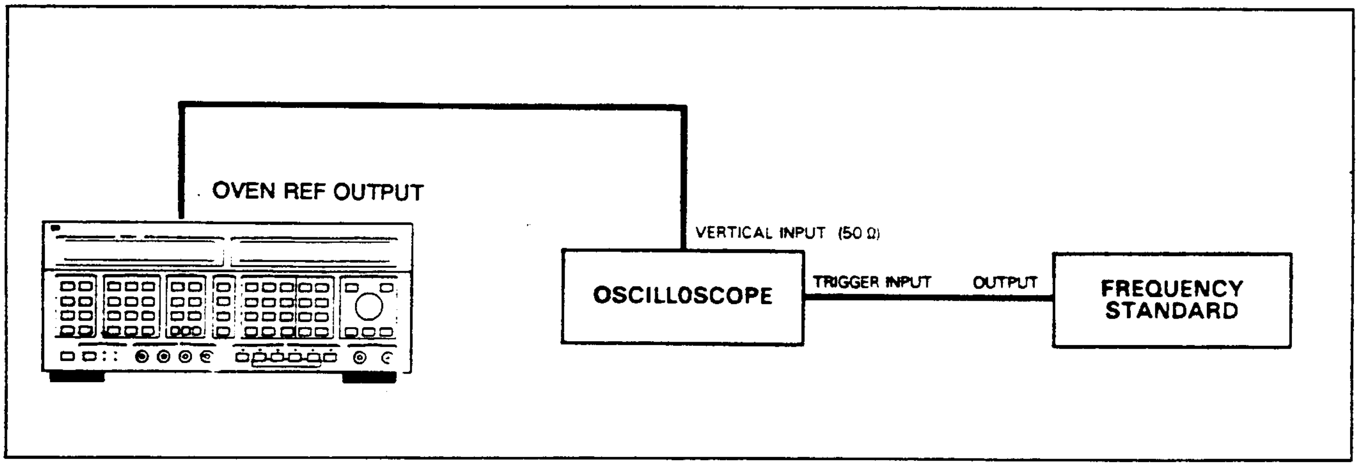


Figure 9-1. Timebase Adjustment Setup

Equipment

Frequency Standard .... HP 5065A
Oscilloscope .... HP 1740A or Tektronix 2245

Procedure

1. Connect an RF cable from the frequency standard to the vertical input of the oscilloscope.
2. Adjust the oscilloscope so that at least one cycle of the sine waveform can be viewed on the oscilloscope screen.
3. Connect the equipment as shown in figure 9–1.
4. Set the oscilloscope for external triggering input and adjust for synchronized (stable) display.
5. Set the OVEN REF Adjust (rear of the Signal Generator; crystal oscillator assembly) so that the waveform on the oscilloscope does not drift more than one cycle in ten seconds.

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