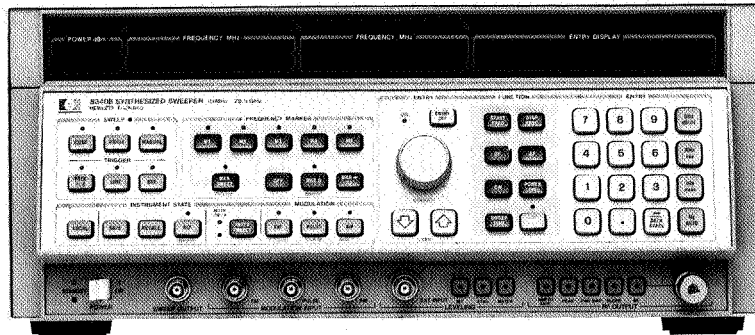


HP 8340B HP 8341B SYNTHESIZED SWEEPERS



**HEWLETT
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HP 8340B/41B SYNTHESIZED SWEEPERS Operating Information

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1400 FOUNTAINGROVE PARKWAY, SANTA ROSA, CA 95401 U.S.A.

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SECTION III

TABLE OF CONTENTS

INTRODUCTION	3-1	Reading HP-IB Messages	3-93
LOCAL OPERATING INFORMATION		Direct Writing to the HP-IB Lines	
		3-95	
Figure	Page	Figure	Page
3-1. Index by Front Panel Keys, Display and Connectors	3-3	3-25. HP-IB Pin-Out	3-83
3-2. Index by Rear Panel Connectors	3-4	3-26. HP-IB Handshake Timing	3-84
3-3. Power dBm Display	3-13	3-27. Representative Status Registers	3-94
3-4. START/CW/CF Frequency Display	3-15	3-28. Representative Control Registers	3-96
3-5. STOP/ Δ F Frequency Display	3-16	Table	
3-6. Entry Display	3-17	3-2. HP 8340B/41B Programming Codes	3-61
3-7. Function Keys	3-19	3-3. The Standard ASCII Code	3-89
3-8. KNOB/STEP Entry	3-22	POWER CONTROL AND MODULATION INFORMATION	
3-9. Frequency Marker Keys	3-24	INTERNAL LEVELING	3-98
3-10. Entry Keys	3-26	Coupled Mode	3-98
3-11. Sweep and Trigger Keys	3-28	Power dBm Display	3-99
3-12. Instrument State Keys	3-31	Decoupled Mode	3-100
3-13. Power Switch, Sweep Output	3-34	UNLEVELED MODE	3-102
3-14. Modulation Keys	3-35	POWER SEARCH	3-104
3-15. Modulation Input	3-36	EXTERNAL LEVELING	3-104
3-16. Leveling Keys/Input	3-37	EXTERNAL SOURCE MODULE LEVELING	3-105
3-17. RF Keys/Output	3-39	Detector Characteristics	3-105
3-18. Rear Panel BNC Connectors	3-42	POWER dBm Display used with the Attenuator	3-107
3-19. Rear Panel RF Output	3-44	Bandwidth	3-107
3-20. HP-IB Connector	3-45	AMPLITUDE MODULATION	3-108
3-21. HP 8410 Interface	3-47	Power dBm Display used with AM	3-108
3-22. HP 8755C Interface	3-49	Dynamic Range	3-109
3-23. Fan Assembly	3-50	Bandwidth for AM Applications	3-109
3-24. Power Line Module	3-51	PULSE MODULATION	3-110
Table	Page	Sample and Hold Leveling	3-110
3-1. Index by Mode and Function	3-5	Response Time	3-114
HP-IB PROGRAMMING INFORMATION		Unleveled Mode used with Pulse Modulation	3-114
Introduction	3-52	Input Characteristics	3-114
Interconnective Cabling	3-52	Pulse Envelope	3-115
Instrument Addresses	3-52	Source Match	3-115
HP-IB Instruments Nomenclature	3-52	Video Feedthrough	3-115
Programming the HP 8340B/41B	3-53	SLOW RISE TIME PULSE MODULATION FOR SCALAR NETWORK ANALYZERS	3-116
HP-IB Command Statements	3-53	Figure	Page
HP 8340B/41B Programming Codes	3-59	3-29. ALC Loop Block Diagram	3-99
Programs that Duplicate Front Panel Operations	3-59	3-30. Reverse Power Effects	3-101
Using the Rotary KNOB	3-63	3-31. Typical Unleveled Modulation Response	3-103
Using Keys that Toggle ON/OFF	3-63	3-32. Typical External Leveling Hookup	3-104
Operator's Programing Check	3-63	3-33. Typical Crystal Detector Response at 25°C	3-106
Unique HP-IB Programming Codes	3-64	3-34. Pulse Measuring System	3-112
System Timing	3-82	3-35. Error Detection and Modulator Drive	3-113
HP-IB Programming Techniques for Special Applications	3-82	3-36. Pulse Input Circuit	3-115
HP-IB Pin-Out Description	3-82	3-37. Video Feedthrough	3-116
The Twelve HP-IB Lines	3-86		
Computer Access of HP-IB Lines	3-91		
Sending HP-IB Messages	3-92		

SUPPLEMENTAL GUIDES

OPERATING GUIDES

- Getting Acquainted with the HP 8340B/41B Synthesized Sweepers
- Using the HP 8340A Synthesized Sweeper with the HP 8755 Frequency Response Test Set
- Externally Leveling the HP 8340B/41B Synthesized Sweepers
- Using the HP 8340A Synthesized Sweeper with X-Y Recorders.
- Using the HP 8340A Synthesized Sweeper with the HP 8410B/C Network Analyzer

PRODUCT NOTES

- Increasing the Frequency Switching Speed on the HP 8340A Synthesized Sweeper.
- List of other Product Notes

PROGRAMMING NOTES

- Introductory Operating Guide (HP-IB) for the HP 8340A/8341A Synthesized Sweepers with the HP 9000 Series 200/300 Desktop Computers (BASIC)
- Quick Reference Guide (HP-IB) for the HP 8340B/41B Synthesized Sweepers

IN CASE OF DIFFICULTY

Section III. Operation

INTRODUCTION

This section completely describes all front- and rear-panel keys, connectors, switches, and displays of the HP 8340B/41B Synthesized Sweeper, and explains all code mnemonics and the procedures used for HP-IB programming. Also described are enhancement procedures for the power control and modulation functions.

The descriptive material in the local operation subsection is organized according to the physical layout of the HP 8340B/41B. To find specific information, use as an index either Table 3-1, or Figures 3-1 and 3-2:

Table 3-1 lists the operation modes and functions of the HP 8340B/41B, shows the keystrokes that initiate those functions, and lists the reference figures that explain the procedures.

Figure 3-1 is a front panel drawing of the HP 8340B, with callouts indicating the reference figures that explain each key connector, switch, and display.

Figure 3-2 is a rear panel drawing of the HP 8340B, with callouts that indicate the appropriate reference figures.

The nucleus for the HP-IB programming material is Table 3-2. Table 3-2 lists all code mnemonics and provides cross referencing to equivalent front panel keys. The codes that do not have an equivalent front panel key, along with the HP-IB programming procedures, are explained following Table 3-2.

The power control and modulation functions have several enhancement provisions. These provisions are mentioned in the relevant parts of the local operation and HP-IB programming subsections, but a collective, detailed explanation is made at the end of this Operation section.

Hewlett-Packard periodically updates the operating information for the HP 8340B/41B, in the form of a Manual Changes Supplement, and publishes a series of Operating Guides and Programming Notes. Contact the nearest HP Sales and Service office (listed inside of the back cover of Volume 3) to obtain this supplemental information as it becomes available.

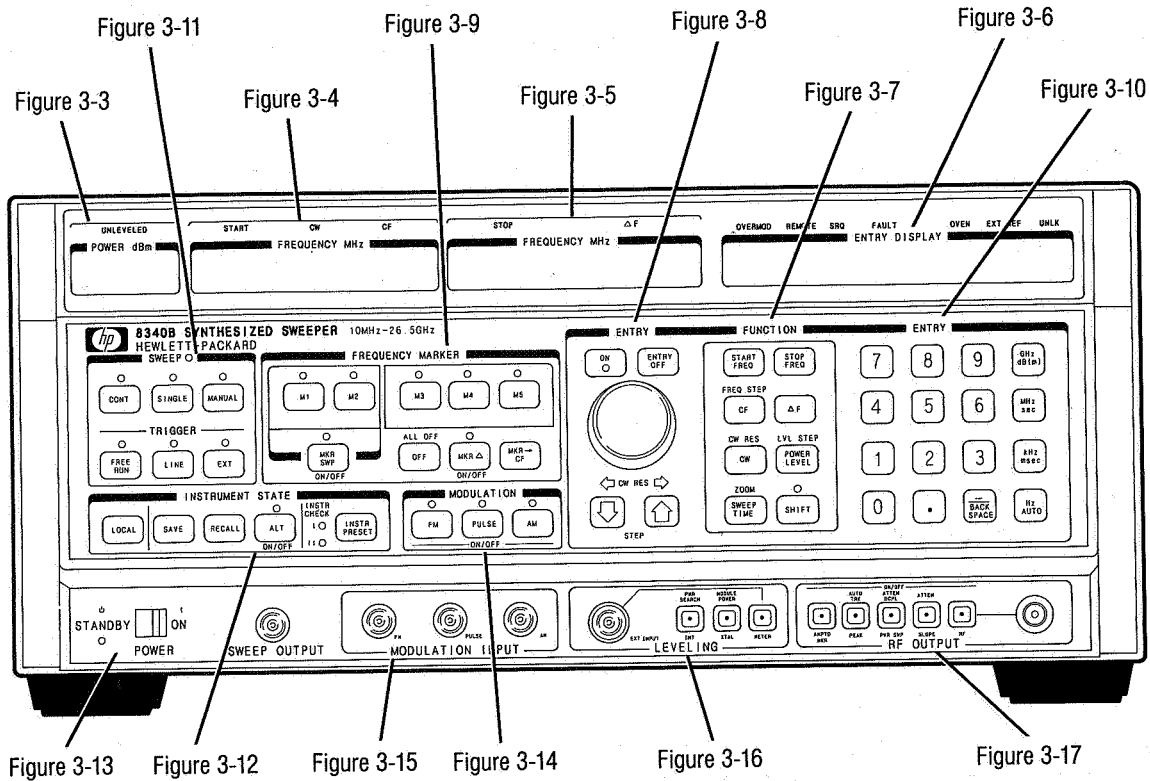


Figure 3-1. Index by front panel keys, display, and connectors

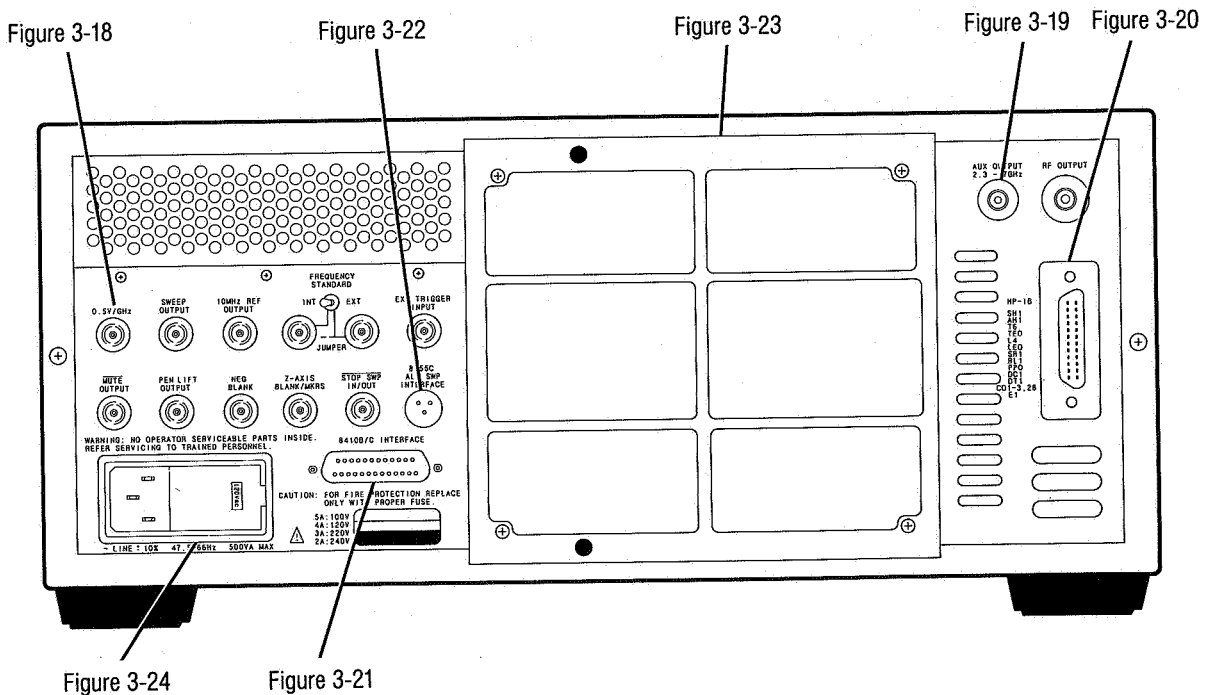


Figure 3-2. Index by rear panel connectors

Table 3-1. Index by Mode and Function (1 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure	
Swept/CW Frequency Selection					
Start/Stop Sweep	START	[START FREQ]	FA	3-7	
	STOP	[STOP FREQ]	FB		
Center Frequency/ ΔF Sweep	CF	[CF]	CF		
	ΔF	[ΔF]	DF		
	ZOOM	[SHIFT] [SWEEP TIME]	SHST		
CW Frequency	CW	[CW]	CW		
	CW RESOLUTION	[SHIFT] [CW]	SHCW		
Frequency Markers					
Turn On and Set Marker Frequency	MARKER 1	[M1]	M1		3-9
	MARKER 2	[M2]	M2		
	MARKER 3	[M3]	M3		
	MARKER 4	[M4]	M4		
	MARKER 5	[M5]	M5		
Turn Off a Frequency Marker	M1 OFF	[M1] [OFF]	M1M0		
	M2 OFF	[M2] [OFF]	M2M0		
	M3 OFF	[M3] [OFF]	M3M0		
	M4 OFF	[M4] [OFF]	M4M0		
	M5 OFF	[M5] [OFF]	M5M0		
Turn Off All Markers	ALL OFF	[SHIFT] [OFF]	SHMO		
Turn On And Set Mkr Δ	MKR Δ, Marker "m" Marker "n"	[MKR Δ]	MD1		
Turn Off Mkr Δ Turn Off Mkr Δ	MKR Δ OFF MKR Δ OFF		MD0		
Active Marker To Center Frequency	MKR → CF	[MKR → CF]	MC		
Marker 1-2 Sweep	MKR SWEEP ON	[MKR SWEEP]	MP1		
	MKR SWEEP OFF		MP0		
Marker 1 to Start Marker 2 to Stop	M1 → START M2 → STOP	[SHIFT] [MKR SWEEP]	SHMP		
Amplitude Frequency Markers	AMPTD MKR ON	[AMTD MKR]	AK1	3-17	
	AMPTD MKR OFF		AK0		

Table 3-1. Index by Mode and Function (2 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure
Sweep Mode, Trigger and Time				
Sweep Mode	CONTINUOUS	[CONT]	S1	3-11
	SINGLE	[SINGLE]	S2 or SG	
	MANUAL FREQUENCY SWEEP	[MANUAL]	S3 or SM	
Sweep Trigger	FREE RUN	[FREE RUN]	T1	
	LINE	[LINE]	T2	
	EXTERNAL	[EXT]	T3	
Sweep Time	SWEEP TIME	[SWEEP TIME]	ST	3-7
RF on Dwell	Increases dwell time by 100µs/count entered for "value", up to 12.8 ms	[SHIFT] [MHz] [1] [7] [Hz] [SHIFT] [kHz] [n] [Hz] where n = "value"	SHMZ 17 Hz SHKZ # Hz where # = "value"	3-11
Return Pre-sweep/ Pre-CW step delay time to 400µs	Instrument Preset	[INSTR PRESET]	IP	
Modulation				
Amplitude Modulation	AM ON	[AM]	AM1	3-14, 3-15
	AM OFF		AM0	
Pulse Modulation	Slow Rise Time Pulse Mod ON	[SHIFT] [PULSE]	SHPM	
	NORMAL PULSE MOD. ON	[PULSE]	PM1	
	PULSE MOD. OFF		PM0	
Frequency Modulation	FM ON	[FM]	FM 1		3-14
	FM OFF		FM 0	
	FM SENSITIVITY 1 MHz/Volt	[FM] [1] [MHz]	FM 1 Mz	
	FM SENSITIVITY 10 MHz/Volt	[FM] [10] [MHz]	FM 1 10 Mz	
	Disable ALC, Search for Desired Power Level	[SHIFT] [INT]	SHRF or SHAI	3-16

Table 3-1. Index by Mode and Function (3 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure
Step Size, Display, and Entry Control				
Set Frequency Step Size	FREQUENCY STEP SIZE	[SHIFT] [CF]	SF or SHCF	3-7
Set Power Step Size	POWER STEP SIZE	[SHIFT] [POWER LEVEL]	SP or SHPL	
Increment Active Parameter	STEP UP ↑	[▲] (STEP KEY)	UP	3-8
Decrement Active Parameter	STEP DOWN ↓	[▼] (STEP KEY)	DN	
Numeric Display Update	RE-ENABLE DISPLAY UPDATE	[SHIFT] [CONT]	SHS1 or DU1	3-11
X-Y Recorder Interface	ENABLE PENLIFT AT BANDCROSSING	[SHIFT] [LINE]	SHT21	
	DISABLE PENLIFT AT BANDCROSSING		SHT20	
Fixed Function To Coupled Mode	AUTO	[Hz/AUTO]	AU	3-10
Active Function	DISABLE ACTIVE FUNCTION	[ENTRY OFF]	EF	3-8
	Reinstate Calibration Constant Access	[SHIFT] [ENTRY OFF]	SHEF	
Frequency Display Scale	MULTIPLICATION FACTOR	[SHIFT] [START FREQ]	SHFA	3-7
	RETAIN MULTIPLICATION FACTOR AT ON/OFF OR INSTR PRESET	[SHIFT] [ALT]	SHAL	3-12
	DISABLES [SHIFT] [ALT], MULTIPLICATION FACTOR PRESETS TO 1	[SHIFT] [INSTR PRESET]	SHIP	
Display Offset	OFFSET FACTOR	[SHIFT] [STOP FREQ]	SHFB	3-7
Instrument State/Registers				
Instrument Preset	INSTR PRESET	[INSTR PRESET]	IP	3-12
Save An Instrument State	SAVE n	[SAVE]	SV	
Recall An Instrument State	RECALL n	[RECALL]	RC	
Lock Registers	SAVE LOCK	[SHIFT] [SAVE]	SHSV	
Unlock Registers	SAVE UNLOCK	[SHIFT] [RECALL]	SHRC	

Table 3-1. Index by Mode and Function (4 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure
Instrument State/Registers (Cont'd)				
Alternate Sweep Mode	ALT ON	[ALT]	AL1	
	ALT OFF		AL0	
Security Memory Erase	ERASE RAM, set all variables and Save/ Recall registers to Instr Preset conditions. Working calibration constants overwritten by protected cal constants.	[SHIFT] [MHz] [1] [8] [Hz] [SHIFT] [kHz] [0] [Hz]	SHMZ18HZ SHKZ0HZ	3-12
Power Level and Control				
Set Output Power Level	POWER LEVEL	[POWER LEVEL]	PL	3-7
Power Sweep Mode	POWER SWEEP ON	[PWR SWP]	PS1	
	POWER SWEEP OFF		PS0	
Power Slope Mode	SLOPE ON	[SLOPE]	SL1	
	SLOPE OFF		SL0	
RF Power	RF ON	[RF]	RF1	3-17
	RF OFF		RF0	
Peak Output Power (CW Mode or Manual Sweep)	PEAK ON	[PEAK]	RP1	
	PEAK OFF		RP0	
Instantaneous Peak	FAST PEAKING	[SHIFT] [AMTD MKR]	SHAK	
Tracking Calibration	AUTO TRACKING CALIBRATION	[SHIFT] [PEAK]	SHRP	
Leveling Modes	INTERNAL	[INT]	A1	3-16
	EXTERNAL CRYSTAL	[XTAL]	A2	
	EXTERNAL POWER METER	[METER]	A3	
	DISABLE ALC TO CONTROL MODULATOR DRIVE DIRECTLY	[SHIFT] [METER]	SHA3	
	ENABLE EXTERNAL SOURCE MODULE LEVELING MODE	[SHIFT] [XTAL]	SHA2	

Table 3-1. Index by Mode and Function (5 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure
Power Level and Control (Cont'd)				
Independent Control of ALC and Attenuator	DECOUPLE ALC AND ATTENUATOR (CONTROL EACH INDEPENDENTLY)	[SHIFT] [PWR SWP]	SHPS	3-17
	CONTROL STEP ATTENUATOR INDEPENDENTLY	[SHIFT] [SLOPE]	SHSL or AT	
Diagnostic Functions				
Display M/N and 20/30 Loop Frequencies	DISPLAY M,N, M/N FREQ., 20/30 FREQ.	[SHIFT] [M1]	SHM1	3-9
Display Band # and Y.O. Loop Frequency	DISPLAY BAND # AND Y.O FREQ.	[SHIFT] [M2]	SHM2	
Display VCO1 and VCO2 Frequencies	DISPLAY VC01	[SHIFT] [M3]	SHM3	
Diagnostic Tests/ Results	DIAGNOSTIC TESTS/ RESULTS	[SHIFT] [M4]	SHM4	
Front Panel Display Test	DISPLAY TEST	[SHIFT] [FREE RUN] ¹	SHT1	3-11
Display Unlock	DISPLAY UNLOCK	[SHIFT] [EXT]	SHT3	
Display Fault Indicators	DISPLAY FAULT INDICATORS	[SHIFT] [MANUAL]	SHS3	
Band Cross Control	DISABLE BAND CROSS	[SHIFT] [MHz] [2] [3] [Hz] [SHIFT] [kHz] [0] [Hz]	SHMZ23HZ SHKZ0HZ	3-16
	RE-ENABLE BAND CROSS	[SHIFT] [MHz] [2] [4] [Hz] [SHIFT] [kHz] [0] [Hz]	SHMZ22HZ SHKZ0HZ	
Cause Manual Band Cross	MANUAL BAND CROSS	[SHIFT] [MHz] [2] [2] [Hz] [SHIFT] [kHz] [0] [Hz]	SHMZ22HZ SHKZ0HZ	
Turn Off Diagnostic Display	DIAGNOSTICS OFF	[SHIFT] [M5] ¹	SHM5	3-9
Read/Write to Internal Circuits	SELECT CHANNEL	[SHIFT] [GHz/dB(m)]	SHGZ	3-10
	SELECT SUBCHANNEL	[SHIFT] [MHz/sec]	SHMZ	
	WRITE DATA	[SHIFT] [kHz/msec]	SHKZ	
	READ DATA	[SHIFT] [Hz/AUTO]	SHHZ	

1. [SHIFT] [M5] will not deactivate the Front Panel Display Test. Instead, press [INSTR PRESET] or cycle power off, then on. [INSTR PRESET] will restore the instrument to its standard starting condition. Cycling the POWER switch will restore the instrument to its previous state.

Table 3-1. Index by Mode and Function (6 of 7)

Mode	Function	Keys	HP-IB Code	Reference Figure
HP-IB Functions				
Status Bytes and Service Requests	CLEAR BOTH STATUS BYTES		CS	
	OUTPUT BOTH STATUS BYTES		OS	
	MASK STATUS BYTE 1		RM	
	MASK STATUS BYTE 2		RE	
Output Operating Configuring	OUTPUT LEARN STRING		OL	
	INPUT LEARN STRING		IL	
	OUTPUT MODE STRING		OM	
Output Parameters	OUTPUT ACTIVE VALUE		OA	
	OUTPUT NEXT BANDCROSS FREQUENCY		OB	
	OUTPUT COUPLED PARAMETERS		OC	
	OUTPUT DIAGNOSTICS		OD	
	OUTPUT FAULTS		OF	
	OUTPUT FIRMWARE ID		OI	
	OUTPUT LAST LOCK FREQUENCY		OK	
	OUTPUT INTERROGATED PARAMETER		OP	
	OUTPUT POWER LEVEL		OR	
Network Analyzer Function	NETWORK ANALYZER CONFIGURE	NA		
	ADVANCE TO NEXT BANDCROSSING	BC		
	KEYBOARD RELEASE	KR		
	SWAP CHANNELS	SW		

Table 3-1. Index by Mode and Function (7 of 7)

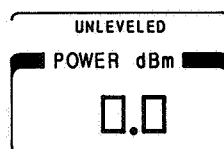
Mode	Function	Keys	HP-IB Code	Reference Figure
HP-IB Functions (Cont'd)				
Control Knob	ENABLE HP 8340B/41B KNOB		EK	
	ENABLE REMOTE KNOB		RB	
Sweep Functions	STEPPED SWEEP		SN	
	INCREMENT FREQUENCY		IF	
	RESET SWEEP		RS	
	TAKE SWEEP		TS	
	TIME LIMIT		TL	
Alternate State Selection	SELECT FOREGROUND		AS0	
	SELECT BACKGROUND		AS1	
Fast Phaselock	FAST PHASELOCK SELECT		FP	
Attenuator Control	INDEPENDENT CONTROL OF ATTENUATOR	AT		
HP-IB Test	TEST HP-IB DATA TRANSMISSION	TI		

Power dBm Display

DESCRIPTION

This display shows the actual power delivered to the RF OUTPUT port of the HP 8340B/41B, and contains the UNLEVELED warning indicator.

PANEL LAYOUT



FUNCTIONS

POWER dBm: The available output power of the HP 8340B/41B is shown in this display, rounded to the nearest 0.1 dB. Depending on the installed attenuator, the available power ranges from a minimum of -110.00 dBm to a maximum that depends on frequency, with a resolution of 0.05 dB (see Table 1-1 for the specified maximum power available for each frequency band). If the user requests a power level that the HP 8340B/41B cannot provide, the instrument will select the closest available power and show that value in the POWER dBm display (to ± 0.1 dB); in this situation the ENTRY DISPLAY, which shows user-selected power level, will not match the POWER dBm display which shows actual power.

The procedures for setting the power level are explained in Figures 3-7 (POWER LEVEL) and 3-17 (POWER SWEEP, PEAKING, and RF OFF).

This display can be blanked (turned off) by pressing **[SHIFT] [CONT]**. Although the display is blank, the power functions can be changed by the same local and remote procedures that are used with an active display. Press **[SHIFT] [CONT]** to regain an active display.

INDICATORS

UNLEVELED: The red UNLEVELED annunciator indicates trouble, either from operator error or machine malfunction, with one exception.

Operator error: request for too much power. If the operator requests a power output that is too high for the HP 8340B/41B at that frequency, the UNLEVELED annunciator lights. Typically, the HP 8340B/41B can deliver more power than listed in the specifications (Table 1-1); the UNLEVELED annunciator will light when the true maximum power level has just been exceeded. To remedy an UNLEVELED condition either **[PEAK]** the instrument (for CW or manual modes, as explained in Figure 3-17), or reduce the requested power.

Figure 3-3. Power dBm Display (1 of 2)

Machine malfunction: If the UNLEVELED annunciator lights, and the cause is not a request for excessive power, one or more of the power circuits are malfunctioning. If this happens, press **[INSTR PRESET]** which will restore standard instrument conditions, then re-enter the desired instrument configuration. If the UNLEVELED annunciator remains lighted, shut down the instrument and consult the In Case of Difficulty section in this manual.

Exception: open-loop operation. The ALC can be bypassed by pressing **[SHIFT] [METER]**, as described in Figure 3-16. Under these conditions the UNLEVELED annunciator is lighted, but acts as a reminder in this case instead of a warning.

DIAGNOSTICS

Test this display (and the three other displays) by pressing and holding **[INSTR PRESET]**, which will cause the UNLEVELED annunciator to light, then release **[INSTR PRESET]** and press **[SHIFT] [FREE RUN]** which will light every segment of the LED display ("88888"). Press **[INSTR PRESET]** or cycle the POWER switch to cancel this diagnostic test.

NOTE: **[INSTR PRESET]** will restore the instrument to its standard starting condition. Cycling POWER switch will restore the instrument to its previous state.

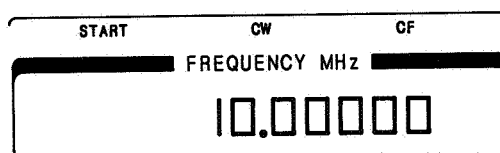
Figure 3-3. Power dBm Display (2 of 2)

START/CW/CF Frequency Display

DESCRIPTION

This display shows (in megahertz) either the start frequency, the CW frequency, or the CF (center frequency) of the HP 8340B/41B depending on its current operating mode.

PANEL LAYOUT



FUNCTIONS

One of three frequencies is shown in this display: Start, CW, or CF. Figure 3-7 explains the implementation of these three functions.

This display can be blanked (turned off) by pressing **[SHIFT] [CONT]**. Although the display is blanked, the Start, CW, or CF values can be changed by the same local or remote procedures that are used when the display is active. Press **[SHIFT] [CONT]** again to turn the display on.

INDICATORS

START, CW, and CF: These three amber annunciators indicate which function value is shown in the display.

DIAGNOSTICS

Press and hold **[INSTR PRESET]** to light the three annunciators, then release **[INSTR PRESET]** and press **[SHIFT] [FREE RUN]** which will light every LED segment ("888888888888"). Press **[INSTR PRESET]** or cycle the POWER switch.

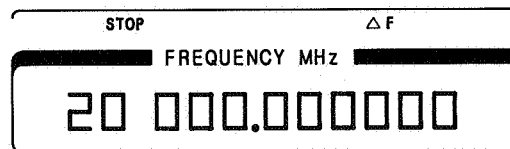
Figure 3-4. START/CW/CF Frequency Display

STOP/ Δ F Frequency Display

DESCRIPTION

This display shows, in megahertz, either the Stop frequency or the Δ F frequency span of the HP 8340B/41B.

PANEL LAYOUT



FUNCTIONS

One of two frequencies is shown in this display: Stop, or Δ F. Figure 3-7 explains the implementation of these two functions.

This display can be blanked (turned off) by pressing **[SHIFT] [CONT]**. Although the display is blanked the Stop or Δ F values can be changed by the same local and remote procedures that are used when the display is active. Press **[SHIFT] [CONT]** again to turn the display on.

INDICATORS

STOP, Δ F: These two amber annunciators indicate which function value is shown in the display.

DIAGNOSTICS

Press and hold **[INSTR PRESET]** to light the two annunciators, then release **[INSTR PRESET]** and press **[SHIFT] [FREE RUN]** which will light every LED segment ("888888888888"). Press **[INSTR PRESET]** or cycle the POWER switch to end this diagnostic routine. (This diagnostic also tests the three other displays.)

NOTE: **[INSTR PRESET]** will restore the instrument to its standard starting condition. Cycling the POWER switch will restore the instrument to its previous state.

Figure 3-5. Stop/ Δ F Frequency Display

Entry Display

DESCRIPTION

This display shows the active function and its present value, and contains the OVERMOD, REMOTE, SRQ, FAULT, OVEN, EXT REF, and UNLK indicators.

PANEL LAYOUT



FUNCTIONS

The most recently activated function and its present value is shown in this display. In local operation, the most recently pressed function key is the active function and will remain active until superseded by the pressing of another function key. The HP 8340B/41B will remember (for approximately three years, or until the battery on the A60 processor board is changed) the activated function even when the power is disconnected, and will display that function in the ENTRY DISPLAY when the power is turned on. The HP-IB address ("HP-IB ADRS=19") is displayed momentarily at power-on, followed by a display of the active function.

In local operation, the active function can be changed by the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keypad. First, press one of the function keys to make that function active and display its present value in the ENTRY DISPLAY. Then, change the value of that function by using either the **[KNOB]**, the **[STEP]** keys, or the numerical keys (with a terminator key).

In remote operation, the ENTRY DISPLAY will show the last function programmed

ENTRY DISPLAY can be blanked (turned off) by pressing **[SHIFT] [CONT]**, which turns off all of the displays. The displays will remain blanked even when the function keys are pressed (although the annunciators will change). To regain a live display, press **[SHIFT] [CONT]** again.

INDICATORS

ENTRY DISPLAY contains two types of indicators: amber identification annunciators, and red warning annunciators.

REMOTE (amber) annunciator lights when the HP 8340B/41B is being remotely controlled by a computer. When REMOTE is lighted all front panel operations are disabled with three exceptions: The POWER switch can only be locally operated, the rotary **[KNOB]** can be enabled by using the EK programming code, and the **[LOCAL]** key will override the computer and restore local control (unless the computer sent a LOCAL LOCKOUT command to the HP 8340B/41B, which disables the **[LOCAL]** key).

Figure 3-6. Entry Display (1 of 2)

FAULT (amber) annunciator lights when one of the internal circuits performs atypically. To identify the affected circuit, press **[SHIFT] [MANUAL]** which will cause "FAULT: CAL KICK ADC PEAK TRK" to appear in the ENTRY DISPLAY. The flashing letters identify the faulty circuit as CAL (calibration constants), KICK (YO or YTM kick pulses), ADC (analog to digital converter), PEAK (power peaking), or TRK (tracking control); at this point the In Case of Difficulty section of this manual should be consulted for further instructions.

EXT REF (amber) annunciator lights when an external frequency source is used as the reference standard instead of the internal crystal oscillator. The internal/external frequency standard is selected by a rear-panel switch; see Figure 3-18 for an explanation of this switch and the associated connectors.

OVERMOD (red) annunciator lights when excessive positive or negative voltage is applied to the front panel FM MODULATION INPUT or when excessive negative voltage is applied to the front panel AM MODULATION INPUT. In the case of AM, this excessive negative voltage causes the HP 8340B/41B to attempt to exceed the maximum modulation depth. This happens at approximately -1 volt AM input. Positive excursions have no limit as long as maximum available power is not exceeded, at which point the UNLEVELED annunciator lights. AM linearity will suffer for inputs above $+1$ volt. As with the UNLEVELED annunciator, an OVERMOD indication may signify an internal malfunction. The OVERMOD condition can be caused by an FM input signal which significantly exceeds a Modulation Index (peak deviation in MHz/modulation in MHz) of 5.

SRQ (amber) annunciator lights when a remotely controlled HP 8340B/41B initiates a Service Request (SRQ does not apply to local operation). Several conditions can cause a Service Request, including altered parameter values, syntax error, power failure, and unleveled power. The SRQ annunciator remains lighted until the computer sends an acknowledgement signal to the HP 8340B/41B. Service Requests are more fully explained in the HP-IB Programming part of this Operation chapter, and in the In Case of Difficulty section.

OVEN (red) annunciator lights when the oven for the reference crystal oscillator is not at operating temperature. A cold oven typically requires 5-30 minutes to reach operating temperature. The STANDBY position of the POWER switch maintains power to the oven heater, thus keeping the oven warm and the crystal oscillator ready for immediate operation. Although the HP 8340B/41B can be operated with a cold crystal oscillator, the instrument might not fully comply with specifications until the proper operating temperature is achieved.

UNLK (red) annunciator lights when the HP 8340B/41B's output signal is no longer phase-locked to the 10 MHz reference oscillator. Press **[SHIFT] [EXT]**, which will cause "OSC: REF M/N HET YO N2 N1" to appear in the ENTRY DISPLAY. The flashing letters indicate which oscillator is not phase locked. Refer to the In Case of Difficulty Section.

DIAGNOSTICS

Press and hold **[INSTR PRESET]** to light the seven annunciators, then release **[INSTR PRESET]** and press **[SHIFT] [FREE RUN]** which will light every LED segment and show the entire ENTRY DISPLAY character set. Press **[INSTR PRESET]** or cycle the POWER switch to end this diagnostic routine. (This diagnostic also tests the three other displays.)

NOTE: **[INSTR PRESET]** will restore the instrument to its standard starting condition. Cycling the POWER switch will restore the instrument to its previous state.

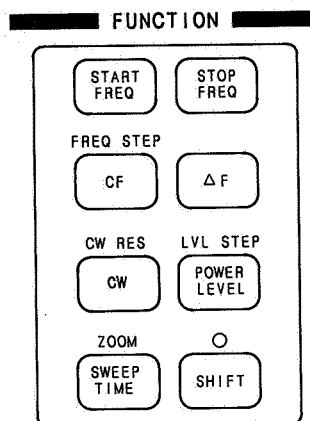
Figure 3-6. Entry Display (2 of 2)

Function Keys

DESCRIPTION

This group of keys selects frequency mode, power level, sweep time, and associated functions.

PANEL LAYOUT



FUNCTIONS

[START FREQ] (HP-IB: FA) selects the start frequency for start/stop swept operation. Press **[START FREQ]**; then use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with a terminator key to set the desired value. The start frequency must be at least 100 Hz lower than the stop frequency. If there is less than 100 Hz between start/stop, or if the start frequency is greater than the stop frequency, the HP 8340B/41B will change the start or stop frequency to achieve the required separation. The order in which start/stop is entered is not important. If start/stop mode is interchanged with CF/ΔF mode (by pressing either of the start/stop keys and then either of the CF/ΔF keys) the sweep limits are the same. The start frequency appears in the left FREQUENCY MHz display.

[SHIFT] [START FREQ] (HP-IB: SHFA) scales the frequency displays by a multiplication factor of -30 to +30. This is used, for example, when a frequency doubler or tripler is connected to the RF output of the HP 8340B/41B, and the display values are multiplied by a factor of two or three to indicate the system output frequency. Press **[SHIFT] [START FREQ]**, then enter the integer multiplication factor (-30 to +30) followed by any terminator key. The selected multiplication factor effects all frequency functions (start, stop, CF, ΔF, markers and marker functions, and the dB/GHz slope function), but the factor is not stored in the SAVE/RECALL registers (the current factor is used when recalling those registers). Cancel the multiplication factor by pressing **[INSTR PRESET]**, or enter a multiplication factor of 1. **[SHIFT] [ALT]** saves the current multiplication factor as the instrument's default value. In this mode, pressing **[INSTR PRESET]** or turning power off and on will not affect the user-defined multiplication factor. This feature can be disabled by pressing **[SHIFT] [INSTR PRESET]**, which sets the default multiplication factor to 1 and presets the instrument.

Figure 3-7. Function Keys (1 of 3)

[STOP FREQ] (HP-IB: FB) selects the stop frequency for start/stop swept operation. Press **[STOP FREQ]**; then use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with a terminator key to set the desired value. The restrictions that apply to **[START FREQ]** also apply to **[STOP FREQ]**. The stop frequency appears in the right FREQUENCY MHz display.

[SHIFT] [STOP FREQ] (HP-IB: SHFB) offsets the frequency displays by a fixed amount ranging from -500 GHz to +500 GHz. This is used, for example, when the RF output of the HP 8340B/41B is connected to a mixer, and for convenience the sum or difference frequency is shown in the displays. Press **[SHIFT] [STOP FREQ]**, then enter the desired offset value (-500 GHz to +500 GHz) followed by any terminator key. The offset effects all frequency values (start, stop CF, CW, and markers), but the offset cancels in difference functions such as **[ΔF]**, **[Δ MRK]** and the dB/GHz **[SLOPE]** function. The offset value is not stored in the SAVE/RECALL registers, but the current offset value does change the values of a recalled register. Cancel the offset by pressing **[INSTR PRESET]**, or by entering an offset value of 0.

[CF] (HP-IB: CF) selects the center frequency for center frequency/delta frequency swept operation. Press **[CF]**; then use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with a terminator key to set the desired value. The order in which CF/ΔF are entered is not important. Start/stop and CF/ΔF modes can be interchanged without changing the actual sweep limits, as described in the **[START FREQ]** paragraph. The CF value appears in the left FREQUENCY MHz display.

[SHIFT] [CF] (HP-IB: SHCF) selects the incremental step size for the STEP keys (the FREQ STEP function). The step size can be as small as 1 Hz, or as large as 10 GHz. Press **[SHIFT] [CF]**, then use either the numerical keys with a terminator key, the rotary **[KNOB]**, or the **[STEP]** keys (which step in a 1-2-5 sequence at this time) to set the desired increment. After setting the step size, "FIXD" appears in the right corner of the ENTRY DISPLAY. An alternative procedure couples the FREQ STEP increment size to the ΔF frequency span: Press **[SHIFT] [CF] [AUTO]** (causing "AUTO" to appear in the ENTRY DISPLAY) and the increment size will become 1/10 of the frequency span. AUTO is the default condition after an **[INSTR PRESET]**. The step size established by the FREQ STEP function is the same for start/stop frequencies, CF/ΔF frequencies, the markers, and manual sweeps. The **[STEP]** keys are explained in Figure 3-8.

[ΔF] (HP-IB: DF) selects the delta frequency (frequency span) for center frequency/delta frequency swept operation. Press **[ΔF]** then use either the **[STEP]** keys, the numerical keys with a terminator key, or the rotary **[KNOB]** to set the desired value. The HP 8340B/41B will sweep from 1/2 ΔF below to 1/2 ΔF above the center frequency. The restrictions that apply to **[CF]** also apply to **[ΔF]**. The right FREQUENCY MHz displays shows the **[ΔF]** value.

[SHIFT] [ΔF] has no effect on the HP 8340B/41B.

[CW] (HP-IB: CW) selects a synthesized CW frequency. Press **[CW]**; then use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with a terminator key to set the desired value. The right side of the ENTRY DISPLAY shows either "AUTO" if the **[STEP]** keys and **[KNOB]** are coupled to the ΔF frequency span, or "FIXD" if they are not coupled (see the **[SHIFT] [CF]** and **[SHIFT] [CW]** paragraphs for an explanation). The left FREQUENCY MHz display shows the CW value.

[SHIFT] [CW] (HP-IB: SHCW) sets the sensitivity of the rotary **[KNOB]** (the CW RES function) for adjusting the CW value. Press **[CW]** to enter CW mode, and set the desired CW value as described in the preceding paragraph. Then, press **[SHIFT] [CW]** and observe the flashing cursor in the ENTRY DISPLAY, which identifies the digit presently affected by the rotary **[KNOB]**. Reposition the cursor by pressing either the left-arrow or right-arrow **[STEP]** key (the arrows are printed in blue above the **[STEP]** keys). When the cursor is positioned over the desired digit, press **[CW]** to return to CW mode. After changing the CW RES, "FIXD" appears in the right corner of the ENTRY DISPLAY. However, the CW RES can be coupled to the ΔF frequency span ("AUTO" in the ENTRY DISPLAY) by pressing **[SHIFT] [CW] [AUTO]**, which causes the CW RES to be 1/1000 of the frequency span, reduced to the

Figure 3-7. Function Keys (2 of 3)

next lowest integer power of ten (for example, a frequency span of 16 GHz corresponds to a CW RES of: $16\text{GHz}/1000=16\text{ MHz}$; 16 MHz reduced to the next lowest integer power of ten equals 10 MHz, which is the CW RES). For frequency spans less than 1000 Hz, the AUTO CW RES is 10 Hz. AUTO is the default condition for CW RES after an **[INSTR PRESET]**.

[POWER LEVEL] (HP-IB: PL) controls the output power level of the HP 8340B/41B, when it is internally leveled. Press **[POWER LEVEL]**; then use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with the **[dB(m)]** terminator key to set the desired value (resolution 0.05 dB). When externally leveled, **[POWER LEVEL]** selects the external detector feedback voltage to which the HP 8340B/41B will attempt to level, with a range of +6 dBV (2.00 V) to -66 dBV (500 μV) and a resolution of 0.1 dB. The EXT INPUT (BNC connector) accepts either positive or negative inputs. When in the **[SHIFT] [METER]** (open-loop) mode the **[POWER LEVEL]** entry controls the linear modulator, as explained in Figure 3-16. In any of these three modes, the POWER dBm display shows the output power to the nearest 0.1 dB (see Figure 3-3 for information on this display, and its UNLEVELED indicator). The output power can range from -110 dBm to a maximum value that depends on frequency (see Table 1-1 for power specifications). Figure 3-17 explains **[PEAK]**, **[PWR SWP]**, and **[SLOPE]** power functions.

[SHIFT] [POWER LEVEL] (HP-IB: SHPL) selects the incremental step size for the **[STEP]** keys when they are used for the power level functions (**[POWER LEVEL]**, **[PWR SWP]**, or **[SLOPE]**). This is the LVL STEP function. Press **[SHIFT] [POWER LEVEL]**; then use either the rotary **[KNOB]**, the **[STEP]** keys (which step in a 1-2-5 sequence in this mode), or the numerical keys with the **[dB(m)]** terminator key to set the desired step size. The step size can range from 0.05 dB to 50.00 dB. Consult Figures 3-3 and 3-17 for further information on power functions.

[SWEEP TIME] (HP-IB: ST) selects the sweep times for frequency sweeps or power sweeps (power sweep is explained in Figure 3-17). Press **[SWEEP TIME]**; then use either the **[STEP]** keys (which increment in a 1-2-5 sequence for sweep time), the rotary **[KNOB]**, or the numeric keys with the **[sec]** or **[msec]** terminator key to set the desired value. Sweep time has an allowable range of 10 msec to 200 seconds, but the fastest sweep time is constrained by the frequency span: The sweep rate cannot exceed 600 MHz/msec (300 MHz/msec for HP 8341B Option 003) (for example, the full 26.49 GHz frequency span of the HP 8340B can be swept no faster than $26490/600=44.15\text{ msec}$). The fastest possible sweep can be determined automatically: Press **[SWEEP TIME] [AUTO]** to obtain the fastest possible calibrated sweep time for any sweep span. The right-hand corner of the ENTRY DISPLAY shows "AUTO" when the sweep time is coupled to the frequency span, or "FIXD" when sweep time is independent. AUTO is the default condition after **[INSTR PRESET]**. Also see TL in the HP-IB section.

[SHIFT] [SWEEP TIME] (HP-IB: SHST) places the HP 8340B/41B into CF/ Δ F sweep mode, with Δ F controlled only by the **[STEP]** keys and CF controlled by either the rotary **[KNOB]** or the numerical keys (with a terminator key). This is the ZOOM function, which allows the operator to quickly zoom-in on a frequency band of interest even from very wide sweeps.

[SHIFT] (HP-IB: SH) activates functions that are printed in blue on the front panel, as well as special functions. All **[SHIFT]** functions are described in this Operation chapter, and are summarized on the two information cards located below the HP 8340B/41B.

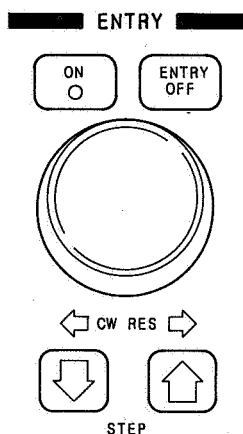
Figure 3-7. Function Keys (3 of 3)

KNOB/STEP Entry

DESCRIPTION

The rotary **[KNOB]** and **[STEP]** keys affect the function that is presently being shown in the ENTRY DISPLAY. **[ENTRY OFF]** blanks the ENTRY DISPLAY.

PANEL LAYOUT



FUNCTIONS

[ENTRY OFF] (HP-IB: EF) blanks (turns off) the ENTRY DISPLAY, and disables the **[STEP]** keys and the rotary **[KNOB]**. When any function key is pressed ENTRY DISPLAY is reactivated, the **ON** indicator next to **[ENTRY OFF]** lights, and the **[KNOB]** and **[STEP]** keys are enabled. To blank the ENTRY DISPLAY without disabling the **[KNOB]** or **[STEP]** keys press **[SHIFT] [CONT]** (as described in Figure 3-6)

[SHIFT] [ENTRY OFF] (HP-IB: SHEF) recalls the Calibration Constant Access Function. This command is used when one wishes to re-enter the calibration constant mode after just exiting it. This saves the trouble of entering the long Cal Constant key sequence again.

ROTARY KNOB (HP-IB: EK) allows analog-type adjustment of the function shown in the ENTRY DISPLAY. Press any function key to activate that function, then turn the rotary **[KNOB]** to obtain the desired value. **[SHIFT] [CW]** in figure 3-7 explains the procedure for adjusting the sensitivity of the rotary Knob. Although the **[KNOB]** has the feel of an analog control, it is actually a digital control that generates 120 pulses per revolution (the **[KNOB]** is frequently referred to as an RPG - rotary pulse generator - in service literature).

[SHIFT] ROTARY KNOB: **[SHIFT]** does not affect the rotary **[KNOB]**.

Figure 3-8. KNOB/STEP Entry (1 of 2)

STEP KEYS (HP-IB: UP for up-increment, DN for down-increment) change the value of any active function by an incremental step. Press any function key to activate that function, then press either the up-arrow or down-arrow **[STEP]** key to incrementally change the value of that function. Press and hold a **[STEP]** key for a repeat action. The active function is always shown in the ENTRY DISPLAY. **[SHIFT] [CF]** and **[SHIFT] [POWER LEVEL]** in Figure 3-7 explain the procedures for changing the size of the increment step (although for sweep times the increment is a fixed 1-2-5 sequence). After an **[INSTR PRESET]** the step size increments default to 1/10 of the current sweep width (changing as the width changes) for the **FREQ STEP**, and to 10.00 dB for the **LVL STEP**.

[SHIFT] STEP KEYS: **[SHIFT]** does not effect the **[STEP]** keys; however, the **[STEP]** keys are used for the shifted **CW RES** function. **CW RES** is accomplished by pressing **[SHIFT] [CW]**, then using the **[STEP]** keys to move the cursor left or right in the ENTRY DISPLAY. **[SHIFT] [CW]** in Figure 3-7 explains the **CW RES** function.

INDICATORS

ON is an LED that is lighted when the **[STEP]** keys and rotary **[KNOB]** are enabled, not lighted when those controls are disabled. The preceding **[ENTRY OFF]** paragraph contains additional information about this indicator.

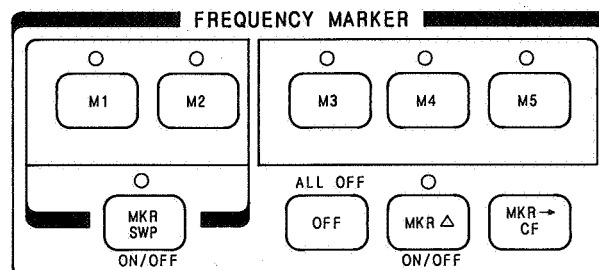
Figure 3-8. **KNOB/STEP** Entry (2 of 2)

Frequency Marker Keys

DESCRIPTION

This key group selects the five markers, the marker functions (MARKER SWEEP, MARKER DELTA, and MARKER TO CENTER FREQUENCY), and several diagnostic functions that are used during servicing.

PANEL LAYOUT



FUNCTIONS

[M1]...[M5] (HP-IB: M1...M5) keys select markers 1-5. Press one **[M1]...[M5]** key, and the present value of that marker will appear in the ENTRY DISPLAY. Use either the rotary **[KNOB]**, the **[STEP]** keys, or the numerical keys with a terminator key to set the desired marker frequency. Repeat this process for the other markers as needed. If the initial marker frequency is outside of the current sweep range, a slight turn of the **[KNOB]** will bring the frequency of that marker to the center frequency of the sweep. markers are normally displayed as z-axis intensity dots but can be changed to amplitude "dips" (an abrupt discontinuity in the sweep trace) by pressing **[AMTD MKR]**, as explained in Figure 3-17. The markers are functional whenever their individual LEDs are lighted; however, only one marker can be "active" at a time (the "active" marker is shown in the ENTRY DISPLAY, and can be changed via **[KNOB]**, **[STEP]** keys, or numerical keys with a terminator key). Press any marker key to make that marker active. After **[INSTR PRESET]** all markers are initialized to 13.255 GHz on the HP 8340B and 9.995 GHz on the HP 8341B; otherwise, the last-used marker values will be remembered by the HP 8340B/41B (for up to three years), even with disconnected ac power.

[SHIFT] [M1] (HP-IB: SHM1) is a service diagnostic that shows (from left to right), the M divisor, N divisor, M/N frequency, and 20/30 loop frequency. Consult the In Case of Difficulty section for additional information.

[SHIFT] [M2] (HP-IB: SHM2) is a service diagnostic that shows (from left to right), the band number and the YIG oscillator (YO) frequency. Consult the In Case of Difficulty section for additional information.

[SHIFT] [M3] (HP-IB: SHM3) is a service diagnostic that shows, from left to right, the PLL #2 VCO frequency and the PLL #3 upconverter frequency. Consult the In Case of Difficulty section for additional information.

Figure 3-9. Frequency Marker Keys (1 of 2)

[SHIFT] [M4] (HP-IB: SHM4) initiates a possible 18 diagnostic tests. These tests are labeled 14 to 31. Other tests are initiated at "power on". These tests are labeled 0 to 13. The results of all of these tests are indicated in the ENTRY DISPLAY, as either a global PASS or FAIL. Each of the test results may be viewed by entering the test number via the **[STEP]** keys, **[NUMERICAL]** keys, or **[KNOB]**. The tests may also be performed over the HP-IB and results read by using the **OD** command (see the HP-IB PROGRAMMING SECTION of this Operating Information manual).

[SHIFT] [M5] (HP-IB: SHM5) turns off all diagnostic routines except the **[SHIFT] [FREE RUN]** display test.

[MKR SWEEP] (HP-IB: MP1 activates the function, MP0 turns off the function) causes the HP 8340B/41B to start sweeping at the frequency of marker **[M1]**, and stop sweeping at the frequency of marker **[M2]** (**[M2]** must have a higher frequency than **[M1]**). If **[MKR SWEEP]** is activated when **[M2]** is at a lower frequency than **[M1]**, the values of **[M1]/[M2]** will be permanently interchanged. Press **[MKR SWEEP]** again to exit from Marker Sweep and return to the previous sweep limits. The LED above the key indicates whether the function is on (lighted), or off (not lighted).

[SHIFT] [MKR SWEEP] (HP-IB: SHMP) causes the sweep limits to permanently change to the frequencies of **[M1]** and **[M2]**. Repeated pressing of **[MKR SWEEP]** alone causes the HP 8340B/41B to toggle between **[M1]/[M2]** sweeps and the previous sweep frequencies; **[SHIFT] [MKR SWEEP]** eradicates the previous sweep values, leaving only the **[M1]/[M2]** frequencies.

[OFF] (HP-IB: M0) turns off (deactivates) any single marker. Press any marker key **[M1]...[M5]**, then press **[OFF]** to deactivate that marker. If **[OFF]** is pressed without first pressing a marker key, the most recently active marker will be turned off. The frequency value of the deactivated marker is retained in memory, and will be recalled when that marker key is pressed once again. A deactivated marker will not affect the **[MKR SWEEP]**, **[MKR Δ]**, or **[MKR → CF]** functions.

[SHIFT] [OFF] (HP-IB: SHM0) turns off (deactivates) all markers, **[M1]** through **[M5]**. However, the frequency values of all markers are retained in memory, and will be recalled when the marker keys are pressed once again. Deactivating the markers will not affect the **[MKR SWEEP]**, **[MKR Δ]**, or **[MKR → CF]** functions.

[MKR Δ] (HP-IB: MD1 turns on the function, MD0 turns off the function) causes the frequency difference between any two markers to appear in the ENTRY DISPLAY. Press any two marker keys **[M1]...[M5]**, then press **[MKRΔ]** and the ENTRY DISPLAY will show the frequency difference. Press any other marker keys **[M1]...[M5]**, and the ENTRY DISPLAY will change to show the frequency difference between the two most recently passed markers. On a CRT display, the trace between the two selected markers is intensified (intensity markers only, not **[AMTD MKR]**). The LED above **[MKRΔ]** shows when the function is on (lighted), or off (not lighted).

[SHIFT] [MKRΔ]: has no effect on the HP 8340B/41B.

[MKR → CF] (HP-IB: MC) sets the center frequency of the sweep to the frequency of the active marker. Press any marker key **[M1]...[M5]**, then press **[MKR → CF]** to change the center frequency of the sweep to that of the marker. The frequency span **[ΔF]** will not change unless the new sweep limits fall outside the frequency range of the HP 8340B/41B; in that case, the HP 8340B/41B will automatically scale down the **ΔF** to be within the frequency range.

[SHIFT] [MKR → CF] has no effect on the HP 8340B/41B.

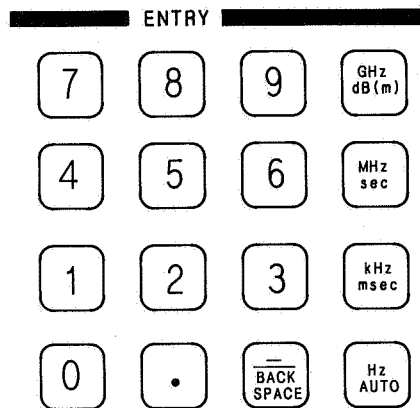
Figure 3-9. Frequency Marker Keys (2 of 2)

Entry Keys

DESCRIPTION

This is the numerical keypad, with the terminator keys, that provides data entry to the HP 8340B/41B.

PANEL LAYOUT



FUNCTIONS

[.] [0]...[9] (HP-IB: decimal numbers 0 through 9, — (minus) sign, and decimal point) are the numerical data entry keys. Press any function key, enter the desired numerical value, then press the appropriate terminator key (GHz, sec, dB(m), etc.). Table 1-1 (Specifications) lists the numerical limits for each function.

[SHIFT] (data entry key) has no effect on the HP 8340B/41B.

[— / BACK SPACE] is a minus sign (—) entry when this key is pressed at the beginning of a data entry sequence, a back space at all other times.

[SHIFT] [— / BACK SPACE] has no effect on the HP 8340B/41B.

[GHz / dB(m)] [MHz / sec] [kHz / msec] [Hz / AUTO] are the terminator keys that must be pressed after a numerical value has been entered. The HP 8340B/41B interprets the terminator key to match the selected function. For example, GHz is selected when a frequency function is active, dB(m) is selected when a power function is active. An explanation of each key follows.

[GHz / dB(m)] (HP-IB: GZ, or DB) selects either gigahertz for a frequency function, decibels or dBm for a power function.

[MHz / sec] (HP-IB: MZ, or SC) selects either megahertz for a frequency function, or seconds for a sweep time function.

[kHz / msec] (HP-IB: KZ, or MS) selects either kilohertz for a frequency function, or milliseconds for a sweep time function.

Figure 3-10. Entry Keys (1 of 2)

[HZ / AUTO] (HP-IB: HZ, or AU) selects hertz for a frequency function; AUTO affects **[SWEEP TIME]**, **FREQ STOP**, and **CW RES**: Press **[SWEEP TIME]** then **[AUTO]** to obtain the shortest possible sweep time for that frequency span; press **[SHIFT] [CF]** then **[AUTO]** to couple the **FREQ STOP** increment size to the ΔF frequency span (all of these shifted functions are explained in Figure 3-7). When one of the AUTO-coupled functions is active, "AUTO" or its complement "FIXD" (which indicates that AUTO is not active) appears in the **ENTRY DISPLAY**.

[SHIFT] (terminator key) allows direct electrical access to the internal circuits, registers, and buffers of the HP 8340B/41B. These tremendously powerful functions are comprehensively explained in the optional Component-Level Service Manual; however, a brief explanation follows:

[SHIFT] [GHz / dB(m)] (HP-IB: SHGZ) allows the I/O channel to be specified. The I/O channel, along with the I/O subchannel (explained in the following paragraph) defines the address for a circuit board or memory register that is accessible via the internal I/O bus. The channel values range from 0 to 15. Channel and subchannel addresses are listed in the optional Component-Level Service Manual. Press **[SHIFT] [GHz / dB(m)]**, then enter a numerical value between 0-15, followed by any terminator key.

[SHIFT] [MHz / sec] (HP-IB: SHMZ) allows the I/O subchannel to be specified. Press **[SHIFT] [MHz / sec.]**, then enter a numerical value followed by any terminator key.

[SHIFT] [kHz / msec] (HP-IB: SHKZ) allows a numerical value to be written to the address defined by the channel and subchannel. The appropriate numerical value is explained in the introduction of the optional Component-Level Service Manual. Press **[SHIFT] [kHz / msec]**, enter a numerical value, followed by any terminator key.

[SHIFT] [Hz / AUTO] (HP-IB: SHHZ) allows a numerical value to be read from the address defined by the channel and subchannel. Press **[SHIFT] [Hz / AUTO]**, and the numerical data will appear in the **ENTRY DISPLAY**. The introduction of the optional Component-Level Service Manual describes the interpretation of this data.

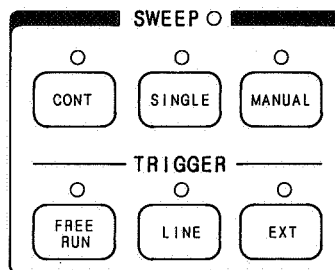
Figure 3-10. Entry Keys (2 of 2)

Sweep and Trigger Keys

DESCRIPTION

Continuous, single, or manual sweeps and internal, external or power line triggering are controlled by these keys. Additionally, display blanking, penlift, and three diagnostic functions are enabled by adding the SHIFT prefix to these keys.

PANEL LAYOUT



FUNCTIONS

[CONT] (HP-IB: S1) allows continuous sweep-retrace-sweep-retrace cycling of the HP 8340B/41B. The sweep is initiated by one of the TRIGGER functions, as explained later in this Figure, while the sweep speed is controlled by the **[SWEEP TIME]** function as explained in Figure 3-7.

[SHIFT] [CONT] (HP-IB: SHS11 disables displays, SHS10 re-enables displays) blanks (turns off) all displays on the HP 8340B/41B. Although the displays are blanked, the functions that are normally shown in the displays can still be changed in the usual manner, and the changed values will be shown when the displays are reactivated. The displays are reactivated in one of two ways: Press **[SHIFT] [CONT]** again to restore the displays.

[SINGLE] (HP-IB: S2) allows single sweeps of the HP 8340B/41B. Press **[SINGLE]** to start the sweep, which will sweep at a rate determined by the **[SWEEP TIME]** function (explained in Figure 3-7). If **[SINGLE]** is pressed in the middle of a single sweep, the sweep will abruptly stop and the HP 8340B/41B will retrace back to the starting point.

[SHIFT] [SINGLE] has no effect on the HP 8340B/41B.

[MANUAL] (HP-IB: S3) allows manual sweeps. Press **[MANUAL]**, then use the rotary **[KNOB]** to manually sweep between the start/stop limits. In manual mode the HP 8340B/41B will not automatically retrace at the sweep end point (the operator must retrace), and the green LED by the SWEEP label will not light. The resolution of the **[KNOB]** is 0.1% of the sweep span in either start/stop or CF/ Δ F mode. Frequencies in manual sweep are synthesized just as they are in CW mode.

Figure 3-11. Sweep and Trigger Keys (1 of 3)

There are two significant differences between **[MANUAL]** sweep and the sweep that can be obtained by having the **[KNOB]** control an active CW function:

1. The sweep output voltage ramp (see Figures 3-13 or 3-18, SWEEP OUTPUT) is 0-10 volts in both modes, but in CW mode 0 volts always corresponds to 10 MHz and 10 volts always corresponds to 26.5 GHz (7.55V at 20 GHz with HP 8341B), while in manual sweep mode 0 volts corresponds to the start frequency and 10 volts corresponds to the stop frequency. In both cases the sweep voltage at intermediate frequencies is a linear interpolation of the frequency span (i.e., a frequency half-way between the start/stop limits has a corresponding sweep voltage of 5 volts).
2. The bandcrossing points in CW mode always occur at precisely 2.3, 7.0, 13.5, and, in the case of the HP 8340B, 20.0 GHz. In manual sweep mode the bandcrossing points have 200 MHz of flexibility, which is automatically used by the HP 8340B/41B for optimum performance (for example, a 2.35 to 7.05 sweep could be accomplished without any band changes in manual sweep mode).

[SHIFT] [MANUAL] (HP-IB: SHS3) activates the FAULT diagnostic routine. When the amber FAULT annunciator appears in the ENTRY DISPLAY, press **[SHIFT] [MANUAL]** to initiate the FAULT diagnostic which will cause "FAULT: CAL KICK ADC PEAK TRK" to appear in the ENTRY DISPLAY. The flashing cursor indicates which circuit (**CAL**ibration constants, **KICK** pulses, **A**nalog to **D**igital **C**onverter, power **PEAK**ing, or **TRAC**king) is causing the problem. Refer to the In Case of Difficulty section.

[FREE RUN] (HP-IB: T1) allows internal triggering of the any sweep function, and is the fastest possible way to accomplish the sweep-retrace cycle.

[SHIFT] [FREE RUN] (HP-IB: SHT1) activates the display self-test diagnostic function. Press **[SHIFT] [FREE RUN]**, which will cause every segment of every LED in the displays to light, followed by a marching pattern of every character in the display lexicon. Press **[INSTR PRESET]** or cycle the POWER switch to cancel this diagnostic routine. **[INSTR PRESET]** will restore the instrument to its standard starting condition. Cycling the POWER switch will restore the displays to their previous condition. If this marching display ever appears spontaneously, especially at power-on, the main processor circuit has failed and Section VIII (Service) should be consulted for further instructions.

Figure 3-11. Sweep and Trigger Keys (2 of 3)

[LINE] (HP-IB: T2) triggers the sweep functions in synchronization with the ac power line frequency, which is typically 50 or 60 Hz.

[SHIFT] [LINE] (HP-IB: SHT21 enables penlift, SHT20 disables penlift) generates a penlift signal at each band crossing. When an HP 8340B/41B sweep crosses frequency bands, the RF is momentarily turned off at each band crossing which can cause a negative spike on X-Y recorders. To prevent the negative spike, **[SHIFT] [LINE]** activates a rear-panel PENLIFT OUTPUT connector that causes the X-Y recorder's pen to lift at each band crossing. The PENLIFT function works only when the sweep time is >5 seconds. See Figure 3-18 for information on the rear-panel connector, and the X-Y Recorder Operating Guide (at the end of Section III) for specific information on X-Y recorder interconnections.

[EXT] (HP-IB: T3) externally triggers the sweep function. Figure 3-18 explains the rear-panel EXT TRIGGER INPUT connector and the trigger signal requirements.

[SHIFT] [EXT] (HP-IB: SHT3) activates the oscillator function. When the red UNLK annunciator appears in the ENTRY DISPLAY, press **[SHIFT] [EXT]**, which will cause "OSC: REF M/N HET YO N2 N1" to appear in the ENTRY DISPLAY. The flashing cursor indicates which oscillator circuit is not phase locked, with the remedy found in the appropriate part of Section VIII (Service). Press **[SHIFT] [M5]** to cancel this diagnostic function and to return the displays to their previous condition.

INDICATORS

SWEEP green LED lights when the HP 8340B/41B is performing an analog sweep. The LED is off during all of the following: retrace, band crossings (band crossings occur at 2.3 GHz, 7.0 GHz, 13.5 GHz, and, in the case of the HP 8340A, 20.0 GHz), during the phase locking that occurs at the start frequency of each new sweep and each new band, and during manual seeps (since manual sweeps are synthesized).

RF ON DWELL is a time delay from when the instrument turns on its RF output to when the start of sweep occurs. In CW mode, this delay determines how long the instrument will wait (after RF power is activated) before allowing another change in CW frequency. This delay is set at the factor to 400us. If the HP 8340B/41B is used with test equipment that requires a longer delay, perform the following command:

Locally: **[SHIFT] [MHz] [1] [7] [Hz]**

[SHIFT] [kHz] [#] [Hz]

Where # is an integer value from 5 to 128 (500us to 12.8ms). To determine what value to enter for a given delay:

$$\text{Value} = \text{Desired Delay (in microseconds)} / 100$$

or

$$\text{Delay} = 100\text{us per count (in the value entry)}$$

Via HP-IB: "SHMZ17HZ SHKZ#HZ"

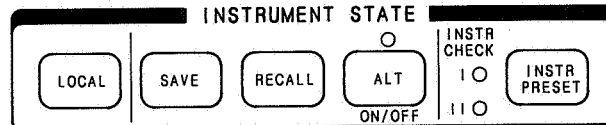
Figure 3-11. Sweep and Trigger Keys (3 of 3)

Instrument State Keys

DESCRIPTION

Instrument check and preset, HP-IB address assignment, storage and recall of operating configurations, alternating operation, and restoration of local control are the functions of this key group.

PANEL LAYOUT



FUNCTIONS

[LOCAL] (HP-IB: LOCAL command). The front panel keys (except **[LOCAL]** and the POWER switch) are inoperative when the HP 8340B/41B is being remotely controlled by a computer. Press **[LOCAL]** to cancel computer control and to reactivate the front panel keys. **[LOCAL]** does not work if the computer executed a LOCAL LOCKOUT command, as explained in the HP-IB section of this chapter.

[SHIFT] [LOCAL] (no HP-IB: code) causes the HP-IB address to appear in the ENTRY DISPLAY. The factory-set address is 19; however, any unique address between 00-30 can be assigned to the HP 8340B/41B by pressing **[SHIFT] [LOCAL]**, entering the address numbers, and pressing any terminator key (GHz, MHz, kHz, Hz). This new address remains in effect until again changed by the operator. The calibration constants (described in Section VIII) can be configured to disable the **[SHIFT] [LOCAL]** function, thus locking the HP 8340B/41B to the address specified in the calibration constants.

[SAVE] (HP-IB: SVn, n=1-9) allows up to 9 different front panel settings to be stored in memory registers 1 through 9. Instrument settings can then be recalled via the **[RECALL] n** (n = 0 through 9, where 0 is the last-used front panel setting) function, or a memory setting can be alternated with the current front panel setting with the **[ALT] n** (n = 1-9) function. Set the front panel controls to any desired configuration, then press **[SAVE]** which will cause "SAVE REGISTER: ?" to appear in the ENTRY DISPLAY. Press any digit 1-9 to select the storage register, and the setting will be saved in that register. The information stored in the memory registers is retained in memory indefinitely when ac line power is constantly available, or for approximately three years without line power.

[SHIFT] [SAVE] (HP-IB: SHSV) is a save-lock that prevents any new front panel settings from being saved. **[SHIFT] [RECALL]** removes the save lock.

[RECALL] (HP-IB: RCn, n=0-9) retrieves a front panel setting that was previously SAVED in storage registers 1-9 (**[RECALL] [0]** retrieves the last-entered front panel setting). Press **[RECALL]**, which will cause "RECALL REGISTER: ?" to appear in the ENTRY DISPLAY. Then press any digit 0-9, or use the **[STEP]** keys, to select the desired memory register. (The rear panel "8410 CONNECTOR" has a pin that duplicates the step-recall function, as explained in Figure 3-21 and the HP 8340A/HP 8410 Operating Guide).

[SHIFT] [RECALL] (HP-IB: SHRC) cancels the save-lock function, which is described in the previous paragraph.

Figure 3-12. Instrument State Keys (1 of 3)

[ALT] (HP-IB: AL1n, n = 1-9 turns on the function. AL0 turns off the function) causes the instrument state to alternate on successive sweeps between the current front panel setting and the setting stored in memory location 1-9. Press **[ALT]**, which will cause "ALT WITH REGISTER: ?" (? is the last used memory register) to appear in the ENTRY DISPLAY, then press a digit 1-9 to select the desired memory register. Although the HP 8340B/41B is in the alternate mode, the panel displays will only show the current front panel state. The power level of the two alternated functions must have the same attenuator setting, or the attenuator must be decoupled from the ALC (automatic leveling control circuit) which will allow up to 40 dB of power level difference. This restriction is necessary to prevent rapid cycling, and subsequent wear, on the mechanical attenuator. See **[PWR SWP]** in Figure 3-17 for an explanation of the attenuator and ALC relationship. Press **[ALT]** again to cancel the alternate function.

[SHIFT] [ALT] saves the current frequency display multiplication factor as the instrument's default value. In this mode, pressing **[INSTR PRESET]** or turning power off and on will not affect the user-defined frequency display multiplication factor. Refer to the **[SHIFT] [START FREQ]** command in Figure 3-7 for more information. This feature can be disabled by pressing **[SHIFT] [INSTR PRESET]**, which sets the default multiplication factor to 1 and presets the instrument.

[INSTR PRESET] (HP-IB: IP) causes an internal self-test of the HP 8340B/41B, and initializes the instrument to a standard starting configuration:

1. Start sweep at 10 MHz, stop sweep at 26.5 GHz (20 GHz with HP 8341B).
2. Power level set to 0.0 dBm; however, this level can be reset by changing the calibration constants (as described in Section VIII).
3. Sweep time to AUTO (44.15 msec) (33.32 msec on HP 8341B).
4. CONT sweep, FREE RUN trigger.
5. All markers set to 13.255 GHz on the HP 8340B and 9.995 GHz on the HP 8341B (center frequency of the sweep).
6. The checksum of the calibration data is calculated, and if an error is detected then the calibration data in protected memory is used. If the checksum of the protected data is not correct then default values are used, and the FAULT annunciator lights in the ENTRY DISPLAY to indicate a calibration constant error (press **[SHIFT] [MANUAL]** when the FAULT annunciator lights, as described in Figure 3-11).
7. All function values stored in memory registers 1-9 remain in their previous states.
8. A self test is performed, and check LEDs are lighted.

Press **[INSTR PRESET]** at any time to test the instrument and restore the standard starting condition. If either of the two red LEDs that are adjacent to **[INSTR PRESET]** (labeled "INSTR CHECK I/II") remain lighted after a preset, the HP 8340B/41B failed the self-test; refer to Section VIII (Service) for further instructions.

[SHIFT] [INSTR PRESET]: disables the **[SHIFT] [ALT]** function. This command sets the default frequency display multiplication factor to 1 and presets the instrument.

Figure 3-12. Instrument State Keys (2 of 3)

SECURITY MEMORY ERASE is typically used to purge all instrument memory locations and registers after the HP 8340B/41B has been used in highly sensitive or classified applications. This feature completely erases RAM memory, filling RAM locations with zeros and then with ones. It then sets all variables and SAVE/RECALL registers to instrument preset values, and downloads protected (ERROM based) Cal Constants into erased RAM (into the Working Cal Constant memory area). The instrument begins operation in the instrument preset mode.

NOTE: Calibration Constants contain no frequency-specific information.

Activating the Security Memory Erase Feature

Locally: Press **[SHIFT] [MHz] [1] [8] [Hz] [SHIFT] [kHz] [0] [Hz]**

Via HP-IB: **SHMZ18HZ SHKZ0HZ"**

INDICATORS

INSTR CHECK I/II red LEDs light if the HP 8340B/41B fails the internal self-test that occurs when **[INSTR PRESET]** is pressed. If this happens, refer to Section VIII (Service) for further instructions.

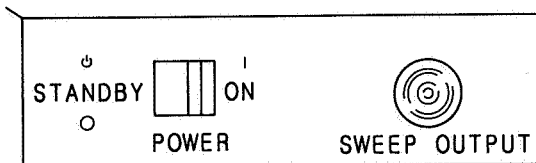
Figure 3-12. Instrument State Keys (3 of 3)

Power Switch, Sweep Output

DESCRIPTION

The POWER switch and the SWEEP OUTPUT front-panel BNC connector are described in this Figure.

PANEL LAYOUT



FUNCTIONS

POWER SWITCH selects either ON, or STANDBY. Once the ac power line has been plugged in, power is always being applied to all or part of the HP 8340B/41B. In STANDBY, power is applied to the crystal oscillator's oven to maintain operating temperature and to the RAM circuits to maintain memory data; in the ON position, power is applied to the entire instrument. When the HP 8340B/41B is connected to ac power for the first time, or after a prolonged period without power, the crystal oscillator's oven requires approximately 30 minutes to reach operating temperature (the red OVEN annunciator in the ENTRY DISPLAY will be lighted during this warm-up period). Power must always be available to the HP 8340B/41B to keep the oven warm; therefore, when the instrument is not in use set the POWER switch to STANDBY, and do not interrupt the ac power.

When the POWER switch is changed from STANDBY to ON, the HP 8340B/41B will automatically initiate an internal circuit check, then momentarily show the HP-IB address in the ENTRY DISPLAY, followed by setting the instrument functions to the last-entered values. If this sequence does not happen, press **[INSTR PRESET]** to initiate an instrument check, as described in Figure 3-12. If a warning annunciator lights at power-on, refer to the display Figures 3-3, 3-4, 3-5, and 3-6 for further instructions.

SWEEP OUTPUT is provided by a front panel BNC connector (and an identical rear panel BNC connector). The output voltage range for this connector is 0 to +10 volts dc. When the HP 8340B/41B is sweeping, the **SWEEP OUTPUT** is 0 Vdc at the beginning of the sweep and +10 Vdc at the end of the sweep, regardless of sweep width. In CW mode, the **SWEEP OUTPUT** ranges from 0 Vdc at the 10 MHz minimum frequency of the HP 8340B/41B, to 10 Vdc at the 26.5 GHz (7.55V at 20 GHz with HP 8341B) maximum frequency, with a proportional voltage for frequencies between 10 MHz-26.5 GHz (20 GHz with HP 8341B). Pressing **[CW]** then **[MANUAL]** locks the CW frequency but allows a full-range voltage output from the SWEEP OUTPUT, which is controlled by the rotary **[KNOB]** (useful, for example, when scaling an X-Y recorder). The output impedance at this **SWEEP OUTPUT** connector is nominally 1 K Ω .

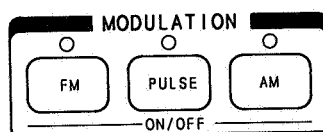
Figure 3-13. Power Switch, Sweep Output

Modulation Keys

DESCRIPTION

These three keys select frequency modulation, pulse modulation, or amplitude modulation of the RF output. These keys are used in conjunction with the front panel FM, PULSE, and AM BNC connectors (shown in Figure 3-15). Table 1-1 lists instrument specifications for the three types of modulation.

PANEL LAYOUT



FUNCTIONS

[PULSE] (HP-IB: PM1 turns on pulse modulation, PM0 turns off the function) activates the pulse modulation function. When pulse modulation is in effect, the RF output of the HP 8340B/41B is turned on (full power selected) and off (>80 dB attenuation) at a rate determined by the pulse modulation input (described in Figure 3-15). Pulse and amplitude modulation can be in effect simultaneously (amplitude modulation is described in a following paragraph). Press **[PULSE]** a second time to turn off the function.

[SHIFT] [PULSE] (HP-IB: SHPM) turns on pulse modulation, allowing proper operation with HP 8755C, 8756A, and 8757A scalar network analyzer. The scalar analyzers' 27.8 KHz square wave modulation output is connected to the HP 8340B/41B **PULSE** input. When the SHIFT PULSE mode is activated, the RF output of the HP 8340B/41B is modulated by the 27.8 kHz square wave. This capability is present on all HP 8340B/41B's regardless of option configuration. Pressing **[PULSE]** (HP-IB: PM0) will turn off this function. This mode may be used for other purposes, providing 2 μ sec rise and fall times for pulse widths wider than about 7 μ s.

[AM] (HP-IB: AM1 turns on amplitude modulation, AM0 turns off the function) activates the amplitude modulation function. Amplitude modulation allows the pre-attenuated RF output of the HP 8340B/41B to be continuously and linearly varied between -30 dBm and the maximum power available, at a rate determined by the **AM** input (described in Figure 3-15). Amplitude and pulse modulation can be in effect simultaneously. Press **[AM]** a second time to turn off the function.

[FM] (HP-IB: FM1 turns on frequency modulation, FM0 turns off modulation) activates the frequency modulation function. Frequency deviation is dependent on the magnitude of the input signal. Pressing **[FM]** a second time turns off the function. FM sensitivity is either 1 MHz/volt or 10 MHz/volt and is selected by following the FM1 "on" sequence with either **[1] [MHz]** or **[1] [0] [Mhz]** respectively.

[SHIFT] [FM] has no effect on the HP 8340B/41B.

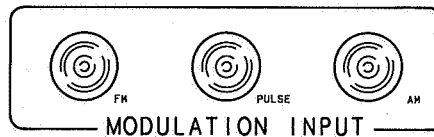
Figure 3-14. Modulation Keys

Modulation Inputs

DESCRIPTION

The external FM, pulse or amplitude modulation signals are applied to the HP 8340B/41B at these three connectors.

PANEL LAYOUT



FUNCTIONS

PULSE MODULATION INPUT is TTL compatible; a TTL high input ($> +2$ volts) causes maximum selected RF power output, while a TTL low input causes minimum RF output (> 80 dB RF on/off ratio). The pulse repetition frequency is dc to 20 MHz in non-leveled applications, 100 Hz to 5MHz when internally leveled. The specifications given in Section I detail the electrical requirements of the **PULSE** modulation input, and explain the subsequent effects on the RF output. The damage levels for this input are $\geq +12$ volts or ≤ -20 volts. This input is also used for the **[SHIFT] [PULSE]** operation.

AM MODULATION INPUT accepts a -1 volt to $+1$ volt signal, at a frequency of dc to 100 KHz (3 dB bandwidth). With an **AM** input of 0 volts, the RF output level (the reference level) is unaffected; at -1 volts input the RF is shut off, and at $+1$ volts input the RF output is 100% (6 dB) higher than the reference level (hence there must be ≥ 6 dB of headroom between the reference power level and the maximum power level available at that frequency). The on (0 volt input) to off (-1 volt input) ratio is a function of power level and frequency, but is always greater than 20 dB. The amplitude of the RF output changes linearly as the **AM** input changes from -1 to $+1$ volts. The specifications given in Section I list all electrical requirements of the **AM** input, and explain the subsequent effects on the RF output. Damage level for this input is $\geq +12$ volts or ≤ -12 volts.

FM MODULATION INPUT accepts a -8 volt to $+8$ volt signal when on the 1 MHz/Volt sensitivity, or a -1 volt to $+1$ volt signal when on the 10 MHz/Volt sensitivity. Any signal greater than these limits will cause distortion. The deviation changes linearly as the FM input changes from 0 to its upper or lower voltage limit. The rate is determined by the frequency of the FM input signal. Table 1-1 lists relevant specifications. Damage level for this input is ≥ 9 volts or ≤ -9 volts.

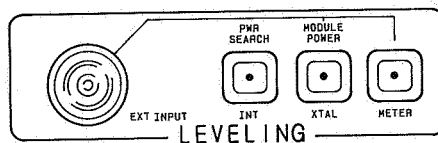
Figure 3-15. Modulation Inputs

Leveling Keys/Input

DESCRIPTION

Internal or external (crystal or power meter) power leveling is selected by these keys, which also select a band crossing diagnostic and allow direct linear modulator access. The external leveling BNC input connector is also described in this Figure.

PANEL LAYOUT



FUNCTIONS

EXT INPUT BNC connector is the input port for an external leveling signal. The signal requirements are listed in the specification tables in Section I. See the Operating Guide "Externally Leveling the HP 8340B/41B Synthesized Sweeper," located at the end of Section III, for detailed information about external leveling procedures.

[INT] (HP-IB: A1) selects internal leveling of the HP 8340B/41B. The specifications tables in Section I list the maximum leveled power for each frequency band, and other power function restraints.

[SHIFT] [INT] (HP-IB: SHA1) bypasses the ALC (automatic leveling control) and allows the user to select a power level to be set in the unleveled mode. The benefit of this function is that an unleveled output power level can be set via HP-IB while allowing; the synthesized sweeper to be pulse modulated with no limit to the minimum pulse repetition frequency, and complete use of the 100 kHz AM bandwidth while simultaneously pulse modulating. Press **[SHIFT] [INT]**, "POWER SEARCH: XXX dBm" will appear in the entry display. The previous internally leveled power will be set automatically. To enter a different power use **[KNOB]**, **[STEP]** keys or numeric keypad terminate with the **[dBm]** key.

[XTAL] (HP-IB: A2) activates external crystal leveling of the HP 8340B/41B. A portion of the RF output (derived from a coupler or a splitter) must be detected, with the detected output being delivered to the **EXT INPUT** BNC connector, thus forming an output-input feedback loop (the loop typically has 80 kHz bandwidth). Press **[XTAL]**, and "ATN: -xx dB, REF: -xx.xx dBV" (where x is the last-entered value) will appear in the entry display. Then use the rotary **[KNOB]** or the numerical keys with the **[dB(m)]** terminator key to change the REFerence level, and the **[STEP]** keys to change the ATN while watching either the POWER dBm display (allowing for losses in the coupler or splitter) or an attached power meter. The "Externally Leveling the HP 8340B/41B Synthesized Sweeper" operating guide located at the end of this section fully explains crystal leveling and shows typical equipment interconnections.

[SHIFT] [XTAL] (HP-IB: SHA2) activates the external source module leveling mode. A portion of the mm-wave signal from the HP 83550 series mm-wave Source Module is detected and delivered to the **EXT INPUT** BNC connector, thus forming an output-input feedback loop. Press **[SHIFT] [XTAL]** and "EXT MODULE POWER: xx.xx dBm" will appear in the entry display. Enter the desired externally leveled module power using either the **[KNOB]**, **[STEP]** keys, or numeric keypad. Terminate with the **[dBm]** key.

Figure 3-16. Leveling Keys/Input (1 of 2)

[METER] (HP-IB: A3) selects external power meter leveling of the HP 8340B/41B. A portion of the RF output must be measured by a power meter, with the power meter also connected to the **EXT INPUT** BNC connector to form an output-input feedback loop (typical bandwidth 0.7 Hz). Press **[METER]**, which will cause (after a brief delay) "ATN: -xx dB, REF: -xx.xx dBV" (where x is the last-entered value) to appear in the ENTRY DISPLAY. Use the rotary **[KNOB]** or the numerical keys with the **[dB(m)]** terminator key to set the REFERENCE level, and the **[STEP]** keys to set the ATN while watching either the POWER dBm display (allowing for coupler or splitter losses) or the power meter. The "Externally Leveling the HP 8340B/41B Synthesized Sweeper" Operating Guide located at the end of this section fully explains power meter leveling.

[SHIFT] [METER] (HP-IB: SHA3) bypasses the ALC (automatic leveling control) to allow direct control of the linear modulator circuit. This is useful when very narrow pulses are being generated in pulse modulation mode. In this mode there is no limit on the minimum pulse repetition frequency. Press **[SHIFT] [METER]**, and "ATN -xx dB, mod; x.x dB" (where x is the last-entered value) will appear in the ENTRY DISPLAY. To set the power, place the HP 8340B/41B in CW mode, or in pulse modulation mode with pulses wider than 2 μ sec. Then use the **[STEP]** keys to set the ATN (attenuator), and the rotary **[KNOB]** or numerical keys with **[dB(m)]** terminator key to set the MOD (linear modulator), as follows: Set MOD entry at 0 dB, increment ATN until the POWER dBm display shows a level 5 dB to 15 dB higher than the desired output power, then reduce the power to the desired level by changing the MOD value. The POWER dBm display shows actual power when the HP 8340B/41B is in CW or wide-pulse pulse modulation modes; this actual power changes very little as the pulse width is narrowed, even though the POWER dBm reading drops. Therefore, at this point reduce the pulse width to the desired value and ignore the POWER dBm display. The ATN and MOD values in the ENTRY DISPLAY also have a limitation: Although the ATN displayed value is always accurate, the MOD becomes saturated in the top 10 dB (approximately) of its range at which point no change occurs in the true power, furthermore, the modulation entry is only approximately calibrated. Consequently, rely on the POWER dBm display for the true power level instead of the MOD value. See Figures 3-14 and 3-15 for additional pulse modulation information **[SHIFT] [METER]** can also be used as a diagnostic function for the ALC circuits, as described in Section VIII (Service).

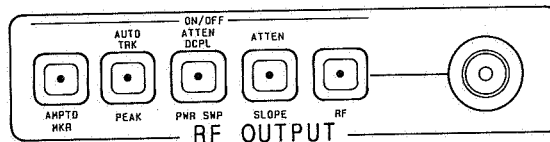
Figure 3-16. Leveling Keys/Input (2 of 2)

RF Keys/Output

DESCRIPTION

All RF power functions, except for power level, are controlled by these keys; and the RF output port is contained in this group.

PANEL LAYOUT



FUNCTIONS

[AMTD MKR] (HP-IB: AK1 turns on amplitude markers, AK0 turns off amplitude markers) on a CRT display. When the markers are activated after an **[INSTR PRESET]**, markers **[M1]...[M5]** appear as intensified dots on a CRT display; press **[AMTD MKR]** to change all of the markers to amplitude spikes. Press **[AMTD MKR]** again to return to intensified-dot markers.

[SHIFT] [AMTD MKR] (HP-IB: SHAK) causes an instantaneous execution of the peaking function, when the HP 8340B/41B is in CW or manual mode. This is one-time implementation of peaking, where the function is quickly turned on then turned off. Peaking is explained in the next paragraph.

[PEAK] (HP-IB: RP1 turns on peaking, RP0 turns off peaking) aligns the output filter (SYTM) so that its passband is centered on the RF output, in CW or manual-sweep mode. Peaking is used to obtain the maximum available power and spectral purity, and best pulse envelopes, at a given frequency. Press **[PEAK]**, and the HP 8340B/41B will automatically peak the present CW frequency, and continue to peak new frequencies as they are entered by the **[KNOB]**, or the **[STEP]** keys, or the numerical keys (with a terminator key). If **[PEAK]** is on for an extended time, the peaking function will automatically re-peak every 7 minutes. Press **[PEAK]** again to cancel this function. When **[PEAK]** is activated, the HP 8340B/41B performs a coarse alignment, and then a fine alignment that begins at the final setting of the coarse search; **[SHIFT] [AMTD MKR]** initiates only a fine alignment which begins at the present instrument setting, **[SHIFT] [AMTD MKR]** is faster, but has less adjustment range than **[PEAK]**. **[SHIFT] [PEAK]**, described in the next paragraph, is a related function.

[SHIFT] [PEAK] (HP-IB: SHRP) is a more extensive version of peaking **[PEAK]** (which requires a fraction of a second to implement), aligns the output filter with a single CW frequency, while **[SHIFT] [PEAK]** aligns all of the YTM tracking calibration constants and requires 5-10 seconds to implement. Use **[SHIFT] [PEAK]** to enhance the power output and spectral purity of swept modes, and to improve tracking performance (especially in harsh environments having wide temperature variations). Press **[SHIFT] [PEAK]**, which will cause "AUTO TRACKING" to appear in the ENTRY DISPLAY. "AUTO TRACKING" will disappear after 5-10 seconds when the calibration has been completed.

Figure 3-17. RF Keys/Output (1 of 3)

[PWR SWEEP] (HP-IB: PS1 turns on power sweep, PS0 turns off the function) allows the power output to be swept when the HP 8340B/41B is in CW mode. This is the procedure:

1. Select a CW frequency, as explained in Figure 3-7.
2. Press **[SHIFT] [PWR SWEEP]**, which decouples the attenuator (ATN) from the automatic leveling control (ALC) and displays the ATN and ALC values in the ENTRY DISPLAY. The ALC range is -20 dBm to an upper value that depends on frequency (see the specifications given in Section I).
3. Use the **[STEP]** keys to set the value of the ATN, and the **[KNOB]** or numerical keys with **[dB(m)]** terminator key to set the ALC for the starting power level, as shown in the POWER dBm display. The ALC value should be as close as possible to -20 dBm to achieve the widest-span power sweep.
4. Set the **[SWEEP TIME]**, as explained in Figure 3-7.
5. Press **[PWR SWEEP]** and "POWER SWEEP: x.xx dB/SWP" (where x is the last-entered value) will appear in the ENTRY DISPLAY. Use either the **[KNOB]**, the **[STEP]** keys, or the numerical keys with the **[dB(m)]** terminator key to select the span of the power sweep (positive values only, ranging from 0.0 to 40.00 dB/SWP).
6. Select SWEEP and TRIGGER, as described in Figure 3-11.

If only narrow-span power sweeps are necessary, the ATN does not need to be decoupled from the ALC: Omit steps 2 and 3 in the preceding text using instead the **[POWER LEVEL]** key to set the initial power output. This simplified procedure restricts the range of power sweeps to that of the coupled ALC, which is -9.95 dBm to the maximum power permitted (maximum power depends on frequency, as listed in the Specification Tables).

[SHIFT] [PWR SWEEP] (HP-IB: SHPS) decouples the attenuator (ATN) from the automatic leveling control (ALC), as explained in the preceding function. Recouple the ATN and ALC by pressing **[POWER LEVEL]**.

[SLOPE] (HP-IB: SL1 turns on the slope function, SL0 turns off the function) compensates for system or cable losses at high frequencies by linearly increasing the power output as the frequency increases. Press **[SLOPE]** and "RF SLOPE: xx.xx dB/GHz" (where x is the last-entered value) will appear in the ENTRY DISPLAY. Use either the **[KNOB]**, the **[STEP]** keys, or the numerical keys with the **[dB(m)]** terminator keys to set any positive slope value between 0.000 to 1.500 dB/GHz. Press **[SLOPE]** again to cancel this function. **[SLOPE]** functions in dB/GHz units, but SL (the equivalent HP-IB code) functions in the fundamental units of dB/Hz. Therefore, the SL code should be programmed as SLmdt, where m is 0 (off) or 1 (on), d is the numerical value in dB/Hz, and t is either "DB" or the ASCII LF terminator. For example, to obtain a slope of 1.5 dB/GHz use this procedure:

1. $1.5 \text{ dB/GHz} = 1.5 \text{ dB}/1,000,000,000 \text{ Hz}$
2. $1.5 \text{ dB}/1\text{E}9 \text{ Hz} = 1.5\text{E}-9 \text{ dB/Hz}$
3. Programming code is then "SL11.5E-9 DB".

[SHIFT] [SLOPE] (HP-IB: SHSL) allows front panel control of the mechanical attenuator (ATN). Press **[SHIFT] [SLOPE]** and "ATN: x dB" (where x is the last-entered value) will appear in the ENTRY DISPLAY. Use the **[STEP]** keys, or the numerical keys with any terminator key to change the attenuator value within the range 0 dB to -90 dB in 10 dB steps. Keyboard entries are automatically rounded to the nearest 10 dB. The clicking sound heard after each attenuator change is the attenuator pad being mechanically switched into the RF output path.

Figure 3-17. RF Keys/Output (2 of 3)

[RF] (HP-IB: RF1 turns on RF output RF0 turns off RF output) turns the RF output on or off. Press **[RF]**, which will cause "-OFF-" to appear in the POWER dBm display and will cause the output power to be turned off (output < -100 dBm). Press **[RF]** again to turn on the RF output, restoring the last-entered power output.

[SHIFT] [RF] has the same effect on the HP 8340B/41B as **[SHIFT] [INT]**.

RF OUTPUT CONNECTOR. The HP 8340B is equipped with a precision 3.5 male connector. The HP 8341B uses a standard Type-N female connector. The output impedance, SWR, and other electrical characteristics are listed in the specification tables in Section I. When making connections, carefully align the center conductor elements, then rotate the knurled barrel while the mating component remains still. Tighten until a firm contact is obtained.

CARE OF APC AND PRECISION 3.5 CONNECTORS (HP 8340B only). Considerable care must be used when working with APC-3.5 connectors: Do not deform the connector by excessive tightening force, and do not allow the connector to get corroded, scratched, or dirty. If cleaning is necessary, use a firm, lintless brush only; do not use any cleaning solvents, since solvents can chemically damage the plastic bead that supports the center conductor. If this connector is mechanically degraded in any way, high frequency losses will occur.

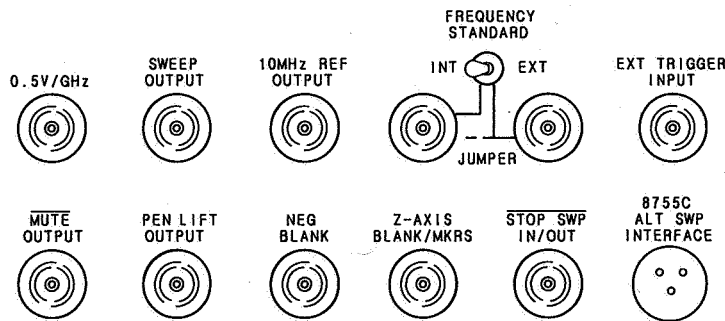
Figure 3-17. RF Keys/Output (3 of 3)

Rear Panel BNC Connectors

DESCRIPTION

The electrical characteristics and requirements of the rear panel BNC connectors are listed in this Figure.

PANEL LAYOUT



FUNCTIONS

0.5V/GHz outputs a voltage that is proportional to the RF output frequency, with a ratio of 0.5 volt output per 1 GHz RF frequency. Load impedance should be $\geq 4 \text{ k}\Omega$. Accuracy is $0.5 \text{ V/GHz} \pm 1\% \pm 2 \text{ mV}$. An output voltage ratio of 1 volts/GHz, to a maximum of 19V, can be achieved by adding two jumpers on the A28 SYTM board (see Section VIII).

SWEEP OUTPUT is provided by a rear panel BNC connector, and an identical front panel BNC connector. The output voltage range for this connector is 0 to +10 volts dc. When the HP 8340B/41B is sweeping, the **SWEEP OUTPUT** is 0 Vdc at the beginning of the sweep and +10 Vdc at the end of the sweep regardless of sweep width. In CW mode, the **SWEEP OUTPUT** ranges from 0 Vdc at the 10 MHz minimum frequency of the HP 8340B/41B, to 10 Vdc at the 26.5 GHz maximum frequency (20 GHz with HP 8341B), with a proportional voltage for frequencies between 10 MHz - 26.5 GHz (20 GHz with HP 8341B). Pressing **[CW]** then **[MANUAL]** locks the CW frequency but allows a full-range voltage output from the **SWEEP OUTPUT**, controlled by the rotary **[KNOB]** (useful, for example, when scaling an X-Y recorder). The output impedance at this **SWEEP OUTPUT** connector is nominally 1 k Ω . Figure 3-13 also describes **SWEEP OUTPUT**.

10 MHz REF OUTPUT provides a 0 dBm, 10 MHz signal derived from the internal frequency standard of the HP 8340B/41B. Test instruments are connected to this 50 Ω BNC connector while the 10 MHz crystal oscillator is being adjusted (as described in Section V, Adjustments, of this Manual), or this can be the master clock reference output for a network of instruments.

Figure 3-18. Rear Panel BNC Connectors (1 of 2)

INT/EXT SWITCH & BNC CONNECTORS select either the internal (INT) 10 MHz crystal oscillator frequency standard, or an external (EXT) frequency standard to be used as the master timebase for the HP 8340B/41B. To select the internal standard, place the switch in the **INT** position and connect a jumper cable between the **INT** and **EXT** BNC connectors (the **INT** BNC is now outputting 10 MHz at +3 dBm). To use an external standard, disconnect the jumper, change the switch to **EXT**, and connect the external source to the **EXT** BNC connector. The external source must be either 5 MHz \pm 50 Hz or 10 MHz \pm 100 Hz, and provide 0 to +10 dBm into the 50 Ω BNC connector. When the switch is in the **EXT** position the amber **EXT REF** annunciator lights in the ENTRY DISPLAY.

EXT TRIGGER INPUT triggers the start of a sweep. Trigger signal must be >2 volts (10 V maximum), and wider than 0.5 μ sec. Nominal input impedance is 2 K Ω . Figure 3-11 describes the front panel procedures that are involved in sweep operations.

MUTE OUTPUT causes the servo motor of an X-Y recorder to pause while the HP 8340B/41B crosses a frequency band switchpoint. The X-Y recorder Operating Guide, located at the end of Section III, explains the interaction of recorders with the HP 8340B/41B.

PENLIFT OUTPUT. For operation with X-Y recorders. PENLIFT disables an X-Y recorder's ability to lower its pen during sweep retrace. If **[SHIFT] [LINE]** is pressed on the front panel, PENLIFT will also disable the pen during forward sweep band switchpoints. Because of X-Y recorder limitations PENLIFT will always disable the X-Y recorder's pen at sweep times under 5 seconds.

PENLIFT enables pen operation by providing a current path to ground for the X-Y recorder's pen solenoid. The voltage at the PENLIFT output in this state will be approximately 0 Vdc. Circuit impedance in this state is approximately .5 Ohms.

PENLIFT disables pen operation by not providing a current path to ground for the X-Y recorder's pen solenoid. The voltage on the PENLIFT output will be equal to the X-Y recorder's pen solenoid supply voltage. Circuit impedance in this state is very high.

NEG BLANKING provides a negative rectangular pulse (approximately -5 volts into 2 K Ω) during retrace and band switchpoints when the HP 8340B/41B is sweeping.

Z-AXIS BLANK/MKRS supplies a positive rectangular pulse (approximately +5 volts into 2 K Ω) during the retrace and switchpoints when the HP 8340B/41B is sweeping. This output also supplies a -5 volt pulse when the RF output is coincident with a marker frequency (intensity markers only, as explained in Figure 3-9).

STOP SWP IN/OUT abruptly stops a sweep when this input is grounded. Retrace does not occur, and the sweep will resume when this input is ungrounded. The open circuit voltage at this connector is TTL High, and is internally pulled low when the HP 8340B/41B stops its sweep. Externally forcing this input High will neither cause damage nor disrupt normal HP 8340B/41B operation.

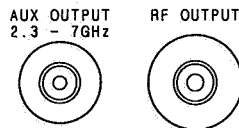
Figure 3-18. Rear Panel BNC Connectors (2 of 2)

Rear Panel RF Outputs

DESCRIPTION

The two rear panel RF Output connectors (one standard, one an option) are described in this Figure.

PANEL LAYOUT



FUNCTIONS

AUX OUTPUT 2.3-7 GHz is a type N female connector that provides a 0 dBm Output from the HP 8340B/41B's fundamental YIG oscillator (the higher frequencies obtainable from the HP 8340B/41B are multiples of this oscillator). Impedance of this connector is 50 Ω (nominal).

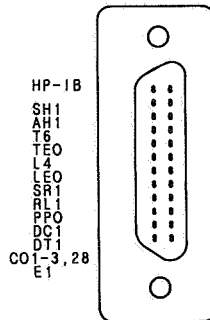
RF OUTPUT is an optional rear panel RF output connector that is functionally equivalent to the standard front panel RF output connector (which is described in Figure 3-17). Option 004 is a rear panel RF output with attenuator, and Option 005 (HP 8340B only) is a rear panel RF output without attenuator. The specifications for each option are listed in Section I of this Manual. Contact the nearest HP Sales and Service office for information about retrofitting an HP 8340B/41B with one of these options.

Figure 3-19. Rear Panel RF Outputs

HP-IB Connector

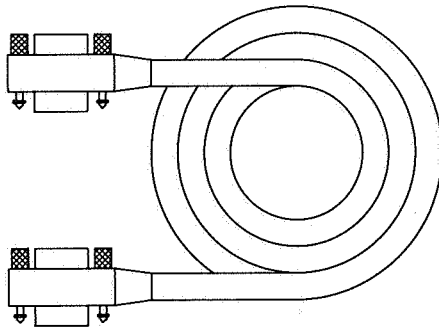
DESCRIPTION

The procedures for connecting the HP 8340B/41B to other HP-IB instruments is explained in this Figure.



The HP-IB interface connector allows the HP 8340B/41B to be connected to any other instrument or device on the HP-IB bus. A complete illustration of pin configuration and signals on the HP-IB interface connector is given in Section II of this Manual.

All HP-IB instruments are interconnected with special HP-IB cables and adapters. These special cables, shown in the accompanying illustration, assure that the proper voltage levels and timing relations are maintained on the HP-IB bus. The adapters are principally extension devices for instruments that have recessed or crowded HP-IB connectors.



HP-IB Interface Cables Available

HP-IB Cable Part Numbers	Lengths
HP 10833A	1 m (3.3 ft.)
HP 10833B	2 m (6.6 ft.)
HP 10833C	4 m (13.2 ft.)
HP 10833D	0.5 m (1.6 ft.)

As many as 14 HP-IB instruments can be connected to the HP 8340B/41B (15 total instruments in the system). The cables can be interconnected in a "star" pattern (one central instrument, with HP-IB cables emanating from that instrument like spokes in a wheel), or in a linear pattern (like boxcars in a train), or in any combination pattern. However, there are certain restrictions:

- Each instrument must have a unique HP-IB address ranging from 0-30 (decimal). Figure 3-12 ([SHIFT] [LOCAL]) explains HP-IB addressing for the HP 8340B/41B.

Figure 3-20. HP-IB Connector (1 of 2)

- In a two-instrument system that uses just one HP-IB cable, the cable length must not exceed 4 metres (13 feet).
- When more than two instruments are connected on the bus, the cable length to each instrument must not exceed 2 metres (6.5 feet) per unit.
- The total cable length between all units cannot exceed 20 metres (65 feet).

Hewlett-Packard manufactures HP-IB extender instruments (Models 37201A, 37203A/L) that overcome the range limitations imposed by the cabling rules. These extenders allow twin-pair cable operation up to 1000 metres (3,280 feet), and telephone modem operation over any distance. HP Sales and Service offices can provide additional information on HP-IB extenders.

The codes next to the HP-IB connector describe the HP-IB electrical capabilities of the HP 8340B/41B, using IEEE Std 488-1978 mnemonics (HP-IB, GP-IB, IEEE-488, and IEC-625 are all electrically equivalent). Briefly, the mnemonics translate as follows:

SH1: Source Handshake, complete capability.

AH1: Acceptor Handshake, complete capability.

T6: Talker; capable of basic talker, serial poll, and unaddress if MLA.

TE0: Talker, Extended address; no capability.

L4: Listener, capable of basic listener, and unaddress if MTA.

LE0: Listener, Extended address: no capability.

SR1: Service Request, complete capability.

RL1: Remote Local, complete capability.

PPO: Parallel Poll, no capability.

DC1: Device Clear, complete capability.

DT1: Device Trigger, complete capability.

CO, 1, 2, 3, 28: Controller capability options; CO, no capabilities; C1 system controller, C2, send IFC and take charge; C3, send REN; C28, send I.F. messages.

E1: Electrical specification indicating open collector outputs.

These codes are completely in the **IEEE Std 488-1978** document, published by The Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, New York 11017.

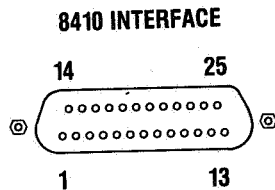
Figure 3-20. HP-IB Connector (2 of 2)

HP 8410B/C Interface/Cable

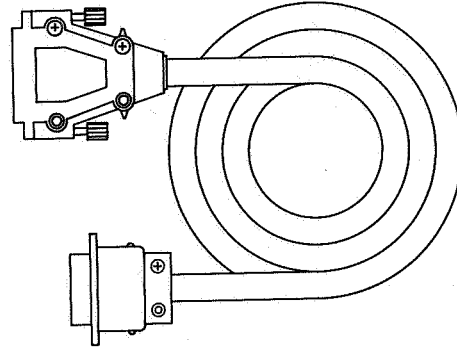
DESCRIPTION

This connector interfaces the HP 8340B/41B to the HP 8410B/C Network Analyzer.

Rear Panel Connector



Interface Cable



Connect the HP 8410B/C Network Analyzer to this port on the HP 8340B/41B, using a Source Control Cable (HP Part Number 08410-60146). An Operating Guide at the end of this Section explains HP 8410B/C to HP 8340B/41B interconnections.

This connector has pins that duplicate several rear panel functions, including EXT TRIGGER INPUT, MUTE OUTPUT, PENLIFT OUTPUT, NEG BLANK, and Z-AXIS BLANK/MKRS. There is also a pin unit input for a switch closure to execute the UP key function, which is used to step through a series of saved instrument states. Additional information is contained in the HP 8410B/C Operating and Service Manual.

Figure 3-21. HP 8410B/C Interface/Cable (1 of 2)

HP 8410C INTERFACE CONNECTOR J18						
J18 Pin	Mnemonic	Levels	Input/Output	Signal Source/ Destination	A62J31 Pin	J18W46 Wire Color Code
1						
2	Z-AXIS BLAND	+5V, -5V*	OUTPUT	A57P1-99	2, 16	2
3						
4	LALTSEL	TTL (LOW TRUE)	OUTPUT	A57P1-59	10,24	0
5	LSSP (LSTOP SWEEP)	TTL (LOW TRUE)	I/O	A57P1-107	5, 19	5
6	+5.2V			A52P1-17, 18, 41, 42	3	3
7						
8						
9	$\overline{\text{MUTE}}$	TTL (LOW TRUE)	INPUT	A57P1-61	8, 22	4
10	EXT TRIG	EXT SOURCE INPUT LEVEL	INPUT	A57P1-106	4, 18	6
11	PEN LIFT	SEE TEXT	OUTPUT	A57P1-108	6, 20	8
12						
13						
14	NEG BLANK	0V, -5V*	OUTPUT	A57P1-41	1, 15	1
15						
16	LRERACE	TTL (LOW TRUE)	OUTPUT	A57P1-58	11, 25	9 - 0
17	LALTEN	TTL (LOW TRUE)	OUTPUT	A57P1-60	9, 23	9
18						
19	GND			STOP SWEEP BNC GND LUG		9 - 0 - 7
20						
21						
22	LSTEPUP	TTL (LOW TRUE)	INPUT	A62J1-28	14	9 - 0 - 8
23						
24	8410 TRIG	TTL (LOW TRUE)	OUTPUT	A57P1-62	7	7
25						

*See text

Figure 3-21. HP 8410 Interface (2 of 2)

HP 8755C Interface/Cable

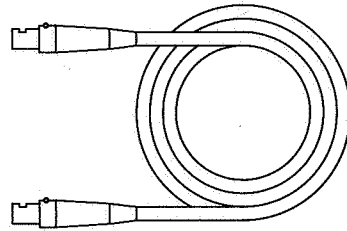
DESCRIPTION

The HP 8755C Scalar Network Analyzer is connected to the HP 8340B/41B at this connector.

Rear Panel Connector



Interface Cable



Connect the HP 8755C Scalar Network Analyzer to the HP 8340B/41B at this connector, using Interface Cable 8120-3174, to provide the alternate sweep function. An Operating Guide at the end of Section III explains the HP 8755C to HP 8340B/41B interconnections.

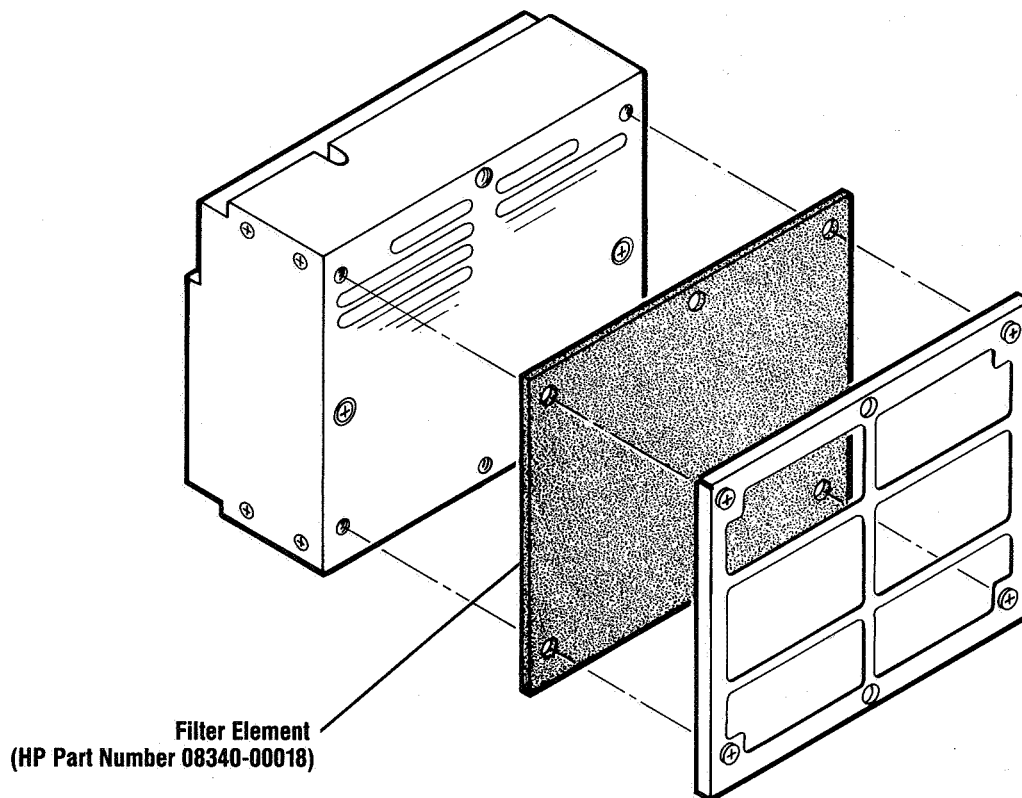
The pin configuration and electrical requirements for this connector are described in Section VIII (Service) of this Manual.

Figure 3-22. HP 8755C Interface/Cable

Fan Assembly

DESCRIPTION

Maintenance of the filter element for the fan is described in this Figure.



The foam filter element requires regular inspection and cleaning. The cooling fan for the HP 8340B/41B is powerful, and pulls a large amount of air through its filter element; subsequently, the filter element collects dust, smoke, and other contaminants even from environments that seem quite clean. To prevent impaired cooling from a dirt-clogged filter, it is imperative that the filter be inspected regularly, and replaced as needed. (Filter replacement is recommended; cleaning by vacuuming or washing and drying, is recommended only if a replacement filter is not available.) Section VI (Replaceable Parts) contains a complete parts listing for the fan, in the B1 Fan Assembly pictorial.

Figure 3-23. Fan Assembly

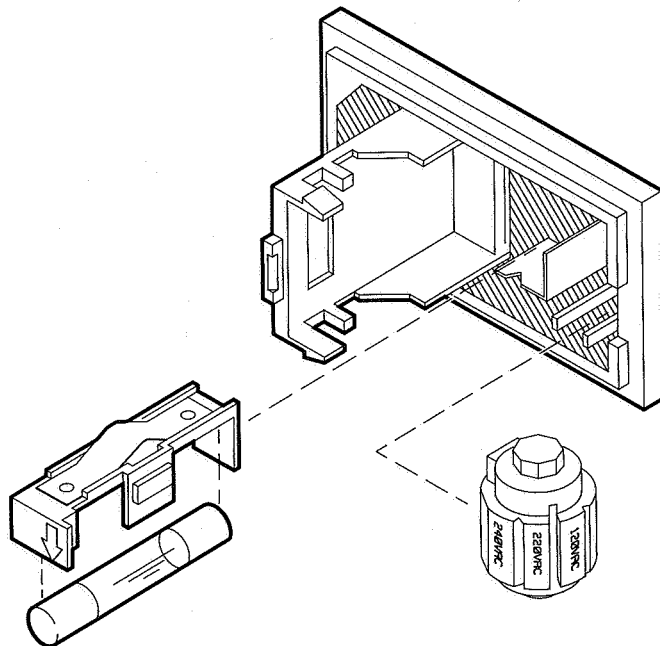
Power Line Module

DESCRIPTION

The line power module contains a safety fuse, and a removable cam that is used as a switch to match the HP 8340B/41B's power supply to the locally available ac power.

CAUTION:

Do not attempt to rotate the voltage selector cam while it is installed in the line module or non-repairable damage will result. The cam must be completely removed from the line module, rotated to the proper position, and reinstalled. Refer to the instructions below.



Replacement of fuse

1. Pry open line module cover door.
2. Pull out fuse carrier.
3. Insert fuse of proper rating.
4. Place carrier back into line module

Selection of Operating Voltage

1. Pry open line module cover door.
2. **REMOVE CAM FROM THE LINE MODULE.**
3. Rotate the cam to the desired voltage. (When the line module cover is closed, the selected voltage will be visible through a small window.)
4. Insert the cam back into the line module.
5. Close the line module cover door.

The HP 8340B/41B requires a maximum of 500 VA of electrical power (40 VA in STANDBY) that is delivered to the instrument through the line power module. The module setting must match the locally available voltage, and be fused to provide a measure of safety to the instrument and the operator.

To determine the module's voltage setting, first measure the locally available ac power source. The HP 8340B/41B requires either 100, 120, 200, or 240 volts with a tolerance of $\pm 10\%$. The HP 8340B/41B also requires an ac frequency of 47.5 Hz to 66 Hz. Some installations may need an autotransformer and/or frequency converters to meet the voltage and frequency requirements. After obtaining suitable voltage and ac frequency, position the selector cam as shown in the accompanying illustration.

The proper fuse rating also corresponds to the voltage selection, and these ratings are printed on the rear panel of the HP 8340B/41B adjacent to the line power module (the fuses are also listed in Section II (Installation) of this Manual).

Appropriate power line cords are listed in Section II (Installation).

Figure 3-24. Power Line Module

HP-IB Programming

INTRODUCTION

HP-IB, the Hewlett-Packard Interface Bus, is the instrument-to-instrument communication system between the HP 8340B/41B and up to 14 other instruments. Any instrument having HP-IB capability can be interfaced to the HP 8340B/41B, including non-HP instruments that have "GPIB," "IEEE-488," "ANSI MC1.1," or "IEC-625" capability (these are common generic terms for HP-IB; all are electrically equivalent although IEC-625 uses a unique connector). This portion of the manual specifically describes interfacing the HP 8340B/41B to one very special type of instrument: a computer.

INTERCONNECTIVE CABLING

Figure 3-20 shows the HP 8340B/41B rear-panel HP-IB connector and suitable cables, and describes the procedures and limitations for interconnecting instruments. Cable length restrictions, also described in Figure 3-20, must be observed to prevent transmission line propagation delays that might disrupt HP-IB timing cycles.

INSTRUMENT ADDRESSES

Each instrument in an HP-IB network must have a unique address, ranging in value from 00-30 (decimal). The default address for the HP 8340B/41B is 19, but this can be changed by the **[SHIFT]** **[LOCAL]** function as described in Figure 3-12 (the examples in this section use 19 as the address for the HP 8340B/41B). Other instruments use a variety of procedures for setting the address, as described in their operating manuals, but typically either a rear panel switch or a front panel code is used.

HP-IB INSTRUMENTS NOMENCLATURE

HP-IB instruments are categorized as "listeners," "talkers," or "controllers," depending on their current function in the network.

Listener

A listener is a device that is capable of receiving data or commands from other instruments. Any number of instruments in the HP-IB network can simultaneously be listeners.

Talker

A talker is a device that is capable of transmitting data or commands to other instruments. To avoid confusion, an HP-IB system allows only one device at a time to be an active talker.

Controller

A controller is an instrument, typically a computer, that is capable of managing the various HP-IB activities. Only one device at a time can be an active controller.

PROGRAMMING THE HP 8340B/41B

The HP 8340B/41B can be entirely controlled by a computer (although the line POWER switch must be operated manually). All functions that are initiated by front panel keystrokes (local operation) can also be initiated by an HP-IB computer additionally, several functions are possible only by computer (remote) control. Computer programming procedures for the HP 8340B/41B involve selecting an HP-IB command statement, then adding the specific HP 8340B/41B programming codes to that statement to achieve the desired operating conditions. The programming codes can be categorized into two groups: Those that mimic front panel keystrokes, and the unique codes that have no front panel equivalent.

In the programming explanations that follow, specific examples are included that are written in a generic dialect of the BASIC language. BASIC was selected because the majority of HP-IB computers have BASIC language capability; however, other languages can also be used. Hewlett-Packard publishes a series of Programming Notes that contain computer-specific, language-specific information for those wishing to use another language; contact the nearest HP Sales and Service Office (listed inside of the back cover) for a list of HP 8340B/41B Programming Notes.

HP-IB COMMAND STATEMENTS

Command statements form the nucleus of HP-IB programming; they are understood by all instruments in the network and, when combined with instrument-specific codes, they provide all management and data communications instructions for the system.

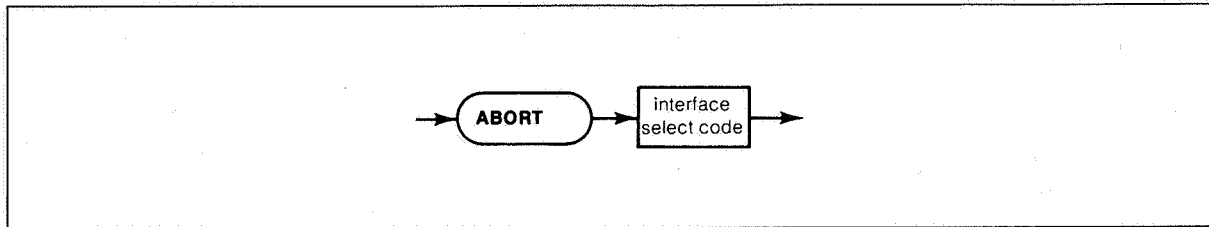
An explanation of the fundamental command statements follows. However, some computers use a slightly different terminology, or support an extended or enhanced version of these commands. Consider the following explanations as a starting point, but for detailed information consult the BASIC language reference manual, the I/O programming guide, and the HP-IB manual for the particular computer being used.

Syntax drawings accompany each statement: All items enclosed by a circle or oval are computer-specific terms that must be entered exactly as described; items enclosed in a rectangular box are names of parameters used in the statement; and the arrows indicate a path that generates a valid combination of statement elements.

Here are the eight fundamental command statements:

Abort

Abort abruptly terminates all listener/talker activity on the interface bus, and prepares all instruments to receive a new command from the controller. Typically, this is an initialization command used to place the bus in a known starting condition. The syntax is



where the interface select code is the computer's HP-IB I/O port, which is typically port 7. Some BASIC examples:

```
10 ABORT 7
```

```
100 IF V>20 THEN ABORT 7
```

Related statements used by some computers:

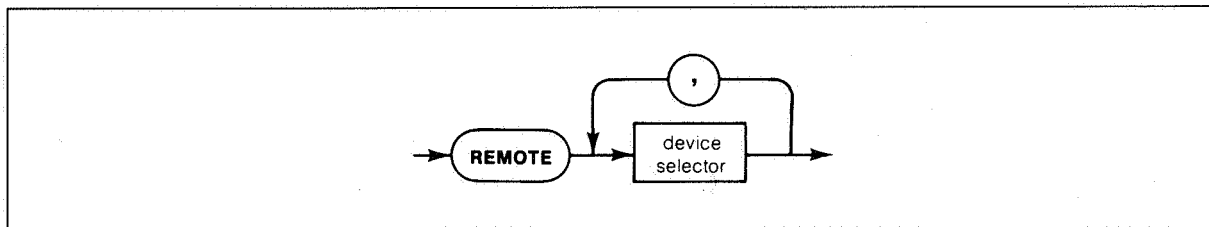
ABORTIO (used by HP-80 series computers)

HALT

RESET

Remote

Remote causes an instrument to change from local control to remote control. In remote control, the front panel keys are disabled (except for the [LOCAL] key and the POWER switch), and the amber REMOTE annunciator is lighted in the ENTRY DISPLAY. The syntax is



where the device selector is the address of the instrument appended to the HP-IB port number. Typically, the HP-IB port number is 7, and the default address for the HP 8340B/41B is 19, so the device selector is 719. Some BASIC examples:

```
10 REMOTE 7
```

which prepares all HP-IB instruments for remote operation (although nothing appears to happen to the instruments until they are addressed to talk), or

```
10 REMOTE 719
```

which effects the HP-IB instrument located at address 19, or

```
10 REMOTE 719, 721, 726, 715
```

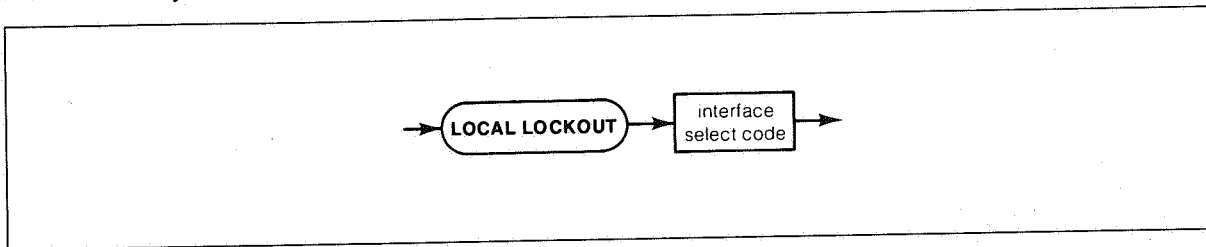
which effects four instruments that have addresses 19, 21, 26, and 15.

Related statements used by some computers:

RESUME

Local Lockout

Local Lockout can be used in conjunction with REMOTE to disable the front panel [LOCAL] key. With the [LOCAL] key disabled, only the controller (or a hard reset by the POWER switch) can restore local control. The syntax is

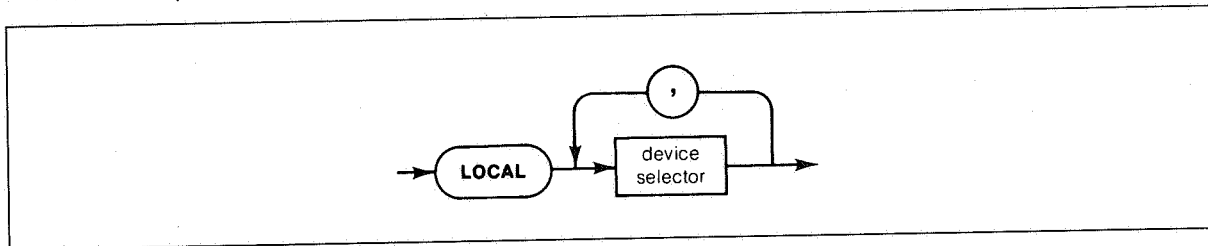


A BASIC example:

```
10 REMOTE 719
20 LOCAL LOCKOUT 7
```

Local

Local is the complement to REMOTE, causing an instrument to return to local control with a fully enabled front panel. LOCAL syntax is



Some BASIC examples:

```
10 LOCAL 7
```

which effects all instruments in the network, or

```
10 LOCAL 719
```

for an addressed instrument (address 19).

Related statements used by some computers:

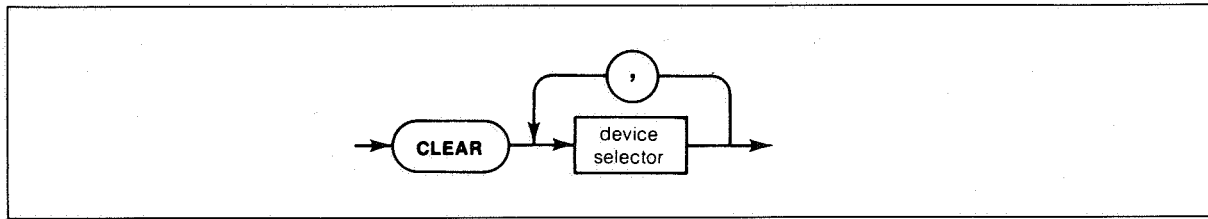
RESUME

Clear

Clear causes all HP-IB instruments, or addressed instruments, to assume a "cleared" condition, with the definition of "cleared" being unique for each device. For the HP 8340B/41B:

1. Both status bytes are reset to zero.
2. All pending output-parameter operations, such as those associated with **OA**, **OP**, and **OR** codes, are halted.
3. The parser (the software that interprets the programming codes) is reset, and now expects to receive the first character of a programming code.

The syntax is



Some BASIC examples:

```
10 CLEAR 7
```

to clear all HP-IB instruments, or

```
10 CLEAR 719
```

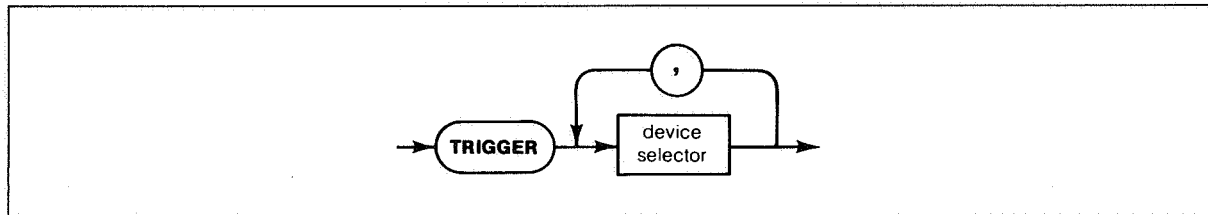
to clear an addressed instrument.

Related statements used by some computers:

```
RESET  
CONTROL  
SEND
```

Trigger

Trigger initiates a single event, such as a single sweep or an instantaneous measurement, from all instruments or an individually addressed instrument. If the HP 8340B/41B is in analog-sweep mode TRIGGER starts the sweep; if in CW, manual sweep, or fast phaselock (code FP) mode TRIGGER increments the frequency. When the upper frequency limit is reached (either the stop frequency for swept modes, or maximum instrument operating frequency for CW mode) the next TRIGGER command will initiate a retrace to the starting frequency. The syntax is



A BASIC example:

```
10 TRIGGER 7
```

to simultaneously trigger all HP-IB instruments, or

```
100 TRIGGER 719
```

to trigger an instrument at address 19, or

```
100 TRIGGER 719, 721, 712
```

to trigger instruments at addresses 19, 21, and 12.

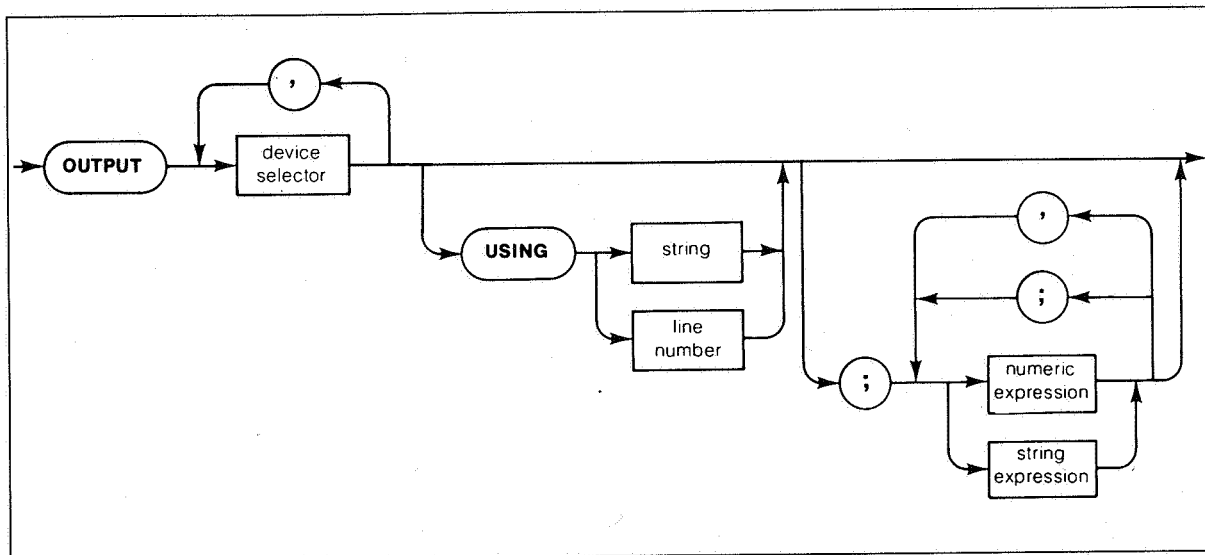
Related statements used by some computers:

```
RESUME  
SEND
```

The preceding statements are primarily management commands that do not incorporate instrument-specific programming codes. The following two statements do incorporate programming codes, and are used for data communication.

Output

Output is used to send function commands and data commands from the controller to the addressed instrument. The syntax is



where USING is a secondary command that formats the output in a particular way, such as binary or ASCII representation of numbers. The USING command is followed by "image items" that precisely define the format of the output; these image items can be a string of code characters, or a reference to a statement line in the computer program. Image items are explained in the programming codes where they are needed. Notice that this syntax is virtually identical with the syntax for the ENTER statement that follows. A BASIC example:

```
100 OUTPUT 719, "programming codes"
```

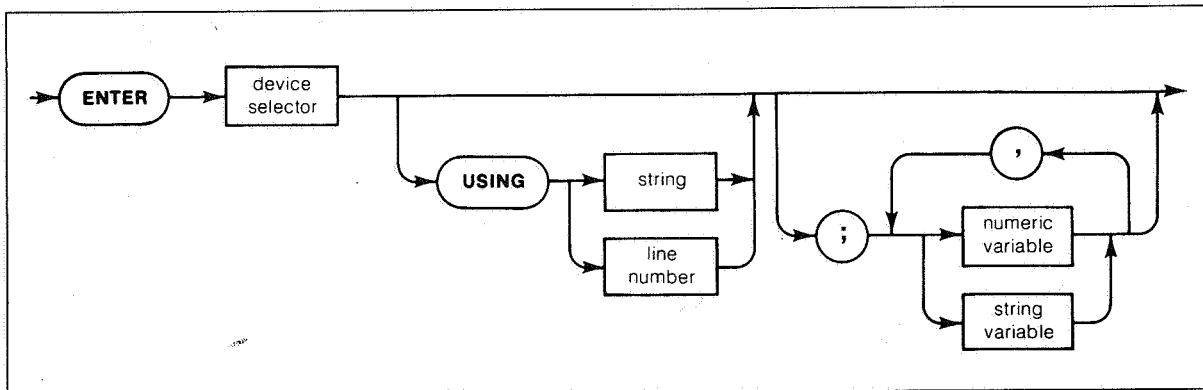
The many programming codes for the HP 8340B/41B are listed in Tables 3-1 and 3-2, and are explained in the Programming Codes subsection.

Related statements used by some computers:

CONTROL
CONVERT
IMAGE
IOBUFFER
TRANSFER

Enter

Enter is the complement to OUTPUT, and is used to transfer data from the addressed instrument to the controller. The syntax is



ENTER is always used in conjunction with OUTPUT, such as:

```
100 OUTPUT 719; "...programming codes..."
110 ENTER 719; "...complementary codes..."
```

ENTER statements are commonly formatted, which requires the secondary command USING and the appropriate image items. The most-used image items involve end-of-line (EOL) suppression, binary inputs, and literal inputs. For example,

```
100 ENTER 719 USING "#, B" A, B, C
```

suppresses the EOL sequence (#), and indicates that variables A, B, and C are to be filled with binary (B) data. As another example,

```
100 ENTER 719 USING "#, 123A"; A$
```

suppresses EOL, and indicates that string variable A\$ is to be filled with 123 bytes of literal data (123A). (Note: Be careful when using byte-counting image specifiers, because if the requested number of bytes does not match the actual number available data might be lost, or the program might enter an endless wait state.)

The suppression of the EOL sequence is frequently necessary to prevent a premature termination of the data input. When not specified, the typical EOL termination occurs when an ASCII LF (line feed) is received. However, the LF bit pattern could coincidentally occur randomly in a long string of binary data, where it might cause a false termination. Also, the bit patterns for the ASCII CR (carriage return), comma, or semicolon might cause a false termination. Suppression of the EOL causes the computer to accept all bit patterns as data, not commands, and relies on the HP-IB EOI (end or identify) line for correct end-of-data termination.

The various programming codes that are associated with the ENTER statement are listed in Tables 3-1 and 3-2, and are explained in the Programming Codes subsection.

Related statements used by some computers:

```
CONVERT
IMAGE
IOBUFFER
ON TIMEOUT
SET TIMEOUT
TRANSFER
```

This completes the HP-IB Command Statements subsection. The following material explains the HP 8340B/41B programming codes, and shows how they are used with the OUTPUT and ENTER HP-IB command statements.

HP 8340B/41B PROGRAMMING CODES

Table 3-1 lists the HP 8340B/41B programming codes arranged by function, and Table 3-2 lists the codes alphabetically. Notice in the Tables that several codes correspond to keys on the front panel of the HP 8340B/41B. All front panel operations (except the POWER switch) can be duplicated by a remote computer program, and those are the programming codes that are used to replace the keystrokes. There are also several programming codes listed in the Tables that are unique to HP-IB operation. The next two subsections describe all of these codes, first by explaining how front panel operations can be duplicated, and then explaining the unique, HP-IB operations.

Programs that Duplicate Front Panel Operations

Any HP 8340B/41B operation that can be established by pressing keys on the front panel can be duplicated by a computer program, with the exception of the POWER switch function. This is the procedure:

1. Determine the keystroke sequence needed for the desired operation. For example, this sequence establishes a 2.3 GHz CW signal at -30 dBm:

[INSTR PRESET] [CW] [2] [.] [3] [GHz] [POWER LEVEL] [-] [3] [dB(m)]

2. Use the Information Cards (located beneath the front panel), or Tables 3-1 and 3-2, to find the programming code for each key. Continuing with the example,

Key	Programming Code
[INSTR PRESET]	IP
[CW]	CW
[2]	2
[.]	.
[3]	3
[GHz]	GZ
[POWER LEVEL]	PL
[-]	-
[3]	3
[0]	0
[dB(m)]	DB

3. Combine the programming codes into an OUTPUT command. For an HP 8340B/41B having address 19, this is the complete program:

```
10 ABORT 7
20 CLEAR 7
30 OUTPUT 719; "IPCW2.3GZPL-30DB"
40 END
```

ABORT, CLEAR, and IP are not always required, but it is good programming practice to use them (in this sequence) because they place the HP 8340B/41B in a completely reset, standard operating condition.

The HP 8340B/41B automatically upshifts lower-case characters, and ignores spaces and unassigned characters; therefore, line 30 in the preceding program could be written as follows, resulting in enhanced readability at a slight cost in execution time:

```
30 OUTPUT 719, "IP CW 2.3 GHz PL -30 dB"
```

Or the information could be written

```
30 OUTPUT 719, "IP"  
40 OUTPUT 719; "CW 2.3 Gz"  
50 OUTPUT 719; "PL -30 dB"  
60 END
```

For interactive programs, the frequencies, power level, and other numerical data can be placed in the OUTPUT statements as variables. For example:

```
30 OUTPUT 719; "IP"  
40 OUTPUT 719; "CW 2.3 Gz"  
50 PRINT "ENTER THE POWER LEVEL"  
60 INPUT P  
70 OUTPUT 719; "PL"; P; "DB"  
80 GO TO 50  
90 END
```

Table 3-2. HP 8340B/41B Programming Codes (1 of 4)

Code	Operation Performed	Equivalent Key	Ref. Figure
A1	Leveling, internal	[INT]	3-16
A2	Leveling, external	[XTAL]	3-16
A3	Leveling, power meter	[METER]	3-16
AK m	Amplitude marker	[AMTD MKR]	3-17
AL m n	Alternate state	[ALT]	3-12
AM m	Amplitude modulation	[AM]	3-14, 3-15
AS m	Alternate state select		
AT d	Attenuator		
AU	Auto	[Hz/Auto]	3-10
BC	Change frequency band		
CF d t	Center frequency	[CF]	3-7
CS	Clear both status bytes		
CW d t	CW frequency	[CW]	3-7
DB	dB(m) terminator	[GHz/dB(m)]	3-10
DF d t	Delta frequency	[ΔF]	3-7
DN	Down step	[▼]	3-8
DU m	Display updating (=SHS1)		
EF	Entry Display off	[ENTRY OFF]	3-8
EK	Enable rotary knob		
FA d t	Start frequency	[START FREQ]	3-7
FB d t	Stop frequency	[STOP FREQ]	3-7
FM m	Frequency modulation	[FM]	3-14, 3-15
FM1 d	FM sensitivity (d=1 or 10)		3-14, 3-15
FP*	Fast phaselock		
GZ	GHz terminator	[GHz/dB(M)]	3-10
HZ	Hz terminator	[Hz/AUTO]	3-10
IF	Increment frequency		
IL 123b	Input learn data		
IP	Instrument preset	[INSTR PRESET]	3-12
KR	Keyboard release		
KZ	kHz terminator	[kHz/msec]	3-10
M0	Marker off (=M0)	[OFF]	3-9
M1 d t	Marker 1 on	[M1]	3-9
M2 d t	Marker 2 on	[M2]	3-9
M3 d t	Marker 3 on	[M3]	3-9
M4 d t	Marker 4 on	[M4]	3-9
M5 d t	Marker 5 on	[M5]	3-9
MC	Marker to center frequency	[MRK→CF]	3-9
MD m	Marker delta	[MRKΔ]	3-9
MO	Marker off (=M0)	[OFF]	3-9
MP m	Marker sweep, M1-M2	[MKR SWEEP]	3-9
MS	milliseconds terminator	[kHz/msec]	3-10
MZ	MHz terminator	[MHz/sec]	3-10
NA 1 b	Network analyzer configure		
OA (d)	Output active parameter		
OB (d)	Output next band frequency		
OC (3d)	Output coupled parameters		
OD*	Output diagnostic values		
OF (d)	Output fault values		
OI (19a)	Output identification		
OK (d)	Output last lock frequency		

Table 3-2. HP 8340B/41B Programming Codes (2 of 4)

Code	Operation Performed	Equivalent Key	Ref. Figure
OL (123b)	Output learn data		
OM (8b)	Output mode data		
OP (d)	Output interrogated parameter		
OR (d)	Output power level		
OS (2b)	Output status bytes		
PL d t	Power level	[POWER LEVEL]	3-7
PM m	Pulse modulation	[PULSE]	3-14, 3-15
PS m	Power sweep	[PWR SWP]	3-17
RB 1b	Remote rotary knob		
RC n	Recall instrument state	[RECALL] [0-9]	3-12
RE 1 b	Extended status byte mask		
RF m	RF output on/off	[RF]	3-17
RM 1 b	Status byte mask		
RP m	RF peaking	[PEAK]	3-17
RS	Reset sweep		
S1	Sweep, continuous	[CONT]	3-11
S2	Sweep, single	[SINGLE]	3-11
S3	Sweep, manual	[MANUAL]	3-11
SC	Seconds terminator	[MHz/sec]	3-10
SF d t	Step frequency size		
SG	Sweep, single		
SH	Shift prefix	[SHIFT]	3-7
SHA1	Disable, ALC, set power	[SHIFT] [INT]	3-16
SHA2	Enable external source module leveling mode	[SHIFT] [XTAL]	3-16
SHA3 d t	Access linear modulator	[SHIFT] [METER]	3-17
SHAK	Immediate YTM peak	[SHIFT] [AMTD MKR]	3-17
SHAL	Save current freq. mult. factor	[SHIFT] [ALT]	3-12
SHAM m	Pulse modulation enhancement	[SHIFT] [AM]	3-14
SHCF d t	Set frequency step size	[SHIFT] [CF]	3-7
SHCW*	CW increment resolution	[SHIFT] [CW]	3-7
SHEF	Restore calibration constant access function	[SHIFT] [ENTRY OFF]	3-8
SHFA d t	Display multiplier	[SHIFT] [START FREQ]	3-7
SHFB d t	Display offset	[SHIFT] [STOP FREQ]	3-7
SHIP	Freq. multiplier defaults to 1	[SHIFT] [INSTR PRESET]	3-12
SHM1	Diagnostic: M/N, 20/30 frequency	[SHIFT] [M1]	3-9
SHM2	Diagnostic: band, YO	[SHIFT] [M2]	3-9
SHM3	Diagnostic: VC01, VC02 frequencies	[SHIFT] [M3]	3-9
SHM4	Diagnostic: test/display results	[SHIFT] [M4]	3-9
SHM5	Turn off diagnostics	[SHIFT] [M5]	3-9
SHMO	Turn off all markers	[SHIFT] [OFF]	3-9
SHMP	Marker sweep, M1-M2	[SHIFT] [MKR SWEEP]	3-9
SHPL d t	Set power level step	[SHIFT] [POWER LEVEL]	3-7
SHPM	Enable HP 8756A/8757A compatibility	[SHIFT] [PULSE]	3-14, 3-15
SHPS d t	Decouple ATN, ALC	[SHIFT] [PWR SWP]	3-17
SHRC	Remove save-lock	[SHIFT] [RECALL]	3-12
SHS1 m	Blank displays	[SHIFT] [CONT]	3-11
SHS 3	Display fault diagnostic	[SHIFT] [MANUAL]	3-11
SHSL d t	Control reference level	[SHIFT] [SLOPE]	3-17
SHST d t	ZOOM function	[SHIFT] [SWEEP TIME]	3-7

Table 3-2. HP 8340B/41B Programming Codes (3 of 4)

Code	Operation Performed	Equivalent Key	Ref. Figure
SHSV	Lock save/recall	[SHIFT] [SAVE]	3-12
SHRF	Same as SHA1	[SHIFT] [RF]	3-17
SHRP	Tracking calibration	[SHIFT] [PEAK]	3-17
SHT1	Test displays	[SHIFT] [FREE RUN]	3-11
SHT2 m	Bandcrossing penlift	[SHIFT] [LINE]	3-11
SHT3	Display unlock indicators	[SHIFT] [EXT]	3-11
SHGZ d t	IO channel	[SHIFT] [Ghz/dB(m)]	3-10
SHMZ d t	IO subchannel	[SHIFT] [MHz/sec]	3-10
SHKZ d t	Write to IO	[SHIFT] [kHz/msec]	3-10
SHHZ	Read from IO	[SHIFT] [Hz/AUTO]	3-10
SL m d t	Power slope	[SLOPE]	3-17
SM d t	Sweep, manual		
SN d t	Steps, maximum		
SP d t	Set power step size		
ST d t	Sweep time	[SWEEP TIME]	3-7
SV n	Save instrument state	[SAVE] [1-9]	3-12
SW m	Swap network analyzer channels		
T1	Trigger, free run	[FREE RUN]	3-12
T2	Trigger, line	[LINE]	3-12
T3	Trigger, external	[EXT]	3-12
T1 b (b)	Test HP-IB interface		
TL d t	Time line		
TS	Take sweep		
UP	Up step	[▲]	3-8

Note: The HP 8340B/41B automatically upshifts codes entered in lower case, and ignores spaces placed between code groups. The warning message "***HP-IB SYNTAX ERROR***" appears in the ENTRY DISPLAY if an error is made in the programming format, and the HP 8340B/41B will ignore the unrecognized code characters. (The HP 8340B/41B also clears HP-IB DIO line 8, which sometimes is used as a parity bit; HP-IB lines are explained later in this Section.)

The lower-case letters listed after the codes indicate typical suffix parameters as follows:

If no suffix follows a code in this Table, the code represents either a self-contained, immediate execute function, or one of the terminator codes that scale and define the associated numerical data.

- a** indicates that alphanumeric ASCII characters are associated with this code.
- b** indicates binary information consisting of 8-bit bytes. Typically, binary information is transmitted by using either the computer's CHR\$ function (which converts a decimal number to a string of binary bytes), such as

```
100 OUTPUT 719; "...code..."&CHR$(decimal)
```

where the "&" concatenates the CHR\$ function to the programming code (and prevents an end-of-line terminator from being placed between the code and the data), or for codes that require strings of binary data an image specifier can be used; for example:

```
100 OUTPUT 719; "...programming code...";
```

```
110 OUTPUT 719 USING #,B"; byte(s)
```

The final semicolon in line 100 inhibits an end-of-line sequence from the computer (an EOL must not separate code from data). The "#" in line 110 suppresses EOL that might occur between data bytes or from a coincidental data bit pattern that mimics an EOL sequence, and the "B" indicates that the subsequent variables represent binary data.

Table 3-2. HP 8340B/41B Programming Codes (4 of 4)

d indicates decimal data, which is allowed in any of these data formats:

single digit: $\pm d$

Integer, decimal: $\pm d^{***}d$

Real, decimal: $\pm d^{***}d.d.^{***}d$

Exponential, decimal: $\pm d^{***}d.d.^{***}dE \pm dd$

m indicates a "1" or a "0" must follow the code letters, where the 1 suffix is usually used to turn on the function, and the 0 suffix turns off the function.

n is a single digit, 1-9 for SV and 0-9 for RC, which indicates the desired memory register.

t indicates that a terminator is required. Typically, the programming codes, GZ, MZ, KZ, HZ, DB, SC, and MS are used as terminators because they also serve as units scalars. Alternatively, a comma or an ASCII LF (decimal 10) can be used as a terminator, which will cause the HP 8340B/41B to scale the corresponding function to the fundamental units of Hertz, seconds, or dB(m).

(...) parenthesis indicate codes that cause the HP 8340B/41B to output information for a subsequent input by the computer, with the format of that information being indicated by the parenthetical letters. For example, code listing OC (3d) indicates that 3 decimal values should be read as a result of the OC command:

```
100 OUTPUT 719; "OC"  
110 ENTER 719; A, B, C
```

As another example, code listing OM (8b) indicates that 8 binary bytes should be read:

```
100 OUTPUT 719; "OM"  
110 ENTER 719 USING "#, B"; B1, B2, B3, B4, B5, B6, B7, B8
```

(The image parameters in line 110 are explained in the preceding "b-binary data" section.)

* follows the codes that have special suffix requirements; consult the detailed explanation of the code for further information.

Using the Rotary KNOB

The rotary [KNOB] can also be enabled for interactive programs. The [KNOB] is normally disabled when the HP 8340B/41B is in REMOTE; however, the "EK" programming code reenables the [KNOB]:

```
80 REM   EK ALLOWS THE KNOB TO CONTROL PL
90 OUTPUT 719; "EKPL"
100 PAUSE
110 REM  EK ALLOWS THE KNOB TO CONTROL CW
120 OUTPUT 719; "EKCW"
130 END
```

The "EK" can precede or follow the programming code for the function key; that is, "EKCW" and "CWEK" are functionally equivalent. If EK is output by itself, the [KNOB] will control the last-activated function:

```
80 OUTPUT 719; "FA10GZ   FB14GZ   PL -90DB   ST100MS"
90 OUTPUT 719; "EK"
100 END
```

Line 80 establishes a start frequency of 10 GHz, stop frequency of 14 GHz, power level of -90 dBm, and a sweep time of 100 milliseconds. Line 90 enables the [KNOB], which will control the sweep time since that was the last-activated function.

Using Keys that Toggle ON/OFF

Several keys, such as the MODULATION keys, activate functions that are either ON or OFF. To turn a function ON or OFF, add a "0" (OFF) or "1" (ON) suffix to the key's programming code. For example:

```
200 REM   TURN THE "AMTD MKR" ON
210 OUTPUT 719; "AK1"
220 PAUSE
230 REM   TURN THE "AMTD MRK" OFF
240 OUTPUT 719; "AK0"
```

Operator's Programming Check

To check the various programming codes that duplicate front panel operations, enter this BASIC program (or equivalent):

```
10 DIM A$"60"
20 REMOTE 719
30 PRINT "ENTER PROGRAMMING CODES"
40 INPUT A$
50 OUTPUT 719; A$
60 GOTO 30
70 END
```

RUN the program, and enter any combination of programming codes (60 characters maximum) when prompted; for example:

ENTER PROGRAMMING CODES?

FA12GZ FB18GZ PL -65DB STAU (followed by RETURN or END LINE)

The HP 8340B/41B should immediately respond to your commands with, in this example, a 12 GHz start frequency, 18 GHz stop frequency, power level of -65 dBm, and a sweep time set to auto (auto selects the fastest possible sweep rate for a given frequency span).

The preceding applications of the OUTPUT command are sufficient for writing computer programs that duplicate all front panel operations. The next subsection explains programming codes that do not have an equivalent key on the front panel.

Unique HP-IB Programming Codes

Several programming codes are available which do not have an equivalent front panel key; these codes are listed in Table 3-2 and described here, in alphabetical order (the lower case letters that follow each code mnemonic are explained in Table 3-2).

ASm Alternate State Select, is primarily used when the HP 8340B/41B is operating in certain network analyzer systems. AS is always used in conjunction with alternate state mode ([**ALT**], Figure 3-12) where it causes an abrupt change from one operational state to the other. Use AS when automatic alternation does not occur (for example, when CW mode is used for one or both operational states), or when it might be necessary to interrupt the alternating operation.

First, establish alternating operation between the present operating configuration (called the "foreground" state) and one of the previously SAVED operating configurations (called the "background" state). For example, code AL13 activates alternating operation between the foreground and background states, with the background state being derived from the contents of memory register 3 (the code parameters are ALn_x, where n = 1/0 to activate/deactivate alternating operation, and x = 1-9 indicates the memory register that will be transferred to the background register).

With alternating mode in effect, AS is used to abruptly change the operating state: AS0 causes the present HP 8340B/41B operation (whether that operation is foreground or background) to abruptly halt, retrace to the beginning of the foreground state, and begin operating under the foreground configuration; AS1 causes the present operation to abruptly halt, retrace to the beginning of the background state, and begin operating under the background configuration. After the AS-initiated foreground or background change has been completed, the previously established alternating state operation resumes. A BASIC example:

```
100 REM PREPARE BACKGROUND STATE, SAVE IN REGISTER 3
110 OUTPUT 719; "... (programming codes) ... SV3"
120 REM
130 REM PREPARE FOREGROUND STATE, AND ALTERNATE
140 OUTPUT 719; "... (programming codes) ... AL13"
150 REM
160 REM ABRUPTLY CHANGE STATUS IF NECESSARY
170 IF X > Y THEN OUTPUT 719; "AS1"
180 IF X < Y THEN OUTPUT 719; "AS0"
(X and Y in lines 170 and 180 are arbitrary variables for a hypothetical test.)
```

ATd Attenuator, allows the attenuator to be set remotely, and is used when the attenuator is decoupled from the ALC (SHSL initiates the decoupling). The standard attenuator (see the attenuator options listed in Section I) has a range of 0 to -90 dB in 10 dB increments; set the attenuator by using the code ATx_{DB}, where x is the numerical value (the HP 8340B/41B will round values to the nearest 10 dB) and DB is the terminator. A BASIC example:

```
100 OUTPUT 719; "AT-40DB"
```

BC Band Change, causes the HP 8340B/41B to advance to the next frequency bandcrossing point. The BC code is used in two situations: 1) It is used when the HP 8340B/41B is in network analyzer mode (the NA programming code), or 2) it is used when automatic bandcrossing has been disabled by the SHA21 code (in this case, the BC code functions identically to the SHA1 code; bandcross disabling and the SHA1/SHA2 functions are described in Figure 3-16).

CS Clear Status bytes, resets to zero the 16 bits in the two status bytes. Any status bit that is in the process of being set, but was deferred pending completion of some function, will also be cleared by CS. Status bytes, along with the CS code, are explained under the OS (Output Status byte) code.

DUm Display Updating, blanks (DU0) or unblanks (DU1) the front panel displays of the HP 8340B/41B, and is identical in function to SHS1m ([SHIFT] [CONT], which is described in Figure 3-11). In automated systems the displays of the HP 8340B/41B might be redundant, and can be blanked to reduce visual distractions for the operation. A BASIC example:

```
100 OUTPUT 719; "DU0"
```

If DU1 is output while the HP 8340B/41B is in the middle of a sweep, the sweep will abruptly stop, retrace, and the resume sweep operations.

EK Enable Knob, activates the rotary [KNOB] on an otherwise remote HP 8340B/41B front panel. Once the [KNOB] is enabled it is automatically coupled to the presently active function, such as:

```
100 OUTPUT 719; "CWEK"           ([KNOB] adjusts CW frequency)
```

```
200 OUTPUT 719; "PLEK"           ([KNOB] adjusts Power Level)
```

In the above examples, the CW and PL function codes were output along with EK to explicitly specify the active function; since no data accompanied the function codes, the last-used data values (or the IP default values) will be re-established. EK can also be output alone:

```
300 OUTPUT 719; "EK"
310 OUTPUT 719; "CF70MZ"
320 PAUSE
330 OUTPUT 719; "DF1MZ"
340 PAUSE
350 OUTPUT 719; "ST50MS PL -25DB"
360 PAUSE
```

EK always controls the active function; hence, at line 320 the [KNOB] controls the center frequency (initially at 1 MHz); and at line 340 the [KNOB] controls the delta frequency (initially at 1 MHz); and at line 360 the [KNOB] controls the power level (initially at -25 dBm). Notice at line 360 that the [KNOB] controls PL, not ST, because PL is the last-activated function.

FP Fast Phaselock, is used when the fastest possible frequency transition is necessary between CW frequencies. FP can be used for fast transitions between steps in a stepped CW sweep, or it can be used when the CW frequencies must be rapidly changed to any value in the frequency span of the HP 8340B/41B.

FP achieves rapid frequency transition by limiting some of the normal HP 8340B/41B features: The plotter control functions are disabled, the 0-10 volt sweep ramp is frozen, and the HP 8340B/41B does not wait for a complete locking of the phase lock loop oscillators before releasing the HP-IB handshake. The FP code must have a numerical suffix (14 characters maximum) in Hz units, without any terminator code (ASCII "LF," normally sent by the computer is the only allowable terminator), that sets the starting frequency. A BASIC example of a stepped CW sweep:

```
100 OUTPUT 719; "IP SF1KZ CW"
110 OUTPUT 719; "FP1E9"
120   FOR J = 1 TO 100
130     TRIGGER 719
140     NEXT J
150   GOTO 110
```

Line 100 sets the step size (SF) to 1 kHz, and causes the HP 8340B/41B to enter CW mode (the unspecified CW frequency at this point will be the last used CW frequency, or the IP default value). Line 110 initiates fast phaselock mode, and establishes a starting CW frequency of 1E9 Hz (1 X 10⁹ Hz, or 1 GHz). At this point in the program, the HP 8340B/41B is outputting 1 GHz CW but will not increment until line 130 is reached. Line 150 causes a retrace to 1 GHz.

For irregular frequency steps use a variable to represent the numerical data, such as:

```
100 FOR N = 1 TO 4
110 READ A
120 OUTPUT 719; "FP";A
130 NEXT N
140 DATA 1E7, 1E8, 1E9, 1E10
```

Line 140 contains the list of frequencies (in Hz units; hence, 10 MHz, 100 MHz, 1 GHz, and 10 GHz) which are read in line 110. The semicolon between the "FP" and A (an arbitrary variable) in line 120 signifies to the computer that a terminator should not separate the code from the variable.

IF Increment Frequency, is similar to the HP-IB commands TRIGGER and GET (group execute trigger). IF must be used to trigger the SN function, and can be used to increment SM and other CW frequency functions (however, IF cannot be used to trigger FP). For example:

```
100 OUTPUT 719; "SF1GZ CW1GZ"
110 FOR N = 1 TO 20
120 OUTPUT 719; "IF"
130 NEXT N
```

The step size and the starting CW frequency are both set to 1 GHz in line 100. Lines 110 to 130 cause the CW frequency to increment 20 times (i.e., a 1-21 GHz stepped sweep).

IL123b Input Learn data, is used in conjunction with OL (Output Learn data) to save/recall various operating configurations of the HP 8340B/41B. IL/OL is similar to the SAVE/RECALL functions, except with IL/OL the active function in use prior to OL storage is once again active after the IL restoration (no function is active after a RECALL), and there is virtually no limit to the number of instrument states that can be stored (SAVE/RECALL has a capacity of 9 memory registers, located in the HP 8340B/41B; IL/OL data is stored in the computer's mass storage device). IL is explained under the OL programming code.

KR Keyboard Release, is used with the NA code. If NA bit 1 is set True (=1), the HP 8340B/41B front panel keys are in a lock-and-release mode. In this mode, the keyboard is locked (disabled) after any one key has been pressed, and remains locked until released by the KR code. The typical loop program involves three steps: 1) Determine which key was pressed by using the OM code 2) process the key closure information; 3) use KR to release the keyboard, and return to step 1.

NAb Network Analyzer configuration, established the operating modules that are used when the HP 8340B/41B is interfaced with certain network analyzers. The modes are established by adding a binary or decimal number to the NA code, where the bits of the number are deciphered as follows:

Bit 0 set true (1);

Enable network analyzer mode with the following features:

1. Enable group-execute trigger (GET) to start a sweep after a mid-sweep update, if in analog sweep mode.
2. Use Stop Frequency to calculate the end of the band.
3. Disable HP 8340B/41B detection of sweep event markers, bandcrossing points, and sweep end point.
4. Do binary search to set sweep reset DAC.
5. Issue end of sweep SRQ for mid-sweep update.
6. Disable automatic alternation when alternating in manual or CW non-swept mode.
7. Ignore BC following mid-sweep updates, until next GET.

Bit 1 set true (1): Enable keyboard hold off, released by KR.

Bit 2 set true (1): Disable "HP-IB SYNTAX ERROR" annunciator that would otherwise appear in the ENTRY DISPLAY.

Bits 3-7: Not used

Bit 0 is set true by decimal "1," bit 1 is set by decimal "2," and bit 2 is set by decimal "4." A BASIC example that sets bits 0, 1, and 2 true:

```
100 OUTPUT 719; "NA"&CHR$(7)
```

In this example, the binary value of decimal 7 (CHR\$(7)) is concatenated to the NA code (&). Alternatively, a formatted OUTPUT statement could be used to output the same binary information.

```
100 OUTPUT 719 USING "2A, B"; "NA", 7
```

The image specifier "2A, B" indicates that two literal characters will be output, followed by a single binary byte.

Consult the Operating Guide for the specific network analyzer being used for detailed interfacing information.

OA(d) Output Active parameter, allows the computer to read the numerical value of the presently active HP 8340B/41B function. The active function is the last-used function, and appears in an unblanked ENTRY DISPLAY. A BASIC example:

```
100 OUTPUT 719; "FA65MZ FB75MZ PL10DB ST1SC"  
110 OUTPUT 719; "OA"  
120 ENTER 719; A  
130 PRINT "ACTIVE PARAMETER ="; A
```

Sweep time is the active parameter, because it was the last-entered function (line 100). The OA value read by the computer (read in line 120, and assigned to arbitrary variable A) is always in the fundamental units of Hz, dB(m), or seconds.

The Om code (byte 2) can be used to determine the presently active function.

OB(d) Output next Band frequency, indicates the frequency of the next bandcrossing. Bandcrossings occur at 2.4 GHz, 7.0 GHz, 13.5 GHz, and, in the case of the HP 8340B, 20.0 GHz. A BASIC example:

```
100 OUTPUT 719; "CW6GZ"  
110 OUTPUT 719; "OB"  
120 ENTER 719; A  
130 PRINT "NEXT BANDCROSSING"; A/1E9; "GIGAHERTZ"
```

In this example, the HP 8340B/41B is outputting a 6 GHz CW signal, so the next bandcrossing points is 7.0 GHz. The OB frequency is always in Hz; line 130 divides the OB value by 1×10^9 for conversion to GHz units.

OC(3d) Output Coupled parameters, allows the computer to read the values of the start frequency, center frequency, and sweep times (in this order) of the HP 8340B/41B. The values are always read in the fundamental units of Hz and seconds. In BASIC:

```
100 OUTPUT 719; "FA1GZ FB19GZ STAU"  
110 OUTPUT 719; "OC"  
120 ENTER 719; S, C, T  
130 PRINT "START FREQUENCY"; S/1E9; "GHZ"  
140 PRINT "CENTER FREQUENCY"; C/1E9; "GHZ"  
150 PRINT "SWEEP TIME"; T; "SECONDS"
```

The computer would display, for this example, a start frequency of 1 GHz, a center frequency of 10 GHz, and a sweep time of 0.030 seconds.

OD Output Diagnostic values, allows the computer to read the values that result from the diagnostic functions (always in the fundamental units of Hz, dB(m), or seconds). There are three diagnostic functions that can be used with OD:

1. Oscillator frequencies diagnostic: Programming code SHM1 (keystrokes **[SHIFT] [M1]**; see figure 3-9) activates this diagnostic, which outputs the M value, N value, M/N loop frequency, and the 20/30 loop frequency. In BASIC:

```
100 OUTPUT 719; "SHM1 OD"
110 ENTER 719; M,N,R,L
120 PRINT "M VALUE"; M
130 PRINT "N VALUE"; N
140 PRINT "M/N FREQUENCY"; R; "HZ"
150 PRINT "20/30 LOOP FREQ"; L; "HZ"
```

2. Band number and YIG oscillator diagnostic: Programming code SHM2 (keystrokes **[SHIFT] [M2]**; see Figure 3-9) causes the band number and YIG oscillator frequency to be output, in this order. In BASIC:

```
100 OUTPUT 719; "SHM2 OD"
110 ENTER 719; B, Y
120 PRINT "BAND NUMBER"; B
130 PRINT "YIG OSC FREQUENCY"; Y; "HZ"
```

3. Phase lock loop (PLL) frequencies diagnostic: Programming code SHM3 (keystrokes **[SHIFT] [M3]**; see Figure 3-9) causes the PLL #2 VCO frequency and the PLL #3 upconverter frequency of the 20/30 loop to be output, in this order. In BASIC:

```
100 OUTPUT 719; "SHM3 OD"
110 ENTER 719; F2, F3
120 PRINT "PLL #2"; F2; "HZ"
130 PRINT "PLL #3; F3; "HZ"
```

4. Diagnostic Tests and Results: Programming code SHM4 (keystrokes **[SHIFT] [M4]**; see Figure 3-9) causes a series of up to 18 diagnostic tests. These tests are labeled 14 to 31. Other tests are initiated at "power on". These tests are labeled 0 to 13. Test results are available from the front panel or as a string of 32 characters over the HP-IB. These characters may be either 1 or 0, indicating, respectively, a passed or failed test. In BASIC:

```
100 DIM Test no$(32) [20]
110 OUTPUT 719; "SHM4"
120 FOR I = 1 TO 32
130 READ Test no$(I)
140 DATA "PROCESSOR TST", "ROM 1 CKSUM", "ROM 2 CKSUM", "ROM 3
CKSUM", "ROM 4 CKSUM", "RAM 1 RD/WR", "RAM 2 RD/WR", "EEROM 1
RD/WR", "EEROM 2 RD/WR"
150 DATA "MRK RAM RD/WR", "PIT (LED REG)", "PIT RESPONDS", "IO ADDR
BUSS", "IO DATA BUSS", "A-D CONVERTER", "LEVEL REF DAC", "MAN SWP
DAC" "MARKER RAMP"
160 DATA "RESET DAC", "LEVEL SWP DAC", "BND CROSS DAC", "SWP WIDTH
DAC", "SWP RANGE ATN", "V/GHz CIRCUIT", "V/GHz BND ATN", "BRK PNT
1 DAC", "BRK PNT 2 DAC"
170 DATA "ATN SLOPE DAC", "YO PRETUN DAC", "SWEPTIME DAC", " NOT
, USED" "A27 INSTALLED"
180 NEXT I
190 DIM Dt$(32)
200 OUTPUT 719; "OD"
210 ENTER 719; Dt$
220 FOR I = 1 TO 32
```

```

230 IF D1$(I, I) = "1" THEN
240 IMAGE 13A, 10X, "PASS"
250 PRINT USING 240; Test_no$(I)
260 ELSE
270 IMAGE 13A, 10X, "FAIL"
280 PRINT USING 270; Test_no$(I)
290 END IF
300 NEXT I
310 END

```

Consult Section VIII, Service, for a detailed explanation of these diagnostic functions.

OF(d) Output Fault, outputs a decimal value that can be decoded to determine which fault conditions have occurred. These fault conditions are automatically accumulated by the HP 8340B/41B, and are only cleared by an Instrument Preset or when the fault has been output following an OF command. The outputted decimal number is interpreted at the bit level, where the bits are defined as follows:

```

Bit 0: Not used.
Bit 1: Not used.
Bit 2: N1 oscillator unlocked.
Bit 3: N2 oscillator unlocked.
Bit 4: YIG oscillator unlocked.
Bit 5: HET oscillator unlocked.
Bit 6: M/N oscillator unlocked.
Bit 7: REF oscillator unlocked.
Bit 8: Not used.
Bit 9: Not used.
Bit 10: LVC - preset of level control board failed.
Bit 11: PEAK - peaking algorithm failed.
Bit 12: ADC - ADC time out.
Bit 13: KICK - YO or SYTM kick pulse time out.
Bit 14: CAL - calibration data checksum incorrect.
Bit 15: Not used.

```

If any of these fault conditions are encountered, consult the In Case of Difficulty section or Section VIII (Service) for further instructions. A BASIC example:

```

100 OUTPUT 719; "OF"
110 ENTER 719; F
120 FOR N = 0 TO 15
130 PRINT "BIT"; N; " = "; BIT(F, N)
140 NEXT N

```

Line 130 determines each bit of arbitrary variable F in the BIT(F,N) statement.

OI(19a) Output Identification, outputs the revision date of the firmware presently loaded into the HP 8340B/41B as:

08340BREV day month year
(2 numbers for the day, 3 letters for the month, and 2 numbers for the year)

A BASIC example:

```

10 DIM A$(19)
:
:
:
100 OUTPUT 719; "OI"
110 ENTER 719; A$
120 PRINT "FIRMWARE REVISION"; A$

```


OK(d) Output last locked frequency, indicates the last phase locked frequency of the HP 8340B/41B, in Hz. A BASIC example:

```
100 OUTPUT 719; "CWEK"  
110 PAUSE  
120 OUTPUT 719; "OK"  
130 ENTER 719; F  
140 PRINT "LAST FREQUENCY"; F; "HZ"
```

In line 100, the rotary [**KNOB**] is enabled (EK) and used to adjust the CW frequency. After completing the frequency adjustment, press [**CONTINUE**] on the computer and the last phase lock frequency (the current CW frequency in this example) is read and printed.

OL(123b) Output Learn data, is used on conjunction with IL (Input Learn data) to save and recall specific instrument operating configurations. OL/IL is similar to SAVE/RECALL, except: the function that was active prior to OL storage is once again active after an IL recall; and SAVE/RECALL is restricted to nine instrument configurations and uses the memory of the HP 8340B/41B while OL/IL uses the computer's memory and is restricted only by the size of that memory.

The learn data consists of 123 bytes of information. This information is heavily coded and densely packed for conciseness, so a byte-by-byte deciphering is not recommended (use OP to obtain information about a specific function or state). This is a typical BASIC program using OI and IL:

```
10 DIM A$(123)  
:  
:  
:  
100 OUTPUT 719; "... (programming codes) ..."  
110 REM  
120 REM STORE THIS INSTRUMENT STATE  
130 OUTPUT 719; "OL"  
140 ENTER 719 USING "#, 123A"; A$  
150 REM  
160 REM RETRIEVE THIS INSTRUMENT STATE  
170 OUTPUT 719; "IL" & A$
```

Line 140 is a formatted I/O statement, where the # suppresses the end-of-line sequence (so valid data is not misinterpreted as EOL), and the 123A is an instruction to fill A\$ with 123 bytes of literal data. Line 170 concentrates the literal data in A\$ (which is an arbitrary variable) with the IL programming code. For additional I/O formatting information, consult the I/O Programming Manual for the specific computer being used.

OM(8b) Output Mode, outputs 8 bytes of information that completely describes the presently active function of the HP 8340B/41B.

Byte 1 records the last-pressed front panel key.

Byte 2 indicates the active function.

Byte 3 records the active and previously active markers.

Byte 4 indicates the marker status.

Byte 5 indicates trigger, sweep, and frequency modes.

Byte 6 indicates the status of various front panel functions.

Byte 7 indicates output power and leveling status.

Byte 8 indicates the status of the modulation and other functions.

A BASIC example:

```

10 DIM B(8)
.
.
100 OUTPUT 719; "0M"
110 ENTER 719 USING "#,B"; B(1), B(2), B(3), B(4), B(5), B(6), B(7),
    B(8)
120 FOR J = 1 to 8
130 PRINT "BYTE"; J
140 PRINT "DECIMAL"; B(J)
150 FOR K = 0 TO 7
160 PRINT "BIT"; K; "="; BIT(B(J), K)
170 NEXT K
180 PRINT
190 NEXT J
    
```

Line 110 suppresses the normal end-of-line sequence by using the "#" image specifier (this must be done in case the bit pattern of the data coincidentally duplicates the bit pattern of the EOL, which would cause a false termination), and inputs the 8 bytes of data (image specifier "B" indicates binary data). Lines 120-190 prints the bytes' decimal and bit values. This is how to interpret the byte data:

BYTE 1 indicates the last-pressed front panel key, and the decimal value of this byte corresponds to the keys as follows:

Decimal Value	Key	Decimal Value	Key
0-9	[0] - [9] numerical keys	82	[RECALL]
10	[.]	83	[ALT]
11	[-] minus key	84	not used
12	[- / BACK SPACE]	85	[PULSE]
	used as the back space	86	[AM]
13	[▲]	87	[ENTRY OFF]
14	[▼]		
15	[MKR→CF]	88-96	not used
16	[SHIFT] [MKR SWEEP]	97	[START FREQ]
17	[INSTR PRESET]	98	[STOP FREQ]
18-64	not used	99	[CF]
65	[CONT]	100	[ΔF]
66	[SINGLE]	101	[CW]
67	[MANUAL]	102	[POWER LEVEL]
68	[M1]	103	[SWEEP TIME]
69	[M2]	104	[SHIFT]
		105	[GHz/dB(m)]
70	[M3]	106	[MHz/sec]
71	[M4]	107	[kHz/msec]
72	[M5]	108	[Hz/AUTO]
73	[FREE RUN]	109	[INT]
74	[LINE]		
75	[EXT]	110	[XTAL]
76	[MKR SWEEP]	111	[METER]
77	[OFF]	112	[AMTD MKR]
78	[MKRΔ]	113	[PEAK]
79	not used	114	[PWR SWP]
		115	[SLOPE]
		116	[RF]
80	[LOCAL]	117-128	not used
81	[SAVE]		

Decimal Value	Key	Decimal Value	Key
(Note: Although all possible shift-key combinations are listed, some of these combinations have no effect on the HP 8340B/41B.)		161	[SHIFT] [START FREQ]
		162	[SHIFT] [STOP FREQ]
		163	[SHIFT] [CF]
		164	[SHIFT] [Δ F]
		165	[SHIFT] [CW]
		166	[SHIFT] [POWER LEVEL]
		167	[SHIFT] [SWEEP TIME]
		168	[SHIFT] [SHIFT]
		169	[SHIFT] [GHz/dB(m)]
129	[SHIFT] [CONT]	170	[SHIFT] [MHz/sec]
130	[SHIFT] [SINGLE]	171	[SHIFT] [kHz/msec]
131	[SHIFT] [MANUAL]	172	[SHIFT] [Hz/AUTO]
132	[SHIFT] [M1]	173	[SHIFT] [INT]
133	[SHIFT] [M2]	174	[SHIFT] [[SHIFT] [XTAL]
134	[SHIFT] [M3]	175	[SHIFT] [METER]
135	[SHIFT] [M4]	176	[SHIFT] [AMTD MKR]
136	[SHIFT] [M5]	177	[SHIFT] [PEAK]
137	[SHIFT] [FREE RUN]	178	[SHIFT] [PWR SWP]
138	[SHIFT] [LINE]	179	[SHIFT] [SLOPE]
139	[SHIFT] [EXT]		
140	not used	180	[SHIFT] [RF]
141	[SHIFT] [OFF]	181	[SHIFT] [0]
142	not used	182	[SHIFT] [1]
143	not used	183	[SHIFT] [2]
144	[SHIFT] [LOCAL]	184	[SHIFT] [3]
145	[SHIFT] [SAVE]	185	[SHIFT] [4]
146	[SHIFT] [RECALL]	186	[SHIFT] [5]
147	[SHIFT] [ALT]	187	[SHIFT] [6]
148	not used	188	[SHIFT] [7]
149	[SHIFT] [PULSE]	189	[SHIFT] [8]
150	[SHIFT] [AM]	190	[SHIFT] [9]
151	[SHIFT] [ENTRY OFF]	191	not used
152	[SHIFT] [▼]		
153	[SHIFT] [▲]		
154-160	not used		

BYTE 2 shows the presently active function. Decipher the decimal value of BYTE 2 as follows:

Dec. Value	Active Function	Dec. Value	Active Function
0	non-numerical function (either SAVE LOCK, CLEAR LOCK, or ENTRY OFF)	23	HP-IB address ([SHIFT] [LOCAL])
1	SAVE in register n	24	not used
2	RECALL from register n	25	ZOOM frequency function
3	ALternate with register n	26	MANUAL sweep
4	I/O read ([SHIFT] [kHz/msec])	27	Frequency offset ([SHIFT] [STOP FREQ])
5	UNLK indicators ([SHIFT] [EXT])	28	Frequency multiplier ([SHIFT] [START FREQ])
6	Power LVL STEP size	29	RF SLOPE
7	POWER LEVEL	30	not used
8	SWEEP TIME	31	not used
9	CW RESolution	32	PWR SWEEP
10	CW frequency	33	not used
11	CF center frequency	34	Power meter leveling ([METER])
12	Δ F delta frequency	35	Decoupled ATN/ALC ([SHIFT] [PWR SWP])
13	START frequency	36	Attenuator control ([SHIFT] [SLOPE])
14	STOP frequency	37	Bypassed ALC ([SHIFT] [METER])
15	Marker 1	38	not used
16	Marker 2	39	not used
17	Marker 3	40	I/O channel ([SHIFT] [GHz/dB(m)])
18	Marker 4	41	I/O subchannel ([SHIFT] [MHz/sec])
19	Marker 5	42	I/O write ([SHIFT] [kHz/msec])
20	not used	43	Sweep time limit (programming code TL)
21	FREQuency STEP size	44-245	not used
22	Calibration constants accessed	246	Fault diagnostic ([SHIFT] [MANUAL])
		247-256	not used

BYTE 3 shows the presently active and previously active markers. The marker information is coded in bit groups 0-2 (active marker), 3-5 (previously active marker), and 6-7 (not used); the decimal value of those bit groups is the marker number. For example:

BIT NUMBER	7	6	5	4	3	2	1	0
BIT PATTERN	X	X		1	0	0	1	1

is decoded as "active marker is M3 (decimal value of bits 0-2 is 3), and previously active marker is M2 (decimal; value of bits 3-5 is 2)."

BYTE 4 shows the on/off status of the markers and marker functions. If a bit is set True (=1) the marker or function is on, if the bit is False they are off. This is the bit code:

Bit	Marker or Function
0	MKR SWP
1	M1
2	M2
3	M3
4	M4
5	M5
6	not used (always = 0)
7	MRK Δ

BYTE 5 shows the status of the TRIGGER, SWEEP, and FREQUENCY modes. Like byte 3, the mode information is organized by bit groups, and is decoded by using the decimal value of those groups. This is the bit group organization:

Bits	Mode Information
0-1	TRIGGER MODE 0 = FREE RUN 1 = LINE 2 = EXT
2-4	SWEEP MODE 0 = CONT 1 = SINGLE 2 = MANUAL with Hz resolution (code SM) 3 = not used 4 = MANUAL with STEP resolution (code SN)
5-7	FREQUENCY MODE 0 = START/STOP 1 = CF/ Δ F 2 = CW, with sweep on 3 = CW, with sweep off

BYTE 6 shows the status of miscellaneous modes and functions, which are ON if the appropriate bit is True (=1), or are OFF if the bit is False.

Bit	Mode or Function
0	AMTD MKR
1	not used (always = 1)
2	not used (always = 1)
3	not used (always = 0)
4	Entry enabled and rotary [KNOB] on
5	SAVE lock enabled
6	ALT mode
7	Keyboard [SHIFT] on

BYTE 7 shows the status of the power and leveling functions. The decimal value of bit group 0-1 indicates the leveling modes, while the remaining bits indicate whether the function is on (=1) or off (=0).

Bit	Mode or Function
0-1	ALC leveling modes 0 = INT 1 = XTAL 2 = METER
2	not used (always = 0)
3	PWR SWEEP
4	SLOPE
5	RF
6	not used
7	not used

BYTE 8 shows the remaining front panel modes and functions, with the True bits (=1) indicating ON, and the False bits (=0) indicating OFF.

Bits	Mode or Function
0	not used (always = 0)
1	not used (always = 0)
2	not used (always = 1)
3	PULSE
4	not used
5	AM
6	PEAK
7	Penlift enabled ([SHIFT] [LINE])

OP(d) Output interrogated Parameter, instructs the HP 8340B/41B to output the numerical value of any specified function, even if that function is not presently active. The code for any function that has a numerical value associated with it as appended to OP; for example, OPCF for the center frequency (but not CFOP), or OPST for the sweep time (but not STOP). The numerical value is always output in the fundamental units of Hz, dB(m), or seconds. A BASIC example:

```
100 OUTPUT 719; "OPCF"  
110 ENTER 719; N  
120 PRINT "CENTER FREQUENCY = "; N; "HZ"
```

In this example, N is an arbitrary variable.

OR(d) Output power level, causes the HP 8340B/41B to output the present power level of the instrument. PLOA, OPPL and OR can be used to output power level, but there is a significant difference in the implementation of these codes by the HP 8340B/41B. OR causes the power to be measured by the internal ADC, while PLOA and OPPL reflect the user-requested power that is shown in the ENTRY DISPLAY.

PLOA or OPPL accurately indicate the power output only when the HP 8340B/41B is internally leveled and is not being amplitude modulated (AM) by a modulation signal containing a dc component. Under these conditions the values of PLOA, OPPL, and OR will agree to within the tolerances of the measuring circuits (± 0.1 dB).

OR can always be used to measure power output, and must be used whenever any of these conditions exist: 1) The HP 8340B/41B is unleveled for any reason; 2) the instrument is being amplitude modulated by a modulation signal having a dc component; 3) the HP 8340B/41B is being externally leveled.

A BASIC example:

```
100 OUTPUT 719; "OR"  
110 ENER 719; P  
120 PRINT "POWER LEVEL = "; P; "DBM"
```

OS(2B) Output Status bytes, is used to read the two 8-bit status bytes from the HP 8340B/41B. The first status byte concerns the cause of an SRQ (Service Request), while the second status byte concerns failures and faults, as follows:

STATUS BYTE (#1)								
BIT #	7	6	5	4	3	2	1	0
DECIMAL VALUE	128	64	32	16	8	4	2	1
FUNCTION	SRQ on New frequencies or Sweep Time in Effect	REQUEST SERVICE (RQS)	SRQ on HP-IB Syntax Error	SRQ on End of Sweep	SRQ on RF Settled	SRQ on Changed in Extended Status Byte	SRQ on Numeric Entry Completed (HP-IB or Front Panel)	SRQ on Any Front Panel Key Pressed
EXTENDED STATUS BYTE (#2)								
BIT #	7	6	5	4	3	2	1	0
DECIMAL VALUE	128	64	32	16	8	4	2	1
FUNCTION	Fault Indicator On	RF Unleveled	Power Failure	RF Unlocked	External Freq. Ref. Selected	Oven Cold	Over Modulation	Self Test Failed

Status Byte 1

Bit 0: SRQ caused by a key closure on the front panel of the HP 8340B/41B (use the OM code to determine the front panel status).

Bit 1: SRQ caused by the completion of a numeric entry (use the OA code to determine the value of the numerical entry).

Bit 2: SRQ caused by a change in the extended status byte (status byte 2) affected by the RE-coded mask (see the RE code for an explanation of this masking).

Bit 3: SRQ caused by the completion of phase locking and the settling of the RF source (use the OK code to determine the last lock frequency).

Bit 4: SRQ on end-of-sweep or mid-sweep update in NA (network analyzer code) mode.

Bit 5: SRQ caused by HP-IB syntax error.

Bit 6: SERVICE REQUEST; by IEEE-488 convention, the instrument needs service from the controller when this bit is set true.

Bit 7: SRQ caused by a change in the coupled parameters (start frequency, center frequency, and sweep time). Use the OC code to determine the new values of the coupled parameters.

Status Byte 2 (Extended Status Byte)

Bit 0: Self test failed at power on or at Instrument Preset. This bit remains latched until this status byte has been read, or until cleared by the CS or CLEAR 719 commands.

Bit 1: Excessive amplitude modulation input.

Bit 2: Oven for the reference crystal oscillator is not at operating temperature.

Bit 3: External reference frequency was selected by the rear-panel FREQUENCY STANDARD switch.

Bit 4: RF is unlocked (UNLK appears in the ENTRY DISPLAY). Use OF to determine the source of the unlocked output. This bit remains latched until this status byte has been read, or until cleared by the CS or CLEAR 719 commands.

Bit 5: AC line power interruption has occurred since the last Instrument Preset. This bit also remains latched until read or cleared.

Bit 6: RF is unlevelled (use OR to determine present power level). This bit also remains latched until read or cleared.

Bit 7: FAULT annunciator is on (seen in the ENTRY DISPLAY of the HP 8340B/41B). Use OF to determine the cause of the fault.

A BASIC example:

```
10  REM CLEAR (RESET TO ZERO) BOTH STATUS BYTES
20  OUTPUT 719; "CS"
.
.
.
100 OUTPUT 719; "OS"
110 ENTER 719 USING "#, B"; S1, S2
120 S = S1
130 FOR K = 1 TO 2
140   PRINT "STATUS BYTE"; K
150   FOR N = 0 TO 7
160     PRINT "BIT"; N; "="; BITS(S, N)
170   NEXT N
180   S = S2
190 NEXT K
```

Line 110 is a formatted I/O statement, where # suppresses the end-of-line sequence (to avoid misinterpreting valid data as an EOL sequence), and B indicates that each of the following variables (arbitrary variables S1 and S2) should be filled with one byte of information. Line 160 determines each bit of the status bytes, status byte 1 first (S = S1, N = 0 to 7) then status byte 2 (S = S2, N = 0 to 7).

Programming codes RM and RE explain how the status bytes can be masked.

RBb Remote knob, allows the rotary knob of other instruments (computers, network analyzers) to control the active function of the HP 8340B/41B. The knob is sometimes called an RPG (rotary pulse generator) or cursor wheel in the manual of other instruments. Here is a demonstration program for the HP 9826/9836 (926/936) series of computers:

```
10  REM PRINT TO THE CRT, NOT THE LINE PRINTER
20  PRINTER IS 1

30  OUTPUT 719; "IP CWI GZ"
40  ON KNOB .075 GOSUB 60
50  GOTO 50

60  Count = KNOBX
70  PRINT "KNOB COUNT ="; Count
80  OUTPUT 719; "RB" & CHR$(Count)
90  RETURN

100 END
```

Line 30 establishes CW as the active function, with an initial value fo 1.0 GHz. ON KNOB in line 40 instructs the computer to detect any rotation of the knob. The computer's knob generates 120 pulses per revolution; when the first pulse is detected, line 40 starts a sampling-time clock (75 milliseconds in this example) and branches to the subroutine located at line 60.

KNOBX in line 60 counts the pulses that occur in the sampling-time interval (the sampling time range is 0.01-2.55 seconds, but the sampling time must be short enough to keep the pulse count in the range of -127 to +128), and assigns the value of that count to arbitrary variable Count. Line 70 displays the pulse counts on the computer's CRT (pulse counts of $\pm 1-30$ are typical for this sampling time). Line 80 sends the pulse count information to the HP 8340B/41B, where it affects the active function (CW in this example).

In line 80, the pulse count is converted from decimal to binary by the CHR\$ function, and concatenated to the RB code. One byte of numerical data can accompany RB, so the decimal value of Count has an allowable range of -127 to +128. The sampling time is arbitrary; 75 milliseconds was selected for this example because the resultant response of the computer's knob approximates the response from the HP 8340B/41B's knob (the exact effects of the sampling time must be ascertained by experiment).

REb, RMb Request mask Extended, and Request Mask, allow masking of the extended status byte (status byte 2) and the service request status byte (status byte 1), respectively. Masking is usually done for interrupt programming, where non-critical bits of the status bytes are masked to prevent them from initiating an unimportant interrupt.

To mask a status byte, the HP 8340B/41B must receive the RE and/or RM code that includes the numerical value of the enabled bits. The numerical value of the bits, in decimal, is:

BIT	7	6	5	4	3	2	1	0
DECIMAL	128	64	32	16	8	4	2	1

For example, to enable bit 2 on status byte 1 while occluding the six other bits, the programming code is "RM"&CHR\$(4), where the decimal value of bit 2 is converted to binary by the CHR\$ function and concatenated to the RM code.

Masked interrupt programming requires the identification and enabling of the computer's interrupt register, and the transmission of the RM/RE codes to the HP 8340B/41B. Here is a typical BASIC example:

```

100 OUTPUT 719; "CS"
110 OUTPUT 719; "RM"&CHR$(4)
120 OUTPUT 719; "RE"&CHR$(64)
130 ENABLE INTR 7; 8
140 ON INTR 7 GOTO 500
150 OUTPUT 719; "PLEK"
.
.
.
500 PRINT "WARNING: RF UNLEVELED"

```

Line 110 enables bit 2 (only) of status byte 1, which is the bit that causes an SRQ to be sent when any of the bits in status byte 2 change. Line 120 enables bit 6 (only) of status byte 2, which detects an unlevelled RF output. Thus, an unlevelled RF is the only condition that will cause the HP 8340B/41B to send an SRQ.

Line 130 enables the computer's interrupt register that is associated with I/O port 7, and instructs the computer to monitor bit 3 (decimal 8) for a true condition. Bit 3, in this example, is the SRQ RECEIVED bit, but the actual bit depends upon the particular computer being used (e.g., bit 2 for the HP 9826A (926), bit 3 for the HP-85A). Line 140 directs the program in the event of a true bit 3, which could occur if the power level is set too high (line 150 allows operator adjustment of the power level via the rotary [KNOB]).

Once set, several status byte bits remain latched until cleared by CS or CLEAR (or until after the status bytes are read a second time). The OS explanation describes all status byte bits.

RS Reset Sweep, causes the HP 8340B/41B to retrace to the start frequency. If a sweep is in progress when an RS code is received, the sweep will abruptly terminate and retrace. In BASIC:

```
100 OUTPUT 719; "RS"
```

SFdt Step Frequency size, sets the size of the frequency increment that can be stepped by UP or DN (equivalent to the up/down front-panel **[STEP]** keys). The SF code is equivalent to the SHCF code, and both are equivalent to the **[SHIFT] [CF]** keystroke operation (as described in Figure 3-7).

The SF step size can be as small as 1 Hz, as large as 10 GHz, or it can be coupled to the ΔF frequency span with the AU (auto) code (the coupling is explained in Figure 3-7). A BASIC example:

```
100 OUTPUT 719; "SF 1 MZ"  
110 OUTPUT 719; "CW 400 MZ"  
120   FOR N = 1 TO 200  
130   OUTPUT 719; "UP"  
140   NEXT N  
150 GOTO 110
```

This program sets the step size to 1 MHz, establishes a starting CW frequency of 400 MHz, then performs a 400-600 MHz discrete sweep.

SG Single sweep, is identical to the S2 code, and both are equivalent to the front-panel **[SINGLE]** key which is described in Figure 3-11. SG causes the HP 8340B/41B to perform single sweeps, and is used in conjunction with the TRIGGER codes (T1, T2, and T3). If trigger code T1 (**[FREE RUN]**) is in effect, the SG code (or the TS code) is output every time a single sweep is needed. If SG is output in the middle of a sweep, the sweep will abruptly terminate and retrace. A BASIC example:

```
100 OUTPUT 719; "IP SG T1"  
110 PRINT "PRESS [CONTINUE] TO START THE SWEEP"  
120 PAUSE  
130 OUTPUT 719; "SG"  
140 GOTO 120
```

SMdt Sweep Manual, is identical to the S3 code, and both are equivalent to the front-panel **[MANUAL]** key which is described in Figure 3-11. SM is used by first establishing the start and stop sweep frequencies, then outputting SM to activate manual sweep mode. A BASIC example:

```
100 OUTPUT 719; "IP FA5GZ SF1MZ FB15GZ EK SM"
```

This example sets a 5 GHz start frequency, a 1 MHz frequency step size, and a 15 GHz stop frequency. The last two codes in line 100 enable the rotary **[KNOB]** and activate manual sweep mode. In addition to **[KNOB]** control of the sweep, UP and DN can be used and would have a 1 MHz step size.

There are two significant differences between manual sweep and a stepped CW sweep:

1. The sweep voltage ramp (see Figures 3-13 and 3-18, SWEEP OUTPUT) is 0-10 volts for both modes; however, in CW mode 0 volts always corresponds to 10 MHz and 10 volts always corresponds to 26.5 GHz (in the case of the HP 8341B, 7.55v at 20.0 GHz), while in manual sweep mode 0 volts corresponds to the start frequency and 10 volts corresponds to the stop frequency. In both cases the sweep voltage at intermediate frequencies is a linear interpolation of the frequency span (i.e., a frequency half-way between the start/stop limits would have a corresponding sweep voltage of 5 volts).
2. The bandcrossing in CW mode always occur at precisely 2.4 GHz, 7.0 GHz, 13.5 GHz, and, in the case of the HP 8340B, 20.0 GHz. In manual sweep mode the bandcrossing points have 200 MHz of flexibility and could, for example, accomplish a 13.45-20.05 GHz sweep in a single band instead of the three bands required in stepped CW (8340B). The HP 8340B/41B automatically adjusts the manual sweep bandcrossing point for optimum results.

SNdt Sweep Number, is used to establish the number of steps for a stepped sweep. The minimum number of steps is 10, while the maximum number is 1000; the frequency sweep span is divided by this SN number to determine the step increment. SN initializes the stepped sweep conditions, but the IF code or the HP-IB statement TRIGGER must be used in conjunction with SN to actually initiate each frequency step. A BASIC example:

```
100 OUTPUT 719; "FA8GZ FB12GZ SN400"  
110 FOR N = 1 TO 400  
120 OUTPUT 719; "IF"  
130 NEXT N
```

This program causes a sweep that starts at 8 GHz and makes 400 steps (19 MHz increments) to the 12 GHz stop frequency. The IF code in line 120 initiates each of the 400 increments; alternatively, line 120 could be:

```
120 TRIGGER 719
```

SPdt Set Power step size, is identical to the SHPL code, and both are equivalent to the [SHIFT] [POWER LEVEL] key which is described in Figure 3-7.

The power step size can be as small as 0.05 dB, or as large as 50.00 dB. Once set, the power level can be incremented by the UP code or decremented by the DN code. Here is a BASIC example of a 120 dB, discrete power sweep at a 12 GHz CW frequency:

```
100 OUTPUT 719; "CW 12 GZ"  
110 OUTPUT 719; "SP 0.05 DB"  
120 OUTPUT 719; "PL -110 DB"  
130 FOR N = 1 TO 2400  
140 OUTPUT 719; "UP"  
150 NEXT N  
160 GOTO 120
```

The power sweep starts at -110 dBm, and increments in 2400 discrete, 0.05 dB steps to an end value of 10 dBm.

SWm SWap network analyzer channels, is used in conjunction with alternate mode and causes the foreground and background instrument states to be transposed.

Foreground refers to the present operating configuration of the HP 8340B/41B as seen on the front panel displays and indicators, while background is the configuration that is derived from one of the SAVE/RECALL registers 1-9. When the HP 8340B/41B is alternating between the foreground and background configurations only the foreground configuration shows on the front panel displays and indicators, even when the instrument is operating under background conditions. Hence, only the foreground configuration can be changed. SW transposes foreground and background, causing the background to show on the front panel where changes can be made.

Define the foreground configuration as state "B" at the moment that alternating operation begins: At any time thereafter, SW0 causes state "A" to be the front panel state, while SW1 causes state "B" to be the front panel state.

SW does not change any of the values in the SAVE/RECALL register from which the background was derived, even if the background values are changed (when alternate mode is initiated the values in the RECALL register are transferred into the background register; after this transfer, only the background register is involved in alternating operations).

T1b(b) Test HP-IB Interface, verifies correct data transmission along the HP-IB interface. The procedure involves sending a data byte to the HP 8340B/41B, then having the HP 8340B/41B return the same byte to the computer where the out-going and incoming data is compared. In BASIC:

```

100 FOR N = 0 TO 255
110 OUTPUT 719; "TI"&CHR$(N)
120 ENTER 719 USING "#,B"; A
130 IF A <>N THEN GOSUB 500
140 NEXT N
150 PRINT "TEST COMPLETED"
.
.
.
500 PRINT "TEST FAILED"
510 PRINT "TRANSMITTED";N;"RETURNED";A
520 PRINT
530 RETURN

```

The decimal numbers 0 through 255 cover all possible bit patterns for an 8-bit byte (thus thoroughly exercising all 8 HP-IB data lines), and these numbers are concatenated onto the TI code in line 110. The image items in line 120 specify that EOL should be suppressed (#), and that variable A (an arbitrary variable) should be filled with one byte of binary data (B). In line 130, a returned value that is less than or greater than (i.e., not equal to) the transmitted value signifies an HP-IB test failure.

TLdt Time Limit, constrains the minimum allowable sweep time. The full sweep-time range of the HP 8340B/41B is 10 milliseconds minimum to 200 seconds maximum (although the minimum sweep time is frequency-span dependent, and cannot exceed a sweep rate of 600 MHz / 1 millisecond). This is a non-warranted supplemental performance characteristic. Also, HP 8341B's equipped with Option 003 (Low Harmonics) has a different maximum sweep rate. Refer to the Option 003 supplement for the actual value. TL sets a limit on the minimum sweep time, with that limit ranging from 10 milliseconds to 40 seconds. For example,

```
100 OUTPUT 719; "TL15SC"
```

changes the permissible sweep-time range to 15-200 seconds. STAU is normally used to obtain the fastest possible sweep time for a given frequency span; however, AU will not override a TL restriction.

TS Take Sweep, initiates a single, non-interruptible sweep. All HP-IB commands are deferred until that sweep has been completed. If TS is output while a sweep is in progress, that sweep will abruptly stop, retrace, and begin a new, non-interruptible sweep. The HP 8340B/41B will resume the previous sweep operations at the completion of the TS initiated sweep. A BASIC example:

```

100 OUTPUT 719; "IP SG"
110 PRINT "PRESS [CONTINUE] TO START THE SWEEP"
120 PAUSE
130 DUPUT 719; "TS"
140 GOTO 120

```

This completes the listing of unique HP-IB programming codes.

SYSTEM TIMING

It is sometimes necessary to determine the time required for a sequence of programming codes to be implemented by the HP 8340B/41B. This can be accomplished by the computer's set-time and read-time commands:

```
100 set-time command (computer specific)
.
.
.
200 OUTPUT 719; "... (programming codes) ..."
.
.
.
300 C = read-time command (computer specific)
310 PRINT "TIME REQUIRED"; C
```

For example, the clock commands for the HP 9826/9836 (926/936) computers are:

```
100 SET TIME 0
.
.
.
300 Clock = TIMEDATE MOD 86400
310 PRINT "TIME REQUIRED"; Clock
```

For the HP-80 series computers the commands are:

```
100 SETTIME 0, 0
.
.
.
300 C = TIME
310 PRINT "TIME REQUIRED"; C
```

Other computers use similar commands.

HP-IB PROGRAMMING TECHNIQUES FOR SPECIAL APPLICATIONS

Although the preceding programming codes are sufficient for most applications, it is possible to program the HP 8340B/41B at a fundamental level by directly manipulating signals on the HP-IB lines. The following material presents an introductory explanation of these specialized procedures, first by briefly explaining the HP-IB signal lines, followed by the computer codes necessary for direct control of the HP-IB lines.

HP-IB PIN-OUT DESCRIPTION

Figure 3-25 shows a detailed view of the HP-IB connector, with a pin-out description. Notice that HP-IB has 16 dynamic TTL-level signal lines which can be categorized into three groups: data lines, handshake lines, and system control lines. The signal level on these lines is either TTL low (a "True" condition), TTL high (a "False" condition), or floating (electrically disconnected).

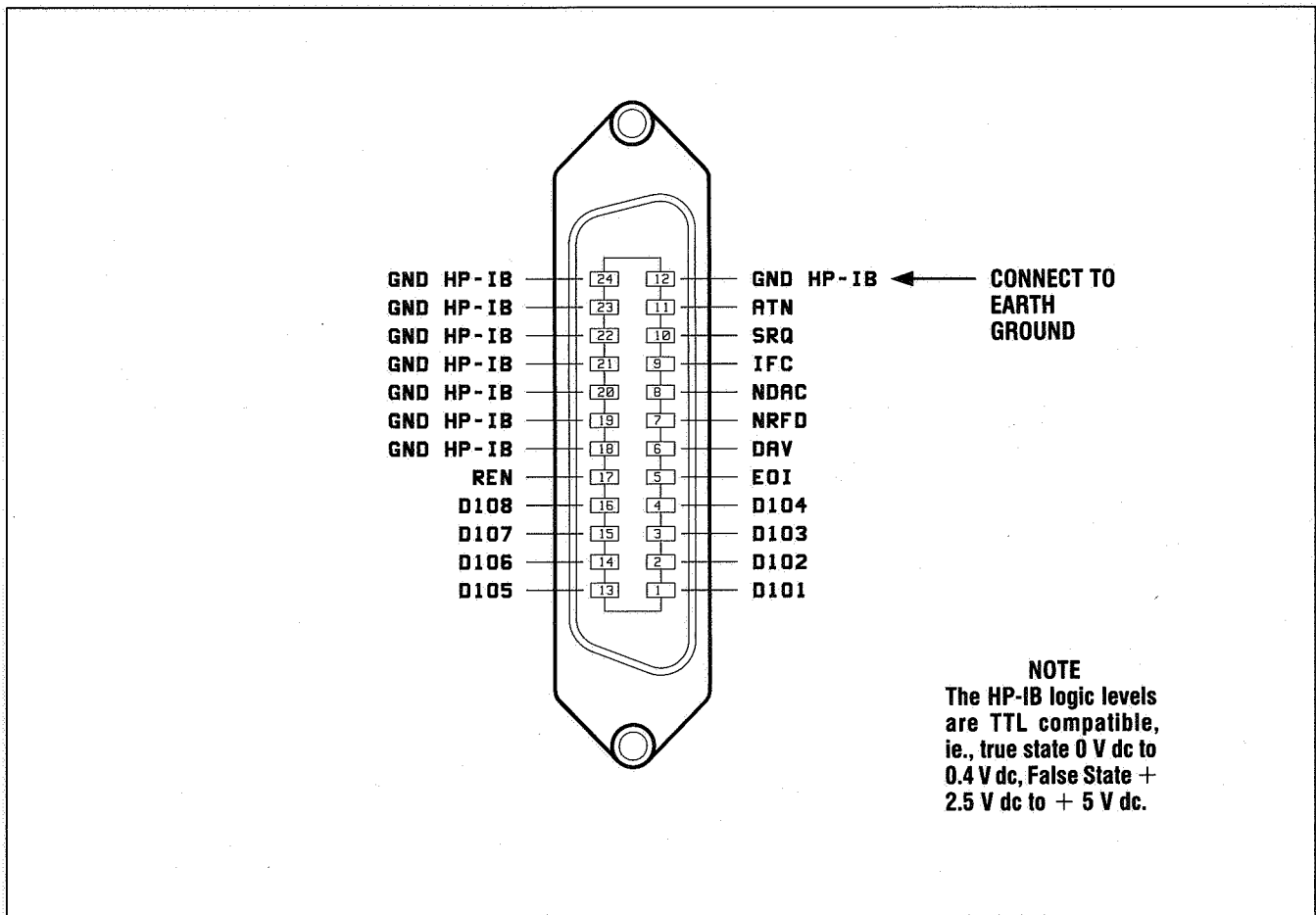


Figure 3-25. HP-IB Pin-Out

Data lines, DIO1-DIO8

These are the eight Data Input/Output lines. Data is transceived on the eight HP-IB data lines as a series of eight-bit bytes, with DIO1 being the least significant bit (LSB) and DIO8 being the most significant (MSB). The meaning of each byte is arbitrary, being different for each type of instrument. The rate of data transfer is controlled by the handshake sequence.

Handshake lines, DAV, NRFD, NDAC

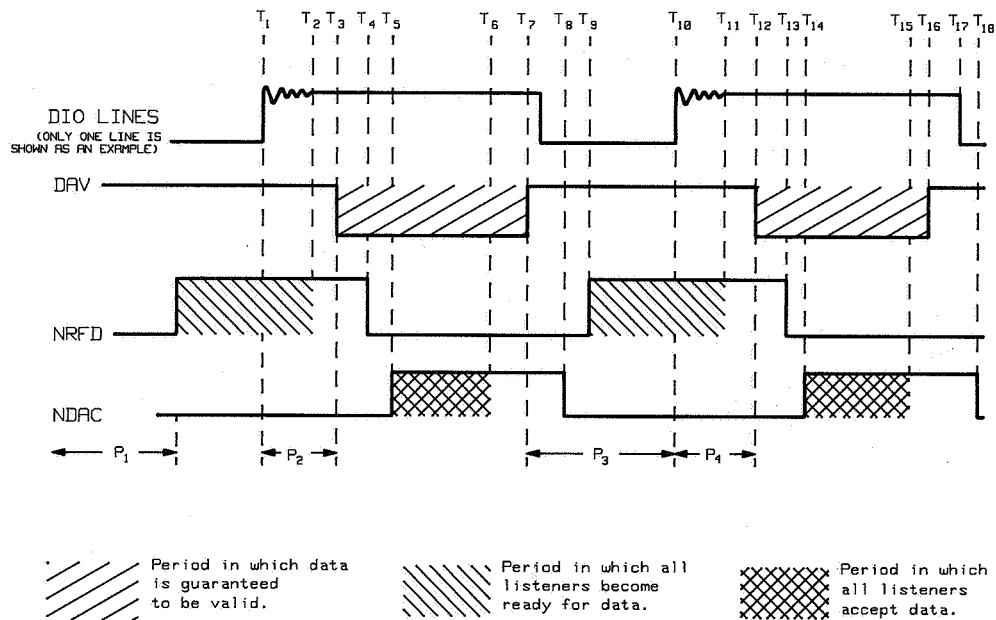
These three lines control the data transfer process.

DAV, Data Valid, line is high (False - data not valid) or low (True - data valid) to indicate the validity of the signals on the DIO lines.

NRFD, Not Ready for Data, line indicates whether the instruments receiving data are prepared to accept that data; NRFD is either low (True - the instruments are not ready for data) or high (False - the instruments are ready for data).

NDAC, Not Data Accepted, line indicates whether the data-receiving instruments have accepted the transmitted data. NDAC is either high (False - the data has been accepted) or low (True - the data has not been accepted).

Figure 3-26 illustrates a representative handshake timing sequence.



This timing diagram illustrates the handshake process by indicating the actual waveforms of the DAV, NRFD, and NDAC lines. The NRFD and NDAC signals each represent composite waveforms resulting from two or more listeners accepting the same data byte at slightly different times, which is usually caused by variations in the transmission path length and individual instrument response rates. Two cycles of the handshake sequence are shown.

The handshake process follows this typical list of events:

- P₁ Source initializes DAV to high (False — data not valid). Acceptors initialize NRFD to low (True — none are ready for data), and set NDAC low (True — none have accepted the data).
- T₁ Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines.
- P₂ Source delays to allow data to settle on DIO lines.
- T₂ Acceptors have all indicated readiness to accept first data byte; NRFD goes high.
- T₃ When the data is settled and valid, and the source has sensed NRFD high, DAV is set low.
- T₄ First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data. Other acceptors follow at their own rates.
- T₅ First acceptor sets NDAC high to indicate that it has accepted the data (NDAC remains low due to other acceptors driving NDAC low).
- T₆ Last acceptor sets NDAC high to indicate that it has accepted the data; all have now accepted and NDAC goes high.
- T₇ Source, having sensed that NDAC is high, sets DAV high. This indicates to the acceptors that data on the DIO lines must now be considered invalid. Upon completion of this step, one byte of data has been transferred.
- P₃ (T₇-T₁₀) Source changes data on the DIO lines.
- P₄ (T₁₀-T₁₂) Source delays to allow data to settle on the DIO lines.

Figure 3-26. HP-IB Handshake Timing (1 of 2)

- T₈ Acceptors, upon sensing DAV high, set NDAC low in preparation for the next cycle. NDAC goes low as the first acceptor sets it low.
- T₉ First acceptor indicates that it is ready for the next data byte by setting NRFD high (NRFD remains low due to other acceptors driving it low).
- T₁₁ Last acceptor indicates that it is ready for the next data by setting NRFD high; NRFD signal line goes high.
- T₁₂ Source, upon sensing NRFD high, sets DAV low to indicate that data on the DIO lines is settled and is valid.
- T₁₃ First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data.
- T₁₄ First acceptor sets NDAC high to indicate that it has accepted the data.
- T₁₅ Last acceptor sets NDAC high to indicate that it has accepted the data (as at T₆).
- T₁₆ Source, having sensed that NDAC is high, sets DAV high (as at T₇).
- T₁₇ Source removes data byte from the DIO signal lines after setting DAV high.
- T₁₈ Acceptors, upon sensing DAV high, set NDAC low in preparation for the next cycle. All three handshake lines return to their initialized states (as at T₁ and T₂).

Figure 3-26. HP-IB Handshake Timing (2 of 2)

System Control Lines, ATN, IFC, SRQ, REN, EOI

The remaining five lines coordinate communications between the HP-IB LISTENERS, TALKERS, and CONTROLLERS. The system control lines are used as follows:

ATN, Attention, signals Command Mode when low (True), or Data Mode when high (False). All devices must monitor ATN at all times and respond to it within 200 nanoseconds. In Command Mode, the controller is the only talker in the network, while all other devices are listening for instructions.

When a high (False) ATN signifies Data Mode, data may be transferred along the DIO lines. The meaning of each data byte is device dependent, and selected by the instrument designer.

IFC, Interface Clear, when low (True) abruptly terminates all HP-IB communications activity: All talkers and listeners are "unaddressed," and along with the controllers go to an inactive HP-IB state (the instruments' local functions are not impaired). All devices must monitor IFC at all times and respond to it within 100 μ sec.

SRQ, Service Request, line is set low (True) by any instrument that needs service from the controller. An SRQ could result, for example, when an instrument is ready to transmit data upon the completion of a measurement, or from an error condition. When the controller detects an SRQ it performs a serial poll of all devices to determine which requested service, and why (polling is explained in the System Commands). The controller can mask the SRQ to prevent any inconvenient interruptions (as explained in the RE/RM programming codes). The HP 8340B/41B lights a red SRQ annunciator in the ENTRY DISPLAY when it initiates an SRQ.

REN, Remote Enable, when low (True) enables HP-IB instruments to respond to commands from the controller or other talkers, when high (False) all devices return to local operation. The HP 8340B/41B lights an amber REMOTE annunciator in the ENTRY DISPLAY when REN is true, and disables front panel control of the instrument (with three exceptions: the POWER switch can only be controlled locally, the **[LOCAL]** key re-enables front panel control unless locked-out by the controller, and the rotary **[KNOB]** can be re-enabled by an EK command from the controller). All devices must constantly monitor REN and respond to it within 100 μ sec.

EOI, End or Identify, is used in conjunction with ATN: When ATN is high (False) EOI goes low (True) to indicate the end of a data transmission sequence; when ATN is low (True) and EOI is low (True) a parallel poll of the HP-IB instruments is performed (the HP 8340B/41B does not respond to parallel polling).

Typically, HP-IB data messages are sent as ASCII characters and are terminated with an ASCII "LF" (line feed, decimal 10). However, when blocks of binary information are being sent LF cannot safely be used as a terminator because the LF bit pattern could unintentionally occur in the middle of a data sequence. To prevent a false termination, the EOI line is used to signify the true end of a data sequence (alternatively, a byte-counting method that explicitly defines the number of expected data bytes may be used).

THE TWELVE HP-IB MESSAGES

The HP-IB control, handshake, and data lines interact to transfer information between interconnected instruments. This information transfer process can be organized into 12 distinct categories which are, by convention, referred to as bus messages. These messages will be explained using the following HP-IB mnemonics:

- ATN Attention HP-IB line TRUE, indicating Command operating mode.
- ATN Attention line FALSE, indicating DATA transfer mode.
- CA Controller active state.
- CR Carriage Return ASCII decimal 13.
- data One or more ASCII data bytes (the HP 8340B/41B accepts lower-case ASCII characters, which it automatically upshifts).
- DCL Device Clear, returns all instruments (addressed or not addressed) to an instrument-defined state; DCL is accomplished by ASCII "DC4" (decimal 20).
- GET Group Execute Trigger, initiates a simultaneous instrument-defined response from all instruments; accomplished by ASCII "BS" (decimal 8).
- GTL Go To Local, returns instruments to local (front panel) control; accomplished by ASCII "SOH" (decimal 1).
- LA Listener active state.
- LAD Listen Address of a specific Device (see LAG).
- LAG Listen Address Group (listen addresses of specified instruments). An HP-IB instrument may have any unique address in the range 00-30 (decimal). The distinction between a listen address and a talk address is made in bits 5 and 6; using address 19 as an example:
- | | | | | | | | | |
|--------|---|---|---|---|---|---|---|---|
| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| TALK | X | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| LISTEN | X | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
- The corresponding ASCII codes for the available HP-IB addresses are listed in Table 3-3.
- LF Line Feed, ASCII decimal 10.

- LLO Local Lockout disables the instruments [**LOCAL**]-reset key; LLO is accomplished by ASCII "DCI" (decimal 17).
- MLA My Listen Address (listen address of the controller).
- MTA My Talk Address (talk address of the controller).
- PPC Parallel Poll Configure (not used by the HP 8340B/41B).
- PPU Parallel Poll Unconfigure (not used by the HP 8340B/41B).
- SC System controller.
- SCG Secondary command group (also abbreviated SEC).
- SDC Selected Device Clear, causes addressed instruments to clear to an instrument-defined state; accomplished by ASCII "EOT" (decimal 4).
- SPD Serial Poll Disable, accomplished by ASCII "EM" (decimal 25).
- SPE Serial Poll Enable, accomplished by ASCII "CAN" (decimal 24). A serial polled instrument responds with a byte of information, with each bit corresponding to a specific instrument function.
- TA Talker active state.
- TAD Talk Address of a specified device (see LAG for related information).
- TCT Take Control, transfers active controller responsibility to another instrument; accomplished by ASCII "HT" (decimal 9).
- UNL Unlisten, clears bus of all listeners in preparation for assigning new listeners; accomplished by ASCII "?" (decimal 63).
- UNT Untalk, unaddresses the current talker so that no talker remains on the bus; accomplished by ASCII "_" (underscore, decimal 95).

These are the 12 bus messages (refer also to the HP-IB Command Statements that have the same names as these messages):

DATA represents the actual transfer of numerical information between instruments. The previous BASIC examples used OUTPUT and ENTER for data messages; the HP-IB bus sequence for a typical OUTPUT statement is:

ATN MTA UNL LAG $\overline{\text{ATN}}$ (ASCII data) CR LF

The HP-IB sequence for a typical ENTER statement:

ATN UNL MLA TAG $\overline{\text{ATN}}$ (ASCII data) CR LF

TRIGGER causes the listening instruments to perform in instrument-defined function, such as starting a sweep. A typical HP-IB sequence:

ATN UNL LAG GET (REN line must be True before executing GET)

CLEAR causes the listening instruments to establish an instrument-specific predefined state. The HP-IB sequence:

ATN DCL (for all bus instruments)

ATN UNL LAD SDC (for an addressed instrument)

REMOTE causes listening instruments to switch from local (front panel) control to remote program control. The HP-IB sequence:

REN ATN UNL LAG

LOCAL clears the REMOTE message and causes the listening instruments to return to local control. The HP-IB sequence:

ATN UNL LAG REN GTL

LOCAL LOCKOUT prevents an instrument over-ride of remote control. The front panel [LOCAL] key is inoperative, and only the controller (or a hard reset by the POWER switch) can restore local control. The sequence:

REN ATN LLO

CLEAR LOCKOUT/ LOCAL causes all instruments on the bus to be removed from local lockout and to return to local control. The HP-IB sequence:

REN

REQUIRE SERVICE (SRQ) can be sent by an instrument at any time to signify that attention is required from the controller. The HP-IB sequence:

SRQ

The SRQ is held true until the instrument no longer needs service, or until a poll is conducted to determine the nature of the SRQ.

STATUS BYTE is an 8-bit byte of information from an addressed instrument, with each bit signifying the status of a specific instrument. The HP-IB sequence:

ATN UNL LAD SPE ATN (data byte) CR LF ATN SPD

STATUS BIT is a parallel poll of the bus instruments. The HP 8340B/41B does not respond to parallel polling.

PASS CONTROL transfers active control of the bus from one controller to another. The HP-IB sequence:

ATN UNL TAD TCT

ABORT terminates all bus transactions, and causes all instruments to listen for a command from the controller. The HP-IB sequence:

IFC REN ATN

This completes the 12 HP-IB messages.

Table 3-3. The Standard ASCII Code (1 of 3)

ASCII	HP-IB DIO LINES 8 7 6 5 4 3 2 1	Octal	Decimal	Hexadecimal	HP-IB
NUL	X0000000	000	000	00	
SOH	X0000001	001	001	01	GTL
STX	X0000010	002	002	02	
ETX	X0000011	003	003	03	
EOT	X0000100	004	004	04	SDC
ENQ	X0000101	005	005	05	PPC
ACK	X0000110	006	006	06	
BEL	X0000111	007	007	07	
BS	X0001000	010	008	08	GET
HT	X0001001	011	009	09	TCT
LF	X0001010	012	010	0A	
VT	X0001011	013	011	0B	
FF	X0001100	014	012	0C	
CR	X0001101	015	013	0D	
S0	X0001110	016	014	0E	
SI	X0001111	017	015	0F	
DLE	X0010000	020	016	10	
DC1	X0010001	021	017	11	LLO
DC2	X0010010	022	018	12	
DC3	X0010011	023	019	13	
DC4	X0010100	024	020	14	DCL
NAK	X0010101	025	021	15	PPU
SYN	X0010110	026	022	16	
ETB	X0010111	027	023	17	
CAN	X0011000	030	024	18	SPE
EM	X0011001	031	025	19	SPD
SUB	X0011010	032	026	1A	
ESC	X0011011	033	027	1B	
FS	X0011100	034	028	1C	
GS	X0011101	035	029	1D	
RS	X0011110	036	030	1E	
US	X0011111	037	031	1F	
space	X0100000	040	032	20	LA0
!	X0100001	041	033	21	LA1
"	X01000010	042	034	22	LA2
#	X01000011	043	035	23	LA3
\$	X01000100	044	036	24	LA4
%	X01000101	045	037	25	LA5
&	X01000110	046	038	26	LA6
'	X01000111	047	039	27	LA7
(	X01010000	050	040	28	LA8
)	X01010001	051	041	29	LA9
*	X01010010	052	042	2A	LA10
+	X01010011	053	043	2B	LA11
,	X01010100	054	044	2C	LA12
-	X01010101	055	045	2D	LA13
.	X01010110	056	046	2E	LA14
/	X01010111	057	047	2F	LA15
0	X01100000	060	048	30	LA16
1	X01100001	061	049	31	LA17
2	X01100010	062	050	32	LA18
3	X01100011	063	051	33	LA19
4	X01101000	064	052	34	LA20
5	X01101001	065	053	35	LA21
6	X01101010	066	054	36	LA22
7	X01101011	067	055	37	LA23
8	X01110000	070	056	38	LA24
9	X01110001	071	057	39	LA25
:	X01110010	072	058	3A	LA26

Table 3-3. The Standard ASCII Code (2 of 3)

ASCII	HP-IB DIO LINES 8 7 6 5 4 3 2 1	Octal	Decimal	Hexadecimal	HP-IB
:	X 0 1 1 1 0 1 1	073	059	3B	LA27
^	X 0 1 1 1 1 0 0	074	060	3C	LA28
=	X 0 1 1 1 1 0 1	075	061	3D	LA29
>	X 0 1 1 1 1 1 0	076	062	3E	LA30
?	X 0 1 1 1 1 1 1	077	063	3F	UNL
@	X 1 0 0 0 0 0 0	100	064	40	TA0
A	X 1 0 0 0 0 0 1	101	065	41	TA1
B	X 1 0 0 0 0 1 0	102	066	42	TA2
C	X 1 0 0 0 0 1 1	103	067	43	TA3
D	X 1 0 0 0 1 0 0	104	068	44	TA4
E	X 1 0 0 0 1 0 1	105	069	45	TA5
F	X 1 0 0 0 1 1 0	106	070	46	TA6
G	X 1 0 0 0 1 1 1	107	071	47	TA7
H	X 1 0 0 1 0 0 0	110	072	48	TA8
I	X 1 0 0 1 0 0 1	111	073	49	TA9
J	X 1 0 0 1 0 1 0	112	074	4A	TA10
K	X 1 0 0 1 0 1 1	113	075	4B	TA11
L	X 1 0 0 1 1 0 0	114	076	4C	TA12
M	X 1 0 0 1 1 0 1	115	077	4D	TA13
N	X 1 0 0 1 1 1 0	116	078	4E	TA14
O	X 1 0 0 1 1 1 1	117	079	4F	TA15
P	X 1 0 1 0 0 0 0	120	080	50	TA16
Q	X 1 0 1 0 0 0 1	121	081	51	TA17
R	X 1 0 1 0 0 1 0	122	082	52	TA18
S	X 1 0 1 0 0 1 1	123	083	53	TA19
T	X 1 0 1 0 1 0 0	124	084	54	TA20
U	X 1 0 1 0 1 0 1	125	085	55	TA21
V	X 1 0 1 0 1 1 0	126	086	56	TA22
W	X 1 0 1 0 1 1 1	127	087	57	TA23
X	X 1 0 1 1 0 0 0	130	088	58	TA24
Y	X 1 0 1 1 0 0 1	131	089	59	TA25
Z	X 1 0 1 1 0 1 0	132	090	5A	TA26
[	X 1 0 1 1 0 1 1	133	091	5B	TA27
\	X 1 0 1 1 1 0 0	134	092	5C	TA28
]	X 1 0 1 1 1 0 1	135	093	5D	TA29
^	X 1 0 1 1 1 1 0	136	094	5E	TA30
_	X 1 0 1 1 1 1 1	137	095	5F	UNT
.	X 1 1 0 0 0 0 0	140	096	60	SC0
a	X 1 1 0 0 0 0 1	141	097	61	SC1
b	X 1 1 0 0 0 1 0	142	098	62	SC2
c	X 1 1 0 0 0 1 1	143	099	63	SC3
d	X 1 1 0 0 1 0 0	144	100	64	SC4
e	X 1 1 0 0 1 0 1	145	101	65	SC5
f	X 1 1 0 0 1 1 0	146	102	66	SC6
g	X 1 1 0 0 1 1 1	147	103	67	SC7
h	X 1 1 0 1 0 0 0	150	104	68	SC8
i	X 1 1 0 1 0 0 1	151	105	69	SC9
j	X 1 1 0 1 0 1 0	152	106	6A	SC10
k	X 1 1 0 1 0 1 1	153	107	6B	SC11
l	X 1 1 0 1 1 0 0	154	108	6C	SC12
m	X 1 1 0 1 1 0 1	155	109	6D	SC13
n	X 1 1 0 1 1 1 0	156	110	6E	SC14
o	X 1 1 0 1 1 1 1	157	111	6F	SC15
p	X 1 1 1 0 0 0 0	160	112	70	SC16
q	X 1 1 1 0 0 0 1	161	113	71	SC17
r	X 1 1 1 0 0 1 0	162	114	72	SC18
s	X 1 1 1 0 0 1 1	163	115	73	SC19
t	X 1 1 1 0 1 0 0	164	116	74	SC20

Table 3-3. The Standard ASCII Code (3 of 3)

ASCII	HP-IB DIO LINES 8 7 6 5 4 3 2 1	Octal	Decimal	Hexadecimal	HP-IB
u	X 1 1 1 0 1 0 1	165	117	75	SC21
v	X 1 1 1 0 1 1 0	166	118	76	SC22
w	X 1 1 1 0 1 1 1	167	119	77	SC23
x	X 1 1 1 1 0 0 0	170	120	78	SC24
y	X 1 1 1 1 0 0 1	171	121	79	SC25
z	X 1 1 1 1 0 1 0	172	122	7A	SC26
{	X 1 1 1 1 0 1 1	173	123	7B	SC27
|	X 1 1 1 1 1 0 0	174	124	7C	SC28
}	X 1 1 1 1 1 0 1	175	125	7D	SC29
~	X 1 1 1 1 1 1 0	176	126	7E	SC30
DEL	X 1 1 1 1 1 1 1	177	127	7F	SC31

ASCII Abbreviations

NUL	null	VT	vertical tab	SYN	synchronous idle
SOH	start of heading	FF	form feed	ETB	end transmission block
STX	start text	CR	carriage return	CAN	cancel
ETX	end text	SO	shift out	EM	end of medium
EOT	end of transmission	SI	shift in	SUB	substitute
ENQ	enquiry	DLE	data link escape	ESC	escape
ACK	acknowledge	DC1	direct control 1	FS	form separator
BEL	bell	DC2	direct control 2	GS	group separator
BS	backspace	DC3	direct control 3	RS	record separator
HT	horizontal tab	DC4	direct control 4	US	unit separator
LF	line feed	NAK	negative acknowledge	DEL	delete

HP-IB Abbreviations

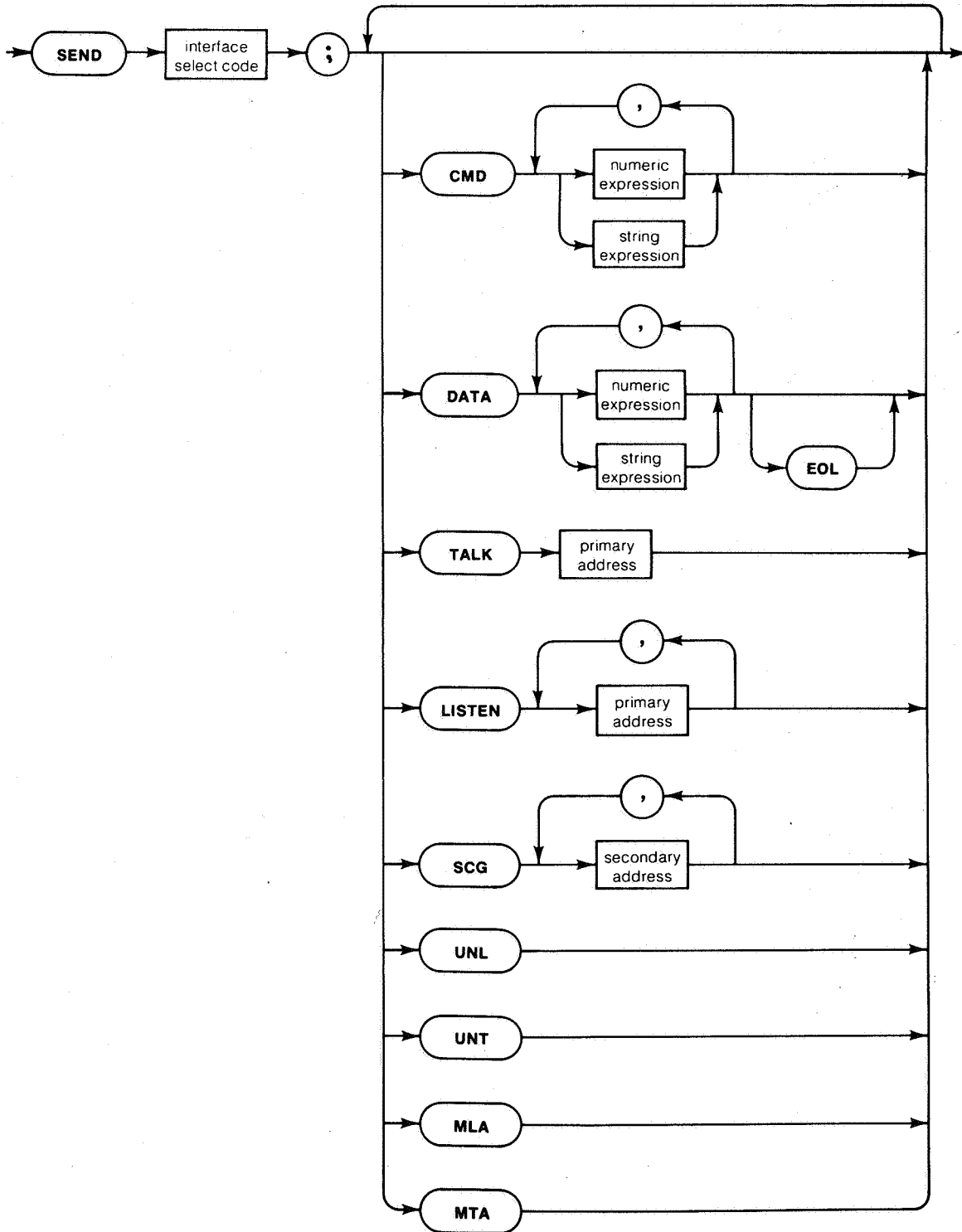
GTL	go to local	LLO	local lockout	LAO-30	listen address
SDC	selected device clear	DCL	device clear	UNL	unlisten
PPC	parallel poll configure	PPU	parallel poll unconfigure	TAO-30	talk address
GET	group execute trigger	SPE	serial poll enable	UNT	untalk
TCT	take control	SPD	serial poll disable	SCO-31	secondary command

COMPUTER ACCESS OF HP-IB LINES

The I/O Programming Guide for the specific computer being used must be consulted for detailed information about direct access to the HP-IB lines; however, the intent of the following discussion is to introduce the fundamental procedures involved in this type of programming. After this introduction, the programmer will know what specific information to look for in the computer's I/O Programming Guide.

Sending HP-IB Messages

The BASIC statement used to transmit information directly to the HP-IB lines is the SEND statement, which has this syntax:



The secondary command DATA sets the ATN line False; all other secondary commands (CMD, TALK, LISTEN, UNL, MLA, and MTA) set ATN True. Information accompanying the SEND statement can be either ASCII encoded characters that correspond to the HP-IB functions (see Table 3-3), or computer-recognized mnemonics. For example, to read the status bytes from the HP 8340B/41B, the HP-IB sequence is:

UNL MLA (the computer's) TAD (HP 8340B/41B's) SPE (data bytes) SPD UNT

This sequence is accomplished, in BASIC, by using either computer-recognized mnemonics:

```
100 SEND 7; UNL MLA TALK 19 CMD 24
110 ENTER 7 USING "#,B";S
120 SEND 7; CMD 25 UNT
```

where CMB 24 is SPE, and CMD 25 is SPD; or the same sequence can be accomplished using ASCII encoded HP-IB information:

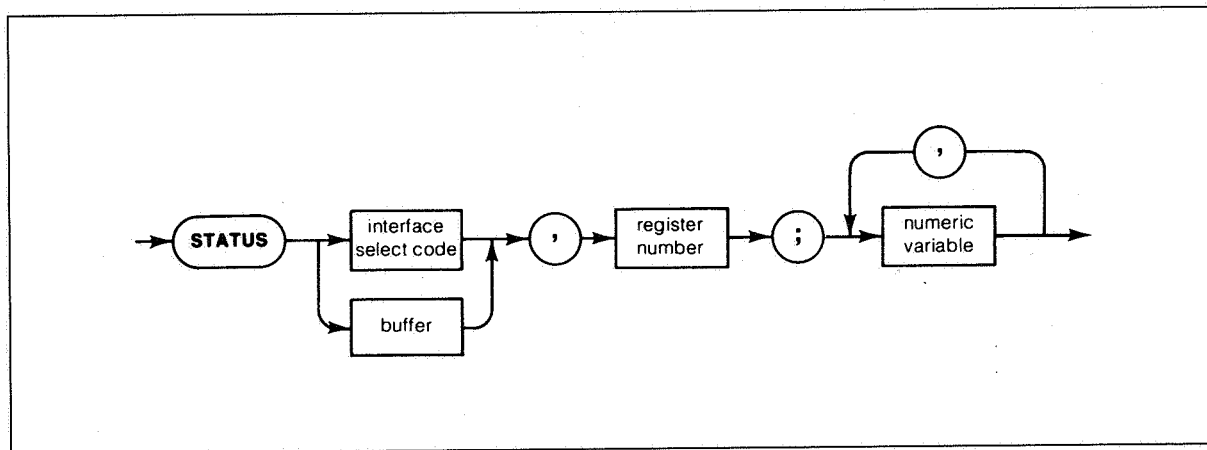
```
100 SEND 7; CMD "?5S"&CHR$(24)
110 ENTER 7 USING "#,B";S
120 SEND 7; CMD CHR$(25)&" _"
```

In line 100, ? is the ASCII code for UNL, 5 is a representative MLA, and S is TA19. In line 120, " _" (underscore) is the ASCII code for UNT. In both examples the ATN line is set True or False by the computer, depending on the context of the mnemonics, and does not require any specific commands.

(This is an illustrative example only; status bytes can be more easily read using a simple OUTPUT "OS" statement.)

Reading HP-IB Messages

The HP-IB lines are read by examining the computer's status registers, using the STATUS statement. The STATUS statement has this syntax:



The function assignment of each status register is computer specific. Figure 3-27 shows representative status register assignments, from the HP 9826 and HP-85A computers.

HP 9826/9836 (926/936) Status Register 7

Most Significant Bit

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
ATN True	DAV True	NDAC* True	NRFD* True	EOI True	SRQ** True	IFC True	REN True
Value = 32 768	Value = 16 384	Value = 8 192	Value = 4 096	Value = 2 048	Value = 1 024	Value = 512	Value = 256

Least Significant Bit

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1
Value = 128	Value = 64	Value = 32	Value = 16	Value = 8	Value = 4	Value = 2	Value = 1

*Only if addressed to TALK, else not valid.
 **Only if Active Controller, else not valid.

HP 85A HP-IB Status Registers

Status Register Number	Bit Number								Default Value	Register Function
	7	6	5	4	3	2	1	0		
SR0	0	0	0	0	0	0	0	1	1	Interface Identification
SR1	IFC	LA	CA	TA	SRQ	DCL or SDC	GET	SCG	0	Interrupt Cause
SR2	0	REN	SRQ	ATN	EOI	DAV	NDAC	NRFD	64	HP-IB Control Lines
SR3	DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1	Not Applicable	HP-IB Data Lines
SR4	0	0	SC	A4	A3	A2	A1	A0	53	HP-IB Address/ System Controller
SR5	SC	LA	CA	TA	SPE	Parity Error	REN	LLO	160	State Register
SR6	0	0	0	SC5	SC4	SC3	SC2	SC1	0	Secondary Commands

Figure 3-27. Representative Status Registers

Here is a BASIC example of reading the status registers:

```

100 FOR N = 0 TO 6
110 STATUS 7,N; S
120 PRINT "STATUS REGISTER"; N
130 PRINT
140   FOR J = 0 TO 7
150     PRINT "BIT"; J; "="; BIT; (S,J)
160   NEXT J
170 PRINT
180 NEXT N

```

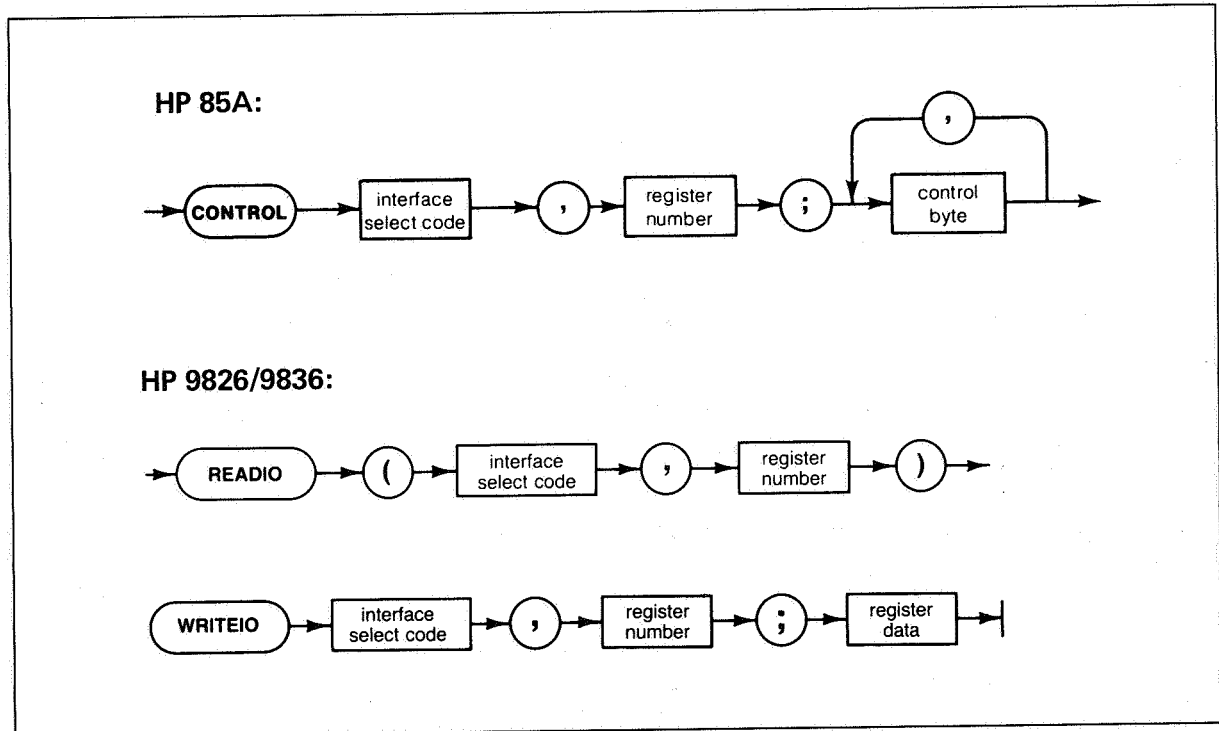
Direct Writing to the HP-IB Lines

The final programming technique covered in this manual involves direct writing to the HP-IB data, handshake, and control lines. This is very advanced programming, and should be attempted only by experienced programmers who are thoroughly familiar with the HP 8340B/41B and HP-IB protocols.



Bus malfunctions or damage can result from errant applications of direct writing to HP-IB lines.

Direct writing to the HP-IB lines is accomplished by the CONTROL statement, which has this syntax:



The CONTROL statement (ASSERT, READIO/WRITEIO are related statements used by some computers) is used to send information to the computer's control registers, which have bit patterns that correspond to the HP-IB lines. The bit pattern of the control registers is computer specific; Figure 3-28 shows representative control registers from the HP 9826 and HP-85A computers.

HP 85A HP-IB Control Registers

Register Number	Bit Number								Default Value	Register Function
	7	6	5	4	3	2	1	0		
CR0	X	X	X	X	Odd	Even	Always One	Always Zero	0	Parity Control
CR1	IFC	LA	CA	TA	SRQ	DCL or SDC	GET	SCG	0	Interrupt Mask
CR2	X	REN	SRQ	ATN	EOI	DAV	NDAC	NRFD	Not Applicable	HP-IB Control Control Lines
CR3	DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1	Not Applicable	HP-IB Data Lines

HP 9826/9836 (926/936) HP-IB READIO Register 23

Control-Line Status

Most Significant Bit

Least Significant Bit

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ATN True	DAV True	NDAC* True	NRFD* True	EOI True	SRQ** True	IFC True	REN True
Value = 128	Value = 64	Value = 32	Value = 16	Value = 8	Value = 4	Value = 2	Value = 1

*Only if addressed to TALK, else not valid.

**Only if Active Controller, else not valid.

HP 9826/9836 (926/936) HP-IB READIO Register 31

Bus Data Lines

Most Significant Bit

Least Significant Bit

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1
Value = 128	Value = 64	Value = 32	Value = 16	Value = 8	Value = 4	Value = 2	Value = 1

HP 9826/9836 (926/936) HP-IB WRITEIO Register 31

Data-Out Register

Most Significant Bit

Least Significant Bit

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1
Value = 128	Value = 64	Value = 32	Value = 16	Value = 8	Value = 4	Value = 2	Value = 1

Figure 3-28. Representative Control Registers

The bits in the control registers are set using this statement:

CONTROL 7, (register number); (decimal value of True bits)

To set the bits (and the corresponding HP-IB lines True (=1), use their corresponding decimal values:

BIT	7	6	5	4	3	2	1	0
DECIMAL	128	64	32	16	8	4	2	1

For example,

100 CONTROL 7, 2; 16

sets bit 4 (decimal 16) of control register 2 True, while all other bits in that register are set False. As another example,

100 CONTROL 7, 3; 63

sets bits 0-5 True (decimal $1+2+4+8+16+32 = 63$) and bits 6-7 False.

This completes the HP-IB programming information.

USING THE 8340B/41B POWER CONTROL AND MODULATION SYSTEMS.

The preceding explanations of the power control and modulation functions are sufficient for the majority of applications; however, to extract the utmost performance from this instrument the following special information might be helpful.

INTERNAL LEVELING

The RF Output is controlled by the automatic level control (ALC) circuit, otherwise referred to as the leveling loop. Figure 3-29 shows a simplified diagram of this system. The leveling loop is a feedback control system, in which the output power is measured and compared to the desired level. If the two are not equal the loop changes the output until they are equal.

The two inputs labeled "ALC INPUTS" convey the desired power level. One of these is a voltage derived from the power value shown in the ENTRY DISPLAY. In the absence of modulation this voltage is used to set the output power level. The amplitude modulation (AM) input causes the output to increase or decrease relative to this level. (The pulse modulation input is essentially an ON/OFF switch, not an ALC input.)

The RF power level from the level control circuits is referred to as the "ALC level," and is measured by a crystal detector. The DC output from this detector is fed back to the level control circuits for comparison with the ALC inputs. Since crystal detectors lose sensitivity at low power levels, the detector provides an accurate power indication for ALC levels down to -10 dBm, and is acceptable (± 1 dB) down to -20 dBm. The maximum amount of power available from the level control circuits varies with RF frequency, from $+1$ dBm specified at 26.5 GHz (HP 8340B only) to typically $+21$ dBm at 4.5 GHz; therefore, the level control circuits can provide continuous control of ALC levels over a maximum span of approximately -20 dBm to $+20$ dBm.

Coupled Mode

Since many applications require power levels less than -20 dBm, a step attenuator¹ is provided that has a range of 0 to -90 dB in 10 dB steps. Thus, power levels down to -110 dBm is achieved when the attenuator and ALC work in conjunction. Because of the attenuator, the ALC will normally be used over only a portion of its 40 dB range: Since accuracy suffers below -10 dBm and at some (HP 8340B) frequencies only $+1$ dBm is available, the ALC is normally set between -10 and 0 dBm. To get power less than -100 dBm, the attenuator is left at -90 dB, and the ALC used from -10 to -20 dBm; however, the ALC accuracy and noise performance is degraded at this level, and is the reason that some specifications apply only down to -100 dBm. At frequencies where power levels above 0 dBm are desired, the attenuator is left a 0 dB and the ALC used from 0 to $+20$ dBm (or whatever power is available at the RF frequency in use). The proper combination of ALC and attenuator is decided by the internal microprocessor: the user need only set the desired power in the ENTRY DISPLAY via the [POWER] key.

¹ HP 8340B's equipped with Options 001 or 005 are not supplied with the step attenuator.

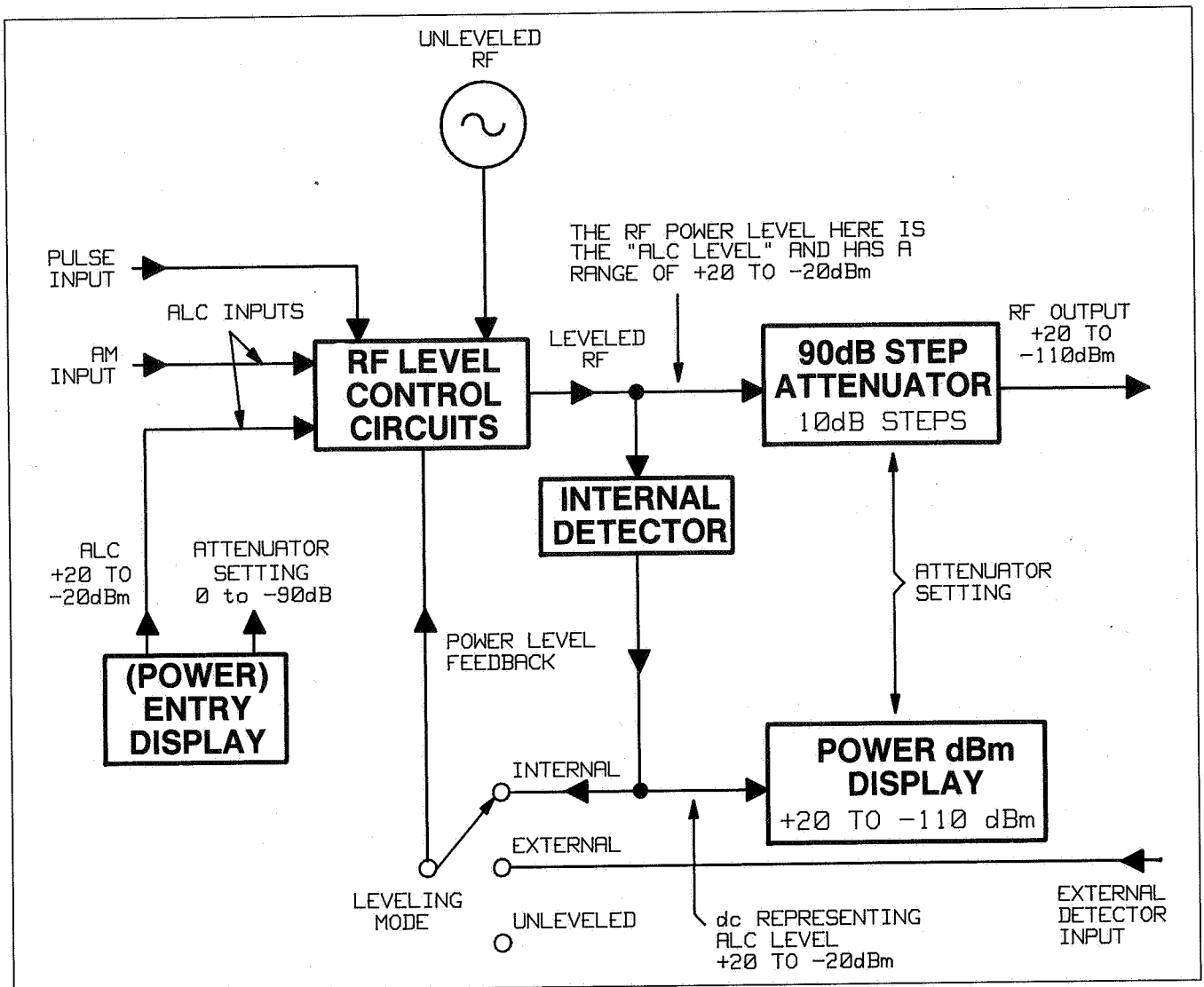


Figure 3-29. ALC Loop Block Diagram

POWER dBm Display

If the requested power is greater than can be provided, the level control loop will provide maximum available power and light the UNLEVELED annunciator. When unlevelled, the output power does not equal the value shown in the ENTRY DISPLAY. The internal detector is monitoring the actual power, however, and its output voltage controls the POWER dBm display. The detector voltage is interpreted to give ALC level, and the attenuator setting is subtracted to yield actual output power, even when unlevelled.

The AM input is DC coupled, and a DC input will change the output power. This change does not appear in the ENTRY DISPLAY, but the POWER dBm display accurately indicates the real output.

When the instrument is internally levelled, the UNLEVELED annunciator is off, and AM is off, the POWER dBm display simply repeats the value shown in the ENTRY DISPLAY. When externally levelled, or the UNLEVELED annunciator is on, or AM is on, the POWER dBm display indicates the ALC level and reflects the true output power. This might not agree with the ENTRY DISPLAY value, which shows the desired level in the absence of modulation.

The above should be understood when using power sweep. When the POWER dBm display is repeating the ENTRY DISPLAY, it indicates start power. If the POWER dBm display is indicating ALC level, it shows the average power over the sweep. (The circuit is heavily filtered above 5 Hz.) Since the start and stop dwell times are unequal, this average reading has little meaning.

In a variety of situations it is possible to drive the ALC level below -20 dBm, such as putting DC into the AM input, or when externally leveled. Since the internal detector is inaccurate at these levels, the POWER dBm display would be very misleading. For that reason, and as a warning, the POWER dBm display blanks at ALC levels below -22.0 dBm. This may occur at an output power of -22 dBm, -32 dBm, -42 dBm, etc., depending on the attenuator setting.

Decoupled Mode

In some applications it is advantageous to control the ALC and attenuator separately, achieving combinations of settings which are not available in the coupled mode. Press **[SHIFT] [PWR SWP]** to achieve decoupled mode, which causes "ATTN: _____ dB, ALC: _____ dBm" to show in the ENTRY DISPLAY. The ALC setting is entered via keypad or **[KNOB]**, while the attenuator is incremented with the **[STEP]** keys. As before, the POWER dB display indicates the true, composite output power. (Note: If an entry is made in decoupled mode, and subsequently **[POWER LEVEL]** is pressed, the HP 8340B/41B reverts to coupled mode. It will set itself to the same power level, but the attenuator and ALC settings may be different.)

One use of decoupled operation is power sweep, where the output power linearly tracks the sweep voltage ramp. The HP 8340B/41B can generate power sweeps of up to 40 dB, depending on frequency. The power at the start of the sweep is set via **[POWER LEVEL]** (coupled operation) or **[SHIFT] [PWR SWP]** (decoupled operation), and the sweep range (the amount the power increases during the sweep) is entered by pressing **[PWR SWP]** followed by the desired dB sweep value. If the sweep range entered exceeds the ALC range (stop power greater than maximum available power) the UNLEVELED annunciator will light at the end of sweep. No warning is given at the time of entry. If the start power is entered via the **[POWER LEVEL]** key, the ALC is set no lower than -10 dBm, limiting available power sweep range to 30 dB at 4.5 GHz, or 11 dB at 26.5 GHz (HP 8340B). Using decoupled mode and setting the ALC to -20 dBm gives an additional 10 dB of sweep range (although at -20 dBm, start power uncertainty is degraded by ± 1 dB).

Decoupled mode is also useful when working with mixers. Figure 3-30A shows a hypothetical setup where a HP 8340B/41B is providing the small signal to a mixer. The HP 8340B/41B output is -8 dBm, which in coupled mode results in ALC = -8 dBm, ATTN = 0 dB. The mixer is driven with an LO of $+10$ dBm, and has LO to RF isolation of 15 dB. The resulting LO feedthrough of -5 dBm enters the HP 8340B/41B's OUTPUT port, goes through the attenuator with no loss, and arrives at the internal detector. Depending on frequency, it is possible for most of this energy to enter the detector. Since the detector responds to its total input power regardless of frequency, this excess energy causes the leveling circuit to reduce its output. In this example the reverse power is actually larger than the ALC level, which may result in the HP 8340B/41B output being shut off.

Figure 3-30B shows the same setup, with decoupled mode used to give a -8 dBm output: ALC = $+2$ dBm, ATTN = -10 dB. The ALC is 10 dB higher, and the attenuator reduces the LO feedthrough by 10 dB. Thus the detector sees $+2$ dBm desired signal versus a possible -15 dBm undesired one. This 17 dB difference results in a maximum 0.1 dB shift in the HP 8340B/41B output level.

Reverse power is a problem with spectrum analyzers that do not have preselection capability. Some analyzers have as much as $+5$ dBm LO feedthrough coming out of their RF input, at some frequencies. The effects of reverse power are less in the heterodyne band (.01 to 2.3 GHz) where the power amplifier provides some broadband matching. Similarly, from 2.3 to 26.5 GHz, reverse power that is within 10 MHz of the HP 8340B/41B's frequency may be partially absorbed by the YIG filter. If the frequency difference is small enough to be within the leveling loop bandwidth (typically 10 kHz CW, 200 kHz sweep or AM), the effect of reverse power is amplitude modulation of the HP 8340B/41B's output. The AM rate equals the difference in RF frequencies. Reverse power problems may be treated by using the unlevelled mode, as described below.

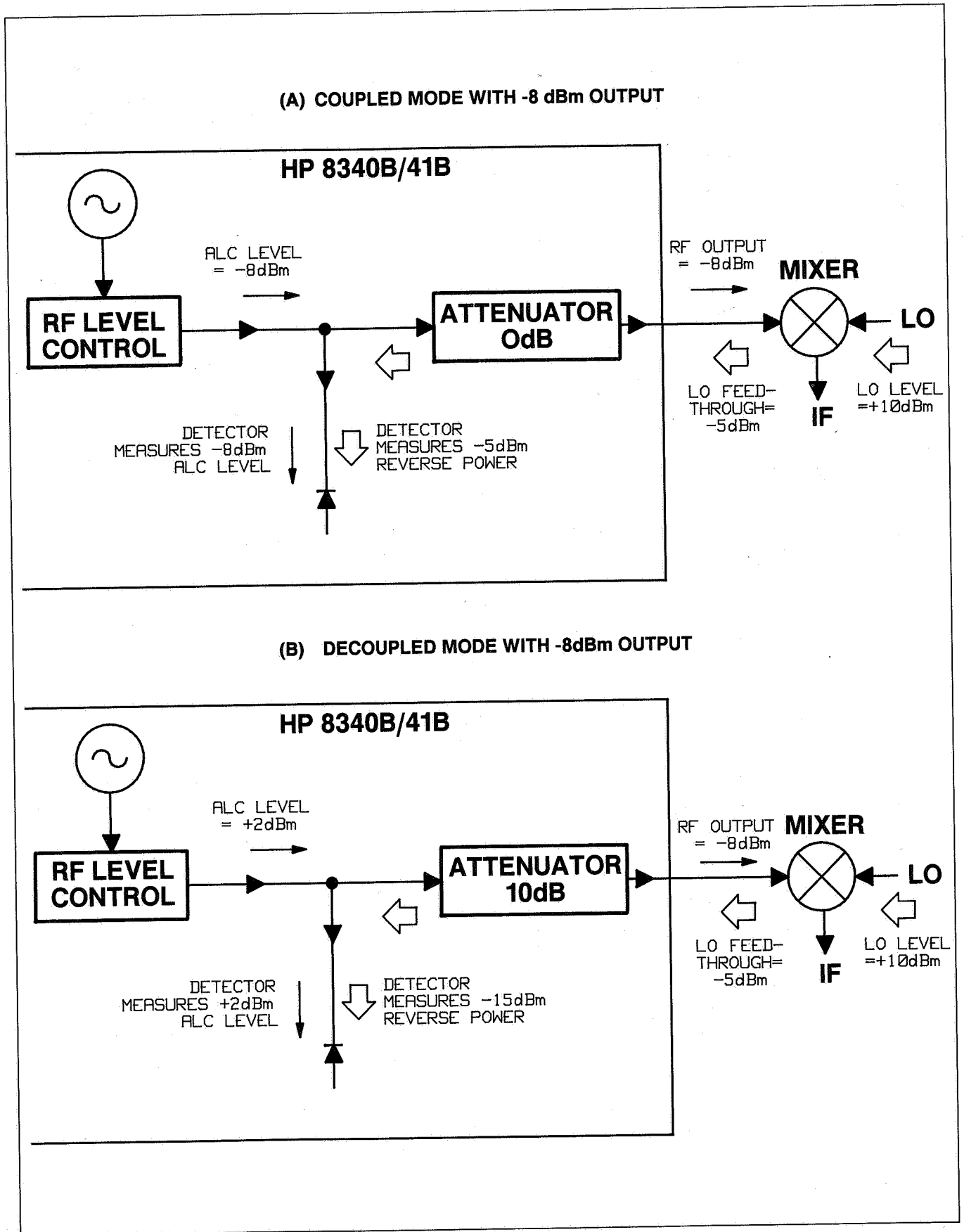


Figure 3-30. Reverse Power Effects

When using decoupled mode to set low ALC levels, some caution is necessary. At ALC = -20 dBm, the amplitude accuracy degrades by ± 1 dB. This results from temperature induced drift in the detection circuitry. Some spurious signals, such as ac power line related sidebands are worse at -20 dBm and may exceed specifications (which do not apply at ALC = -20 dBm). Despite its level uncertainty, the output power at ALC = -20 dBm is more stable than a normal power meter. In checking the output, care must be taken to zero the meter with the HP 8340B/41B's RF turned off. Pressing the "sensor zero" button on a power meter does not assure that it is zeroed, since the display on some meters is blank for inputs below -30 dBm when in the "dBm" mode. Selecting the "WATT" mode keeps the display alive, and the user can then see if the meter is really zeroed (press the zero button several times if necessary).

When the HP 8340B/41B's heterodyne band (.01 to 2.3 GHz) is in use, approximately -30 dBm of broadband noise is generated along with the desired signal. If the desired signal is -20 dBm and the result is measured on a power meter, the reading will be about 0.5 dB high. To accurately measure the signal, the power meter must be zeroed in the presence of the noise: Connect the power meter, then press [RF] to shut off any RF output; although the RF is off, the noise is still present and the power meter can now be zeroed. When going to frequencies above 2.3 GHz, the meter must be re-zeroed. The broadband noise is attenuated by the step attenuator, along with the desired signal. Noise makes a 0.05 dB contribution at ALC = -10 dBm.

UNLEVELED MODE

The HP 8340B/41B has a power control mode in which the leveling feedback loop is opened. The ALC inputs are used to directly control the RF modulator. Pressing [SHIFT] [METER] activates this mode. The annunciators on the leveling mode keys are extinguished, the UNLEVELED annunciator is lighted, and the ENTRY DISPLAY shows: ATTN:_____dB, MOD:_____dB. As with the decoupled mode, the attenuator is set via the [STEP] keys, and the modulator entry is made with keypad or [KNOB]. The entry range is 0 to -100 dB. The modulator entry is an approximately calibrated relative indication, because the modulator's gain and maximum output change with frequency. See Figure 3-31.

AM works in this mode with unspecified distortion. Pulse modulation works. Power sweep works with linearity as depicted in Figure 3-31. The POWER dBm display still indicates actual output power. As with other leveling modes, it indicates the sum of "ALC level" and attenuation, with useful accuracy down to ALC levels of -20dBm. Sweeps will, of course, be unleveled. When in the unleveled mode, there is no feedback stabilization of power, and its stability versus time and temperature is unspecified.

This mode is useful for signal tracing while troubleshooting the HP 8340B/41B. It is also useful in some pulse modulation applications, as explained in that section. It can also be used to output in the presence of large reverse power (a problem described under "decoupled mode"). To do so, the reverse power's effect on the POWER dBm display must be eliminated by shutting that power off, or temporarily setting the HP 8340B/41B's attenuator to a high value. Then, in the unleveled mode (SHIFT METER), use the knob to set the desired ALC level via the power dBm display (remember to mentally compensate for any attenuation in use). Then remove attenuation or turn on the reverse power. In the presence of reverse power, the POWER dBm display will change to an incorrect value, but the output power will be as previously set.

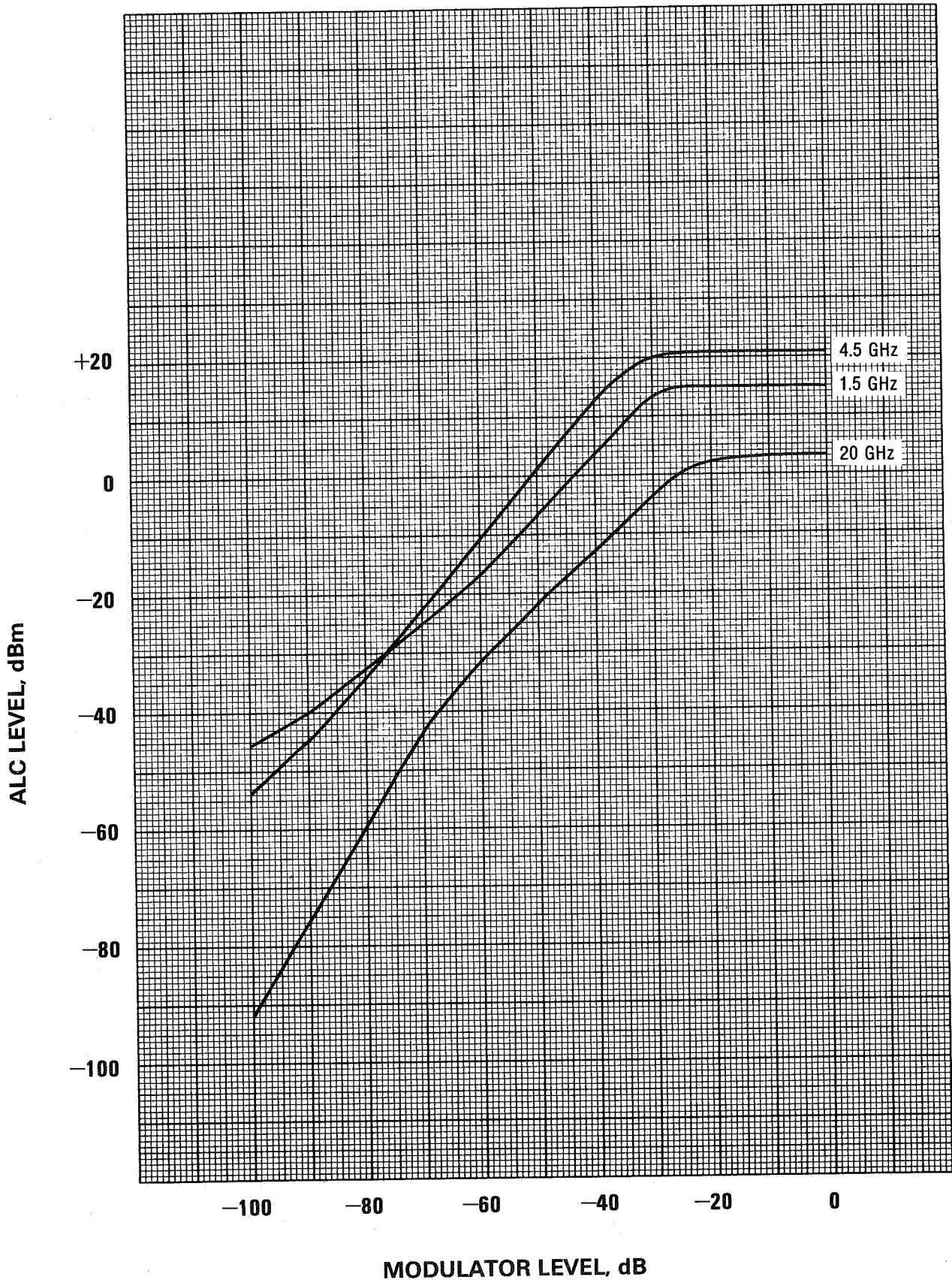


Figure 3-31. Typical Unleveled Modulation Response

POWER SEARCH

Unleveled mode may also be accessed by pressing **[SHIFT] [INT]**. The ENTRY DISPLAY now reads "POWER SEARCH _____dBm" and the "INTERNAL" annunciator comes on. The power reading that appears is the same as the internal leveling power, and it can be changed via keypad, **[KNOB]**, or **[STEP]** keys. In this mode, the instrument is unleveled as in the **[SHIFT] [METER]** mode, but the microprocessor automatically searches out the correct power level. This search occurs with each power entry change or frequency change, and requires about 200 ms. Once the search is completed, the instrument behaves exactly as with **[SHIFT] [METER]**. In this mode the attenuator is set automatically. For decoupled operation while unleveled, the **[SHIFT] [METER]** mode must be used.

EXTERNAL LEVELING

In externally leveled operations, the output power from the HP 8340B/41B is detected by an external sensor. The output of this detector is returned to the HP 8340B/41B's leveling circuits, and the output power is automatically adjusted to keep the power constant at the point of detection. Figure 3-32 shows a basic external leveling arrangement. The output of the detected arm of the splitter or coupler is held constant. If the splitter response is flat, then the output of the other arm will be constant also. This arrangement offers superior flatness over internal leveling, especially if long cables are involved. For best flatness a good resistive splitter with power meter detection should be used.

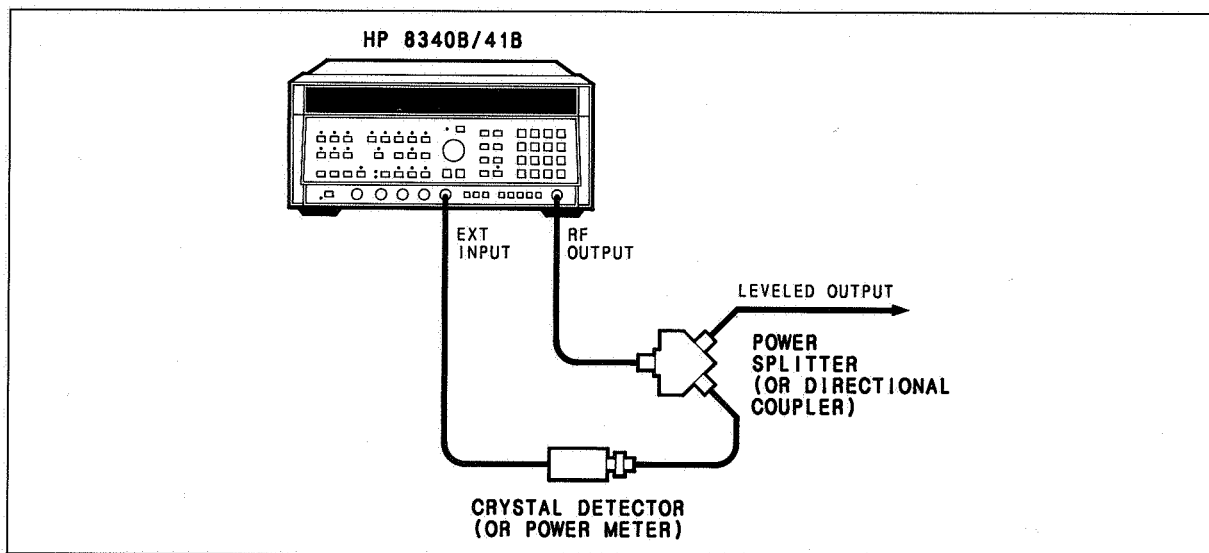


Figure 3-32. Typical External Leveling Hookup

Reference to Figure 3-29 indicates that when externally leveled, the power level feedback is taken from the external detector input rather than the internal detector. This feedback voltage is what the loop is trying to control. For a given ALC input, the loop will adjust its output until the feedback is, for instance, 10 mV. The type of coupler or detector has no influence on this — if the loop is able, it will drive the feedback to the requested level. Since there is no inherent relationship between ALC input and the amount of externally leveled RF power, the power level ENTRY DISPLAY shows the feedback voltage which the loop is seeking. This voltage is called the reference voltage and is displayed alongside the attenuator setting as ATTN: _____dB, REF: _____dBV. The entry units are dBV (dB relative to 1 volt), where 1.00 V = 0dBV, 0.1 V = -20 dBV, etc. As with the decoupled mode of internal leveling, the REF is set with the keypad or **[KNOB]** while the attenuator is set with the **[STEP]** keys. The attenuator will normally be left at 0 dB. Its use is described below.

The reference voltage may be set over a range of -66 dBV (.0005V) to $+6$ dBV (2.00V). This wide range accommodates a variety of detectors and leveling situations. The input accepts either positive or negative voltages automatically. For example, with REF = 20 dBV, the loop will level with an input of either $+0.1V$ or $-0.1V$. The input will accept overloads of ± 25 volts with no damage. The input resistance is $1\text{ M}\Omega$. Figure 3-33 shows the input power versus output voltage characteristics for typical HP crystal detectors. From the chart the leveled power at the crystal detector input resulting from any reference setting may be determined. The range of power adjustment is approximately -30 dBm to $+18$ dBm.

Detector Characteristics

As shown in Figure 3-33, crystal detectors may be characterized by three operating regions. In the square law region ($P_{in} < -20$ dBm) the output voltage is proportional to the square of the input voltage, in other words, proportional to input power. In the linear region ($P_{in} > +5$ dBm) the output voltage is directly proportional to the input voltage. Because of this, when leveling in the linear region a 1 dB reference change causes a 1 dB power change, while in square law a 1 dB reference change causes a $1/2$ dB power change. This should be understood when using power sweep or AM. The power sweep function will sweep the reference by up to 40 dB, but if a square law detector is being used, the power will only sweep 20 dB. The power sweep will only be linear if the operation is entirely in square law or entirely in linear. In the transition region, the power sweep will be non-linear. As may be seen in Figure 3-33 by drawing a line between -10 dBV and -50 dBV, the worst deviation from a straight line is 3 dB of reference voltage, or 2 dB of RF power. The amplitude modulation system is designed to be linear with a square law detector. With a linear detector, the modulation depth will be more than expected, and there will be significant distortion.

HP power meters have a rear panel output ("recorder" output) which responds linearly with power. The output is $+1.00V$ for full scale on whatever range is selected $+0.50V$ for 3 dB below full scale, $+0.10V$ for 10 dB below full scale. These numbers may be seen directly on the $0 - 1$ "WATTS" scale on an analog power meter (e.g., HP 432, 435). This response is the same as a square law detector, so all the comments above for such detectors apply to power meters.

Setting the desired power with a non-autoranging meter (HP 432, 435) is straightforward. Assume $+3$ dBm is desired at the power sensor. Set the power meter on the $+5$ dBm range, so the desired power is 2 dB below full scale. Since the RF power changes $1/2$ dB for each 1 dB reference change, set the reference for -4 dBV.

Auto ranging meters (e.g., HP 436) must be used in their range hold modes to prevent range change during blanking or other RF-off intervals. To lock the meter to the desired range, internal leveling must be used. Adjust the HP 8340B/41B output power until the meter is on the desired power range, then press range hold. As an example, consider the HP 436: The HP 436 changes ranges every 10 dB, so if -8 dBm is desired, the reference must be set for 8 dB below full scale (REF = 16 dBV) with the HP 436 locked on the -10 to 0 dBm range. (Caution: the HP 436 range change circuits have intentional hysteresis. Setting the power to 0 dBm may place the meter on either the -10 to 0 range or the 0 to $+10$ range. For no ambiguity, force the meter to the middle of the range (-5 dBm, $+5$ dBm, etc.), then press range hold.)

POWER dBm Display used with the Attenuator

Some external leveling applications require low output power from the HP 8340B/41B, for example, leveling the output of a 30 dB amplifier to a level of -10 dBm. In this application, the output of the HP 8340B/41B is around -40 dBm when leveled. At some frequencies this level is beyond the range of the ALC modulator alone. If so, the OVERMOD annunciator lights. Inserting 40 dB of step attenuation results in an ALC level of 0 dBm, which is well within the range of the ALC. At 26.5 GHz, where only $+1$ dBm is available (8340B), 30 dB attenuation is a better choice as it results in an ALC level of -10 dBm. This gives a margin for AM or other functions that vary the power level.

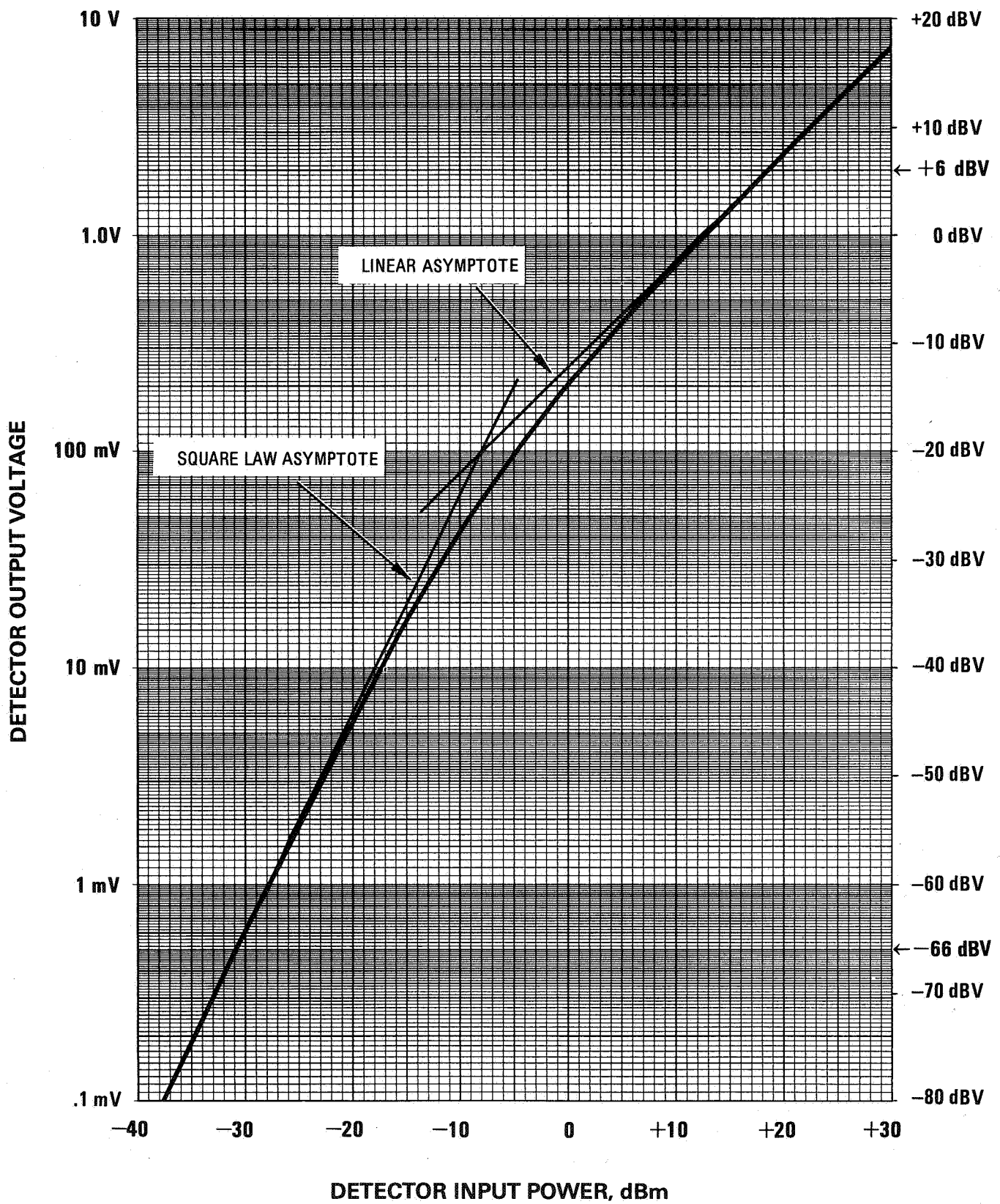


Figure 3-33. Typical Crystal Detector Response at 25°C

Referring to Figure 3-29, it is seen that when externally leveled, the POWER dBm display is still connected to the internal detector of the HP 8340B/41B. Thus, it always tells the true output power, regardless of external leveling setup. This is a useful aid to determining if the external hardware is functioning properly. In the above example, if the POWER dBm display shows -40 dBm when the amplifier output is leveled to -10 dBm, the user knows the gain is 30 dB. As explained in the internal leveling section above, the POWER dBm display is only accurate down to ALC levels of about -22 dBm, below which it is intentionally blanked, therefore, that display is only useful if the ALC level is forced to be greater than -22 dBm. This is done by inserting step attenuation until the display lights up again. As still more attenuation is added, the POWER dBm reading remains essentially constant as the external leveling loop holds the output level constant. With each additional 10 dB step of attenuation, the ALC level jumps 10 dB, until finally maximum available ALC level is reached and the UNLEVELED annunciator lights. For best display accuracy and minimum noise, the ALC level should be greater than -10 dBm. This is achieved by using attenuation equal to the tens digit of output power. Example: output power = -43 dBm; use ATTN. = -40 dB, ALC = -3 dBm.

When sweeping while externally leveled, the output power changes with frequency in order to level at a distant point. The POWER dBm display tries to follow this change. Due to its heavy filtering, at fast sweep speeds the meter displays an average power level.

When using mixers, or in other situations where reverse power may be encountered, caution is necessary. See the decoupled mode and unleveled mode sections above. Reverse power into the HP 8340B/41B when externally leveled makes the POWER dBm display read incorrectly; unwanted RF energy entering the external detector causes the loop to level at the wrong power level.

Bandwidth

When externally leveled, the leveling loop bandwidth differs from what it is when internally leveled. If AM is on or when sweeping with sweep time < 5 seconds, the nominal loop bandwidth is:

Internal: 150 kHz

External, crystal: 80 kHz with square law detector, 40 kHz with linear detector.

External, power meter: 0.7 Hz

The significance of loop bandwidth is that it generally equals AM bandwidth and influences the fastest useable sweep speed. The best way to set sweep time is to increase it until measured flatness no longer changes. For the sake of understanding — observe a plot of unleveled flatness across the band of interest. The number of ripples divided by sweep time gives the number of "ripples per second" which the leveling loop must remove. The loop bandwidth must be several times this number in order to do so. From the above it is apparent that the useable sweep time will depend on frequency range and RF hardware in use. When using long cables there will be many ripples, and their amplitude is dependent on the match at each end of the cable. Inserting 10 dB of step attenuation greatly improves the source match when externally leveled, thereby reducing the ripple amplitude.

For best stability of the leveling loop, the video bandwidth of the external detector should be 100 kHz or more when XTAL leveling is selected. The capacity of coaxial cables reduces the video bandwidth of crystal detectors. A typical point-contact detector (HP 420 series, 423A, 8470A) will work with up to 4 feet of 50 Ω coax on its output. Typical HP low barrier schottky detectors (HP 423B, 8470B, 3330 series) will drive up to 40 feet of 50 Ω cable.

The above paragraph applies to square law detectors with no dc offset ($V_{out} = 0$ for $P_{in} = 0$).

In METER mode, the external leveling bandwidth is reduced to 0.7 Hz in order to allow operation with power meters. Power meters have a very slow response due to thermal delay time and heavy electrical filtering. The 0.7 Hz bandwidth assures proper operation with any HP power meter on any range.

When turning on the RF power, either when unblanking or using the RF key, the slow response of the power meter can cause serious power overshoot in some external leveling systems. This overshoot may damage active devices or some power sensors. To prevent this problem in the HP 8340B/41B, a slow turn on circuit is employed when METER leveling is selected. This circuit raises the power slowly over a period of 2 seconds. The sweep generator automatically waits for this settling time to end before beginning a sweep.

Amplitude modulation is possible when power meter leveled. The system provides linear AM and is dc coupled. For rates below 0.7 Hz, the leveling is done via the power meter sensor and behaves just like internal leveling. Above 0.7 Hz, feedback from the power meter rolls off and is replaced by feedback from the HP 8340B/41B's internal detector. Thus, high frequency envelopes are under control of the internal detector, while the power meter controls the power level. The modulation depth is still accurate and the bandwidth is nominally 80 kHz. The power sensor is not following the modulation; hence, it will average the power. When modulating with a sinusoid symmetric about 0V, the average output power increases (by 50% for 100% AM). The power sensor senses this increase and reduces the HP 8340B/41B's output until the average equals what the power was with no modulation. As long as the modulation depth remains constant across the frequency band (use moderate rates and depths), this system will level the power while providing amplitude modulation.

EXTERNAL SOURCE MODULE LEVELING

The HP 8340B/41B provides an external leveling mode, for use with compatible Hewlett-Packard instruments, which provides leveling at a remote location along with power calibration and flatness compensation. Compatible instruments are the HP 83550 series millimeter-wave source modules when driven by an HP 8349B Microwave Amplifier. The HP 8349B may also be used in a stand-alone amplifier configuration. Refer to an appropriate HP 83550 mm-wave source-system guide for interconnect instructions.

Once the HP 8340B/41B - HP 8349B - HP83550 series instruments are hooked up, press **[SHIFT] [XTAL]** on the HP 8340B/41B. This causes "EXT MODULE POWER: XX.XX dBm" to be displayed in the ENTRY DISPLAY, which will accept power level changes via the **[KNOB] [STEP]** keys or ENTRY keyboard. The HP 8340B/41B will accept power level requests from -20 to +20 dBm, however, this range exceeds the operational range of existing mm-wave source modules. Refer to the mm-wave source module manual for more information.

The SHIFT XTAL mode is unlike external leveling in that the POWER dBm display indicates the output power of the remote module, not the HP 8340B/41B RF output. This mode provides all the modulation features of an internally leveled HP 8340B/41B, with performance limited by the dynamic range and leveling bandwidth of the individual source modules.

AMPLITUDE MODULATION

The HP 8340B/41B provides linear, dc coupled amplitude modulation when internally leveled or externally leveled with a square law detector or power meter. The input resistance is 600 Ω whether the AM function is on or off. The sensitivity is 100% per volt $\pm 5\%$. This means that +1.0 volt doubles the output voltage (+6 dB), while -1.0 volt shuts the output completely off. The input accepts ± 15 V dc with no damage, and is resistor-diode clamped to protect against higher voltage transients. Most sine wave generators are calibrated in terms of RMS voltage, so 0.707 V RMS equals 1.00 V peak. The generator's output meter is accurate only if the load impedance equals the source impedance.

POWER dBm Display used with AM

The POWER dBm display on the HP 8340B/41B always tells actual output power. A dc input to the AM jack causes the power level to shift, and the display reflects this: +1.0 volt causes the display to increase 6 dB. If that much power is not available, the UNLEVELED annunciator lights and the display shows the actual output. Inputs which reduce the ALC level below -22 dBm will blank the display. Inputs of -1.0 volt or more negative shut off the output and light the OVERMOD annunciator.

The POWER dBm display is filtered so that it will not flicker for AM rates above 20 Hz. The filtering creates an average of RF voltage, which is then displayed as power in a 50 Ω system (dBm, 50 Ω).

Therefore, modulation inputs with no dc component do not cause the POWER dBm display to shift, and this displayed number represents the power of the unmodulated carrier. A power meter measurement of output power changes with modulation present, increasing 1.76 dB with 100% deep, sinusoidal, no dc component modulation. Attempted deep modulation at high rates causes the POWER dBm display to shift, because the AM system cannot keep up with the input and the resultant high distortion causes a shift in average power.

Dynamic Range

As mentioned previously with reference to Figure 3-29, the AM input is an ALC input which does not differ in its effect from a power entry input. Therefore, the AM system is limited by where it is operating within the ALC range. In the normal "coupled" operating mode, the ALC will likely be set between -10 dBm and 0 dBm (see the preceding pertinent section). Depending on frequency, the maximum available power is between +1 dBm (HP 8340B) and +21 dBm. The ALC is reasonably accurate down to -20 dBm, and typically is well behaved to about -30 dBm. Expressing the desired modulation depth in dB's will let the user determine the range over which the ALC loop is being exercised. Thirty percent AM creates excursions of +2.3 dB to -3.1 dB, relative to the quiescent level; 50%: +3.5 dB to -6.0 dB; 90%: +5.6 dB to -20.0 dB. (The above assumes a modulation waveform symmetric about 0 V.)

For example: Output power = -19.0 dBm. In coupled mode this results in ATTN = -10 dB, ALC = -9.0 dBm. Ninety percent modulation depth results in an ALC range of -9.0 dBm + 5.6 dB = -3.4 dBm maximum, -9.0 dBm - 20 dB = -29.0 dBm minimum. This is within the ALC limits at any frequency but the distortion may suffer due to operation below -20 dBm. Using decoupled operation the desired output power may be set with ATTN = -20dB, ALC = +1.0 dBm. Then 90% depth swings the ALC from +6.6 dBm to -19.0 dBm. The distortion will probably be better under these conditions if +6.6 dBm is available at the frequency of interest. At some frequencies +20 dBm is available, and setting ATTN = -30 dB, ALC = +11.0 dBm may give a further improvement, especially if attempting greater than 90% depth. For minimum distortion the ALC should be used between -15 dBm and +15 dBm, but not within 2 dB of maximum available power.

On HP 8340B's operating above 23 GHz the available output power is limited: +1 dBm specified, +3 dbm typical. If the ALC is set close to 0 dBm, the headroom available for modulation is limited. Three dB excess power allows a maximum of 40% peak modulation. The available depth is not affected. Decoupled mode may be used to advantage here. For example, in coupled mode an output power of -10 dBm results in ATTN = 10 dB, ALC = 0.0 dBm. Using decoupled mode, setting ATTN = 0 dB, ALC = -10.0 dBm gives plenty of headroom with enough depth available for 90% symmetric AM. Available power can be maximized at a CW frequency by using the PEAK function.

Bandwidth for AM Applications

The small signal AM bandwidth extends from dc to a -3 dB frequency of at least 100 kHz. The actual upper limit is a direct function of the loop gain of the ALC loop. The primary variable in the loop gain is the gain of the modulator, which varies with both power level and frequency. In general, the modulator gain deviates the most from nominal at power levels just below maximum, although at some frequencies the gain will deviate at lower power levels because of non-optimum YTM bias. The latter is only a problem above 7.0 GHz. The small signal (30% depth) bandwidth may be expected to vary between 100 kHz and 300 kHz as power and/or frequency is changed. The bandwidth for greater depths is less. At 90% depth expect about 1/2 the 30% bandwidth.

The above bandwidths are for internal leveling. When external leveling with a crystal detector in its square law region the bandwidth is 1/2 of the internally leveled bandwidth at the same frequency and output power level. With a crystal detector in its linear region, the bandwidth is 1/4.

The external leveling system is designed to provide linear AM when using a square law detector. The RF output follows this law:

$$V_{out} = V_o \times (V_{in} + 1).$$

This applies also to internal leveling. When externally leveled with a linear detector the relationship is:

$$V_{out} = V_o \times (V_{in} + 1)^2$$

A power meter is a square law detector, so AM with power meter leveling is linear. For bandwidth see the external leveling section.

For simultaneous AM and pulse modulation, see the next section.

PULSE MODULATION

The HP 8340B/41B provides leveled pulse modulation over a wide range of pulse widths and rates. Characteristics such as leveling accuracy and response time vary with pulse width, pulse rate, temperature, power level, and RF frequency. In order to use the pulse leveling system to best advantage it is helpful to understand its operation and limitations.

Sample and Hold Leveling

The basic leveling loop was previously explained with reference to Figure 3-29. Fundamental to its operation is the internal detector which measures the RF amplitude. The leveling performance is limited by the accuracy of this measurement. The most difficult aspect of leveled pulse modulation is measuring the amplitude of a very narrow RF pulse.

Figure 3-34 is a block diagram of the detector circuitry, with waveforms. Trace 1 is the pulse modulation input signal to the HP 8340B/41B. It controls a fast RF modulator which is either full on or full off. The amplitude when on is controlled by the linear modulator used for CW leveling and AM. Trace 2 is the resultant RF pulse, which is the HP 8340B/41B's output. This pulse is detected by the crystal detector. It trails the pulse input by 55 nsec, representing propagation delays in the pulse modulator and its drive circuits.

The output of the crystal detector is amplified by a logarithmic amplifier (log amp). The log amp is used for several reasons, one of which is its high gain for small signals, reducing the effects of sample and hold errors. Trace 3 is the output of the log amp. The delay and relatively slow rise time are caused by the finite bandwidths of the detector and log amp. The pedestal (arrow) represents the RF amplitude. This level is captured for further processing by the sample and hold circuit (S/H), represented by the switch-capacitor combination. Trace 4 shows the signal controlling the switch, which is closed when trace 4 is high.

Trace 4 is timed to coincide with the pedestal of trace 3. This timing is done by circuitry associated with the pulse modulator and is factory adjusted for best coincidence. Since the S/H switch is closed only during trace 3's pedestal, the capacitor charges to a constant dc voltage. This voltage is the same as what comes out of the log amp during CW operation at the same power level. The capacitor is isolated by a buffer to prevent the following circuits from discharging it between pulses. The output of the buffer is compared to the ALC inputs in the same manner as with CW operation.

Figure 3-34 shows a 200 nsec pulse. If the pulse were narrowed to 100 nsec, trace 3 would not quite reach its pedestal before it begins to fall. The result is a dc output from the S/H that is smaller than it would be in CW. The ALC circuits respond by raising the RF output until that voltage is what it should be. This is the reason for poor leveling accuracy with narrow pulses. As the pulses are made narrower, their amplitude grows.

The amount of accuracy degradation as the pulses are narrowed varies with frequency, temperature, and power level. The variation with frequency and temperature is due to detector characteristics and RF envelope shape. The detector has a finite rise time determined by its output resistance and shunt capacitance. At some frequencies there is a slight amount of overshoot on the RF envelope, which tends to charge the shunt capacity faster, resulting in better narrow pulse leveling accuracy. A much more pronounced effect is due to the use of a different detector for frequencies below 2.3 GHz. The low band detector has a higher shunt capacity in order to make it function properly at low frequencies. For operation below 400 MHz, a large amount of additional capacity is switched in, enabling detector operation down to 10 MHz. Trace 3 in Figure 3-34 is representative of operation above 2.3 GHz, where pulse accuracy is within 1.5 dB at 100 nsec. From 0.4 to 2.3 GHz, the slower rise time gives a 1.5 dB specification at 200 nsec width. Operation below 0.4 GHz is not specified, but typically is within 1.5 dB at 2 μ sec width.

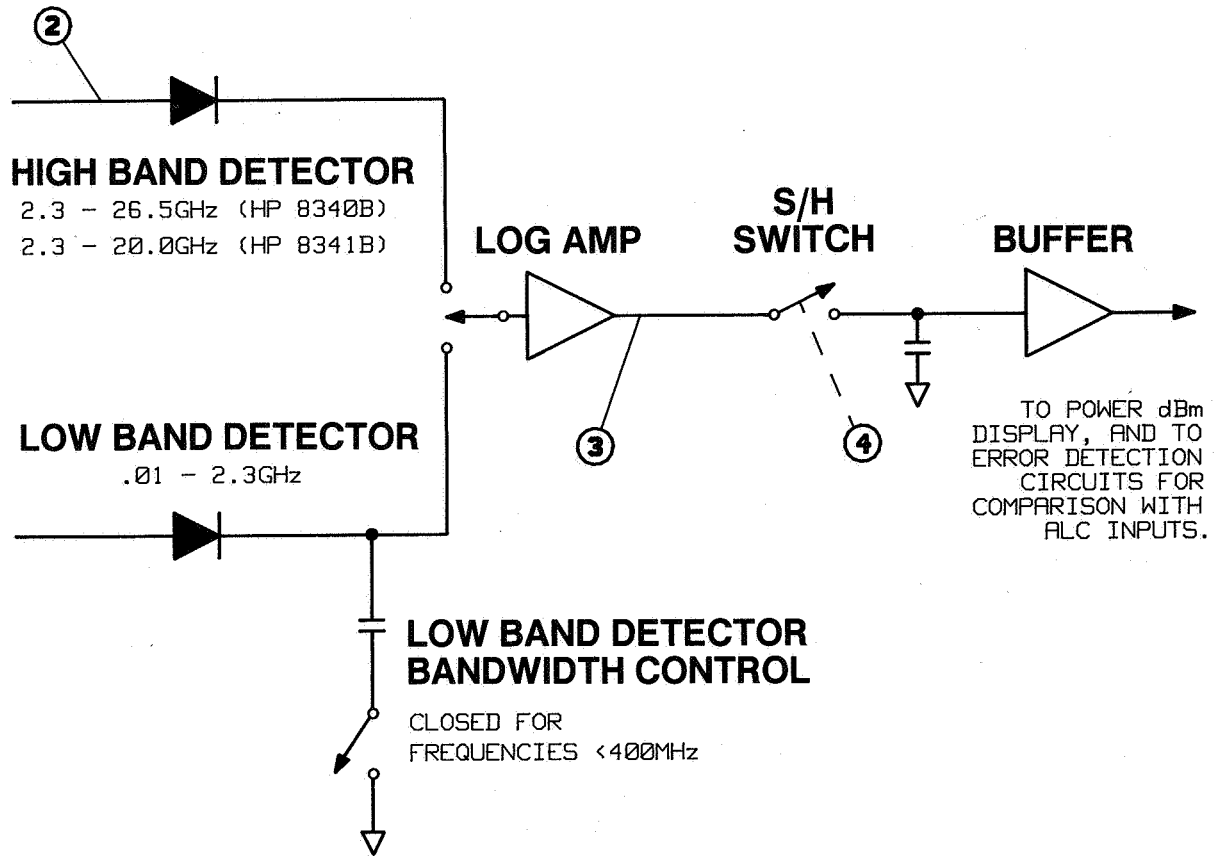
The detector's rise time depends on its output resistance, which drops with increasing temperature. Therefore, the narrow pulse leveling accuracy improves at higher operating temperatures.

Narrow pulse accuracy is also power level dependent. Very high ALC levels reduce the detector's output resistance, improving rise time and therefore accuracy. The rise time of a log amp is dependent on signal level, degrading with small signals. In low band (<2.3 GHz) the log amp is faster than the detector at any ALC level above -10 dBm, so there is no degradation due to the log amp in any coupled mode operation. In high band, the log amp rise time at ALC = -10 dBm is slow enough to be comparable to the detector rise time. Therefore, as power is decreased, the leveling accuracy slightly degrades (narrow pulse amplitude grows relative to CW).

The leveling specifications apply to coupled operation, with no AM; in other words, ALC > -10 dBm. Using the decoupled mode or AM, the ALC level can be driven down to -20 dBm or lower. At -20 dBm, the log amp slows down enough that high band accuracy is typically 1.5 dB at 150 nsec, 3.0 dB at 100 nsec. Decoupled mode can also be used to operate the ALC at high levels and achieve better narrow pulse accuracy.

The above discussion applies to internal leveling only. Externally leveled pulse performance will, of course, depend on the detector, but even with a perfect detector the external leveling circuitry is not as fast as internal. It typically will level pulses wider than 2 μ sec.

(A) DETECTOR CIRCUITRY



(B) PULSE WAVEFORMS, 50nsec/DIV.

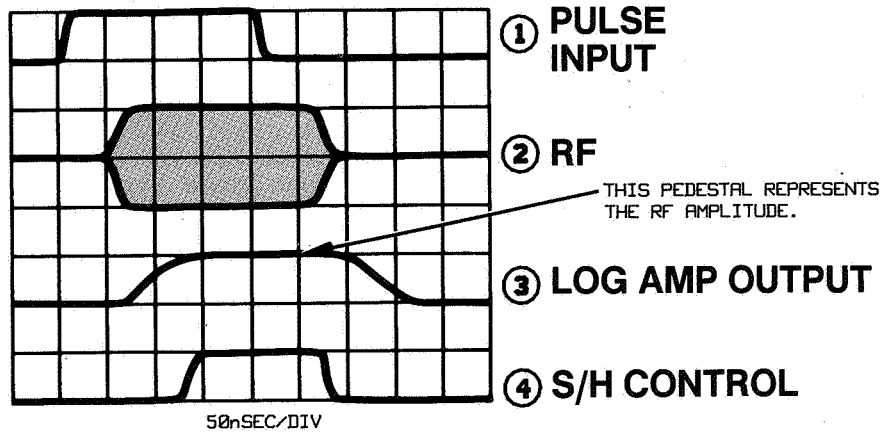


Figure 3-34. Pulse Measuring System

Another type of leveling error arises from long pulse periods (low repetition rates), or more precisely, long off times between pulses. The problem lies in the error detection and modulator drive circuits shown in Figure 3-35. On the left is the comparison point, where the ALC input is compared to the detector output. For this discussion assume the two resistors are equal in value, so if the ALC and detector voltages are equal in magnitude but opposite in polarity, the error signal will be zero. The error is fed to an integrator through the integrate/hold switch. This switch is closed continuously during CW operation. Any error signal causes the integrator output to change at a controlled rate (determined by capacitor C), changing the RF output via the linear modulator. The integrator output continues to change until its input is zero, which means the detector voltage is balancing the ALC input voltage. The time required to cancel an error is about 70 μsec (4 μsec with AM on or when sweeping fast, under which conditions a smaller value of C is switched into the circuit).

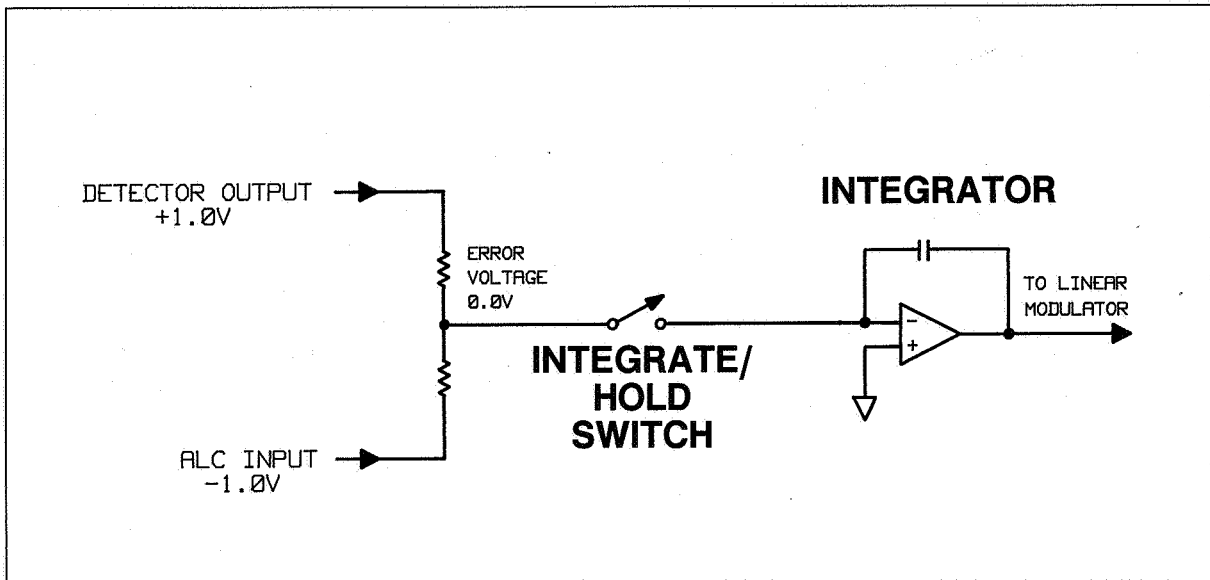


Figure 3-35. Error Detection and Modulator Drive

Consider now pulse operation with a period of 1 msec. The detector S/H measures a pulse and holds its value until the next pulse. Assuming an error is present, the integrator responds to that error, reaching the proper modulator drive in about 40 μsec . Since the detector S/H is still holding the error from the last pulse, the integrator keeps changing until the next pulse, overshooting its mark and causing instability. For this reason the integrate/hold switch is only closed during a pulse. During the period between pulses, the switch is opened, thus the integrator input is zero so the modulator drive doesn't change. This assures that the amplitude at the beginning of the next pulse is the same as at the end of the previous pulse. Corrections take place only during the pulses, until equilibrium is reached.

Since this may cause very long response times for narrow pulses, the integrate/hold switch is held closed a minimum of 10 μs per pulse, for pulses narrower than that. This is not long enough to cause overcorrections but speeds response time for 100 ns pulses by a factor of 100.

During the period between pulses, the integrate/hold circuit is expected to hold the modulator drive constant. Because of leakage currents, the output will in fact drift, causing the pulse amplitude to be in error. This error will grow with off time and also temperature, as leakage is strongly temperature dependent. The circuit is designed worst case for <0.1 dB droop in 10 msec at an ambient temperature of 55°C. At 25°C, a typical unit drifts about 1 dB per minute. The drift may be in either direction.

Response Time

The response time to a step change in level is a function of pulse width and rate and is detailed in the specifications. The response time is a function of ALC loop bandwidth, which varies with frequency and power as explained in the AM section. The listed response characteristics apply at the minimum expected loop bandwidth. An intuitive feeling for response may be gained by the following: At minimum bandwidth in CW it takes 70 μ s to respond to a change and settle to within 10% of the size of the change. In pulse mode, the same degree of settling requires 70 μ s of closure of the integrate/hold switch. This may come from one of 70 μ s pulse, two 35 μ s pulses, etc. Any pulse less than 10 μ s wide is treated as a 10 μ s pulse. If the pulse *period* is less than 10 μ s, the integrate/hold switch is continuously closed, so the system responds in 70 μ s regardless of width or period.

Simultaneous AM and pulse modulation is provided by the HP 8340B/41B. The AM is dc coupled and linear, just as with normal CW leveling. If AM is used to exercise the ALC below -10 dBm, the narrow pulse leveling accuracy degrades as explained above. The bandwidth is given by the equation: $3\text{dB BW} = 0.35/\text{Tr}$, where Tr is the response time to a step change described above.

Uneveled Mode Used With Pulse Modulation

Decoupled operation may be used for dynamic range extension or any of the other uses described for CW or AM. Several pulse related problems may be treated with the uneveled ([SHIFT] [METER]) operating mode already described.

Narrow pulse leveling accuracy problems may be treated by simply not attempting to level them. The uneveled mode allows the user to control the linear modulator directly. The setting of this modulator does not change with pulse width, so the pulse amplitude remains constant as the pulse is narrowed. Pulses as narrow as 25 nsec may be produced in this mode. To set the amplitude, go to CW operation (pulse off) and set the desired power via the POWER dBm display.

As the pulses are narrowed, the POWER dBm reading drops since it is measuring the output of the detector S/H system and it is the limitations of this system which cause the narrow pulse leveling problems. The real amplitude remains essentially constant, however. In uneveled mode, the POWER dBm display accuracy is the complement of the corresponding leveled pulse accuracy; that is, -1.5 dB $+0.3$ dB for width = 100 to 200 ns, frequency ≥ 2.3 GHz. If operating close to maximum ALC output there is some amplitude drift (a few tenths of a dB) due to component self-heating when going from 100% duty cycle to low duty cycles.

Since uneveled mode does not involve the integrate/hold circuit, there is no leakage induced amplitude drift between pulses. Consequently, very long periods may be employed that are limited only by the long term drift of the modulator drive circuits. This is not negligible and should be characterized by the user at the frequency of interest. Drifts of a few dB should be expected during warmup. Since this mode is not feedback leveled, the power changes markedly with frequency.

In uneveled mode the ALC inputs control the linear modulator directly, so the response time is not dependent on pulse parameters. The response time is 70 μ s maximum in CW, sweeps >5 seconds, normal AM; or 4 μ s maximum for sweeps <5 seconds. AM works in uneveled mode, but the linearity and sensitivity varies with power level and frequency. See the pertinent preceding section.

Input Characteristics

When pulse mode is activated, the HP 8340B/41B RF output is controlled by the voltage at the pulse input. The input circuit is shown in Figure 3-36. The output is off for inputs below approximately $+1.5$ V. If the input is left open it pulls itself up to $+1.8$ V, which will turn the output on. The HP 8340B/41B's delay and compression specifications assume an input of 0 to $+3.0$ V, which requires sinking about 1.6 mA and sourcing about 2.7 mA respectively. The input accepts $+12$ V to -20 V with no damage, which is compatible with the ± 6 V modulator drive of certain network analyzers. Aside from small effects on delay and compression, the waveform and amplitude of the input is unimportant, as long as it transitions from $+0.5$ to $+2.5$ V in 2 μ s or less. This transition is sufficient to generate the fastest rise time. Since the input is not linear, input overshoot will not appear on the output.

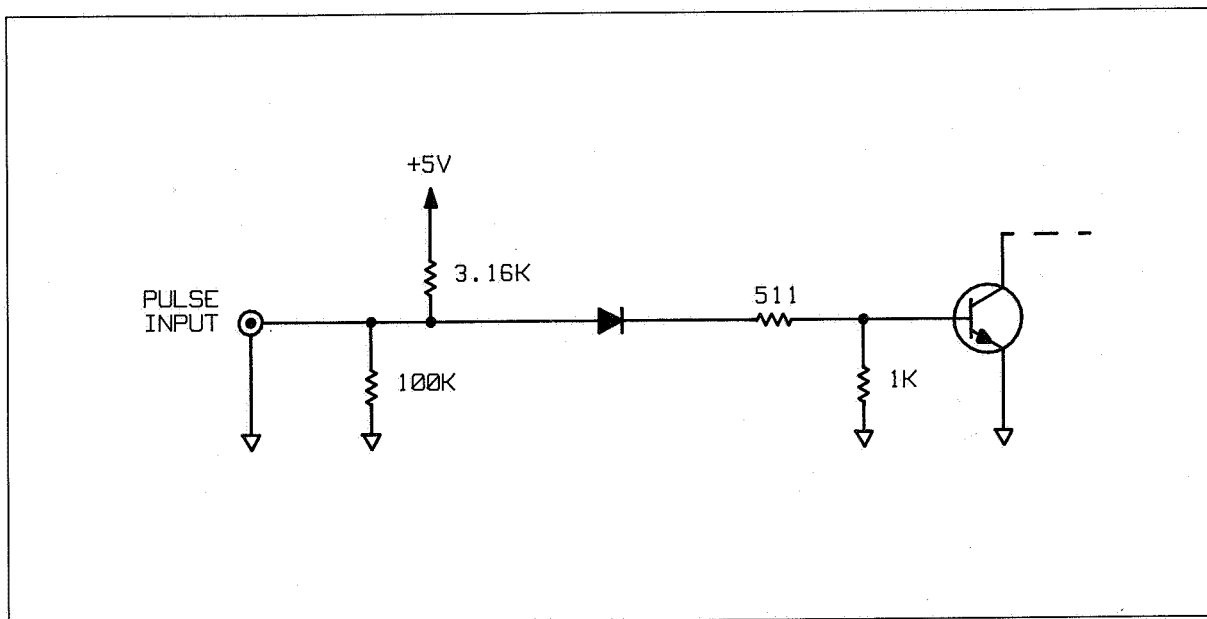


Figure 3-36. Pulse Input Circuit

Pulse Envelope

The pulse envelope produced by the HP 8340B/41B is not a perfect rectangle, rather it has finite rise time, overshoot, and video feedthrough. Below 2.3 GHz the rise time and overshoot are essentially independent of frequency, but above 2.3 GHz they are strongly influenced by the passband shape and centering of the HP 8340B/41B's tracking YIG filter. Best envelopes are normally obtained by using the PEAK function. The envelopes will change with frequency and slightly with power level.

Source Match

In the absence of attenuation with a resistive pad, a leveled microwave source generally provides a 50Ω source match at its operating frequency only. The source match at other frequencies is that of the unleveled RF hardware. In this case this is a YIG filter which is a good reflection for anything more than about 20 MHz off center, and not much better within its passband. The match is good only for signals at the output frequency plus or minus the leveling loop bandwidth. Thus a CW reflection will be absorbed. A time varying reflection, as from a reflective modulator, may contain modulation sidebands outside the leveling loop bandwidth. If so, these sidebands may be re-reflected. When pulse modulating, any reflection of the pulse will contain sidebands far outside the loop bandwidth, so the leading edge of the reflection will be re-reflected. In this manner a poorly matched system can generate very poor envelopes (anywhere in the system, not only at the source). Performance is improved by padding between the reflections. At the source, if output powers above -10 dBm are in use, coupled mode results on 0 dB RF attenuation. If enough power is available, decoupled mode may be used to improve the HP 8340B/41B's source match by inserting 10 dB attenuation and using a 10 dB high ALC level.

Video Feedthrough

Video feedthrough is a low frequency signal, at the modulation rate, which is superimposed on the RF envelope. See Figure 3-37. If large enough, video feedthrough can disturb mixer balance, amplifier bias, crystal detector output, etc. Since it is low frequency energy, it can disturb systems which are not intended to deal with it, especially demodulation systems.

The HP 8340B/41B's high band (>2.3 GHz) employs a tracking YIG filter which essentially eliminates video feedthrough. Attempts to measure it can turn out to be measurements of ground currents in coaxial cables. The HP 8340B/41B's low band (<2.3 GHz) employs a low level mixer followed by a high gain amplifier. At high power levels, the bias levels in the amplifier shift slightly as the RF is turned on or off. The slew of the bias from one level to another couples to the output and produces the video feedthrough waveform. For this reason the 5% specification is only valid for power levels up to +8 dBm. At low ALC levels (-10 dBm), another mechanism predominates. Mixer imbalance produces dc at the output of the mixer, and its magnitude varies with RF amplitude and/or modulator state. This shifting dc level couples through the amplifier, which is AC coupled, and emerges as video feedthrough spikes. In percentage terms this mechanism gets worse at low levels. The lowest percentage video feedthrough is probably found at ALC levels around 0 dBm.

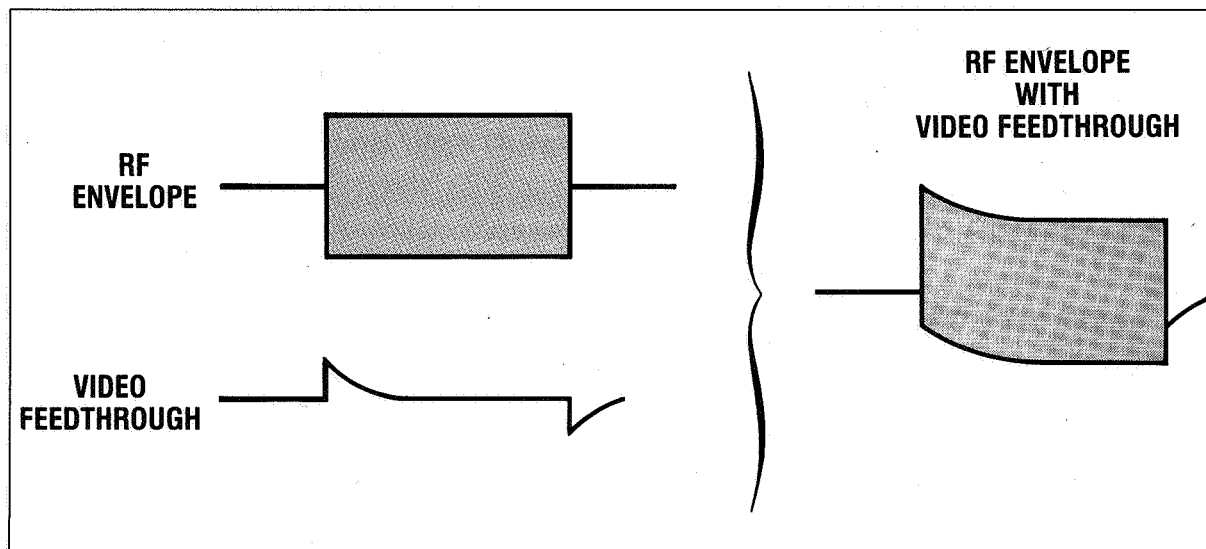


Figure 3-37. Video Feedthrough

SLOW RISE TIME PULSE MODULATION FOR SCALAR NETWORK ANALYZERS

For proper operation of HP 8755C, 8756A, and 8757A scalar analyzers, the HP 8340B/41B offers a pulse modulation mode which provides approximately 2 μ s rise and fall times. Press **[SHIFT] [PULSE]** to enter this mode. The scalar analyzer's modulation output is connected to the HP 8340B/41B **PULSE** input. The slow waveform reduces the spectral width of the output, improving measurements made on filters with steep skirts. This mode may be used for other purposes, and functions properly for pulse widths wider than about 7 μ s.

FURTHER INFORMATION

This completes Section III of the HP 8340B/41B Synthesized Sweepers Operating and Service Manual. For further information, there are several Programming Notes, Operating Guides, and general-reference Application Notes that are applicable to the HP 8340B/41B.