Operating and Service Manual

MODEL

PM2002 PH2000

PART NUMBER

1009878-501 1009896-501

SERIAL NUMBER

25002 24953

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SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2 This instruction manual provides general information, Installation and operating instructions, and application notes for the Model PM2002 RF power meter.

1-3 DESCRIPTION.

1-4 The Model PM2002 series is a DSP (digital signal processor) based dual channel, solid state RF power meter. They are capable of measuring RF power levels from –70 dBm to +44 dBm. The RF frequency range and power level range are head dependent. Amplifier Research Model PH2000 series of power heads provide measurement capabilities for frequencies from 10kHz to 100GHz.

1-5 FEATURES.

1-6. POWER HEADS. A wide range of diode and thermocouple power heads for both coaxial and waveguide applications are available for use with the model PM2002. Head data adapters are supplied with each power head, however, the power heads must be ordered separately.

1-7. Diode heads measure the voltage across a precision resistor, using specially selected diodes. Detection is square law (true RMS) over approximately the lower two-thirds of the head's dynamic range, and peak detecting over the upper portion. Because the instrument is calibrated for sine waves over the entire range, measurements at the top one-third of the head's dynamic range are valid only for non-modulated signals. In the RMS region, linearity is excellent, and any signal type can be measured. The diode range has been extended into the peak detecting region with the use of real time shaping for the diode curve. When coupled with the high sensitivity of the diode, such shaping allows a dynamic range of 90 dB. Diode heads are rugged and have overload headroom of more than 5 dB for continuous signals. The dynamic range in the RMS region can be extended further through use of an external attenuator.

1-8 Thermal heads measure the voltage developed across a dissimilar metal junction caused by thermal gradient generated by the RF power being measured. Because these heads are heat detecting, they provide true RMS response over their entire range. Very high peak powers (15 to 30 watts) can be accommodated for very short duty cycles and still provide valid results. The dynamic range is 50 dB. Thermal heads are not as sensitive as diode heads.

1-9 The head data adapter contains non-volatile memory for storage of the calibration data. In addition, calibration data for up to four heads can be stored in the instrument's non- volatile memory. The user can enter both the linearity and high frequency head calibration correction data, which are supplied with each head. For heads ordered with the Model PM2002, the calibration data is loaded into the head data adapter prior to shipment. When the frequency of the RF signal to be measured by these heads is entered; the instrument looks up the appropriate calibration factors, interpolates as necessary, and automatically applies the correction to the measured value. Calibration factors for heads ordered with the instrument are stored on the label and in the manual.

1-10 Simple Instrument Setup and Operation. In the operating mode the functions: Frequency, Averaging Time, Reference Level, Zeroing/Calibration are selected with a single keystroke. Values for these parameters are displayed and can be adjusted by using the arrow and enter keys. Additional operating parameters can be modified through the menu driven structure accessible via the <Menu> and <Sensor> keys.

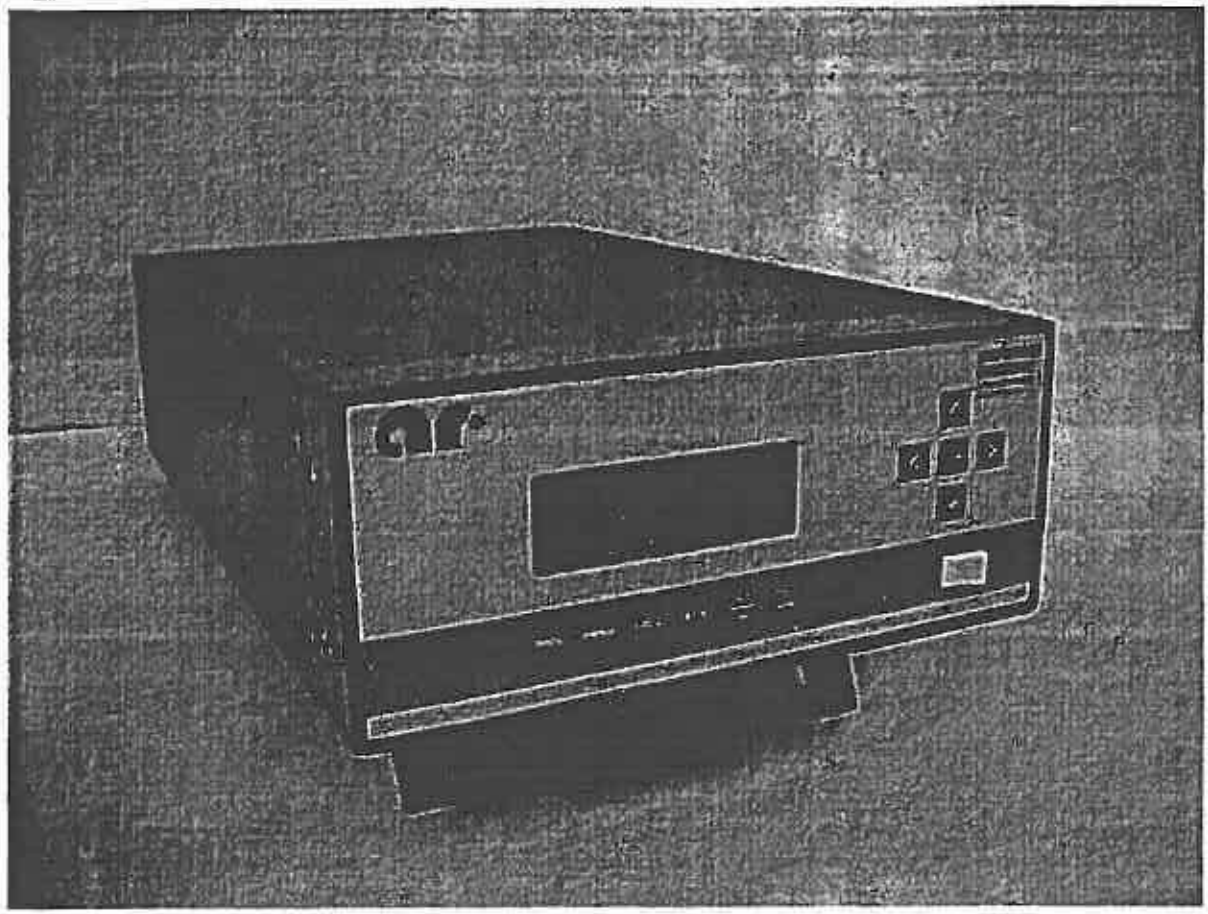


Figure 1-1 Model PM2002 Series RF Powermeter

1-11 Alphanumeric Display. The alphanumeric LCD provides clear, unambiguous readouts of the instrument's setup and measurement values. Simultaneous display of both channels is available in duel channel mode. A bar graph provides a display of the channel's measured value for nulling and peaking applications.

1-12 Selectable Ranging. Any of seven measurement ranges, or autoranging, can be selected during instrument setup. The selection will be held until the instrument is turned off. When measuring signals with levels that fall within a narrow range, selecting one specific instrument range may reduce measurement time. Autoranging is useful if the RF signal level is unknown, or if RF signals with widely varying levels are to be measured.

1-13 Selectable Filtering. Measurement speed and display stability can be optimized through the use of selectable filtering. Filter times can be adjusted up to 20 seconds maximum in 50 millisecond increments.

1-14 Zeroing. Automatic zeroing (nulling of offsets for the head and input channel) is done independently on each range to eliminate zero carryovers.

1-15 Built-In Precision Calibrator. A built-in 50MHz calibrator provides an accurate, stable, and convenient power source for calibration of the instrument to specified tolerances. The calibrator may be toggled on or off from the Setup menu. The connector is mounted on the rear panel.

1-16 Chart Reorder Output. A 0 to 10 volt DC output, proportional to the measurement values, is available for application to a chart recorder.

1-17 Optional Interface.

1-18 ACCESSORIES.

1-19 A head data adapter, for each installed channel and an AC line cord are supplied with each instrument. One or more PH2000 SERIES power heads are required. The power heads are not supplied as part of the instrument, but must be ordered separately. A five-foot power head cable, Model 66239, is supplied with each head ordered. Additional available accessories include the following:

a. Model 66240 Head/Probe Interconnecting Cable (10 ft)
b. Model 66241 Head/Probe Interconnecting Cable (20 ft)
c. Model 66242 Head/Probe Interconnecting Cable (50 ft)
d. Model 66243 Head/Probe Interconnecting Cable (100 ft)
e. Model 61303 AF/F Adapter, (for connecting cables end to end)
f. Model FT3000 Bulkhead Connector F/F, (for connecting cables end to end)
g. Model RM2000 A Rack Mounting Kit

1-20 OPTIONS.

1-25. SPECIFICATIONS. Performance specifications of the Model PM2002 are listed in Table 1-1.

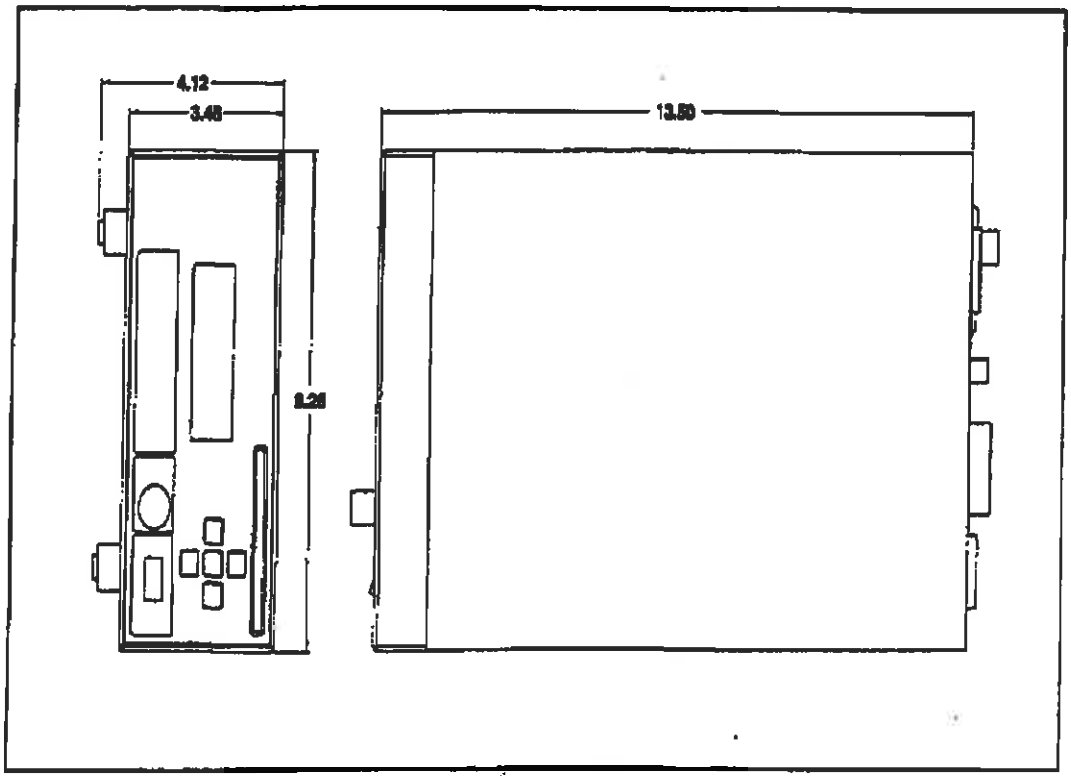


Figure 1-2 Outline Dimensions
See Figures 3-1 and 3-2 for a detailed drawing

Table 1-1. Performance Specification.

Parameter	Specification
Frequency Range	10 kHz to 100 GHz, head dependent
Power Range	-70 dBm to +44 dBm, head dependent
Power Heads	Accepts head data adapter and is compatible with all Amplifier Research diode and thermal heads
Dynamic Range	Up to 90 dB with diode heads; up to 50 dB with thermal heads
Inputs	Rear panel head connector; rear panel IEEE-488 connector.
Outputs	Rear panel PWR REF connector, 50 MHz, 0 dBm; Rear panel recorder BNC Connector, 9.06 kilohm impedance, 0 to 10 volts into 1 megohm (may be operated into 1 kilohm for IV fs).
Display	Menu-driven 20 character x 4 line LCD
Display Units	MW, kW, W, mW, µW, nW, dBm, dBr, %
Display Resolution	0.001 (db, dBm, dBr) or 5 digits (nW, mW and W)
Display Offset	-99.99 dB to +99.99 dB in 0.01 dB steps
Alarm	Individual high and low limit thresholds, -99.99 dB to +99.99 dB
Peak Power Mode	Programmable duty cycle from 0.01 to 100.00% in 0.01 steps
Ranging	Autoranging or manual (7 ranges)
Filtering	Filter times to 20.00 seconds in 0.05 second increments
Zeroing	Automatic function; calibrates, stores, and applies zero corrections to each range
High Frequency Cal Factors	+3 dB to –3 dB in 0.01 dB steps; cal factors for up to four power heads with up to 60 frequencies each may be stored in the instrument's non-volatile memory; cal factors also stored in head data adapter.
Reference Level	-99.99 dB to +99.99 dB in 0.01 dB steps for dBr measurements
Power Reference:	
Frequency	50 MHz ± 1.5%
Output Level	0 dBm
Level Accuracy	±0.7% (±0.03 dB) (23 degrees C) for 90 days; ±0.9% (±0.04 dB) RSS, ±1.2% (±0.05 dB) worst case (0 to 55 degrees C) for 1 year
Source Impedance	50 ±1 ohm
VSWR	< 1.05
Harmonic Output	<-50 dBc
Measurement Accuracy	Sum of following uncertainties (errors are ± worst case): instrument uncertainty, noise/signal percentage, power reference uncertainty, head shaping, temperature drift, mismatch, and high frequency calibration factors
Instrument uncertainty	.002% at full scale
Noise/Signal Percentage	Refer to Power Head Specification
Power Reference Uncertainty	Refer to Table 2-1 Power Reference: Level Accuracy
Head Shaping	Refer to Power Head Manual, Table 3-1
Temperature Drift	Refer to Power Head Specification
Power Requirements	100, 120, 220, or 240 VAC (±10%), 50-60 Hz or 400Hz, 15 VA maximum
Ventilation Requirements	1 ½" clearance after installation, top, side, rear
Temperature	
Operating	0 to 55°C
Non-operating	-40 to +75°C
Altitude Operating	10,000 ft.
CE Mark:	Declares conformity to European Community (EC) Council Directives: 89/336/EEC II/93/68/EEC, 73/23/EEC//93/68/ EEC & Standards: EN61326-1, EN55022, EN61000-4/-2,3,4,5,6,11,ENG1010-1
Humidity	95% non-condensing
Weight	7 lb (3.2 kg)
Dimensions	8.26 in. (21.0cm) wide 3.48 in. (8.9cm) high, 13.5 in. (34.3cm) deep

SECTION II
INSTALLATION

2-1 INTRODUCTION.
This section contains the installation instructions for the Model PM2002 RF Power Meter. It includes unpacking, mounting, power connections, cable connections and preliminary checkout procedures.

2-2 UNPACKING. The instrument is shipped complete and ready to use upon receipt. Unpack the instrument from its shipping container and inspect it for damage that may have occurred during shipment. Refer to Figure 2-1.

NOTE
Save the packing material and container
For possible use in re-shipment of the instrument.

2-3 MOUNTING. For bench use, choose a clean, dry and uncluttered surface. For rackmounting, a Model RM2000 accessory kit is available which contains the necessary parts for mounting a single half-width Model PM2002 (or a compatible product) in a single 19-inch rack

2-4 POWER REQUIREMENTS. The Model PM2002 has a tapped transformer and a power entry module containing a line voltage selector switch and two fuses. Operation is permitted from 100,120, 220 and 240 Volt ± 10%, 50 to 60Hz, single phase AC power supplies.

CAUTION

Always make certain that the setting of the line voltage selector switch most nearly corresponds to the voltage of the ac power source, and that fuses of the correct rating according to the chart just above the power entry module, are installed.

To change the line voltage selector switch or the fuses, follow this procedure:

1. REMOVE the power cable from the power entry module.
2. To open the power entry module, place a small screwdriver or coin in the slot at the top of the module and gently pry the cover open.
3. Using a small screwdriver gently pry the voltage selector cylinder from the module. Turn the cylinder so that when it is re-inserted into the module, the desired voltage will appear in the small window in the cover.
4. To remove the fuses, move the fuseholder tabs in the direction of the arrow and pull the holder out. Place a new fuse in the holder and put it back in the slot, restoring the tab to its original position.
5. After all changes are completed, close the cover. Make sure the alignment of the selector cylinder and window is correct and that the cover snaps into place.

VOLTAGE	FUSE	IEC TYPE
100/120V	0.315A	T
220/240V	0.160A	T

2-5 CONNECTIONS. An AC power cable is supplied with the instrument and a standard interconnecting cable, or cable/adapter combination is supplied with each RF head. Longer RFHead cables are available as accessories. All other cables required must be supplied by the user.

2-6 **HEAD.** Connector the RF Head that is to be used for measurement to the cable or Data Adapter-Cable combo supplied with the head. If the Data Adapter is a separate item, also connect the cable to the adapter. Make sure that the serial number on the Data Adapter matches the serial number of the RF head. Insert the 10-pin adapter plug into one of the two head inputs.

2-7 **RECORDER.** A data recorder or other similar device can be connected to the Recorder BNC connector on the rear panel. The output is a DC voltage proportional to the channel 1 display value. The voltage range is 0 to 10 volts with an output impedance of approximately 9 kohms.

2-8 **GPIB.** The standard instrument is equipped with an IEEE-488 bus interface for remote operation. The connector is located on the rear panel.

2-10 **PRELIMINARY CHECK.**

The following preliminary check verifies that the model PM2002 is operational. It should be performed before the instrument is placed in service. Proceed as follows:

a. Ensure that the voltage selector switch and fuses correspond to the AC power source voltage to be used.

b. Connect the AC power cable to the instrument and to the power source.

c. Connect one or two RF Heads to the instrument as described above.

d. Set the front panel OFF/ON power switch to the ON position.

e. Verify that Amplifier Research PM2002
423XA RF POWER METER
REV. X.XX
is momentarily displayed.

f. Verify that the measurement display showing "CH 1" and "CH 2" for Model PM2002. Other data on this display will depend upon previous settings.

g. Press the <MENU> key and select DIAGNOSTICS with the down arrow key. Press <ENTER>. Verify the following submenu:
DIAGNOSTICS:
RTN
SELFTEST<
SWITCHES
RECORDER

h. Press <ENTER> to execute the selftest. The items tested are:
1. Processor
2. SRAM Memory
3. EEPROM
Each test will display the OK message if it passed. When the test is completed the menu will reappear.

i. Use the <Down Arrow> key to move the "<" cursor to SWITCHES and press <ENTER>. Press each front panel key, avoiding <MENU> until last. Each key press will result in an identifying message; <MENU> will exit the test and return to the MENU.

j. Use the <Down Arrow> key to select RECORDER and press <ENTER>. This test will sequentially send a DC voltage in 1-volt steps to the recorder output BNC connector on the rear panel. The test will continue until <MENU> is pressed. Use a DC voltmeter to verify correct operation.

k. Press <MENU> to return to the measurement display.

l. Press the <Sensor> key and verify that the RF Head serial number(s) appear under the channel heading(s). An active channel with no head installed will report a table number.

m. Press the <AVG>key and verify that the filter time and number of samples appear for each active channel.

n. Presses the <REF Level> key and verify that a reference level and mode is shown for each active channel.

o. With each installed head connected to the reference output, press the <ZERO/CAL> key and select ZERO/CAL function for the active channel. Verify the ZERO/CAL operation completes successfully. Repeat this operation for the other channel if installed.

p. For standard instruments equipped with the IEEE-488 interface, connect a GPIB controller to the Model PM2002. Verify that the instrument can be addressed to listen at its IEEE bus address, and set to Remote. The display must show the correct status on the bottom line of the display. For message passing, the line terminators for the controller and the Model PM2002 must be compatible for both Listen and Talk. Use <MAIN><SETUP><IEEE> to set address and terminators for the PM2002. Address the Model PM2002 to Listen/Remote and send the command "?ID" or "*IDN?" EOL. Then address the Model PM2002 to Talk (controller to listen) and verify that the correct identification string is returned.

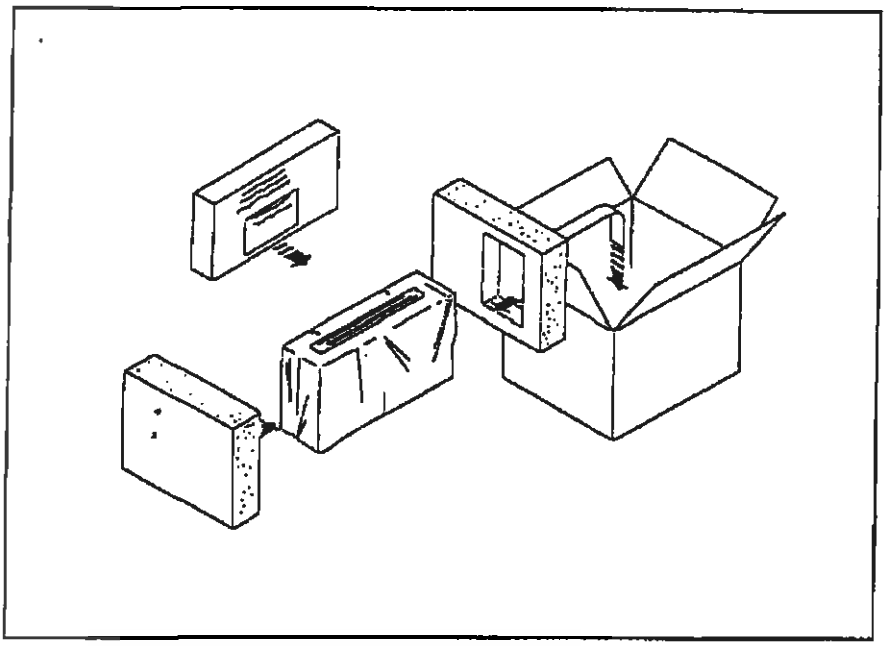


Figure 2-1 Packing and Unpacking Diagram

SECTION III
OPERATION

3.1 INTRODUCTION.

3-2 This section contains operation instructions for the Model PM2002. It is strongly recommended that the operator become familiar with all the material in this section and with the application notes in Section IV before attempting to operate the instrument; otherwise, the full capabilities of the instrument may not be realized.

3-3 OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

3-4 See Figure 3-1 and 3-2 for the location of the operating controls and connectors. Refer to Table 3-1 for the function of each of these items.

3-5 OPERATING THE INSTRUMENT

3-6 Energize the instrument by setting the POWER switch to the ON position. The instrument will perform a self-test routine and initialize the operating parameters to the power-up values.

3-7 MEASUREMENT DISPLAY.

3-8 The measurement screen shown in Figure 3-3 can be configured to display one or two channels along with the corresponding bar graph. In alarm mode, the ∧ and the ∨ symbols are displayed before the channel mode to indicate that the measured values is above or below the defined limits. An asterisk is displayed before the channel mode when the Manuel range mode and the measured value is below the lower range limit indicating an uncalibrated measurement. The alarm indicators have precedence over the range limit display. In peak pulse, the $^{P}{}_{k}$ symbol is displayed after the measurement unit. The Δ symbol is displayed when the measurement is associated with an offset. When the instrument is configured for remote operations over the IEEE-488 bus, the last line, as shown in Figure 3-4, is always used for the bus indicators.

TABLE 3-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

INDEX AND FIG. No.	NOMENCLATURE	FUNCTION
3, 3-1	Display	LCD readout of the measurements and user interface for editing of the instrument's operating parameters.
4, 3-1	Left Arrow Key	In entry mode, advances the cursor to the left.
5, 3-1	Up Arrow Key	In entry mode, advances the cursor upwards. In parameter entry mode, scrolls forward through the parameter list. In numerical entry mode, advances the value to the next higher digit.
6, 3-1	Enter Key	In entry mode, initiates the procedure to change a parameter. In parameter entry mode, terminates the current command and changes the parameters to the last displayed values.
7, 3-1	Right Arrow Key	In entry mode, advances the cursor to the right.
8, 3-1	Down Arrow Key	In entry mode, advances the cursor downwards. In parameter entry mode, scrolls backward through the parameter list. In numerical entry mode, advances the value to the next lower digit.
9, 3-1	Power Switch	Turns the instrument off and on.
11, 3-1	<REF Level> Key	Selects the reference level menu for relative measurements.
12, 3-1	<Zero/Cal> Key	Selects the zeroing and 0 dBm reference level calibration functions.
13. 3-1	<AVG> Key	Selects the filter averaging display for the measurement value.
14, 3-1	<FREQ> key	Selects the operating frequency display.
15, 3-1	<SENSOR> Key	Displays the serial numbers of the installed heads and allows for editing of the head parameters.
16, 3-1	<Menu> Key	Displays and allows editing of the instrument's operating parameters. Returns instrument to local mode when operating in the bus remote mode. Escapes back to measurement screen from any menu.
17, 3-2	Power Receptacle	Provides means for connecting the AC power cord to the instrument.
18, 3-2	Fuse	Protects the power circuits from overload.
19, 3-2	Voltage Selector Switch	Switches the power circuits of the instrument to accommodate 100, 120, 220 or 240 volt AC power sources.

TABLE 3-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (*continued*)

INDEX AND FIG. No.	NOMENCLATURE	FUNCTION
20, 3-2	Recorder Connector	Provides a DC voltage proportional to the measured values for use by an external recorder.
21, 3-2	GPIB Connector]	Provides means for connecting the instrument to the IEEE- for remote control.
22, 3-2	Head connector, Channel 2	Provides the means of connecting the power head to channel 2 of the instrument.
23, 3-2	0 dBm 50 MHz connector	Provides 50 MHz, 0dBm output for instrument calibration.
24, 3-2	Head Connector, Channel 1	Provides the means of connecting the power head to channel 1 of the instrument.

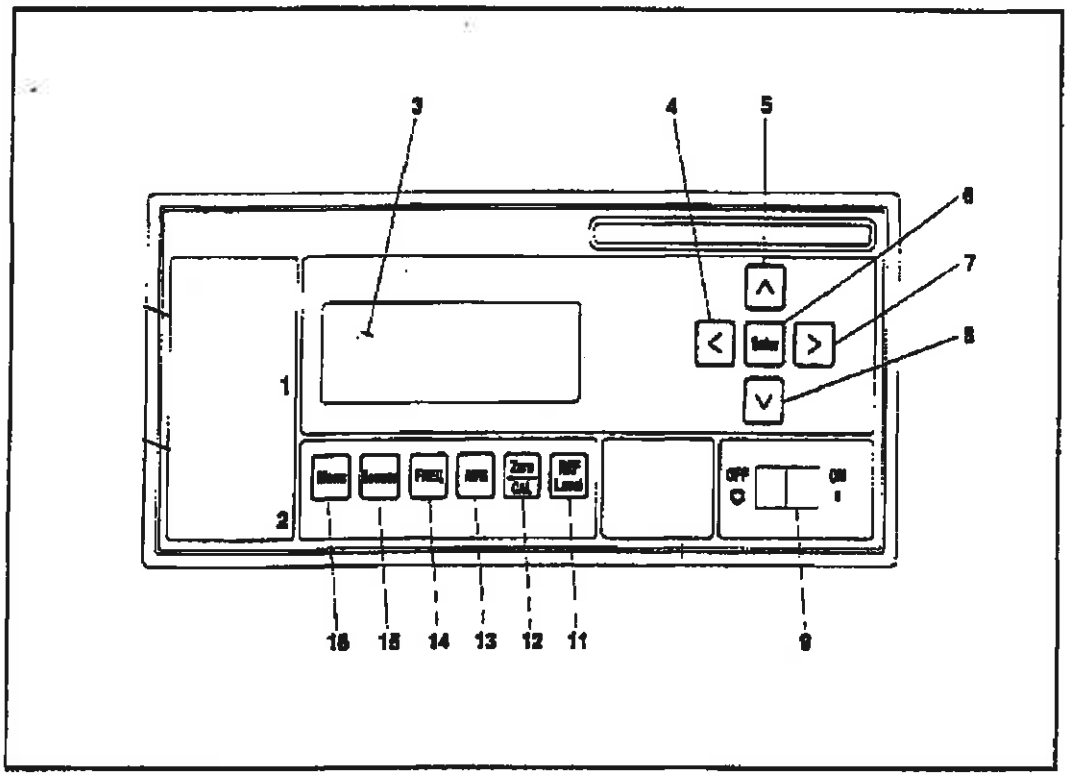


Figure 3-1 Front Panel Controls and Connectors

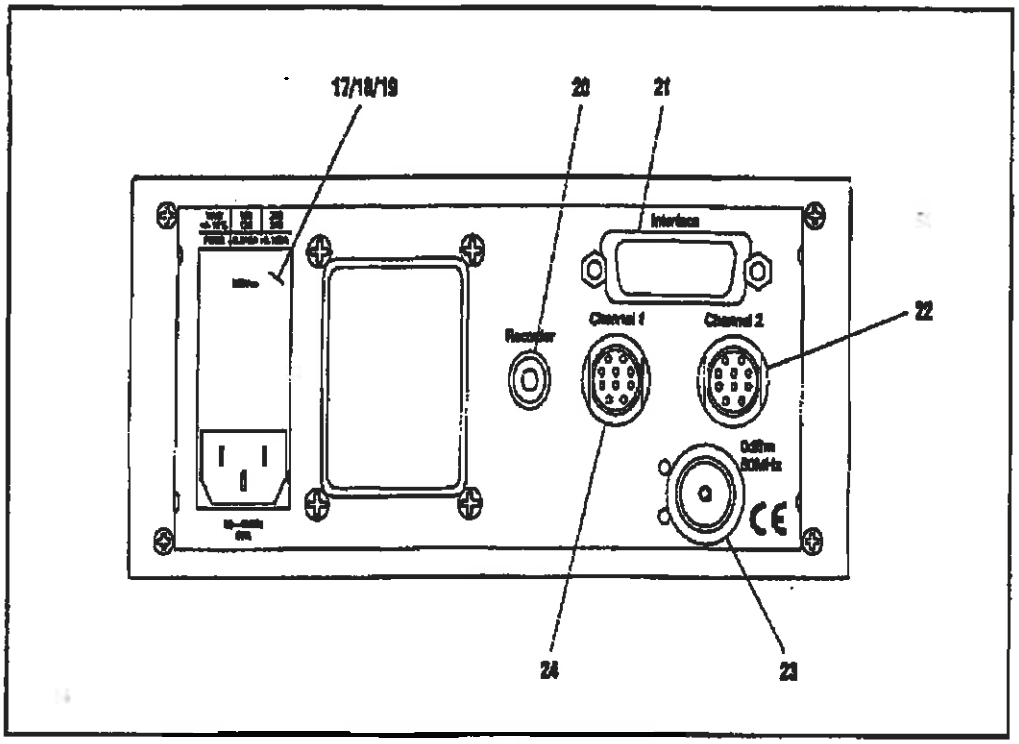


Figure 3-2 Model PM2002, Rear Panel Controls and Connectors

3-9 Menu Structure

3-10 The Model PM2002 can be configured for operation via the six switches on the front Panel; <Menu>, <Sensor>, <FREQ>, <AVG>, <Zero/Cal>, <REF LEVEL>. Pressing a key will bring the instrument to the next submenu. A flow chart of the instrument's command structure is shown in Figure 3-5. The <Menu> Key also serves as an ESCAPE key to cancel the current operation from any point and return to the measurement screen.

3-11 To change a value, use the arrow keys to position the cursor to the desired parameter. Press the <Enter> key and then use the up/down arrow keys to scroll through the parameter list. When a number is to be entered, use the left/right arrow keys to position the cursor under the number that is to be changed, then use the up/down arrow keys to increment/decrement the number. Holding the up/down arrow key will initiate repeat mode to allow rapid movement through the selections. The <Enter> key must be pressed to accept the current selection.

3-12 Within a submenu, the ΛV indicators are displayed in the upper right portion of the display when the current screen has additional information that can be obtained by scrolling with the up/down arrow keys. Three conditions are possible:

a. Λ Use the up arrow key to scroll the screen upward for additional information.

b. V Use the down arrow key to scroll the screen downward for additional information.

c. ΛV Use the up/down arrow keys to scroll the screen upward/downward for additional information.

DUAL CHANNEL

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P_K	Δ
			(	B	A	R		G	R	A	P	H	)						
L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P_K	Δ
			(	B	A	R		G	R	A	P	H	)						

SINGLE CHANNEL

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P_K	Δ
			(	B	A	R		G	R	A	P	H	)						

Key: O = 0 though 9 or a decimal point

L = Λ,V, (alarm mode), *(range hold-low)
MMMMM = CH1, CH2, CH1+2, CH1/2
UUU = nW, µW, mW, kW, MW, dBm, dBr, %

Figure 3-3 Measurement Display, Local Mode

L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P_K	Δ
			(	B	A	R		G	R	A	P	H	)						
L	M	M	M	M	M		±	D	D	D	D	D	D	U	U	U		P_K	Δ
	R	E	M		L	S	N			T	L	K			S	R	Q		

Key: REM = Remote mode enabled
LSN = Listen addressed
TLK = Talker addresses
SRQ = Service request activated

Figure 3-4 Measurement Display, Remote Mode

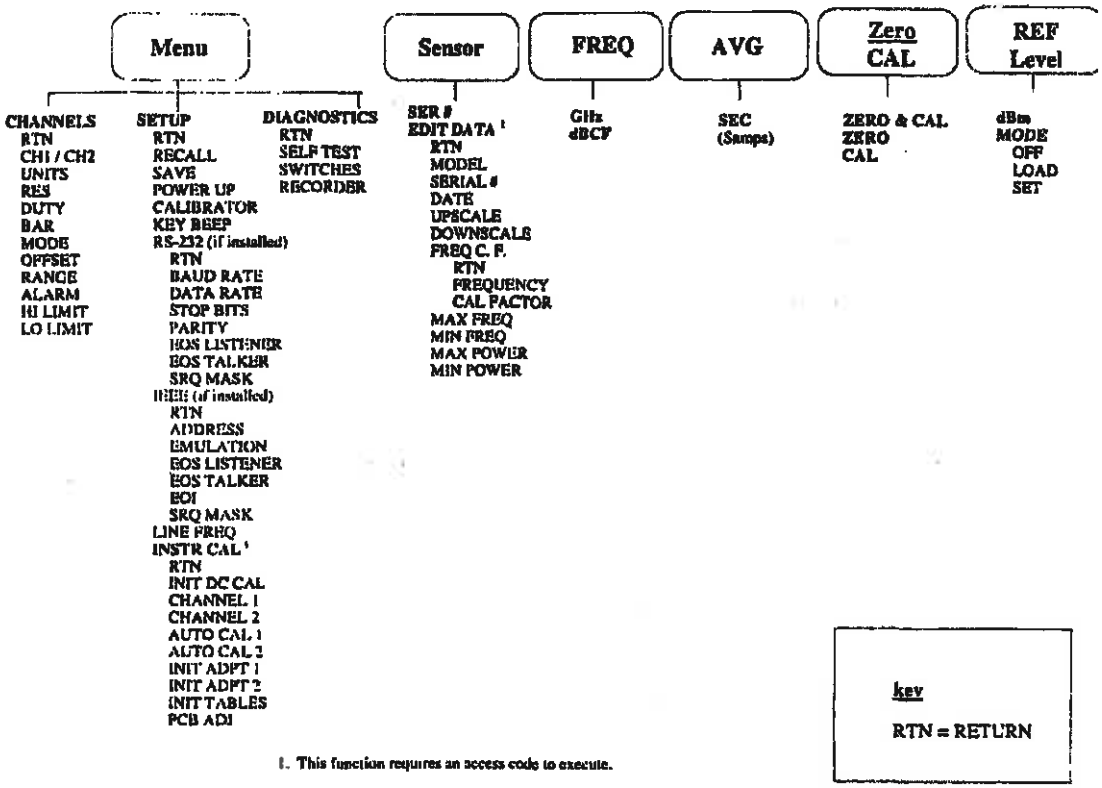


Figure 3-5 Model PM2002, Command Set

3-13 MENU KEY.

3-14 The instrument's CHANNELS, SETUP, AND DIANOSTIC commands are accessed when the <Menu> key is pressed.

3-15 Using the up/down arrow keys, the cursor can be positioned to select from the three submenus.

3-16 CHANNEL MENU. An example of the display for the channel menu, when two channels are installed in the Model PM2002, is shown in Figure 3-7. Although the figure shows eleven lines, the instrument can only display four at a time. Therefore, it will be necessary to use the up/down arrow keys to sequence through the commands. When viewing the commands, the instrument will retain the first line as a header and use the next three lines to scroll through the remaining commands.

3-17 Table 3-2 gives a description of the commands available from the Channels menu. The associated parameters, and factory default settings are also given.

3-18 SETUP MENU. An example of the display for the Setup menu, when the Model PM2002 configured with an IEEE interface, is shown in Figure 3-8. It will be necessary to use the up/down arrow keys to sequence through the commands since there are more than four lines of information to be displayed. When sequencing through the commands, the instrument will retain the first line as a header and use the next three lines to scroll through the command list.

C	H	A	N	N	E	L	S				<								
S	E	T	U	P															
D	I	A	G	N	O	S	T	I	C	S									

Figure 3-6 Main Menu Display

R	T	N					C	H	l					C	H	2		V	^
U	N	I	T	S		>	W	A	T	T	S			d	B	m			
R	E	S					X	X	X	X				X	.	X	X		
D	U	T	Y				1	0	0	.	0	0		1	0	0	.	0	0
B	A	R					O	F	F					O	N				
M	O	D	E											C	H	2			
O	F	F	S	E	T		0	.	0	0				1	0	.	0	0	
R	A	N	G	E			A	U	T	O				4					
A	L	A	R	M			O	N						O	F	F			
H	I		L	M	T		1	0	.	0	0			0	.	0	0		
L	O		L	M	T		1	.	0	0					0	.	0	0	

Figure 3-7 Channels Menu Display

TABLE 3-2 CHANNEL MENU FUNCTIONS

Command	Description	Parameters	Default
RTN	Return the instrument to the previous menu.	N/A	N/A
UNITS	Units used for measurement display	dBm, WATTS	dBm
RES	Display resolution	x.x, x.xx, x.xxx dBm or/ xxx, xxxx, xxxxx watts	X.XX
DUTY	Duty cycle for pulse power applications; a value less than 100.00 enables pulse power mode	0.01 to 100.00%	100.00
BAR	Enables the bar graph on the measurement display.	ON, OFF	ON
MODE	Sets the display mode for channel 2; only available when two channels are installed. The units for the sum and ratio modes track the units selected for Channel 2.	CH2, CH1+2, CH1/2, OFF	CH2
OFFSET	Sets the offset added to the measured value.	-99.99 to 99.99 dB	0.00
RANGE	Selects and holds the instrument's measurement range. If repetitive measurements are to be made over a narrow range of levels, selecting the appropriate instrument range may speed measurement.	Auto, 0, 1, 2, 3, 4, 5, 6	AUTO
ALARM	Enables alarm mode; the v or ^ symbol is displayed before the channel mode designator on the measurement display to indicate the upper or lower threshold limit is exceeded.	ON, OFF	OFF
HI LMT	Upper threshold limit for the alarm function.	-99.99 to 99.99 dBm	0.00
LO LMT	Lower threshold limit for the alarm function.	-99.99 to 99.99 dBm	0.00

R	T	N																v	^
R	E	C	A	L	L						>	1							
S	A	V	E								<	2							
P	O	W	E	R	-	U	P					D	E	F	A	U	L	T	
C	A	L	I	B	R	A	T	O	R			O	F	F					
K	E	Y		B	E	E	P					O	F	F					
I	E	E	E																
I	N	S	T	R		C	A	L											

Figure 3-8 Setup Menu Display, IEEE Installed

3-19 Table 3-3 gives a description of the commands, parameters & settings of the Setup menu.

TABLE 3-3 SETUP MENU FUNCTIONS

Command	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	N/A	N/A
RECALL	Recalls one of the ten user defined instrument configurations or the factory setup.	Default, 1-10	Default
SAVE	Saves the current instrument configuration to one of ten non-volatile memory locations.	1-10	1
POWER-UP	Instructs the instrument to power-up to the specified configuration.	Default, 1, 2, 3, 4	Default
CALIBRATION	Turns on/off the internal 50 MHz 0 dBm calibrator.	ON, OFF	ON
KEY BEEP	Turns ON/OFF the key beep.	ON/OFF	ON
IEEE	Brings the instrument to the IEEE menu. (if installed)	See table 3-4	N/A
LINEFREQ	Select line (mains) frequency.	50Hz, 60Hz	N/A
INSTRCAL	Refer to Service Manual.	N/A	N/A

3-20 **Programming Interfaces.** The appropriate setup menu will appear in the list.

3-21a. **IEEE Menu.** The IEEE submenu is used to configure the Model PM2002 for communications over the GPIB. An example of the menu is shown in Figure 3-10 and description of the commands, parameters and factory defaults is given in Table 3-4.

R	T	N																V	^
A	D	D	R	E	S	S						1	5						
E	M	U	L	A	T	I	O	N				4	2	3	0				
E	O	S		L	S	T	N					L	F						
E	O	S		T	A	L	K	E	R			C	R	L	F				
E	O	I										O	F	F					
S	R	Q		M	A	S	K					0							

Figure 3-10 IEEE Menu Display

TABLES 3-4 IEEE MENU FUNCTIONS

Command	Description	Parameters	Default
RTN	Returns the instrument to the previous menu.	N/A	N/A
ADDRESS	GPIB address assigned to the instrument.	0 to 30	N/A
EMULATION	GPIB emulation mode.	NONE, HP437B, HP438A	2002
EOSLSTN	End of string indicator for received message.	LF, CR, CRLF, NONE Where: LF = Line Feed CR= Carriage Return CRLF= Carriage Return and Line Feed	LF
EOSTALKER	End of string of character sent with transmitted messages.	LF, CR, CRLF, NONE	CRLF
EOI	Enables/disables the end or identify hardware control line.	ON, OFF	OFF
SRQMASK	Service request interrupts mask. See table 4-7 for bit descriptions.	0 to 255 Where: 255 enables all interrupts	0

3-22 Diagnostics Menu. The Model PM2002 can be directed to perform self-test from the diagnostics menu. The Diagnostics menu is shown in Figure 3-12 and a description of each command is given in Table 3-6.

3-23 SENSOR KEY.

3-24 Pressing the <Sensor> key brings the instrument to the Head's menu and facilitates viewing and editing of the power head's parameters. An access code is required to enter the editing mode (refer to Figure 3-14). A sample display of the Head menu is shown in Figure 3-13.

3-25 The instrument is capable of using head calibration data from either the head data adapter or from one of four internal tables. The head calibration data contained within the head data adapter is only accessible to the installed channel. For example, Channel 1 can use the head calibration data from any of the internal tables or the head data adapter 1. Similarly, Channel 2 can use the head calibration data from any of the internal tables or the head data adapter2.

3-26 Referring to Figure 3-13, the cursor can be positioned to three fields. The two fields below the 'CH 1' and 'CH 2' indicate the serial number of the head whose calibration data is selected for channels 1 and 2 respectively. The instrument uses this data for the linearity and high frequency correction data and automatically applies the correction to the measured value.

R	T	N				<													
S	E	L	F	T	E	S	T					<							
S	W	I	T	C	H	E	S												
R	E	C	O	R	D	E	R												

Figure 3-12 Diagnostics Menu Display

TABLE 3-6 DIANOSTICS MENU FUNCTIONS

Command	Description	Parameters	Default
RTN	Return the instrument to the previous menu	N/A	N/A
SELF-TEST	Instructs the instrument to perform internal diagnostics and the display test.	N/A	N/A
SWITCHES	Interactive test to verify proper operation of the front panel switches.	N/A	N/A
RECORDER	The recorder output DAC is exercised through its full range from 0 to 10 V.D.C. in IV steps until the <Menu> key is depressed.	N/A	N/A

							C	H	1						C	H	2		
S	E	R	#		>	5	0	1	4	0				4	2	9	1	0	
E	D	I	T		D	A	T	A			5	0	1	4	0				

Figure 3-13 Head Display Menu

3-27 To change the current selection for channel 1, use the arrow keys to move to the SER# command line and position the cursor below the 'CH 1' field. Press the <Enter> key and use the up/down arrow keys to scroll through the parameter list. The parameter list typically consists of serial numbers for each power head. Scroll through the list until the desired serial number is displayed and press <Enter> to accept. Move the cursor below the 'CH 2' field and follow the same procedure used to change the table for channel 2.

3-28 The instrument detects the presence of the head data adapter and automatically down-loads the head calibration data. This occurs when the power to the unit is first applied or after plugging the head data adapter into the instrument. The power head and corresponding head data adapter have matching serial numbers for maintaining them as a matched pair.

3-29 The parameter list will show TBLn (where n= 1,2,3,4) when a serial number has not been entered for the corresponding internal table. For example, TBL3 will be displayed if the serial number has not been previously entered for internal Table 3. In addition, the parameter list will show ADPTn (where n=1,2) if a serial number has not been entered for the table contained within the head data adapter. For example, ADPT2 is displayed when the serial number has not been previously entered for head data adapter 2.

EDIT DATA ACCESS CODE

The access code to enter the Edit Data menu is as follows:
Press the front panel switches in the following order:
<FREQ><AVG><AVG><FREQ><Sensor><Enter>

Figure 3-14 Access Code

R	T	N																V	^
M	O	D	E	L								5	1	0	7	5			
S	E	R	I	A	L		#				>	4	2	9	1	0			
D	A	T	E									0	7	/	2	9	/	9	6
U	P	S	C	A	L	E						0	:	4	0	6	5		
D	O	W	N	S	C	A	L	E				0	:	0	0	0	0		
F	R	E	Q		C	.	F	.											
M	A	X		F	R	E	Q					1	8	.	0	0			
M	I	N		F	R	E	Q					0	.	0	3				
M	A	X		P	O	W	E	R				+	2	0	.	0	0		
M	I	N		P	O	W	E	R				-	7	0	.	0	0		

Figure 3-15 Edit Data Menu Display

	R	T	N					F	R	E	Q			C	A	L		V	^
	0				>	0	0	0	.	0	3			+	0	0	.	0	0
	1					0	0	2	.	0	0			+	0	0	.	0	1
	2					0	0	3	.	0	0			+	0	0	.	0	4

Figure 3-16 Cal Factor Menu Display

3.30 To edit the head calibration data, move the cursor to the EDIT DATA function and press <Enter>. Scroll through the power head serial numbers until the desired selection is displayed. Press <Enter> to proceed. Enter the access code to edit or depress the <Menu> key to escape. (See Figure 3-14.)

3.31 **Edit Data Menu.** An example of the Edit Data menu is shown in Figure 3-15. Table 3-7 contains a description of the commands and associated parameters.

3-32 **Linearity Factors.** Seven upscale and downscale linearity factors are assigned to each power head. These values can be viewed or edited by moving the cursor to the UPSCALE or DOWNSCALE command and pressing the <Enter> key. The instrument will sequence through the linearity factors by pressing up/down arrow keys. If a value is to be edited, scroll to the desired linearity factor, use the right arrow key to move the cursor to the first digit in value field and then use the up/down arrow keys to increment/decrement the number. Set the remaining digits in the same manner. If another value needs to be changed, move the cursor back to the range field and use the up/down arrow keys to display the next value to be modified. Press the <Enter> key when all of the changes have been entered.

TABLE 3-7. EDIT DATA MENU FUNCTIONS

Command	Description	Parameters	Default
RTN	Returns the instrument to the previous menu	N/A	N/A
MODEL	Power head model number	0 to 99999	0
SER#	Power head serial number	0 to 99999	0
DATE	Calibration date	MM/DD/YY Where: MM = 01 to 12 DD = 01 to 31 YY = 00 to 99	01/01/01
UPSCALE	Upscale linearity factors	Range: Factor [0 to 6] : [0 to 9999]	5000
DOWNSCALE	Downscale linearity factors	Range: Factor [0 to 6] : [-999 to 999]	0
CAL FACTOR	Brings the instrument to the calibration factor menu	N/A	N/A
MAX FREQ	Power head's maximum frequency	0,100.00 GHz	18
MIN FREQ	Power head's minimum frequency	0,100.00 GHz	0.03
MAX POWER	Power head's maximum power input	[-99.99, 99.99] dBm	20
MIN POWER	Power head's minimum power input	[-99.99, 99.99] dBm	-75

3-33 FREQUENCY Calibration Factors. Up to 60 head frequency calibration factors can be entered for each power head. Position the cursor to the FREQ C.F. command. Press the <Enter> key to advance to the Cal Factor menu. A sample of the display is shown in Figure 3-16, and an explanation of the commands is shown in Table 3-8.

3-34 The up/down arrow keys are used to scroll through the calibration factor table. Use the arrow keys to move to the desired field and press the <Enter> key to change a value. The up/down arrow keys increment/decrement the value and the left/right arrow keys Select the digits. Press the <Enter> key when the desired value is displayed. Move the cursor to the RTN field or depress the <Menu> key to return to the Head menu.

3.35 The instrument scans the head calibration table for a value that matches the operating frequency. Linear interpolation is used if the operating frequency is between two of the table entries. To ensure proper operation, the calibration table must be entered in ascending order and terminated in the last table entry with a zero (o) value for both the FREQ and CAL FACTOR. In addition, new calibration values should be entered while adhering to the chronological order of the table. For example, to add the –0.01 dB calibration factor at 3.5 GHz to the example shown in Figure 3-17, the calibration factors for items four through six are re-entered.

Factor #	Frequency (GHz)	Cal Factor (dB)
0	1	0.00
1	2	0.08
2	3	-0.02
3	4	-0.15
4	5	-0.08
5	6	-0.08

Factor #	Frequency (GHz)	Cal Factor (dB)
0	1	0.00
1	2	0.08
2	3	-0.02
3	3.5	-0.01
4	4	-0.15
5	5	-0.08
6	6	-0.08

Figure 3-17 Calibration Data Example

TABLE 3-8 Head Calibration Menu Functions

Command	Description	Parameters	Default
FREQ	Frequency	0.01 to 100.00 GHz	0.05
CAL	High frequency calibration factor	-3.00 to 3.00 dB	0.00

3-36 **SAVE.** Exiting the EDIT DATA menu displays the confirmation menu as shown in Figure 3-18. Move the cursor to YES to save the edited parameters or NO to leave the data unchanged.

3-37 **FREQ Key.**

3-38 The frequency of the signal being measured must be entered in order to use the stored high frequency calibration factors. The instrument will then compute, display and apply the required correction factor to subsequent measurements.

3-39 The operating frequency is entered by pressing the <FREQ> key. The instrument will advance to the frequency menu as shown in Figure 3-19. The frequency for Channel 1 is entered by positioning the cursor to the value field under the CH1 heading and pressing the <Enter> key. A value between 0.01GHz and 100GHz can be entered. The power on default is 0.05GHz. Once the frequency is entered, the corresponding Cal Factor is displayed in dB beneath the frequency.

3-40 **AVG KEY.**

3-41 The averaging time may be adjusted to optimize measurement speed and display stability. Averaging time, in seconds, can be adjusted in 0.05 increments to a maximum of 20.00 seconds. The length of the filter in number of samples is shown on the display.

3-42 To adjust the averaging time, press the <AVG> key and the instrument will display the screen as shown in Figure 3-20. Position the cursor under the desired channel heading and press the <Enter> key. Use the arrow keys to set the desired value and then press <Enter> to accept. Entering 00.00 selects the auto-filtering Mode. This menu can be accessed to show the filter setting in the auto mode.

3-43 ZERO/CAL Key.

3-44 Zeroing should be performed when the unit is first warmed-up, a head has been changed or the instrument has drifted a significant amount with respect to the signal level being measured. For large signals (measurements taken on range 4, 5, or 6), this may be done once every several hours. For small signals, (measurements taken on range 0, 1, 2, or 3),zeroing should be done before each measurement for optimum results. When zeroing is performed, the instrument calculates and stores zero corrections for each range, and supplies the corrections to subsequent measurements.

C	O	N	F	I	R	M		S	A	V	E								
														>	N	O			
															Y	E	S		

Figure 3-18 Save Display

F	R	E	Q	U	E	N	C	Y											
							C	H	1						C	H	2		
G	H	z		>	0	1	8	.	0	0			0	0	2	.	5	0	
d	B	C	F		0	0	0	.	1	0			-	0	0	.	0	2	

Figure 3-19 Frequency Display

T	I	M	E																
					C	H	1						C	H	2				
S	E	C		>	1	0	.	5	0				0	0	.	8	0		

Figure 3-20 Averaging Time Display

												C	H	1		C	H	2		
Z	E	R	O		&		C	A	L				>							
Z	E	R	O																	
C	A	L																		

Figure 3-21 Zero and Calibration Display

R	E	F	E	R	E	N	C	E		L	E	V	E	L						
					C	H	1						C	H	2					
d	B	m			+	0	0	.	0	0			+	2	5	.	0	0		
M	O	D	E		L	O	A	D					S	E	T					

Figure 3-22 Reference Level Display

TABLE 3-9 REFERENCE LEVEL MENU FUNCTIONS

Command	Description	Parameters	Default
dBm	Reference level value in Preset mode.	-99.99 to 99.99 dBm	0
MODE	Reference level mode. "LOAD" makes the current channel measurement as the reference level. The Set mode is used to select the entered reference level. The Off mode disables the reference level adjustment.	LOAD, SET, OFF	OFF

3-45 The built-in 50 MHz calibrator provides a convenient means for calibrating the instrument. Calibration can be performed any time to assure accuracy.

3-46 The <Zero/Cal> key invokes three commands as shown in Figure 3-21.

3-47 The cursor can be positioned in any of six fields that are indicated by the '>' symbol in Figure 3-21. To zero and calibrate Channel 1 of the model PM2002, Connect the power Head to the internal 50 MHz 0 dBm calibrator, move to the ZERO& CAL command and position the cursor in the CH1 field and press <Enter>. The unit will display ZERO-ING: CHANNEL 1, Range#" followed by CALIBRATE: CHAN 1 and then return to the measurement display when complete. If a power level is detected during zeroing, the instrument will not zero and will display the error message "ZERO ERROR: CHAN 1". If a 0 dBm signal is not detected during the Calibrate function, the display will indicate "CALIBRATOR:CHAN1-NOT CONNECTED-". The Zero and Calibrate function can also be invoked individually with the ZERO & CAL commands.

3-48 REF LEVEL Key.

3-49 Press the <REF Level> key to enter a value or to use the current channel measurement for the reference level. The measurement units will automatically change to dBr for subsequent measurements. An example of the instrument's display is shown in Figure 3-22.

3-50 To set a reference level, depress the <REF Level> key to display the REFERENCE LEVEL sub-menu. Move the cursor to the reference value for the appropriate channel. (Channel 1 is default). Depress the<Enter> key to initiate the editing process. Use the arrow keys to edit the reference value in dBm. Once the desired value has been selected, depress the <Enter> key to leave the editing function. To use this value as the reference, depress the <Down> arrow key to MODE, depress the <Enter> key for mode selection and using the <Up> or <Down> arrow keys, select SET. Depress the <Enter> key will place the appropriate channel to the "dBr" mode of operation using the set value as the reference.

The instrument cal also load the current measured value as the reference level. To do this, depress the <REF Level> key to display the REFERENCE LEVEL sub-menu. Navigate the cursor using the arrow keys to the MODE selection of the desired channel. Depress the <Enter> key for the mode selection and using the <Up> or <Down> arrow keys, select LOAD. Depressing the <Enter> key will place the appropriate channel to dBr mode of operation using the measured value as the reference level. To turn off relative measurements, select OFF as the MODE.

SECTION IV
APPLICATION NOTES

4-1 INTRODUCTION.

4-2 This section provides detailed background information on various aspects of operation of the PM 2002. It is assumed that the reader is familiar with the basic operating procedures covered in Section III. This section covers the following topics:

a. Head calibration
b. Zeroing
c. Filtering
d. Noise
e. Dynamic range
f. Measurement time
g. High frequency accuracy
h. Chart recorder operation
i. Waveform sensitivity
j. Remote operation

4-3 HEAD CALIBRATION.

4-4 **GENERAL.** Two types of calibration are associated with the Model PM 2002 instrument calibration and head calibration. The instrument (less heads) must be calibrated using a stable and accurate DC source to ensure interchangeability of heads. Instrument calibration procedures are covered in the Model PM 2002 Service Manual. Head calibration data is of two types: Linearity and High frequency calibration factors. Head calibration data for up to four heads can be stored in non-volatile EEPROM plus each head data adapter contains the data matched to the corresponding power heads.

4-5 **14-Point Linearity Data.** Linearity data, also referred to as AC reference frequency linearity data, is supplied with the head and can be manually entered into the non-volatile Tables or Adapters. For heads ordered with the instrument, linearity data is stored in the head data adapter before the instrument is shipped.

4-6 At the reference frequency (50 MHz), each head has two Gain factors for each range: upscale and downscale points. Refer to Figure 4-1. The upscale points are in the range of 4000-7000, which is a gain correction factor. Upscale points are calibrated at the factory at about 70% of full scale. The downscale number is an offset correction at about 25% of full scale. Thus, for a diode head (7 ranges), there are 14 points; for thermal heads there are eight points. Range 0 and 1 share the same data points.

4-7 **High Frequency Calibration Points.** In addition to linearity data, there are high frequency calibration points. Calibration points covering the entire head frequency range are supplied with each head. Below 1 GHz, the head response is flat, and frequency calibration points need not be entered.

4-8 The Model PM 2002 provides space for up to 60 points for each head table. Frequency calibration points need not be equal frequency increments; however, the entry of data must be done in ascending order of frequency. For both diode and thermal heads, a calibration factor of 0 dB is implied at 0.00 GHz so that the instrument may be operated below the first data point.

4-9 ZEROING.

4-10 The automatic zeroing routine of the instrument takes measurements on the lowest five ranges and applies these as correction factors on subsequent measurements. Offsets in the head and input amplifiers are linearly corrected in the internal software. Offsets on the highest ranges are below 0.02% of the full scale, and do not need correction.

4-11 Input power to the head must be removed before the zeroing function is executed or an error message will be displayed. The instrument will perform zeroing, however, if the signal is less than full scale on range 0. This feature provides a great deal of offset capability for temperature effects without rezeroing the input amplifier hardware.

4-12 For full accuracy at low levels, power must be removed from the head several seconds before zeroing to allow the head to settle. This is especially true if a large signal had been applied to the head in the previous 20 seconds or so because of the dielectric absorption of the capacitors in diode heads, and because of thermal retention in thermal heads. The error resulting from different input conditions can be determined from Figure 4 -2 or 4 -3, as applicable. The curves in these figures show the decay of measured power after a large signal has been applied. The typical error that can be expected by zeroing too quickly after application of a large signal is equal to the offset power at the time of zeroing.

4-13 The Model PM2002 initiates zeroing when the ZERO & CAL or ZERO commands are invoked. The user must delay zeroing according to system requirements when the heads are used over a wide dynamic range. For example, if it is determined from the application that five seconds are required from power off to zeroing operation, then the user must wait five seconds after removing power from head before executing the zero command.

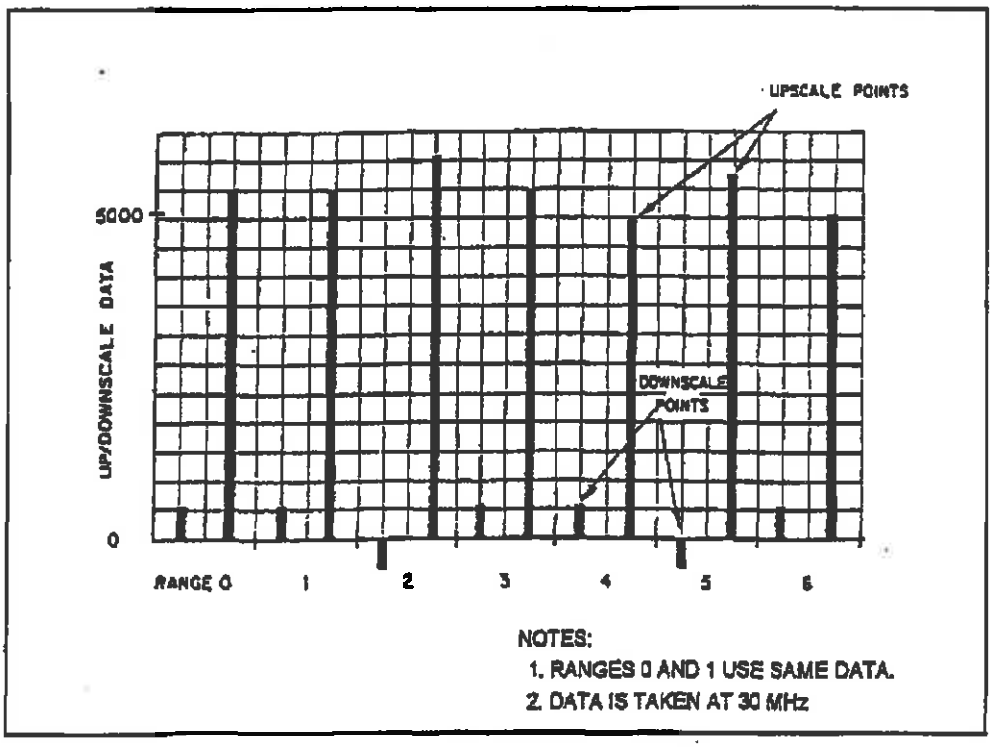


Figure 4-1 14-Point Head Calibration

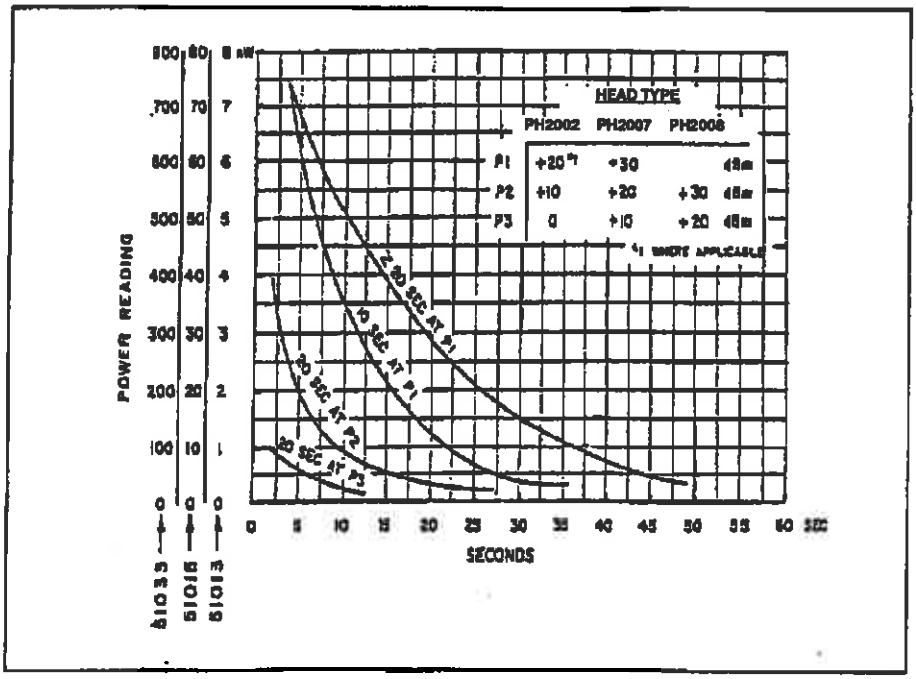


Figure 4-2 Diode Head Decay

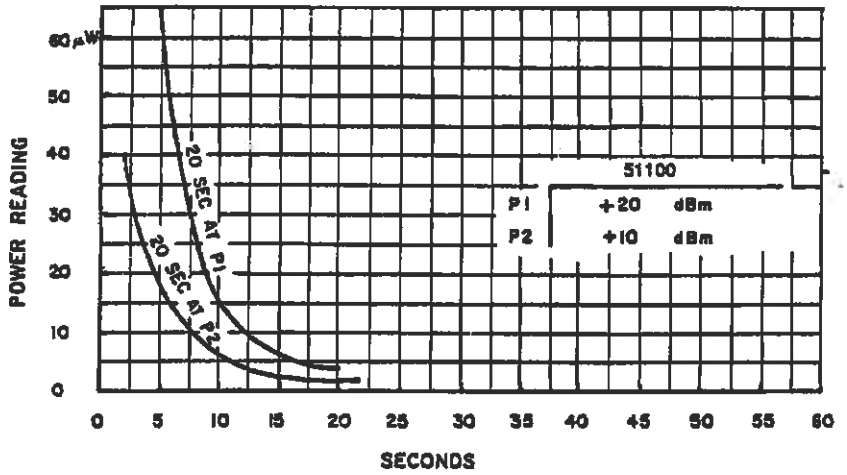


Figure 4-3 Thermal Head Decay

4-14 The zeroing time on each range has been optimized for speed and accuracy. Total zeroing time is approximately 30 seconds.

4-15 Zeroing should be done when the instrument is turned on, the head has been changed, or the instrument has drifted a significant amount with respect to the signal being measured. For large signals (range 4, 5, or 6), this may be once every several hours, if at all. For very small signals (range 0, 1, 2, or 3), for optimum results, zeroing should be done before each measurement.

4-16 DYNAMIC RANGE

4-17 The hold range mode is useful when it is known that the signal will vary over a certain limited range. (The hold range mode is active when a specific instrument range, other than autorange, has been selected.) The dynamic range of this mode is limited by the zero offset and the resolution, as shown in Figure 4 -4. It can be seen from this figure that the useful dynamic range is 20 dB if the error is to be kept below 0.1 dB. An asterisk is displayed before the channel when the measured value is below the lower range limit indicating an uncalibrated measurement.

4-18 FILTERING.

4-19 The Model PM 2002 employs digital filtering (average of measurements) to reduce the noise floor of the instrument and to stabilize measurements. The default values are optimized for speed and low noise under general conditions. Default values for normal and fast mode are as follows:

Range	Normal (sec.)	Fast (sec.)
0	2.8	2.8
1	0.8	0.8
2	0.8	0
3	0.8	0
4	0.8	0
5	0.8	0
6	0.8	0

4-20. The filtering technique used is digital pipeline filtering, also referred to as circular filtering or moving average filtering. The displayed measurement is simply an equally weighted average of the last X seconds worth of samples, where X is the filter length in seconds. For purposes of noise and settling time, the number of samples is not important, but the time is important. For example, if a three-second filter is used, the noise is the same whether 60 or 600 samples are taken in that interval, provided that the samples are taken above a certain rate. For this reason, filter selection in the Model PM 2002 is done on the basis of seconds, rather than the number of samples.

4-21 The bottom end sensitivity of the instrument is limited by head noise. An RMS noise specification is valid since the head noise and the amplifier noise are band-limited and Gaussian. The noise level, specified in picowatts at a certain filter length, is sufficient to calculate the error due to noise at any signal level, for any filter, as shown in the discussion of noise that follows.

4-22 NOISE.

4-23 Noise Reduction. The amount of noise reduction that can be realized has no theoretical limitations, except that drift enters into the picture at filter lengths over 20 seconds. The digital filter has a bandwidth and rolloff curve just as any filter does; the bandwidth can be reduced arbitrarily. The effective noise bandwidth is 0.469/t, where it is the filter length. For example, with a filter length of 4 seconds, the equivalent noise bandwidth is 0.12Hz.

4-24 Figure 4-5 is a nomograph showing the noise reduction that applies for various filter lengths, given the head noise with 2.8 seconds filtering. (This is the time for which diode head noise is specified.) Noise power is inversely proportional to the square root of the filter length. Normally, noise power varies directly with filter bandwidth; however, because power heads are square-law devices (detected voltage is proportional to power), the noise power is proportional to the square root of the bandwidth. This can be demonstrated with noise measurements. At very low filter lengths (less than 150 milliseconds), however, the noise does not increase without bound for all heads because the input amplifier noise is restricted with hardware filters. This additional filtering is not shown in the nomograph.

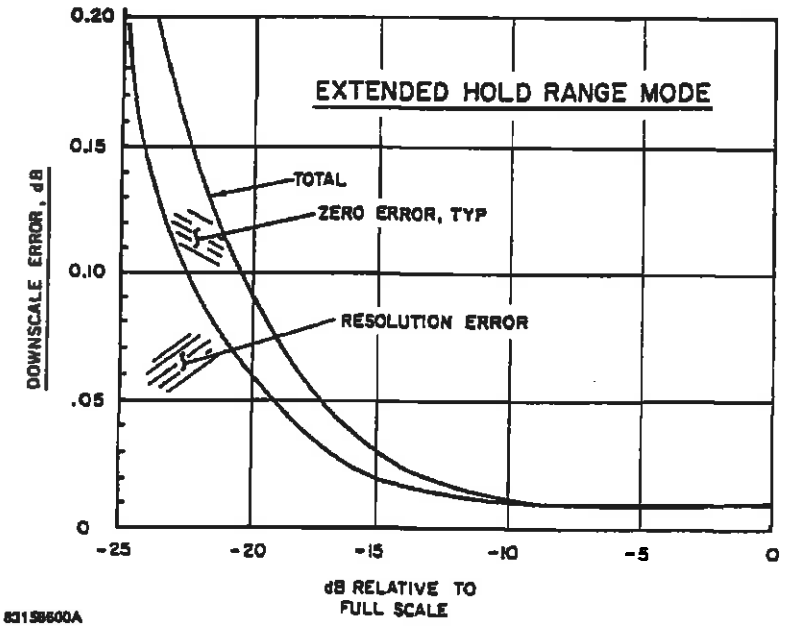


Figure 4-4 Extended Hold Range Mode

4-25 **Error Computation.** Since the noise is Gaussian, both before and after filtering, statistics show the level of confidence factor that can be associated with a given reading. (At medium and high power levels, the confidence factor is essentially unity.) Figure 4-6 shows a typical set of samples and a typical error band specification of 2 sigma. Under these conditions, 95.4% of the readings will fall within ±2 sigma.

4-26 Figure 4-7 shows the confidence factor for other error bands. The error band is expressed in pW, regardless of the power level. (The percentage error band can also be calculated as shown below.) The RMS noise is taken from the head specifications and modified as necessary for filter lengths other than 2.8 seconds. Knowing any two of the three parameters (error band, RMS noise, and confidence factor), the third can be computed. For example, if the head RMS noise is 65 pW and the confidence factor is to be 95.4%, the error band is 130 pW, single sided (±130pW). If this were the case, at a measurement level of 1300 pW the percent error band would be 10%, corresponding to about ±0.44 dB.

4-27 **Noise Error Examples.** Figure 4–8 and 4–9 show the computed error for the PM2004 diode head at different power levels, for 2.8 and 10 seconds filters. To attain these results, the heads must be at a stable temperature, and zeroing must be done immediately before the measurement is taken.

4-28 **Integration of Power.** With long filtering, instrument readings may seem erroneous because the filter has not been cleared. For example, with a 20 second filter, if a 2 second RF pulse is applied, the instrument display will indicate a nonzero level for 18 seconds after the pulse has terminated. Additional pulses will be integrated along with the first until, by process of selective deletion, the pulses are removed one at a time from the filter. Actually measurement samples are deleted, not the pulses, giving rise to a ramping effect at the instrument display/output. This is shown in Figure 4-10. In all heads, the filter is a simple integrator.

4-29 **Clearing of Filter.** When long filter times are used, it may become troublesome at times to wait for the filter to clear. If the Auto filter function is selected, the filter is cleared after significant power changes, and filtering then resumes. Clearing can also be accomplished by changing the filter length to any different value and then resetting it using the interface bus; however, with bus operation, most of the trigger modes clear the filter at trigger time.

4-30 **Partial Results.** Measurement time is affected by the filter since valid readings to within a certain error band can be obtained only when the filter is full. If the filter has been cleared, data is available at reduced accuracy immediately after the first 50-millisecond sample period. The filter uses the number of samples as a divisor when computing the average, and the output/display does not ramp but homes in on the results instead as the samples accumulate.

4-31 **MEASUREMENT TIME.**

4-32 **Step Response.** The measurement time from a power input step is the sum of the overhead time and the length of the digital filter, where the overhead time is defined as the time delay due to head response time and measurement software (processing). The overhead time is given in paragraph 4-34 for certain conditions.

4-33 **Continuous Response.** Regardless of the overhead time or the digital filter length, the Model PM2002 will output readings at a maximum rate of about 200/second with the display operating. As the head and the digital filter settle, readings will ramp up or down at that rate.

4-34 **Overhead Time.** Overhead time is <350 milliseconds for diode heads and <450 milliseconds for thermal heads under the following conditions:

a. Setting to 99% or 0.04 dB of final power
b. Power step of 10 dB
c. Range does not change
d. Digital filter set to minimum

4-35 The power step may be upward or downward. Smaller power steps will decrease this time slightly; larger power steps in the downward direction will increase the time significantly. A 40dB downward step, for example, will take several seconds to settle to 0.04 dB.

4-36 **Digital Filter.** The digital filter is a moving average or pipeline filter which simply integrates the readings over the last X seconds, where X is the filter length. A step input to the filter will produce a linear ramp at the output, terminating when the filter is full.

4-37 **Default Filter Lengths.** Although any filter length from 0 to 20 seconds may be chosen, default filter length are programmed into the instrument for optimum general conditions. (Refer to paragraph 4 – 19.) For diode heads, the range break-points are roughly in 10 dB steps, with the range 0 to 1 break-points at approximately –54 dBm.

4-38 **Settled Measurement Time.** In the free run settled mode, output data updates are held off until the measurements have settled.

4-39 Fast Mode Measurement Time. The Fast Mode can be invoked over the bus to put the instrument into its fastest sampling mode. Output data is taken after digital filtering and achieves sample rates that are dependent on the applied power level. Figure 4 – 11 shows this relationship.

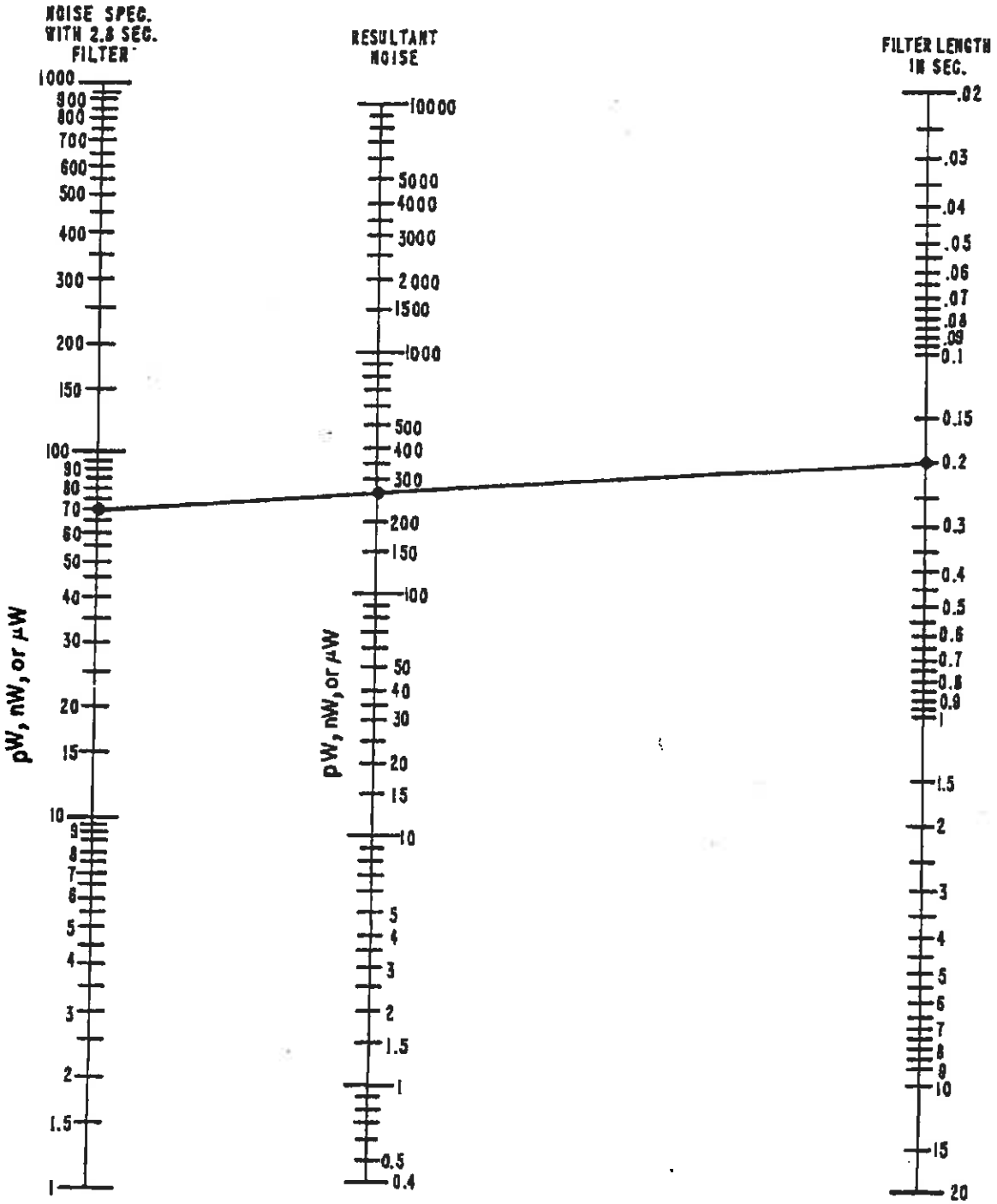


Figure 4-5 Noise Reduction

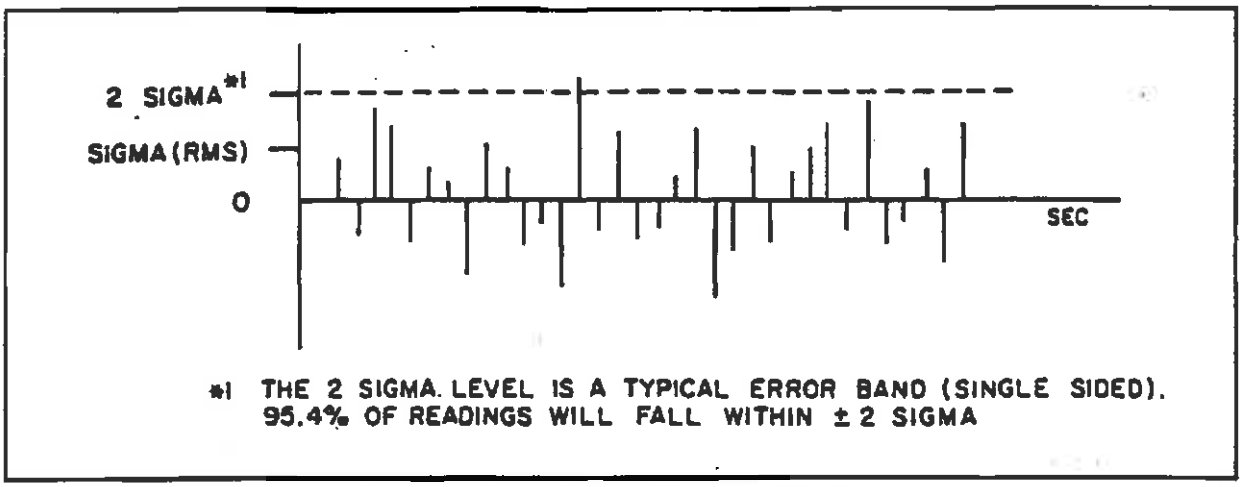


Figure 4-6 Typical Error Band Specifications

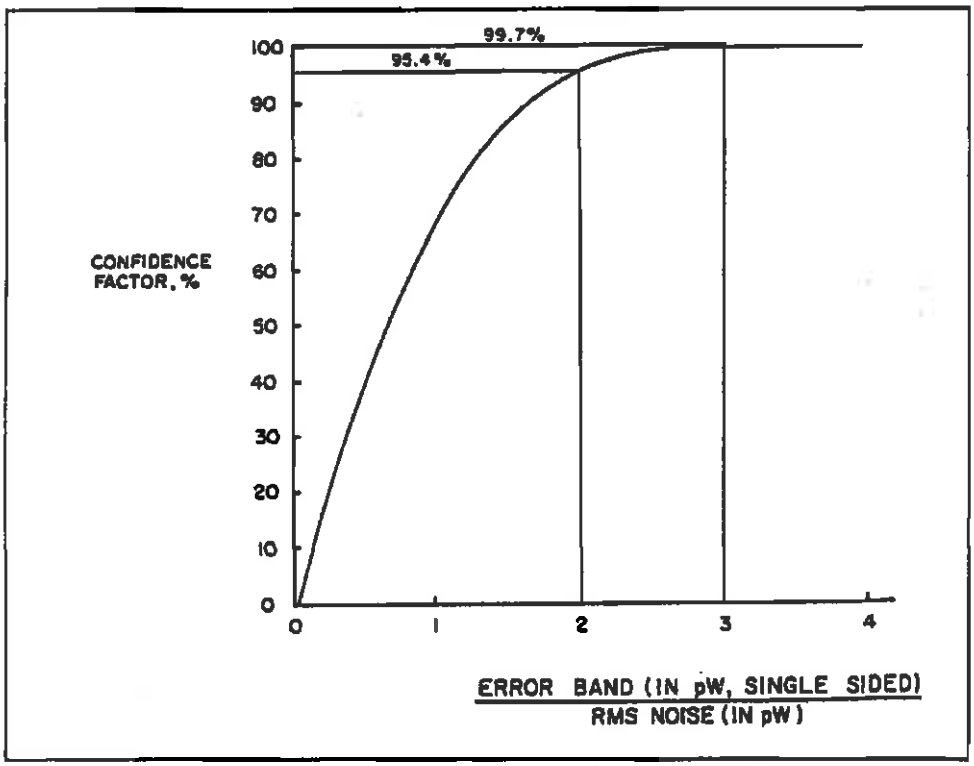


Figure 4-7 Probability of Falling within an Error Band

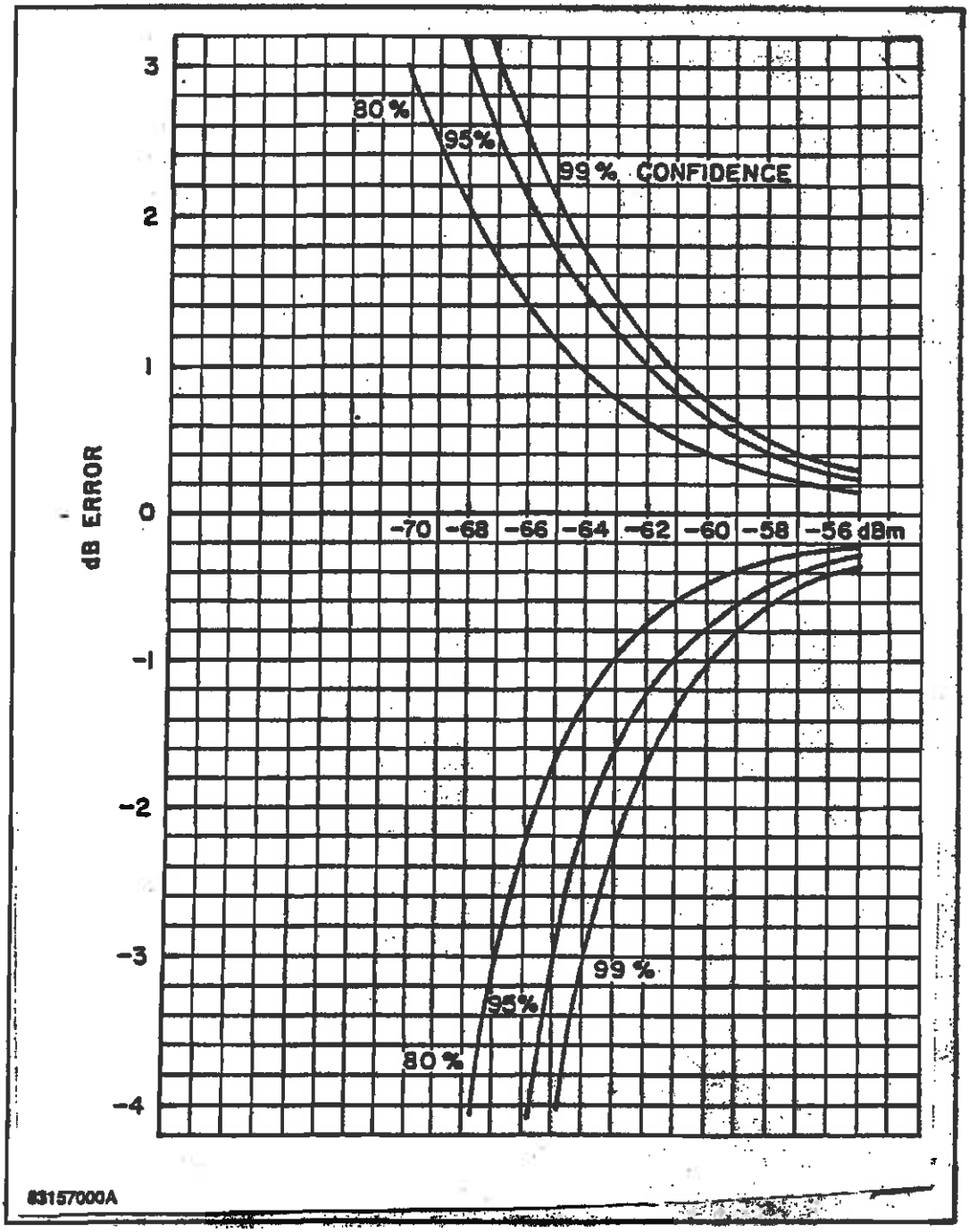


Figure 4-8 Confidence Curves, PH2004 Head with 2.8 Second Filter

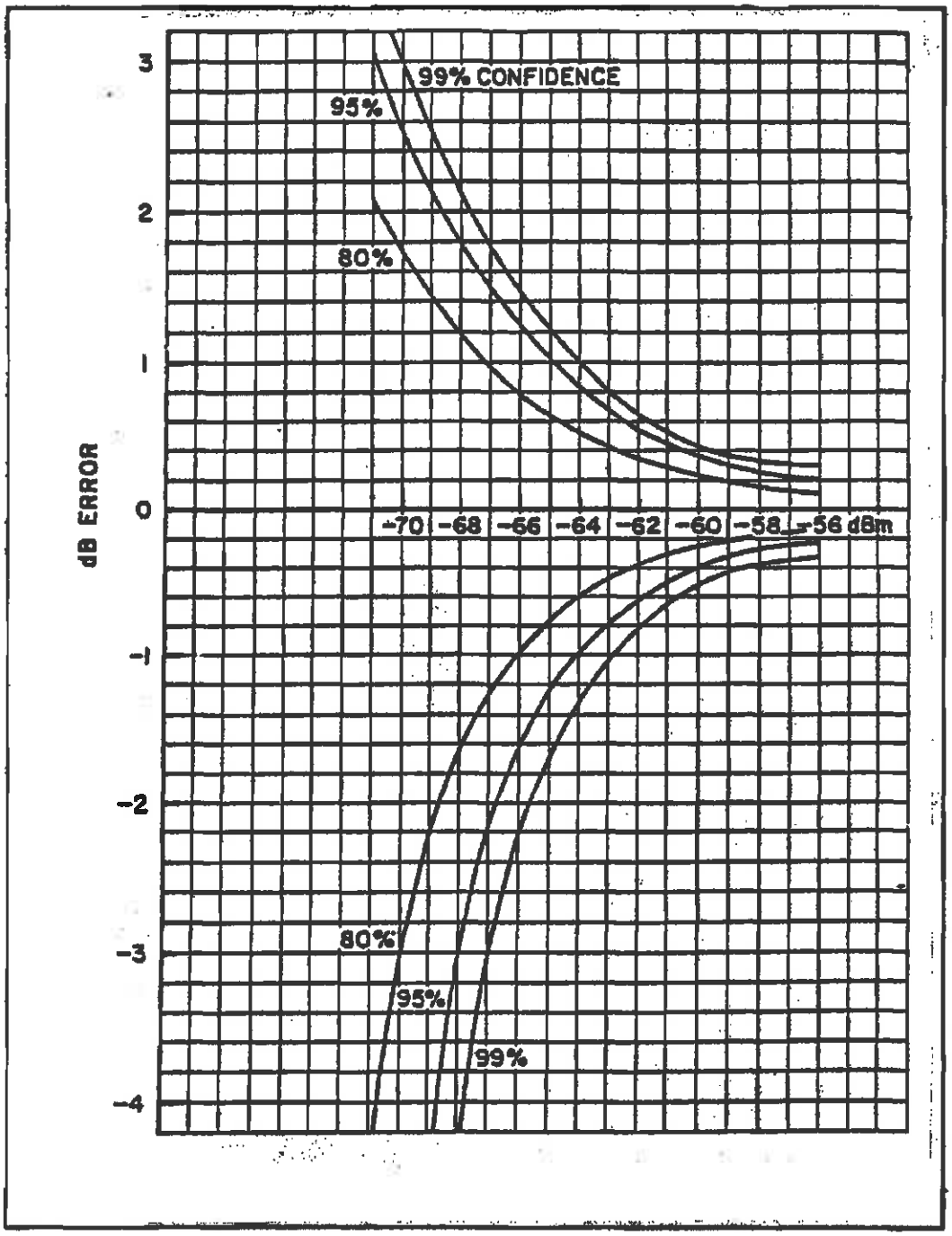


Figure 4-9 Confidence Curves, PH2002 Head with 10 Second Filter

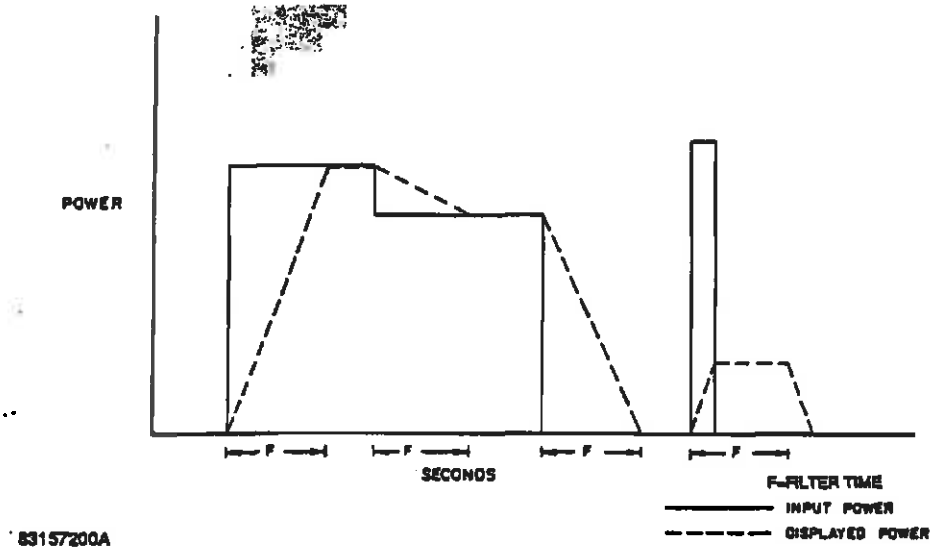


Figure 4-10 Integration of Power

4-40 HIGH FREQUENCY ACCURACY.

4-41 Power measurements, particularly at high frequencies, have a number of uncertainties which generally arise from imperfect SWRs. If all power sources and power meters had impedances that were resistive and equal to Z_o (the characteristic impedance of the measuring system), most problems would disappear. The incident, dissipated, and maximum available powers would all be equal, and the indicated power would differ only by the inefficiency of the power head in converting all dissipated power to indicated power. Tuning eliminates most of the SWR effects, but is cumbersome and is therefore seldom done. The use of attenuator pads can mask imperfect SWRs, as can the use of a directional coupler to level the source and reduce its reflection coefficient to a value equal to the directivity factor of the directional coupler. PH2007 and PH2008 power heads have precision, built-in attenuators which improve the SWR over that of other power heads.

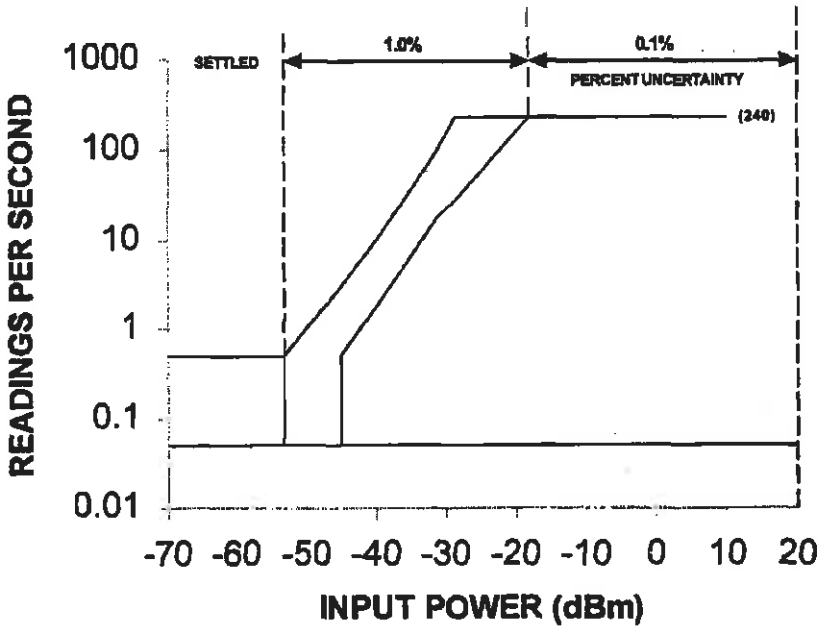
4-42 When the complex coefficients of both an imperfect source and a power head are not known, but the maximum actual SWRs of both are known, the maximum positive and negative uncertainties of the measured power, Pm, can be determined from Figure 4-12. For example, if SWR of the source is known to be 1.2 and the SWR of the power head is 1.25, the uncertainty derived from Figure 4-12 is 2%.

4-43 WAVEFORM SENSITIVITY.

4-44 Thermal heads are insensitive to the waveform because they average RF power over many tens of milliseconds. Modulated signals, non-sinusoidal waveforms, and even pulses can be detected without distortion of the measurement. Thermal heads are referred to as RMS responding.

4-45 Diode heads are also RMS responding below about –20 dBm (-10 dBm and 0 dBm for attenuated models PH2007 and PH2008). This response characteristic is obtained because the heads are dual diode types, and diodes respond in square-law fashion at low and medium levels. This is not an approximation, but rather an inherent effect. This effect results from the fact that the diodes do not turn on and off as switches, but behave as a signal dependent resistors instead. Even with no signal input, the diodes have a finite conductance, and this conductance is modulated on a cycle by cycle basis to give a net DC offset proportional to the power.

4-46 The square-law response can be seen in Figure 4-13, where a 100% amplitude modulated signal is shown to have virtually no effect on the measured power at low levels. Of course, frequency modulated and phase modulated signals can be measured at any level, since the envelope of these modulated signals is flat. Frequency shift keyed (FSK) and quadrature modulated signals also have flat envelops and can be measured at any power level.



Fast mode measurement uncertainty due to settling time and noise as a function of the measurement rate in readings per second using optimal filter settings at various power levels.

Figure 4-11 Fast Mode Sampling Rate

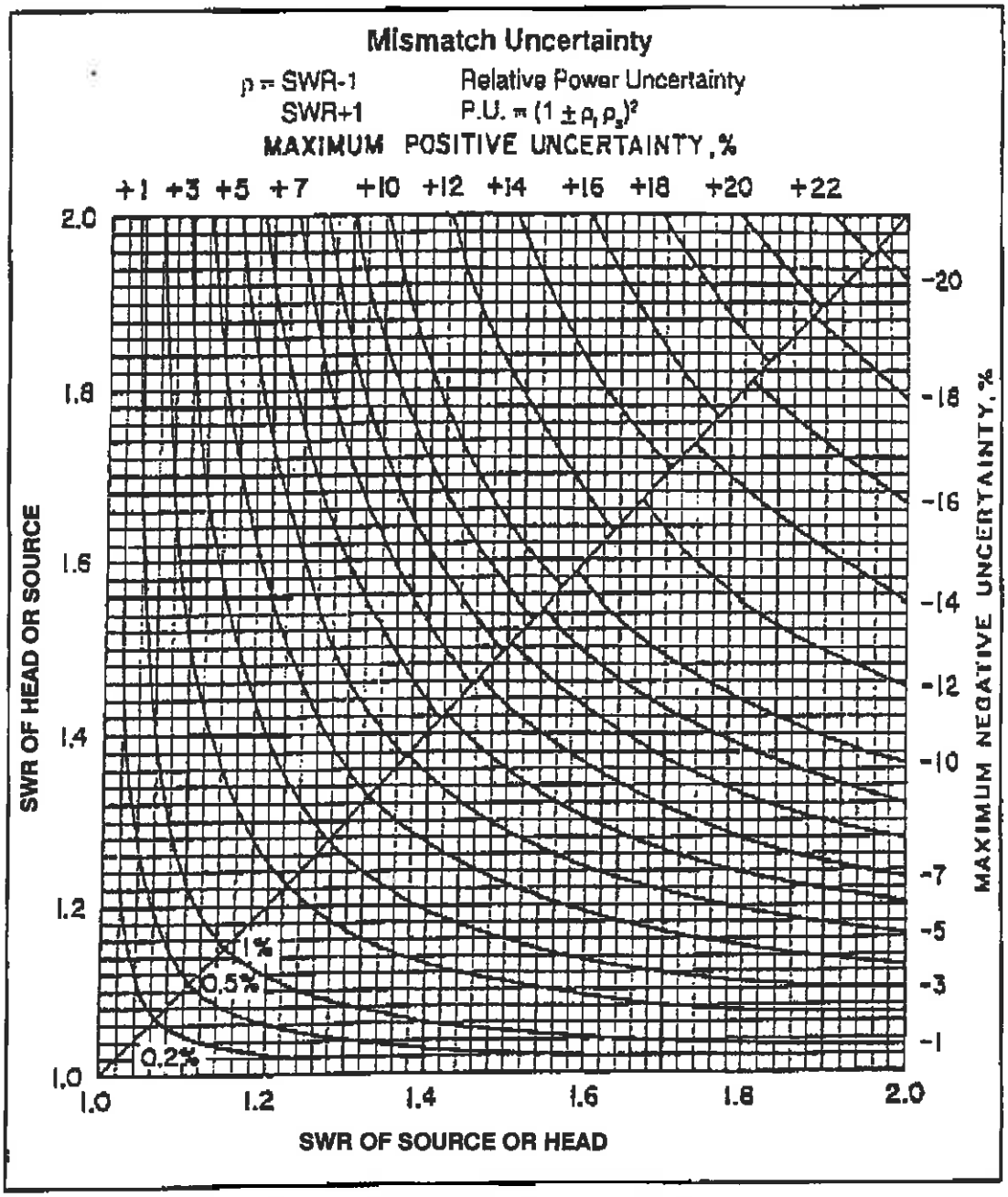


Figure 4-12 Mismatch Uncertainties Chart

4-47 At higher power levels (above approximately –10 dBm for the PH2004 Head), the diodes operate as peak detectors. The Model PM2002 is software calibrated to calculate the RF power based on a shaping transfer function (RF to DC) for each head type. However, only measurements of RF signals with flat envelops (CW, FM, PM, FSK, quadrature, etc.) are valid in this region and in the transition region from –20 dBm to –10 dBm.

A special provision is made for the case of rectangular pulses where the duty cycle (on-time percentage) is known and the top level power of the pulse (pulse power) is to be measured. The duty cycle in percent is set into the DUTY entry in the CHANNELS menu. For example, if the signal consists of pulses with a duty cycle of 25%, set Duty to 25. This will add 6 dB to the displayed power and turn on the "PK" indicator following the units. Only the display is affected by the duty cycle calculation. The measurement process is subject to the same criteria discussed above. For thermal head no correction is needed for level. However, pulse periods on the order of tens of milliseconds may result in unstable readings because of inadequate averaging. If the filter time constant is too short, it can be increased by use of the AVG function and menu.

For diode heads, the RMS power region extends up to –30 dBm with a gradual change to peak voltage response. For accurate pulse power measurement, the power meter should read an average power of -30 dBm or less. This is the power indication when the duty cycle is set to 100%. Somewhat useful measurements can be made up to –20 dBm average power, but the uncertainty will typically be at least ± 1dB.

Extra care should be taken when using the pulse power feature to avoid overload damage to power heads. Pulses with small duty cycle have a very large peak to average power ratio. The average responding power meter has a small indicated power, but the peak signal at the head diode or thermal element may easily exceed the maximum ratings.

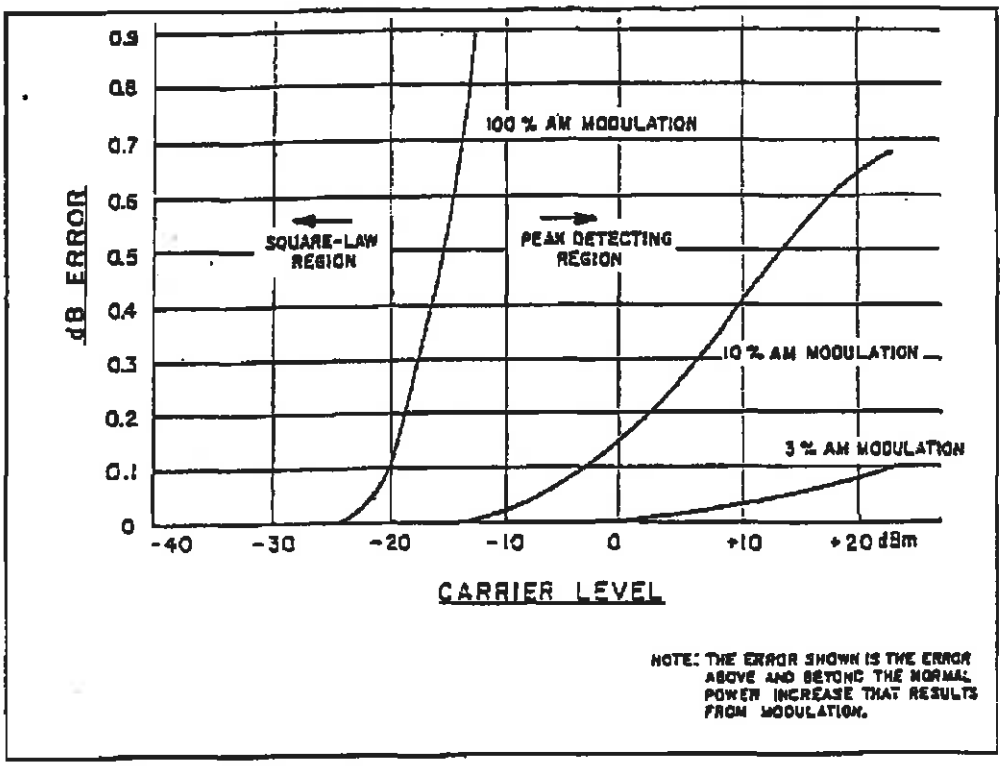


Figure 4-13 Error Due to AM Modulation (PH2004 Diode Head)

4-48 CHART RECORDER OPERATION.

4-49 The chart recorder output is a DC voltage from 0 to 10 volts. In the Watts mode, the output voltage is equal to the digits displayed on the main display divided by 1100. In the dBm or dBr modes, the output voltage is directly proportional to the level of the RF signal being measured. O dBm is at 8.0 volts with a sensitivity of 1.0 volt/10 dB overrange of the head. The output impedance is 9.06 kilohms, which gives the user the option of loading it with 1 kilohm, thereby reducing the full scale output to 1 volt. The normal 12-bit resolution is still maintained with this method. With a 1 megohm load, the circuit is essentially open and the error is small. Absolute accuracy is ± 3%.

4-50 BARGRAPH OPERATION.

4-51 The meter presents the power proportionally in the following manner.

4-52 Watts Mode. The meter follows the digital display as a percentage of the full scale. The bar graph consists of 100 segments resulting in a 1% resolution. A main data display of 1100.0 µW drives the meter to 100 percent of the full scale while a display of 561.0 µW drives the meter 51 percent of full scale. The meter reads full scale at 10 dB increments.

4-53 dBm Mode. The meter follows the digital display as a percentage of the full scale. The bar graph consists of 100 segments resulting in a resolution of 0.1 dB/segment. A main data display of 0.00 dBm (or any 10 dB increment) drives the bar graph to zero percent of full scale while 5.00 dBm and 9.99 dBm drives the meter to 45 percent and 90 percent of full scale respectively. A value of –7 dBm would drive the meter to 27 percent of full scale while a value of –2 dBm would drive the meter to 72 percent of full scale.

4-54 dBr Mode. Selecting the dBr mode positions the bar graph to 50 percent of full scale when the digital display reads 0 dBr. The analog meter thereafter reads 100 percent of full scale at +5 dBr or more and zero percent of full scale at –5 dBr or less.

4-55 REMOTE (GPIB) OPERATION.

4-56 Introduction. If the Model PM2002 is equipped with the IEEE-488 option, the instrument can be operated remotely through an IEEE-488 interface. The IEEE-488 is a hardware standard, which describes the communication and handshaking across the 8-bit parallel bus between a bus controller and up to 15 instruments.

4-57 The Model PM2002 IEE-488 capabilities are as follows:

CO	NOCONTROLLER	Capabilities
SHI	SOURCEHANDSHAKE	Complete capabilities
AHI	ACCEPTORHANDSHAKE	Complete capabilities
RLI	REMOTELOCAL	Complete capabilities
DCI	DEVICECLEAR	Complete capabilities
DTI	DEVICETRIGGER	Complete capabilities
RLI	REMOTELOCAL	Complete capabilities
DCI	DEVICECLEAR	Complete capabilities
DTI	DEVICETRIGGER	Complete capabilities
PPO	PARELLEPOLL	No capabilities
TEO	EXTENDEDTALKER	No capabilities
T6	BASICTALKER	Complete capability except for talker only
LEO	EXTENDEDLISTENER	No capability
L4	BASICLISTENER	Complete capability except for listener only
DMA		Not supported

4-58 Local Operation. This is the front panel operation of the instrument. The instrument initializes to the local mode on bus power on, and the remote mode becomes active only when the instrument is remote addressed by the bus controller. Once in the remote mode, the instrument can be returned to the local mode in any of three ways: by a GTL (go to local) command from the bus controller, by turning off power to the instrument, or by pressing the front panel <Menu> key. The third method can be disabled by a local lockout (LLO) command issued by the bus controller.

4-59 Remote Operation. In the remote mode. All front panel key closures are ignored except for the <Menu> key (which may also be disabled by a LLO command from the bus controller). When the instrument is in remote mode, the front panel REM annunciator is activated.

4-60 Bus Address. The IEEE-488 listen/talk address (MLTA) of the instrument can only be altered from the MENU-Setup-IEEE menu. Refer to paragraph 3-20.

4-61 Terminating Characters. To inform the instrument that a message has been completed, the bus controller must end all messages with a terminating character or EOI control signal. The Model PM2002 can be programmed for several combinations of terminating characters as required by the controller employed. Selection of terminating characters is accomplished via the MENU-Setup-IEEE menu. There the instrument can be programmed for individual end of string characters in both listener and talker modes as well as independently enabling the end or initiate control signal.

4-62 Listen Operation. The instrument may be addressed as a listener without regard for remote or local mode. When the listener state is set by the bus controller, the instrument will receive bytes over the bus and place them in its input buffer. For listen operation, the input buffer is 150 characters long. Only one message can be entered into the input buffer at a time. A second message cannot be sent until the instrument has processed the previous message.

4-63 Talk Operation. When the instrument is requested to talk, the instrument response will depend on how it has been set up. The setup is either through talk modes or talk array commands. Talk modes are associated with making measurements; talk array commands are associated with the downloading of calibration data and instrument states. Refer to paragraph 4-73 for setup of the talk mode.

4-64 Only one instrument at a time can be addressed to talk, but many instruments can be addressed to listen simultaneously. When the Model PM2002 is in the talk mode, the front panel TLK annunciator is illuminated. The format for each talk message is different and is explained in the paragraphs that follow.

4-65 IEEE-488 Command Support. The Model PM2002 supports the following standard IEEE-488 commands:

a. Interface Clear Command. The interface clear (IFC) command forces all devices on the bus to clear their interfaces, and the bus to an initialized state, clearing the error condition. This command can only be issued by the bus controller in charge. The Model PM2002 responds by clearing the interface.

b. Device Clear. For this instrument, the device clear (DCL) command operates the same way as the IFC command described above.

c. Group Execute Trigger. The group execute trigger (GET) command allows the bus controller to issue a trigger to all instruments on the bus simultaneously. The Model PM2002 will save the current reading at the time of the GET command and return it at the time of the next talk message mode. This is in essence a bus latch. The instrument must be set to one of its trigger modes. See paragraph 4-116.

d. SRQ. The service request (SRQ) allows an instrument to inform the bus controller that some special event has occurred. The instrument then expects the bus controller to perform a serial poll to determine what event has occurred. Events that generate service request include instrument error, measurement error, measurement is ready, and zeroing or calibration is completed. When the instrument SRQ is active, the front panel SRQ annunciator is illuminated.

e. Serial Poll. The serial poll (SP) command on the bus allows the bus controller to check the SRQ status byte of each instrument to determine which instrument is requesting service. The byte returned by the Model PM2002 is composed of multiple bits that represent different status and error conditions. These conditions are individually maskable, as shown in Table 4-7.

f. Parallel Poll. The parallel poll (PP) command is not supported.

TABLE 4-1. LISTEN PARAMETER COMMANDS

Mnemonic	Function and Limits	Description	Parameter No.
CH#	Channel select #1, 2	Sets channel	12, N
DY#	Duty cycle #0.01 to 100.00 in 0.01 steps	Sets duty cycle percent (sets pulse power mode when not = 100%)	13, N
FL#	Filter time select #0 to 20.00 in 0.05 steps	Corresponds to AVG-Sec data entry (AUTO FILTER MODE when set to 0) (see FA command)	3, N
FD#	dB calibration factor #-3.00 to 3.00 in 0.01 steps	Change the frequency CAL FACTOR to #. Original CAL FACTOR is restored by entering the frequency	10, N
FR#	Frequency select #0-100.00	Corresponds to FREQ-GHz data entry	4, N
LH#	High limit select # -99.99 to 99.99 in 0.01 steps (or 0 to 99999 in Watts mode)	Corresponds to Menu –Channel-Hi Lmt data entry	14, N
LL#	Low limit select #-99.99 to 99.99 to 0.01 steps (or 0 to 99999 in Watts mode)	Corresponds to Menu-Channels-Lo Lmt data entry	15, N
LM#	Alarm select # 0 disable # 1 enables	Corresponds to Menu-Channels-Alarm command	17, N
OS#	Offset select #-99.99 to 99.99 in 0.01 steps	Corresponds to Menu-Channels-Offset data entry	16, N
RS#	Range select #0 to 6	Corresponds to Menu-Channels- Range selection	5, N (-1= RA)*
SM#	SRQ mask #0 – 255	Corresponds to Menu-Setup-IEEE-SRQ mask data entry	11, N
SR#	Set dBr reference #-99.99 to 99.99 in 0.01 steps	Corresponds to REF Level-dBm data entry with Mode = set	6, N
SS#	Head data source #1-6 where: #1-4 are internal tables #5 is the head data adapter for channel 1 #6 is the head data for adapter channel 2	Corresponds to Sensor-Ser# selection	1, N
TM#	Talk Mode #0 to 6	Sets talk mode for IEEE-488 bus operation	8, N

TABLE 4-2. LISTEN ACTION COMMANDS

Mnemo-nic	Function	Description	Mnemon ic	Function	Description
CF	Calibration off	Turns off 50 MHz calibration	MFD	Measure Fast Dual	Sets fast dual channels measurement mode
CL	Clear	Clears error number and error	MFS	Measures Fast Single	Sets fast single channel (CH1 only) measurement mode
CN	Calibrator on	Turns on 50 MHz calibrator	MN	Measure Normal (free run)	Sets normal free run measurement mode
CP	Calibrate	Corresponds to Zero/ CAL-CAL selection	MS	Measure Settled	Sets settled measurement mode
DB	dBm select	Corresponds to Menu-Channel-Units-dBm selection	TF	Trigger Filtered	Selects filtered trigger mode
DF	Display off	Turns off instrument Display	TFD	Trigger Fast Dual	Selects fast dual channels trigger mode
DN	Display on	Turns on instrument display	TFS	Trigger Fast Single	Selects fast single channel (CH1 only) trigger mode
DR	dBr select	Corresponds to REF-Level-Mode equal to SET using the previous reference level	TN	Trigger Normal	Selects normal trigger mode
			TR	Bus trigger	Bus trigger command
			TS	Trigger Settled	Selects settled trigger mode
			ZR	Instrument zero	Corresponds to Zero/CAL-ZERO selection
FA	Auto filter	Sets instrument to auto filter	?ID	Talk instrument ID	Calls up instrument identification
LR	Load Reference	Loads the current measurement as the reference level. Corresponds to REF Level-Mode equal to LOAD	*IDN?	Talk instrument ID	Calls up instrument identification
MF	Measure filtered	Sets filtered measurement Mode			

TABLE 4-3. LISTEN ARRAY PARAMETER COMMANDS

Mnemonic	Function	Description
SI	Head ac calibration data in	Refer to paragraph 4 -90
FI	Head high frequency calibration data in	Refer to paragraph 4 -98

TABLE 4-4. TALK ARRAY COMMANDS

Mnemonic	Function	Description
SO	Head calibration data out	Refer to paragraph 4 -94
FO	Head high frequency calibration data out	Refer to paragraph 4 -102

TABLE 4-5. TALK MODES

Talk Mode	Description
0	Talk measurement floating point
1	Talk measurement with units
2	Talk error
3	Talk both channels
4	Talk channel status
5	Talk instrument status
6	Talk parameter
7	Talk array
8	Not used

4-66 **Number Formatting.** Number formatting is shown for each of the commands in the paragraphs that follow, but general rules are as follows:

a. Fixed or floating formats are accepted.
b. The optional + or – may precede the mantissa and/or the exponent.
c. An optional decimal point may appear at any position within the mantissa. A decimal point in the exponent is ignored.
d. The optional "E" for exponent may be upper or lower case.
e. All ASCII characters below and including ";" (3Bh) are considered command delimiters. The ASCII characters " " (20h), " , " (2 Ch), ";" (3Bh), and ":" (3Ah) are considered numeric delimiters.

4-67 **String Format.** String formatting is as follow:

a. The programming sequence is in natural order, that is, a function mnemonic is sent first, followed by the argument value (parameter), if applicable.
b. The data strings sent to the instrument are not case sensitive. This means lower case and upper case are the same.
c. Spurious numbers occurring in the listen string are ignored.
d. All block modes have formatted data arrays or ASCII strings. See Tables 4 -3 and 4 – 4 for commands and paragraphs 4 – 88 thru 4 – 112 for format.

4-68 **LISTEN Parameter Commands.** Listen parameter commands are listed in Table 4– 1. These are commands, received by the instrument, that expect one numerical value to follow for setting a particular operating condition. Except as noted in the table, these commands correspond to specific front panel commands. Key commands correspond to single keystrokes; non-key commands are submodes or menu types of data entry.

4-69 The numeric value (parameter) can be sent in the next listen string if the listen parameters command was the last value of the previous string. If, for any reason, a command is sent without a parameter following the command, the CL command can be used to clear the active command, or a new command can be used. The parameter number listed in Table 4 – 1 is the number returned when the talk parameter mode (talk mode 6) is exercised.

4-70 **Listen Action Commands.** Listen action commands are listed in Table 4– 2. These commands initiate an action without any parameters being sent.

4-71 **Listen Array Commands.** Listen array command listed in Table 4 – 3 transfer arrays of data (more than one parameter) to the instrument. Head data and DC calibration data are typical data. The data array is formatted as in paragraphs 4 – 93, 4 – 100, and 4 – 110. The actual amount of data depends on the specific command being used. Listen array commands are only operable over the bus, and have no application from the front panel.

4-72 The talk array commands listed in Table 4 – 4 build a talk sting in the talk buffer for transmission. Not for general purpose measurement (the talk modes are used for that), the talk array commands are used for transmitting arrays of data (more than one parameter), such as head data and DC calibration data. The buffer contents are discarded at the time of the next instrument talk request. These commands automatically change the talk mode to talk mode 7, then reset the Model PM2002 to its previously selected talk mode. This is the only time that the instrument uses the talk buffer or talk array mode. Talk array commands are operable only over the bus.

4-73 **Talk Modes.** When the Model PM2002 is requested to talk, it responds according to how it has been set up. The talk setup is either through talk array commands or talk modes. Talk modes are associated with making measurements; talk array commands are associated with downloading of calibration data and instrument states. The talk modes are described in the following paragraphs.

4-74 The Model PM2002 supports eight talk modes of operation, as listed in Table 4 –5. Once the talk mode has been set, the bus controller need only tell the Model PM2002 to talk and it will respond according to the talk mode.

4-75 Talk modes 0 through 6 can be set directly by use of the talk mode (TM) command. For these modes, the instrument will remain in the selected mode until the talk mode is changed or until a talk array command is received. Talk mode 7 is a temporary talk mode that is automatically enabled in response to a talk array command. This mode cannot be set by the bus controller directly. This temporary talk mode is disabled when the talk array operation is complete.

4-76 The default condition for the talk mode is 0. The talk modes are described individually in paragraphs 4–77 through 4–86.

4-77 **Talk Mode 0 (Talk Measurement Floating Point).** The talk mode 0 format is as follows:

#1, #2

where:

#1 is the error flag (1= error, data invalid).

#2 is the measurement in floating point notation in the units selected (dBm, dBr, or milliwatts). In watts mode, the unit is fixed at mW.

Examples:

0,0.00E00 – No error, power is 0.00 dBm

1,0 – Under range error at –75.00 dBm

0,98.9E-6 – No error, power is 98.9 n W

4-78 Talk Mode 1 (Talk Measurement with Units). The format for talk mode is as follows:

#1, $1

where:

#1 is the error flag (1 = error)

$1 is the measurement. The format is fixed point followed immediately by a three character string that indicates the unit of measurement.
Possible units are "dBm", "dBr", "nW", "uW", "mw", and "W", "kW",and "MW". If needed, the string can be parsed externally into a number and a three character message.

Examples:

0,0.00dBm – No error at 0.00 dBm
1,0dBm – Under range error at –75.00 dBm
0,98.9uW – No error at 98.9 microwatts

4-79 Talk Mode 2 (Talk Error). The talk mode 2 format is as follows:

#1, #2, #3

where:

#1 is the instrument error number. A 0 will always be reported in this position.
#2 is the measurement error, from 0 to 99. A 0 indicates no error. Refer to Table 4 – 6 for error messages.
#3 is the channel reporting errors. A 1 is reported for channel and a 2 is reported for channel 2.

Execution of this talk mode automatically clears the measurement error after it has been reported. If more than one error occurs, the instrument will indicate the first one that occurred.

Examples:

0,0,1 – No error is reported for channel 1
0,3,2 – Power level is underrange for channel 2

4-80 Talk Mode 3 (Talk Both Channels). The talk mode 3 format is as follows:

#1, #2, #3, #4

where:

#1 is the error flag for channel 1 (1 – error, date invalid)

#2 is the measurement in floating point notation in the units selected (dBm, dBr, mW). In watts mode, the unit is fixed at mW.

#3 is the error flag for channel 2 (1 = error, data invalid)

#4 is the measurement in floating point notation in the units selected (dBm, dBr, mW). In watts mode, the unit is fixed at mW.

Examples:

0,0.00E00,0,1.00E00 – No error, power is 0.00 dBm on channel 1 and 1.00 dBm on channel 2.

1,0,0,1.00E00 - Channel 1 under range at –75 dBm and 1.00 dBm on channel 2.

0,90.1E – 6,0,1.00E1 – No error, power is 90.1 nW on channel 1 and 10.00 dBm on channel 2.

4-81 Talk Mode 4 (Talk with Channel Status). The format for talk mode 4 is as follows:

#1, #2, #3, #4, #5, #6, #7

where:

#1 is always 1 in the PM2002

#2 is always 1 in the PM2002

#3 is the measurement units that the channel is set;

- 0 Power in watts, milliwatts, microwatts, or nanowatts
- 1 Power in dBm
- 2 Power in dBr

#4 indicates the trigger mode of operation;

- 0 Measure Normal (also known as free-run)
- 1 Measure Filtered
- 2 Measure Settled
- 3 Trigger Normal
- 4 Trigger Filtered
- 5 Trigger Settled
- 6 Reserved
- 7 Measure Fast Single
- 8 Measure Fast Dual
- 9 Reserved
- 10 Trigger Fast Single
- 11 Trigger Fast Dual

#5 is always 0 in the PM2002

#6 is always 0 in the PM2002

#7 is the software version number.

4-82 Talk Mode 5 (Talk Instrument Status). The format for talk mode 5 is as follows:

#1, #2, #3, #4

where:

#1 is always 0 in the PM2002

#2 indicates calibrator status;

- 0 off
- 1 on

#3 is always 0 in the PM2002

#4 is always 0 in the PM2002

4-83 Talk Mode 6 (Talk Parameter). The format for talk mode 6 is as follows:

#1, #2

where:

#1 is the active parameter number (0 – no parameter selected).

2 is the active parameter value, for example "frequency". The units are defaulted.

4-84 This command returns two numbers which describe the current "opened" or selected parameter in the instrument and its value. For example, the frequency to which the instrument is set can be read over the bus. To read a parameter, it must be "opened" first as described in paragraph 4 – 85. A parameter in the Model PM2002 is defined as a front panel or bus command that allows or requires a numerical value to be entered into it. The parameters and parameter numbers are listed in Table 4 – 1. The data sent over the bus is the same as the data that would appear on the instrument's displays when the parameter is selected.

4-85 To use this talk mode, the instrument is first placed in talk mode 6 and a parameter is then opened (made active) by sending the bus command. No numeric value should follow and the clear command should not be used. Then, while the parameter is active, a talk command is issued to the instrument and the data for that parameter is sent out on the bus. A parameter can be deactivated by simply entering a number or sending another command.

Examples:

0,0	No parameter is active and the second value should be ignored
10, -3.00	The dB cal factor is currently set to –3.00 dB
5, 1	Range 1 is set
4, 1.23	The frequency is set to 1.23 GHz

TABLE 4 – 6. ERROR MESSAGES.

ERROR MESSAGE CODE	DESCRIPTION
0	No errors
1	Number entry out of range for parameter set.
2	Unused
3	-LO- indication on display. Is caused by a. Power level below amount allowed in dBm display during autorange b. Power level below amount allowed for range set in watts or dBm display.
4	-HI- indication on display. Is caused by a. Power level above amount allowed in dBm display during autoranging b. Power level above amount allowed for range set in watts or dBm display.
5	Occurs when input channel attempts to autorange below the range 0. Caused by incorrect zeroing of channel or a head which is damaged or not connected.
6	Unable to zero instrument because power is applied to the head, the head is damaged, or the head is not connected.
7 thru 23	Unused
24	Frequency out of range of entry. This error applies to heads not calibrated at the frequency entered.
25 thru 29	Unused
30	The message string has exceeded 150 characters. All commands sent are ignored.
31	The command string sent has not been recognized by the instrument. If more than one command has been sent, the commands occurring before the unrecognized command have been executed, while subsequent commands will be ignored.
32 thru 38	Unused
39	Calibration attempted when power exceeds ± 3 dB of the 0 dBm reference, or when calibration is attempted at ± 3 dB from –10 dBm,+10 dBm or +20 dBm.

4-86 Talk Mode 7 (Talk Array). Each of the different talk array commands has a different format. (Refer to the applicable section of paragraph 4 – 75). This talk mode is not directly settable by the bus controller; it is set automatically by execution of one of the talk array commands. Talk mode 7 builds a data string in the talk buffer for a one-time transmission. It is used to send an array of numerical data or a string of character data, such as head and/or calibration data. Once executed, this mode is automatically cleared to its previously selected value or default conditions.

4-87 IEEE-488 BUS ONLY COMMANDS.

4-88 General. The following paragraphs cover commands that are available only under remote control on the bus.

4-89 **Talk Mode (T M) Command.** The talk mode command is used to change to a selected talk mode. The range of data for this command is from 0 to 6. Talk mode 7 can only be set indirectly by execution of a talk array command. The talk mode command is classified as a listen parameter command.

Example:

TMI – Set talk mode 1 which is talk measurement with units.

4-90 **SI COMMAND.** Used in conjunction with the SO command, this command is used to send a portion of the head calibration data to the Model PM2002 in form of an array of numeric data. In this way, head data can be transferred from one instrument to another, or stored on a disk.

4-91 The data is the head model, head S/N, and the 14-point linearity data (AC calibration data) for a selected head. This command complements the SO command over the bus, and the SO command would normally be the source of the data string for this command. The SI command is classified as a listen array command.

4-92 In addition to the 14-point linearity data, each head has a high frequency calibration data, which is loaded with the FI command. (See paragraph 4-98.)

4-93 The format for the SI command is as follows:

SI head model, head serial number,
U0, U1, U2, U3, U4, U5, U6, D0, D1, D2, D3, D4, D5, D6

Where:

Head model is a number in the form PHXXXX, where XXXX is a four digit number sent to the instrument. Heads must be resident in the instrument firmware.

Head serial numbers is from 0 to 99999, representing the last 5 digits of the head's full serial number.

U0 through U6 are the upscale gain factors (1000 to 9999, nominally 5000).

D0 through D6 are the downscale factors (-999 to +999).

Each numeric value must be separated by a valid delimiter.

Example:

SII3, 1234, 5012, 5003, 5032, 5013, 4995, 5005, 4891, -20, –21, 2, -3, -14, 15, 6

4-94 **SO Command.** Used in conjunction with the SI command, this command is used to send head 14-point linearity data out to the bus controller. (Refer to the SI command description for general use of these commands.) Head data also includes high frequency calibration data, but this data is handled with the FI command. See paragraph 4 – 98.

4-95 When executed, the SO command instructs the instrument to build an array of numeric data in the talk buffer for transmission by next the talk request. The array consists of head model, head S/N, and numeric data representing the 14-point linearity data (AC calibration data) for a selected head. This command complements the SI command over the bus, and the SI command would normally be the destination of the data string of this command. The SO command is classified as a talk array command.

4-96 The talk mode is set temporarily to talk mode 7 (talk array) when this command is executed. After execution, the talk mode is reset to the previous setting. A clear command will also reset the talk mode.

4-97 Formats are as follows:

a. To the instrument in a listen string: S0

b. From the instrument in the next talk string: head model, Head serial number,

U1, U2, U3, U4, U5, U6, D0, D1, D2, D3, D4, D5, D6, where the format descriptions are the same as in paragraph 4 – 93. Each numeric value must be separated by a valid delimiter.

Example:

To the instrument in a listen string: SO
From the instrument in the next talk string:
PH2004, 1234, 5023,5001, 5012, 5010, 4997, 5005, 5003, 10, 13, -2, -23, 14, –15, 6

4-98 **FI COMMAND.** Used in conjunction with the FO command, this command is used to send head high frequency calibration data to the Model PM2002 for a selected head in the form of an array. In this way, head data can be transferred from one instrument to another, or stored on a disk. In addition to the high frequency calibration data, there is 14-point calibration data for the head, but this is handled by the SI command.

4-99 The data is for a selected head. This command complements the FO command over the bus, and the FO command would normally be the source of the data string for this command. This command is classified as a listen array command. Data is loaded in blocks from 1 to 12 pairs.

4-100 The command format is as follows;

FI n, FRn, CRn, FRn+1, CFn+1,....FRN+11, CFn+11

where:

n is the table number pointer, from 0 to 59.
FRn is the first frequency of this group, from 0.00 to 100 GHz in 0.01GHz increments. It is head dependent.
CFn is the first dB cal factor for this group, from –3.00 to +3.00 dB in 0.01 dB increments.

Each numeric value must be separated by a valid delimiter.

4-101 The total number of frequency points is limited to 60 for head tables 1 through 6. The table number pointer is the beginning location for the frequency/db cal factor pairs. Frequency cal points must be in numerical order of frequency. Generally, the first point is at 0 GHz, with a cal factor of 0.

Example:

F10, 0.00, 0.00, 1.00, -0.05, 2.00, -0.07, 3.00, 0.10, 4.00, -0.06, 5.00, -0.05, 6.00, 0.00, 7.00, 0.13, 8.00, 0.42, 9.00, 0.34, 10.00, 0.00, 11.00, 0.15,
F112, 12,. 12, 13, -13, 14, 1.14, 15, .85

4-102 **FO Command.** Used in conjunction with the FI command, this command is used to send head high frequency calibration data out to the controller. Refer to the FI command description for the general use of these commands. Data points are loaded in blocks of 12.

4-103 When executed. This command instructs the instrument to build an array of numeric data in talk buffer for transmission by the next talk request. The array consists of numeric data representing the dB cal factor information for a selected head table. The FO command is classified as a talk array command.

TABLE 4 – 7. SRQ MASKS—NATIVE MODE

Bit	Description
0	Set bit indicates LO LIMIT alarm in Channel 1
1	Set bit indicates that a measurement error has occurred
2	Set bit indicates that either a Trigger Filter or Trigger Settled measurement is ready
3	Set bit indicates that a CAL/Zeroing command is complete
4	Set bit indicates HI LIMIT alarm in Channel 1
5	Set bit indicates LO LIMIT alarm in Channel 2
6	Set bit indicates that an SRQ is active; this is a summary bit used in serial poll, not a masked bit
7	Set bit indicates HI LIMIT alarm in Channel 2

4-104 The talk mode is temporarily set to talk mode 7 (talk array) when this command is executed. After the command has been executed, the talk mode is reset to the previous setting. A clear command will also reset the talk mode.

4-105 The format for the FO command is as follows:

a. To the instrument in the listen string: FO n

b. From the instrument in the next sting: FRn, CRn, FRn+1, CRN+1,....FRn+11, CFn+11

where:

n is the table number pointer, from 0 to 60.

FRn is the first frequency of this group, from 0.00 to100 GHz in 0.01 GHz increments. It is head dependent.

CRn is the first dB cal factor for this group, from –3.00 to +3.00 dB in 0.01 dB increments.

Each numeric value will be separated by a comma.

4-106 Refer to FI command for limitations on the pointer and starting frequencies, and for general use of this command.

Example:

Command sent to the instrument: FO 0
Numeric array built into the talk buffer:
0.00,0.00,1.00,-0.05,2.00,-0.07,3.00,-0.10,4.00,
-0.06,5.00,-0.05,6.00,0.00,7.00,0.13,8.00,0.42,
9.00,0.34,10.00,0.00,11.00,0.15

Command sent to the instrument: F0 3
Numeric array built into the talk buffer:
3,00, -0.10, 4.00, -0.06, 5.00, -0.05, 6.00, 0.00, 7.00,
0.13, 8.00, 0.42, 9.00, 0.34, 10.00, 0.00, 11.00, 0.15,
12.00, 0.32, 13.00, 0.25, 14.00, 0.43

4-107 DF Command. This command is classified as a listen action command. Its functions are to blank the front panel display for secure ATE applications and to speed up operations by reducing the number of tasks that have to be performed by the Model PM2002. When the display is turned off, the display hardware is still functional, but it is not updated for certain types of information.

4-108 DN Command. This command enables the front panel display, complementing the DF command. This command is classified as a listen action command.

4-109 SM (SRQ MASK) Command. This command is used to set the SRQ mask which selectively enables service requests generated by the Model PM2002. This command is classified as a listen parameter command. The range of numeric entry is from 0 to 255. The SRQ mask is logically ANDed with the SRQ sources to determine if an SRQ should be generated. The SRQ bit map is shown in Table 4 – 7. For more information on SRQ and the related serial poll, refer to paragraph 4 – 65.

Example:

SM 0 – Disable all service requests
SM 2 – Enables SRQ only on measurement errors
SM 8 – Enables service request only when a zeroing operation is complete

4-110 MEASURED AND TRIGGERED OPERATION AND SETTLED READING.

4-111 General. Five measurement modes and five triggered modes are available over the bus. They are:

a. Measure Normal (also known as free-run)
b. Measure Filtered
c. Measure Settled
d. Measure Fast Single Channel
e. Measure Fast Dual Channels
f. Trigger Normal
g. Trigger Filtered
h. Trigger Settled
i. Trigger Fast Single Channel
j. Trigger Fast Dual Channels

The instrument must be in remote bus operation to invoke these modes of operation. When in local operation, only measure normal is available. The five measurement modes are each self-triggering (free running) while the trigger modes require a bus trigger command. The operation of each mode is modified by filter selection and range selection. See paragraphs 4 – 16 and 4 – 18. The modes are described below.

4-112 Measure Normal (MN). This is the mode to which the instrument initializes at power up when the local command is issued in the bus operation or when returning from a calibration mode.

4-113 MEASURE Filtered (MF). In this mode, the front panel display is self triggered and continuously updated. In response to a step change in power of approximately 0.02 dB or an internal range change, the front panel displays the "____. ____ "(dashes) message until the digital filter time constant has elapsed. This mode guarantees that the reading is filtered by holding off the display of partially filtered readings.

4-114 Measure Settled (MS). In the MS mode, the front panel display is self-triggered and continuously updated. In response to a step change in power or an internal range change, the front panel displays the "____ " (dashes) message until the settled condition occurs. The minimum time for a settled reading is twice the selected filter time constant. The maximum time is unlimited, because the settled condition may never occur for noisy signals or constantly varying signals. This mode should not be used in a data acquisition system because the unsettled condition may holdoff the GPIB indefinitely.

4-115 Measure Fast Single (MFS). The measure fast single channel mode of operation provides the instrument's fastest measurement response when addressed to talk over the IEEE bus. Measurements at a rate of 240 readings per second can be obtained (see Figure 4 – 11). This mode only applies to channel 1 and will disable channels 2 when executed. The fast hardware filter for channel 1 is employed.

4-116 Measure Fast Dual (MFD). The measure fast dual channel mode of operation provides the instrument's fastest measurement response for both channels when addressed to talk over the IEEE bus. Measurements at a rate of 120 readings per second for each channel can be obtained. In this mode, the fast hardware filters for channel 1 and channel 2 are employed.

4-117 Trigger Normal (TN). In this mode, the front panel displays the –TRIG- message until the PM2002 is triggered by a bus command. The instrument continuously measures power as in the measure normal mode but does not display the reading. When triggered, the instrument captures the most recent measurement and displays the reading until another trigger command changes the display. This mode provides a quick response to trigger and the capability to hold a reading until required. However, the user is required to assure stability of the reading at the time of trigger.

4-118 Trigger Filtered (TF). When entering this mode, the front panel displays the " –TRIG-" message. When a bus trigger command is received, the instrument begins the measure filtered mode. The PM2002 displays the "-TRIG-" message until the digital time constant has elapsed. The instrument displays and holds the filtered reading until another bus trigger command is received. In this mode, the digital filter guarantees a filtered reading upon trigger and the capability to hold a reading until required.

4-119 Trigger Settled (TS). When this mode is entered, the front panel displays the "-TRIG-" message. The measure settled mode begins when a bus trigger command (GET) is received. The "TRIG" message will continue to be displayed until the settled condition occurs. The minimum time for a settled reading is twice the selected filter time constant. The maximum time is unlimited, because the settled conditions may never occur for noisy signals or constantly varying signals. In a data acquisition system this mode should be used only in connection with a bus service request (SRQ) to signal the controller when the measurement is complete. This allows the user's program to limit the time allowed for settling and take appropriate action if it is not achieved. Otherwise, an unsettled condition may holdoff the (GPIB) indefinitely.

4-120 Trigger Fast Single (TFS). When the TFS command is executed, the front panel displays the "-TRIG-" message. Once a bus trigger command is received, the instrument begins the fast single channel measurement mode of operation. The "-TRIG-" message is displayed until the completion of the measurement. Triggered response times of 5 ms may be obtained (see Figure 4 – 11). This mode only applies to channel 1 and will disable channel 2 when executed. The fast hardware filter for channel 1 is employed.

4-121 Trigger Fast Dual (TFD). When the TFD command is executed, the front panel displays the "-TRIG-" message. Once a bus trigger command is received, the instrument begins the fast single channel measurement mode of operation. The "-TRIG-" message is displayed until the completion of the measurement. Triggered response times of 10 ms may be obtained. In this mode, the fast hardware filters for channel 1 and channel 2 are employed.

4-122 IEEE PROGRAMMING EXAMPLES.

4-123 The following programming examples demonstrate bus operation of the PM2002. The examples are written in a general format of BASIC and are not an example of any specific implementation of the language. The examples assume that the PM2002 is the only instrument connected to the bus so that all commands address the PM2002.

4-124 In the examples, "INPUT" refers to the case where the instrument is addressed as the talker; "OUTPUT" indicates that the controller is the talker.

4-125 **Example 1.** Zero the instrument and take a reading with channel 1 from a signal generator.

Setup conditions:	Select channel 1 head data adapter
	Frequency of 5 Gigahertz
	Reading in milliwatts and also dBm
	Filter of 3 seconds
	Generator output is –17 dBm
OUTPUT "CH1":	Select channel 1
OUTPUT "SS5":	use head data adapter
OUTPUT "FR5":	set frequency to 5 GHz
OUTPUT "FL3":	set filter to 3 seconds
OUTPUT "TM0":	set TALK MODE to "0"

disconnect head from generator

WAIT 1000:	wait one second
OUTPUT "ZR":	zero instrument
WAIT 30000:	wait for zero to complete

Reconnect head to generator

WAIT 3000:	the filter time constant
INPUT A, B:	get reading from PM2002
PRINT A:	print "0" which is the error code
PRINT B:	print".01995" which is the power in milliwatts

Change talk mode and take another reading in dBm

OUTPUT "TMI":	set TALK MODE to "I"
OUTPUT "DB":	set PM2002 to dBm display
WAIT 3000:	the filter time constant
INPUT A$:	gets a reading from the PM2002
PRINT A$:	print string variable "0, -17.00dBm"

4-126 Example 2. Take triggered readings with Channel 1 and 2 from signal generators.

Setup conditions:	Select head data adapters
	Channel 1 power = 100 microwatts
	Channel 2 power = 350 microwatts
	Channel 1 frequency = 18 GHz
	Channel 2 frequency = 5 GHz
	Reading in milliwatts
	Autofilter

Setup channel 1	
OUTPUT "CHI":	select channel 1
OUTPUT "SS5":	use head data adapter
OUTPUT "FRI8":	set frequency to 18 GHz
OUTPUT "PW":	set WATTS display
OUTPUT "FA":	set filter to Autofilter

Setup channel 2	
OUTPUT "CH2":	select channel 2
OUTPUT "SS6":	use head data adapter
OUTPUT "FR5":	set frequency to 5 GHz
OUTPUT "PW":	set Watts display
OUTPUT "FA":	set filter to Autofilter

Setup trigger mode	
OUTPUT "TM3":	set TALK MODE to 3
OUTPUT "TS":	set Trigger Settled operation

Connect head to generator	
TRIGGER:	send Group Execute Trigger
INPUT A,B,C,D:	get reading from Model PM2002
PRINT A,B:	print channel 1 "0,100.00E-3"
PRINT C,D:	print channel 2 "0,350.00E-3"

4-127 ERROR MESSAGES

4-128 The error messages returned over the bus are described in Table 4 – 6. They are in numerical order as would be sent out over the IEEE-488 bus.

4-129 HP 437B AND 438A BUS EMULATION.

4-130 The Model PM2002 native mode is a superset of the mnemonics. Additional commands have been added to support dual channel operation, head data adapters and high speed sampling modes. The Model PM2002 is equipped to emulate the HP 437B and 438A bus mnemonics. These modes are available for users wanting to use the Model PM2002 in existing systems that cannot re-write their application programs. Refer to paragraph 3 – 20 for configuring the Model PM2002 for these modes of operation. The IEEE-488 capabilities in the HP emulation mode are the same as the native mode as described in paragraph 4 – 55 through 4 – 65.

4-131 Turn-on Default Conditions. Several emulation parameters are reset at turn-on. The parameters and their default conditions are listed below.

Bus emulation mode = 2002 (factory default)
GPIB Local Mode
Unaddressed
Service Request Mask cleared
Status Byte cleared
Free Run Trigger Mode
GT2 (Trigger with Delay) response to Trigger message
Event Status Enable Mask = 0

4-132 Sending the Data Message.

4-133 Data Output Format. The output data is usually formatted as a real constant in exponential form. That is; first the sign, then a 5 digit number with the decimal point appropriately located followed by the letter E (signifying that an exponent follows). The letter E is followed by a signed power-of-ten multiplier. The string is terminated by the EOS character set via the Menu-Setup-IEEE-EOS talker/listener commands (refer to paragraph 3 – 20).

Exceptions to this format are the data output for the following functions:

Identification
Read Service Request Mask Value
Read Event Status Register Mask Value
Read Event Status Register Value

Identification. This function is used to identify the Power Meter's model number and the firmware version. After receiving the *IDN? or ID (437B) or the ?ID (438A) mnemonic
and when addressed to talk, the Power Meter sends the following string:

Amplifier Research, PM2002, X.XX.

PM2002 is the instrument model number and X.XX. is the firmware version number.

4-134 Sending the Require Service Message. The Power Meter sends the Require Service message by setting the Service Request (SRQ) bus control line true. The front panel SRQ annunciator is enabled when the Status Byte has been set. The Require Service message is cleared when a serial poll is executed by the controller or when a "CS" (clear status byte) or "*CLS" (clear all status bytes) mnemonic is received via a Data message.

There are five conditions that can be enabled to cause the Require Service message to be sent. These conditions, which are enabled by the Service Request Mask, are as follows:

Data Ready: When the Power Meter has a data point requested by a trigger command.

Cal/Zero Completed: When the Power Meter has completed a calibration or a zeroing cycle.

Entry Error: When a number is entered via GPIB that is out of the allowable range for the selected parameter.

Measurement Error: When the power applied to the head is incorrect for the current instrument configuration.

Event Status Register: When a specified condition in the Event Status Register occurs and the corresponding bit in the Event Status Enable Register is enabled (via *ESE), this bit will be set true.

4-135 Service Request Mask. This mask determines which bits can set the Status Byte's SRQ bit true (see Table 4 – 8). When this bit becomes true, the SRQ line is also true. To set the mask, use the *SRE or "@1" mnemonic followed by an argument between the values of 0 and 255. The argument is determined by summing the weights of each bit to be checked.

4-136 Sending the Service Request Mask Value. The program mnemonics "*SRE" and "RV" will cause the Power Meter to respond when addressed to talk, with the present value of the Service Request Mask. This value is the summed weights of the bits that are set true. The bit pattern can be interpreted with the information in Table 4-8

TABLE 4 – 8. STATUS BYTE AND SERVICE REQUEST MASK (HP437B AND 438A ONLY)

BIT	VALUE (decimal)	(hexadecimal)	DESCRIPTION
0	1	1	Data Ready
1	2	2	Cal/Zero Complete
2	4	4	Entry Error
3	8	8	Measurement Error
4	16	10	Not Supported
5	32	20	Event Status Register
6	64	40	Require Service (RQS)
7	128	80	Not used; always zero

4- 137 Event Status Register. This register is a second status byte which extends the use of the Service Request Status Byte (see Table 4 – 9). The bits are set true when the specified event occurs provided the enable mask has been previously set. The mask is set by sending the "*ESE" mnemonic followed by an argument, the summed value of the bits of the desired condition to request service.
When a bit in the Event Status Register is set true, bit 5 of the Status Byte will also be sent if so enabled. The value of this register can be read via the "*ESR?" program code. After the instrument receives this command, the next time it is addressed to talk a number will be sent representing the weighted value of the bits set.

TABLE 4 – 9. EVENT STATUS REGISTER (HP437B AND HP438A ONLY)

BIT	VALUE	DESCRIPTION
0	1	Not used; always zero
1	2	Not used; always zero
2	4	Not used; always zero
3	8	Device Dependent Error
4	16	Execution Error
5	32	Command Error
6	64	Not used; always zero
7	128	Power On

Device Dependent Error. This bit is set when a measurement error occurs.

Execution Error. This bit is set when improper data has been received by the instrument. For example, sending a negative value for frequency is considered an execution error.

Command Error. This bit is set when the instrument parses a GPIB mnemonic which is not recognized. For example, the program code "XX" would produce a command error.

Power On. This bit is set in the instrument's initialization sequences when the power is toggled from OFF (0) to ON (1).

4-138 HP Emulation Codes. The Model PM2002 has the ability to emulate many of the HP 437B and HP 438A remote programming modes. Tables 4 – 10 and 4 – 11 summarize the HP mnemonic set. In cases where the Model PM2002 cannot execute the HP code, it is noted with the command "NOT SUPPORTED". The Emulation Mode can be enabled either by the Menu-SETUP-IEEE-EMULATION command (437B or 438A option) or by sending the"HPS" or "HPD" program code via the bus. This mode is disabled by setting the Menu-SETUP-IEEE-EMULATION command to the "PM2002" option or sending the "BN" mnemonic over the bus. The PM2002 command set is listed in Table 4 – 12.

TABLE 4- 10. HP 437B EMULATION GPIB COMMANDS

437B	DESCRIPTION	COMMAND
CL	0 dBm Calibration [1]	
*CLS	Clear the status register [3]	
CS	Clear the status byte	
CTO-CT9	Clear head data tables 0 - 9[1]	NOT SUPPORTED
DA	All display segments on	
DC0	Duty cycle on ('DY' ARG # 100)	NOT SUPPORTED
DC1	Duty cycle off ('DY' ARG – 100)	NOT SUPPORTED
DD, DF	Display disable	
DE	Display enable	
DN	Down arrow key	
DU	Display user message	
DY	Duty cycle value[1]	
EN	ENTER	
ERR?	Device error query	
*ESE	Set event status enable mask[3]	
*ESE?	Event status register query[3]	
*ESE?	Event status register (ESR) query[3]	
ETO – ET9	Edit head calibration factor table 0 - 9[1]	NOT SUPPORTED
EX	EXIT	
FA	Automatic filter selection	
FH	Filter hold	
FM	Manual filter selection[1]	
FR	Frequency entry[1]	
GT0	Ignore group execute trigger (GET) bus command	
GT1	Trigger immediate response to GET command	
GT2	Trigger with delay response to GET command	
GZ	Gigahertz	
HZ	Hertz	
ID	GPIB identification query	
*IDN?	GPIB identification query[2]	
KB	Calibration factor[1] in percent	
KZ	Kilohertz	
LG	Log display	
LH	High limit[1]	
LL	Low limits[1]	
LMO	Disable limits checking function	
LM1	Enable limits checking function	
LN	Linear display	NOT SUPPORTED
LP	Learn mode	
LT	Left arrow key	
MZ	Megahertz	
OC0	Reference oscillator off	
OC1	Reference oscillator on	
OD	Output display test	NOT SUPPORTED
OF0	Offset off[4]	NOT SUPPORTED

TABLE 4- 10. HP 437B EMULATION GPIB COMMANDS (*continued*)

437B	DESCRIPTION	COMMAND
OF1	Offset on[4]	NOT SUPPORTED
OS	Offset value[1]	
PCT	Percent	
PR	Preset	
RA	Autorange	
RC	RECALL[1]	1 - 4
RE	Resolution[1]	1 - 3
RF0 – RF9	Enter head reference calibration factor[1]	NOT SUPPORTED
RH	Range hold	
RL0	Exit REL mode	
RL1	Enter REL mode using new REL value	
RL2	Enter REL mode using old REF value	
RM	Set range[1]	
*RST	Soft reset	
RT	Right arrow key	
RV	Read Service Request Mask value	
SE	Head number[1]	1 – 6 Only
SM	Status message	NOT SUPPORTED
SN0 – SN9	Enter head serial number[2]	NOT SUPPORTED
SP – N0P	SPECIAL	NOT SUPPORTED
*SRE	Set the service request mask[3]	
*SRE?	Service request mask query[3]	
ST	STORE[1]	1 - 4
*STB?	Read the status byte	
TR0	Trigger hold	
TR1	Trigger immediate	
TR2	Trigger with delay	
TR3	Trigger-free run	
*TST?	Self-test query[3]	
UP	UP arrow key	
ZE	ZERO	
@1	Set the service request mask	
@2	Learn mode prefix	NOT SUPPORTED
%	Percent	

1 A numeric entry is required by these GPIB codes, followed by the code EN (ENTER).
2 This GPIB code uses the next 6 characters (0 – 9, A-Z, or an underscore) as input data.
3 The * must be included as part of the GPIB command string.
4 Offset value is always applied. Set the offset value to 0 dB for off condition. Any other value the offset is on.

TABLE 4-11. HP 438A EMULATION GPIB COMMANDS

438A CODE	DESCRIPTION	COMMENTS
AD	Measure A – B	
AE	Set A	
AP	Measure head A	
AR	Measure A/B	
BD	Measure B-A	
BE	Set B	
BP	Measure head B	
BR	Measure B/A	
CL	CAL ADJ[1, 2]	
CS	Clear status byte [1]	
DA	Display all[1]	
DD	Display disable[1]	
DE	Display enable[1]	
DO	Measured offset entry	
EN	ENTER[1]	(precede with AE or BE)
FA	Set auto average filtering	(precede with AE or BE)
FH	Hold present average number	(precede with AE or BE)
FM	Set filter number[1, 2]	
GT0	Group execute trigger cancel[1]	
GT1	Group execute trigger single measurement[1]	
GT2	Group execute trigger full measurement with setting[1]	
GZ	Gigahertz[1]	
HZ	Hertz[1]	
?ID	Ask of ID[1]	
KB	Calibration factor[1, 2]	
KZ	Kilohertz[1]	(dB or dBm)[1]
LG	Set log units	
LH	High limit[1, 2]	
LL	Low limit[1, 2]	
LM0	Disable limit checking[1]	
LM1	Enable limit checking[1]	(watts or %)[1]
LN	Set linear units	NOT SUPPORTED
LP1	Set learn mode #1	NOT SUPPORTED
LP2	Set learn mode #2	
MZ	Megahertz[1]	
OC0	Turn off calibrator source[1]	
OC1	Turn on calibrator source[1]	
OS	Offset[1,2]	
PR	Preset instrument to a known state[1]	
RA	Resume autorange[1]	1 – 4 only
RC	RECALL[1, 2]	
RH	Range hold[1]	
RL0	Relative mode off[1]	
RL1	Relative mode on[1]	
RL2	Relative mode with old REL value[1]	
RM	Set manual range[1, 2]	
RV	Ask for status request mask[1]	
SM	Ask for status message[1]	1 – 4
ST	STORE[1,2]	
TR0	Trigger hold mode[1]	
TR1	Trigger single measurement[1]	
TR2	Trigger full measurement with settling[1]	
TR3	Free range trigger mode[1]	(precede with AE or BE)[1]
ZE	Zero head	
@1	Prefix for service request mask[1]	

1. These commands are fully compatible with the HP437B Power Meter command codes.
2 Requires numeric entry followed by program code EN.

Table 4 – 12. PM2002 GPIB COMMANDS

Code	Description	Comments
AM	Measure A – B	
AP	Measure A + B	
AR	Measure A/B	
BD	Measure B – A	
BR	Measure B/A	
BN	PM2002 Native mode	NO EMULATION
CH	Channel select	1 – 2
CF	Calibrator off	
CL	Clear	
CN	Calibrator on	
CP	Calibrate	
DB	dBm select	
DF	Display off	
DN	Display on	
DR	dBr select	
DU	Display user message	
DY	Duty cycle value	0.01-100.00 in 0.01 steps
FA	Auto filter	
FD	dB calibration factor	-3.00 to 3.00 in 0.01 steps
F1	Send high frequency calibration data to instrument	
FL	Filter time select	0 to 20.00 in 0.05 steps
F0	Get high frequency calibration data from instrument	
FR	Frequency select	
HPS	Enable HP 437B emulation mode	
HPD	Enable HP 438A emulation mode	
?ID	Talk instrument ID	
*IDN?	Talk instrument ID	
LH	High limit	99 to 99.99 in 0.01 steps
LL	Low limit	99 to 99.99 in 0.01 steps
LM0	Disable limits checking function	
LM1	Enable limits checking function	
LR	Load reference	
MF	Measure filtered	
MFD	Measure Fast Dual Channels	
MFS	Measure fast single channel	
MN	Measure normal, free run	
MS	Measure settled	
OS	Offset value	99 to 99.99 in 0.01 steps
PW	Watts select	
RA	Autorange	
RB	Recorder bottom	
RC	Recall instrument configuration	1 - 4
RE	Resolution	1 - 3
RN	Recorder normal	
RS	Range select	0 - 6
RT	Recorder top	
SI	Send linearity data to instrument	
SM	Service request (SRQ) mask	0 - 255
SO	Get linearity data from instrument	
SR	Set dBr reference	99.99 to 99.99 in 0.01 steps
SS	Head select	1 - 6
ST	Store instrument configuration	1 – 4
TF	Trigger filtered	

Table 4 – 12. PM2002 GPIB COMMAND (continued)

Code	Description	Comments
TFD	Trigger fast dual channel	1 - 6
TFS	Trigger fast single channel	1 – 4
TN	Trigger normal	
TM	Talk mode	
TR	Bus trigger	
TS	Trigger settled	
ZR	Instrument zero	0 – 6

1 A numeric entry is required by these GPIB codes, followed by the code EN (ENTER).
2 This GPIB code uses the next 6 characters (0 – 9, A-Z, or an underscore) as input data.
3 The * must be included as part of the GPIB command string.

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Seller warrants (i) that seller has title to the goods sold and (ii) that Amplifiers, Antennas, Test Cells, Directional Couplers and Tripods will be free from defects in material and workmanship for a period of three (3) years from date of shipment shown on Amplifier Research invoice. Field Monitoring Equipment and Interference Generators will be free from defects in material and workmanship for a period of two (2) years from date of shipment. Vacuum tubes, traveling-wave tubes and other products will be free from defects in material and workmanship for a period of one (1) year. Seller's sole responsibility in fulfilling these warranties shall be to repair or replace any goods that do not conform to the foregoing warranties or, at seller's option, to give buyer credit for defective goods. The warranty is valid only when used in the country specified at time of order. Warranty service must be obtained from the repair facility designated at that time. If warranty service is not available in the country where the equipment is to be used then it must be returned to Amplifier Research. Warranty service will be provided only for defective goods that are returned within the warranty period, freight costs prepaid to Amplifier Research or its designated repair facility.

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REV0299

Head Model: PH2090

Date: 4/15/99

Head S/N: 24953

Calibration Time: 13:44:54

Ambient: 22C 28 %R.H.

HEAD CALIBRATION CHECK

LEVEL	TOL	MEASURED	
-60	0.65	-59.75	PASS
-55	0.27	-55.05	PASS
-50	0.15	-50.07	PASS
-45	0.11	-45.04	PASS
-40	0.07	-40.00	PASS
-35	0.07	-35.00	PASS
-30	0.07	-30.00	PASS
-25	0.07	-25.00	PASS
-20	0.07	-20.00	PASS
-15	0.07	-15.02	PASS
-10	0.07	-10.00	PASS
-5	0.07	-5.01	PASS
0	0.03	0.00	PASS
5	0.10	5.05	PASS
10	0.07	9.98	PASS
15	0.14	15.00	PASS
20	0.14	19.97	PASS

Head Model: PH2000

Head S/N: 24953

Date: 4/15/99

Calibration Time: 13:44:54

Ambient: 22C 28 %R.H.

HEAD GAIN CONSTANTS

RANGE	UPSCALE	DOWNSCALE
0	5506	4
1	5506	4
2	5517	4
3	5500	-3
4	5467	0
5	5098	24
6	5194	9

FREQUENCY CALIBRATION FACTORS

TABLE #	FREQ	CF	TABLE #	FREQ	CF	TABLE #	FREQ	CF
0	0.03	0.00	20	0.00	0.00	40	0.00	0.00
1	0.10	0.01	21	0.00	0.00	41	0.00	0.00
2	0.30	0.11	22	0.00	0.00	42	0.00	0.00
3	0.50	0.16	23	0.00	0.00	43	0.00	0.00
4	1.00	0.22	24	0.00	0.00	44	0.00	0.00
5	2.00	0.39	25	0.00	0.00	45	0.00	0.00
6	3.00	0.36	26	0.00	0.00	46	0.00	0.00
7	4.00	0.02	27	0.00	0.00	47	0.00	0.00
8	5.00	-0.04	28	0.00	0.00	48	0.00	0.00
9	6.00	-0.18	29	0.00	0.00	49	0.00	0.00
10	7.00	-0.14	30	0.00	0.00	50	0.00	0.00
11	8.00	-0.31	31	0.00	0.00	51	0.00	0.00
12	0.00	0.00	32	0.00	0.00	52	0.00	0.00
13	0.00	0.00	33	0.00	0.00	53	0.00	0.00
14	0.00	0.00	34	0.00	0.00	54	0.00	0.00
15	0.00	0.00	35	0.00	0.00	55	0.00	0.00
16	0.00	0.00	36	0.00	0.00	56	0.00	0.00
17	0.00	0.00	37	0.00	0.00	57	0.00	0.00
18	0.00	0.00	38	0.00	0.00	58	0.00	0.00
19	0.00	0.00	39	0.00	0.00	59	0.00	0.00

Head Model: PH2000

Date:4/15/99

Head S/N: 24839

Calibration Time: 15:42:34

Ambient: 24C 28 %R.H.

HEAD CALIBRATION CHECK

LEVEL	TOL	MEASURED	
-60	0.65	-60.59	PASS
-55	0.27	-55.10	PASS
-50	0.15	-50.06	PASS
-45	0.11	-45.03	PASS
-40	0.07	-40.02	PASS
-35	0.07	-35.01	PASS
-30	0.07	-30.01	PASS
-25	0.07	-25.01	PASS
-20	0.07	-20.01	PASS
-15	0.07	-15.01	PASS
-10	0.07	-10.00	PASS
-5	0.07	-5.02	PASS
0	0.03	-0.01	PASS
5	0.10	5.06	PASS
10	0.07	9.95	PASS
15	0.14	14.99	PASS
20	0.14	19.97	PASS

Head Model: PH2000

Date:4/15/99

Head S/N: 24889

Calibration Time: 15:42:34

Ambient: 24C 28 %R.H.

HEAD GAIN CONSTANTS

RANGE	UPSCALE	DOWNSCALE
0	5708	0
1	5708	0
2	5710	3
3	5690	-3
4	5650	2
5	5279	27
6	5322	15

FREQUENCY CALIBRATION FACTORS

TABLE #	FREQ	CF	TABLE #	FREQ	CF	TABLE #	FREQ	CF
0	0.03	0.00	20	0.00	0.00	40	0.00	0.00
1	0.10	-0.02	21	0.00	0.00	41	0.00	0.00
2	0.30	0.19	22	0.00	0.00	42	0.00	0.00
3	0.50	0.22	23	0.00	0.00	43	0.00	0.00
4	1.00	0.09	24	0.00	0.00	44	0.00	0.00
5	2.00	0.10	25	0.00	0.00	45	0.00	0.00
6	3.00	-0.18	26	0.00	0.00	46	0.00	0.00
7	4.00	-0.62	27	0.00	0.00	47	0.00	0.00
8	5.00	-0.89	28	0.00	0.00	48	0.00	0.00
9	6.00	-0.99	29	0.00	0.00	49	0.00	0.00
10	7.00	-0.77	30	0.00	0.00	50	0.00	0.00
11	8.00	-0.81	31	0.00	0.00	51	0.00	0.00
12	0.00	0.00	32	0.00	0.00	52	0.00	0.00
13	0.00	0.00	33	0.00	0.00	53	0.00	0.00
14	0.00	0.00	34	0.00	0.00	54	0.00	0.00
15	0.00	0.00	35	0.00	0.00	55	0.00	0.00
16	0.00	0.00	36	0.00	0.00	56	0.00	0.00
17	0.00	0.00	37	0.00	0.00	57	0.00	0.00
18	0.00	0.00	38	0.00	0.00	58	0.00	0.00
19	0.00	0.00	39	0.00	0.00	59	0.00	0.00