HP 436A

MARL...

OPERATING INFORMATION

HEWLETT-PACKARD

MLRP

436A
POWER METER

FOR REFERENCE PURPOSES ONLY

DUPLICATE OF SECTIONS 1 THRU 3
OF YOUR OPERATING AND SERVICE MANUAL

KEEP WITH INSTRUMENT

OCTOBER 1975

HEWLETT hp PACKARD

HP 436A

MANUAL IDENTIFICATION	
Model Number:	436A
Date Printed:	October 1975
Part Number:	00436-90001

This supplement contains important information for correcting manual errors and for adapting the manual to instruments containing improvements made after the printing of the manual.

To use this supplement:

Make all ERRATA corrections

Make all appropriate serial number related changes indicated in the tables below.

Serial Prefix or Number	Make Manual Changes	Serial Prefix or Number	Make Manual Changes
►1550A	1		
►1606A	1, 2		
►1611A	1, 2, 3		

► NEW ITEM

ERRATA

► Page 6-16, Table 6-2:
Add A11TB1 LINE VOLTAGE SELECTOR CARD 5020-8122, 1 per.

► Page 8-8, Figure 8-3:
Change gain formula in part C to: GAIN = −R1/R2.

► Page 8-177, Figure 8-26:
Add Note: M1, U1—U4, and U6—U10 are part of A1 Assembly.

► Page 8-195, Figure 8-48:
Remove connection between pins 3 and 5 of connector XA9.

► CHANGE 1

Page 6-16, Table 6-2:
Change A11 to 0960-0444 LINE MODULE, UNFILTERED.

Page 8-195, Figure 8-48:
Change A11 Line Power Module Part Number to 0960-0444.

NOTE

Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

February 1976
2 Pages

HEWLETT hp PACKARD

Printed in U.S.A.

▶ CHANGE 2

Page 6-6, Table 6-2:
Change A2R18 to 0698-3243 RF 178K .125W.

Page 6-7, Table 6-2:
Add A2R81 0757-0288 RF 9.09K .125W.

Page 8-179, Figure 8-30:
Change A2 ASSY REFERENCE DESIGNATIONS to R81.
Change A2R18 to 178K.
Add A2R81* 9090 in series with A2R18 as shown in Figure 8-30.

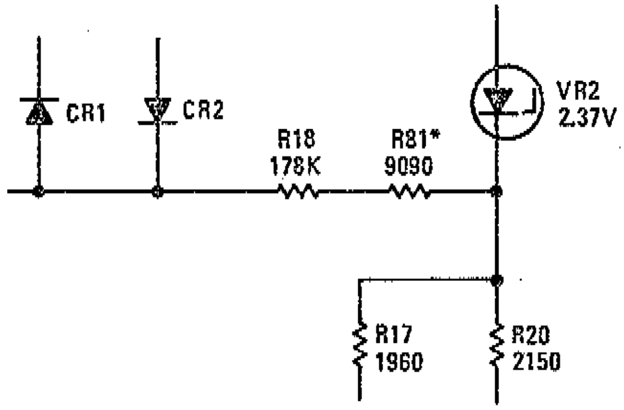


Figure 8-30. AC Gain Assembly Schematic Diagram (Change 2)

▶ CHANGE 3

Page 6-13, Table 6-2:
Change STANDOFF to 0380-0643 STANDOFF METRIC, 2 per.
Add 5951-7587 TAG, HARDWARE.

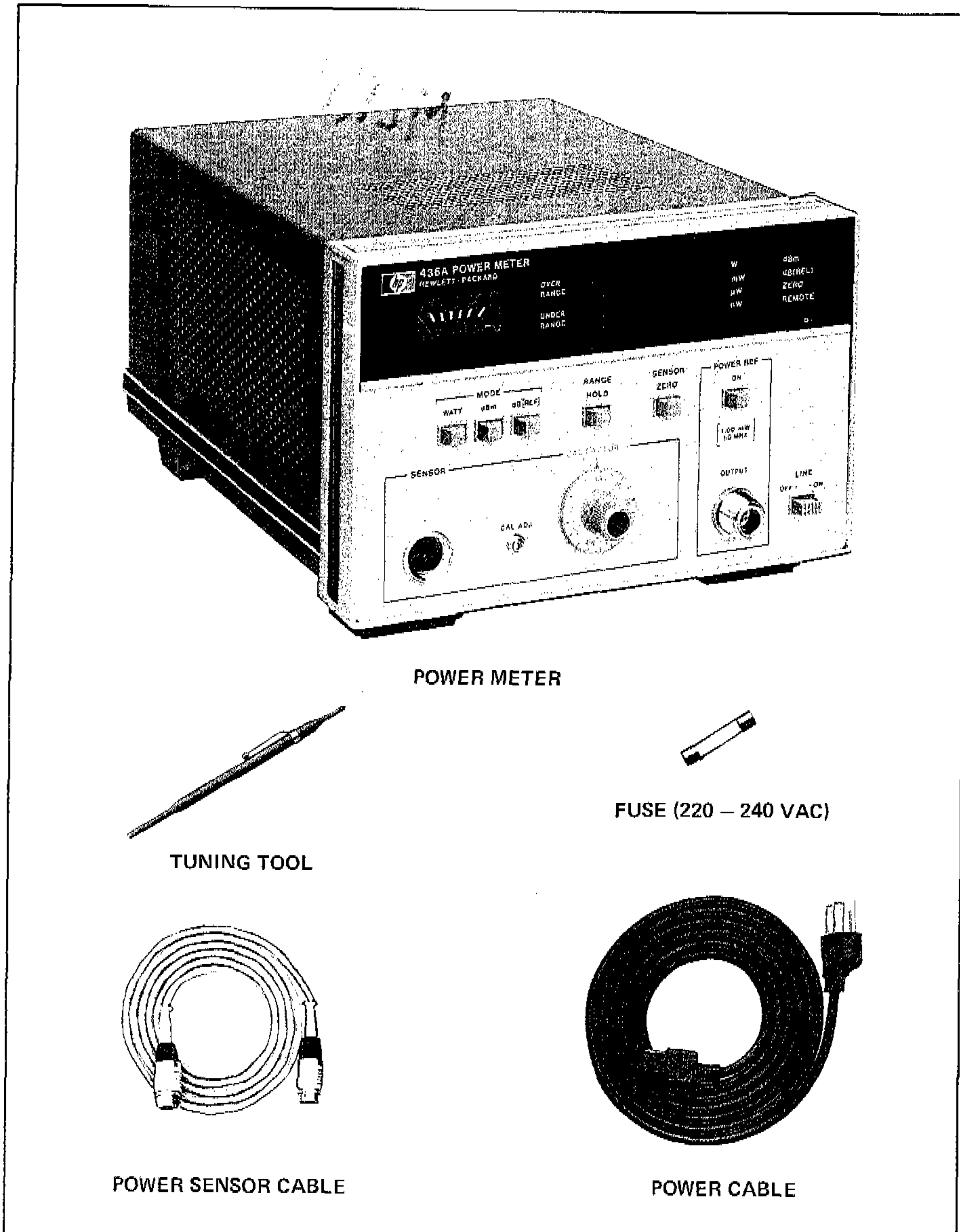


Figure 1-1. HP Model 436A Power Meter and Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual provides information pertaining to the installation, operation, testing, adjustment and maintenance of the HP Model 436A Power Meter.

1-3. Figure 1-1 shows the Power Meter with accessories supplied.

1-4. Packaged with this manual is an Operating Information Supplement. This is simply a copy of the first three sections of this manual. This supplement should be kept with the instrument for use by the operator. Additional copies of the Operating Information Supplement may be ordered through your nearest Hewlett-Packard office. The part numbers are listed on the title page of this manual.

1-5. On the title page of this manual, below the manual part number, is a "Microfiche" part number. This number may be used to order 4x6-inch microfilm transparencies of the manual. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

1-6. SPECIFICATIONS

1-7. Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested.

1-8. INSTRUMENTS COVERED BY MANUAL

1-9. Power Meter Options 002, 003, 009, 010, 011, 012, 013, 022, and 024 are documented in this manual. The differences are noted in the appropriate location such as OPTIONS in Section I, the Replaceable Parts List, and the schematic diagrams.

1-10. This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page.

1-11. An instrument manufactured after the printing of this manual may have a serial prefix that is not listed on the title page. This unlisted serial prefix indicates that the instrument is different from those documented in this manual. The manual for this instrument is supplied with a yellow Manual Changes supplement that contains change information that documents the differences.

1-12. In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to the manual's print date and part number, both of which appear on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

1-13. For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-14. DESCRIPTION

1-15. The Power Meter is a precision digital-readout instrument capable of automatic and manual measurement of RF and Microwave power levels. It is designed for interconnection with a compatible Power Sensor (refer to Table 1-1, Specifications) to form a complete power measurement system. The frequency and power range of the system are determined by the particular Power Sensor selected for use. With the Power Sensors available, the overall frequency range of the system is 100 kHz to 18 GHz, and the overall power range is −30 to +35 dBm.

1-16. Significant operating features of the Power Meter are as follows:

- **Digital Display:** The display is a four-digit, seven-segment LED, plus a sign when in the dBm or dB (REL) mode. It also has under- and

Table 1-1. Specifications

SPECIFICATIONS

Frequency Range: 100 kHz to 18 GHz (depending on Power Sensor Used).

Power Range: With 8481A, 8482A, and 8483A sensors: 50 dB with 5 full scale ranges of 10 and 100 μW; 1, 10 and 100 mW. The display is also calibrated in dBm and dB from −20 dBm to +20 dBm full scale in 10 dB steps.

With 8481H or 8482H sensors: 45 dB with 5 full scale ranges of 1, 10 and 100 mW; 1 and 3 watts. The display is also calibrated in dBm and dB from 0 dBm to +30 dBm full scale in 10 dB steps, and a 5-dB step from +30 dBm to +35 dBm.

Accuracy:

Instrumentation:

Watt Mode: ±0.5% in ranges 1 through 5.

dBm Mode: ±0.02 dB ± 0.001 dB/°C in ranges 1 through 5.

dB (REL) Mode:[1] ±0.02 dB ± 0.001 dB/°C in ranges 1 through 5.

Zero: Automatic operated by a front-panel switch.

Zero-Set: ±0.5% of full scale on most sensitive range; typical. ±1 count on other ranges.

Zero Carry Over: ±0.2% of full scale when zeroed on the most sensitive range.

Noise: With 8481A, 8482A or 8483A sensor: 0.5% of full scale peak-to-peak on the most sensitive range, typical. Less in higher ranges.

Long Term Zero Drift (8 hours): ±2% of full scale on most sensitive range, less in higher ranges (typical at constant temperature).

Response Time: (0 to 99% of reading) with 8481A, 8482A, 8483A sensors:

Range 1 < 10 seconds (most sensitive range)
Range 2 < 1 second
Ranges 3 through 5 < 100 milliseconds (typical, measured at Recorder Output)

[1] Specifications are for within range measurements. For range to range accuracy, add the range uncertainties.

Reference Oscillator: Internal 50 MHz oscillator with type N female connector on front panel or rear panel (option 003 only). Power output 1.0 mW. Factory set to ±0.7% traceable to the National Bureau of Standards.

Accuracy: ±1.2% worst case (±0.9% rms) for one year (0°C to 55°C).

Cal Factor: 16-position switch normalizes meter reading to account for calibration factor. Range 85% to 100% in 1% steps. 100% position corresponds to calibration factor at 50 MHz.

Cal Adjustment: Front panel adjustment provides capability to adjust gain in meter to match power sensor in use.

Recorder Output: Proportional to indicated power with 1 volt corresponding to full scale and 0.316 volts to −5 dB; 1 kΩ output impedance, BNC connector.

RF Blanking: Open collector TTL; low corresponds to blanking, BNC connector.

Display: Digital display with four digits. 20% over-range capability on all ranges.

Analog Meter: uncalibrated peaking meter to see fast changes.

Power: 100, 120, 220, or 240V +5%, −10%, 48 to 440 Hz, 20 Watts.

Dimensions:
134 mm High (5-1/4 inches).
213 mm Wide (8-3/8 inches).
279 mm Deep (11 inches).

Net Weight: 4.5 kg (10 lbs).

DESCRIPTION (cont'd)

overrange indicators. There is a 20 percent overrange capability in all ranges. Large 10 mm (0.375 inch) digits are easy to see even in a high glare environment.

- **Auxiliary Meter:** Complements the digital display by showing fast changes in power level. Ideal for "peaking" transmitter output or other variable power devices.
- **Choice of Display in Watts, dBm or dB:** Absolute power can be read out in watts or dBm. Relative power measurements are made possibile with the dB [REF] switch. Pressing this switch zeros the display for any applied input power and any deviation from this reference is shown in dB with a resolution of ±0.01 dB. This capability is particularly useful in frequency response testing.
- **Power Units and Mode Annunciator:** The units annunciator provides error-free display interpretation by indicating appropriate power units in the watt mode. The mode annunciator indicates the mode of operation: dBm, dB (REL), ZERO or REMOTE.
- **Completely Autoranging:** The Power Meter automatically switches through its 5 ranges to provide completely "hands off" operation. The RANGE HOLD switch locks the Power Meter in one of its ranges when autoranging is not desired.
- **Automatic Sensor Recognition:** The Power Meter continually decodes the sensitivity of the Power Sensor to which it is connected. This information is then used to automatically control the digital display decimal point location and, when WATT MODE operation is selected, to light the appropriate power units annunciator.
- **Auto Zero:** Zeroing the meter is accomplished by merely depressing the SENSOR ZERO switch and waiting until the display shows all zeros before releasing it. The meter is ready to make measurements as soon as the zero light in the mode annunciator goes off.
- **RF Blanking Output:** Open collector TTL; low corresponds to blanking when the sensor zero is engaged. May be used to remove the RF input signal connected to the power sensor.
- **Calibration Accuracy:** A 1.00 mW, 50 MHz reference output is available at the front panel for calibrating the Power Meter and the Power Sensor as a system. Calibration is accomplished using the CAL ADJ and CAL FACTOR % controls. The CAL ADJ control compensates for slight differences in sensitivity associated with a particular type of Power Sensor and the CAL FACTOR % control compensates for mismatch losses and effective efficiency over the frequency range of the Power Sensor.
- **Recorder Output:** Provides a linear output with respect to the input power level. For each range, a +1.00 Vdc output corresponds to a full scale input power level. Refer to Table 1-1, Specifications, for the full-scale range values associated with the various types of Power Sensors available.

1-17. Two programming interfaces are available as options for the Power Meter — a Hewlett-Packard Interface Bus (HP-IB) Option 022; and a BCD Interface, Option 024. Both interfaces allow full remote control of all the power meter functions (CAL FACTOR can be programmed to either 100% or the CAL FACTOR which has been manually set on the front panel). These options may be added by the user at a later time as his requirements grow.

1-18. OPTIONS

1-19. Input-Output Options

1-20. Option 002. A rear panel input connector is connected in parallel with the front panel input connector.

1-21. Option 003. A rear panel input connector replaces the standard front panel input connector; a rear panel POWER REF OUTPUT connector replaces the standard front panel connector.

1-22. Cable Options

1-23. A 1.5 metre (5 ft.) Power Sensor Cable is normally supplied. The 1.5 metre cable is omitted with any cable option. The options and cable lengths are shown in the table below.

Option	Cable Length
009	3.0 m (10 ft)
010	6.1 m (20 ft)
011	15.2 m (50 ft)
012	30.5 m (100 ft)
013	61.0 m (200 ft)

1-24. Remote Control Options

1-25. Options 022 and 024 add remote interface capability to the Power Meter. Option 022 is compatible with the Hewlett-Packard Interface Bus (AH1, C0, DC2, DT1, L2, LE0, PP0, RL2, SH1, SR0, T3, TE0); Option 024 uses dedicated input/output lines to enable remote programming and to provide parallel, BCD-coded output data.

1-26. Option 022 or 024 may be ordered in kit form under HP part numbers 00436-60035 and 00436-60034 respectively. Each kit contains a control assembly printed-circuit board, an input/output assembly printed circuit board, and a data cable for interconnection.

1-27. ACCESSORIES SUPPLIED

1-28. The accessories supplied with the Power Meter are shown in Figure 1-1.

a. The 1.5 metre (5 ft.) Power Sensor Cable, HP 00436-60026, is used to couple the Power Sensor to the Power Meter. The 1.5 metre cable is omitted with any cable option.

b. The line power cable may be supplied in one of four configurations. Refer to the paragraph entitled Power Cables in Section II.

c. A 3/8 A fuse (HP Part No. 2110-0665) is supplied for 220/240 Vac operation of the Power Meter. Refer to Line Voltage Selection in Section II. This fuse may replace the 3/4 A fuse installed at the factory for 110/120 Vac.

d. An alignment tool for adjusting the CAL ADJ front panel control (HP Part No. 8710-0630).

1-29. EQUIPMENT REQUIRED BUT NOT SUPPLIED

1-30. To form a complete RF power measurement system, a Power Sensor such as the HP Model 8481A must be connected to the Power Meter via the Power Sensor cable.

1-31. EQUIPMENT AVAILABLE

1-32. The HP Model 11683A Range Calibrator is recommended for performance testing, adjusting, and troubleshooting the Power Meter. The Power Meter's range-to-range accuracy and auto-zero operation can easily be verified with the Calibrator. It also has the capability of supplying a full-scale test signal for each range.

1-33. Two extender boards (HP Part Numbers 5060-0258, and 5060-0990; 24 and 44 pins respectively) enable the Power Meter printed circuit assemblies to be accessed for service. Rubber bumpers (HP Part No. 0403-0115) should be installed on the extender boards to prevent the boards from touching.

1-34. RECOMMENDED TEST EQUIPMENT

1-35. The test equipment shown in Table 1-2 is recommended for use during performance testing, adjustments, and troubleshooting. To ensure optimum performance of the Power Meter, the specifications of a substitute instrument must equal or exceed the critical specifications shown in the table.

1-36. SAFETY CONSIDERATIONS

1-37. The Power Meter is a Safety Class I instrument. This instrument has been designed according to international safety standards.

1-38. This operating and service manual contains information, cautions, and warnings which must be followed by the user to ensure safe operation and to retain the instrument in safe condition.

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section provides all information necessary to install the Power Meter. Covered in the section are initial inspection, power requirements, line voltage selection, interconnection, circuit options, mounting, storage, and repackaging for shipment.

2-3. INITIAL INSPECTION

2-4. Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-5. PREPARATION FOR USE

2-6. Power Requirements

2-7. The Power Meter requires a power source of 100, 120, 220, or 240 Vac, +5%, −10%, 48 to 440 Hz single phase. Power consumption is approximately 20 watts.

WARNING

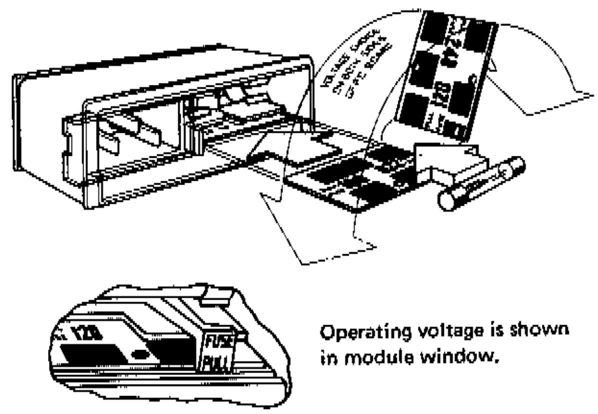
If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

2-8. Line Voltage Selection

CAUTION

BEFORE SWITCHING ON THIS INSTRUMENT, make sure the instrument is set to the voltage of the power source.

2-9. Figure 2-1 provides instructions for line voltage and fuse selection. The line voltage selection card and the proper fuse are factory installed for 120 Vac operation.



SELECTION OF OPERATING VOLTAGE

1. Open cover door and rotate fuse-pull to left.
2. Select operating voltage by orienting PC board to position desired voltage on top-left side. Push board firmly into module slot.
3. Rotate fuse-pull back into normal position and re-insert fuse in holders, using caution to select correct fuse value.

Figure 2-1. Line Voltage Selection

2-10. Power Cable

WARNING

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).

Power Cable (cont'd)

2-11. In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part numbers of the power cable plugs available.

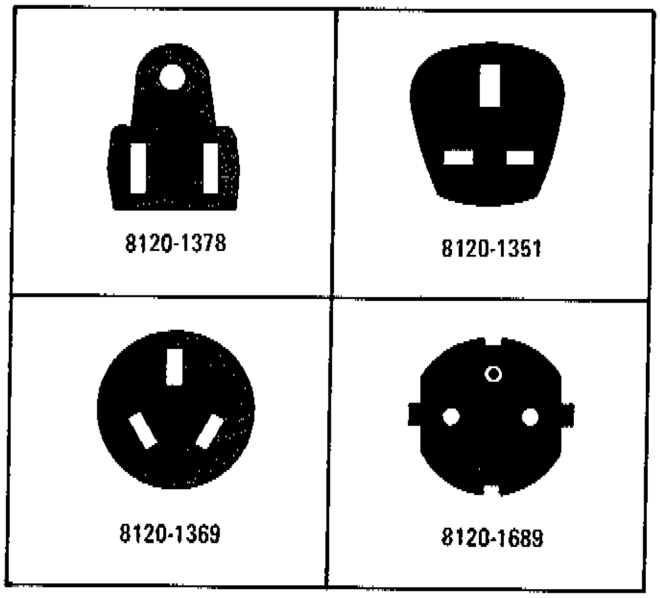


Figure 2-2. Power Cable HP Part Numbers Versus Mains Plugs Available

2-12. Circuit Options

2-13. Jumper options are available for selecting a filtered or unfiltered dc RECORDER OUTPUT, for changing the TALK and LISTEN addresses when Hewlett-Packard Interface Bus Option 022 is installed, and for selecting the desired programming of the SENSOR ZERO function when BCD Interface Option 024 is installed. Table 2-1 lists the factory installed jumper connections and indicates how they may be reconnected to select the options.

2-14. Interconnections

2-15. **Power Sensor.** For proper system operation, the Power Sensor must be connected to the Power Meter using either the Power Sensor cable supplied with the Power Meter or any of the optional Power Sensor cables specified in Section I. Each of these cables employs a sensitivity line to enable the Power Meter to determine the operating range of the Power Sensor and thus, the true value of the input signal. For example, the 8481A and 8481H Power Sensors provide identical full scale outputs in response to input signal levels of 100 milliwatts and 3 watts, respectively. The difference in their sensitivity codes is detected by the Power Meter, however, and the Power Meter digital readout is automatically configured to indicate the appropriate value.

2-16. Hewlett-Packard Interface Bus Option 022. Interconnection data for Hewlett-Packard Interface Bus Option 022 is provided in Figure 2-3. Power Meter programming and output data format is described in Section III, Operation.

2-17. BCD Interface Bus Option 024. Interconnection data for BCD Interface Option 024 is provided in Figure 2-4. Power Meter programming and output data format is described in Section III, Operation.

2-18. Mating Connectors

2-19. **Interface Connectors.** Interface mating connectors for Options 022 and 024 are indicated in Figures 2-3 and 2-4, respectively.

2-20. **Coaxial Connectors.** Coaxial mating connectors used with the Power Meter should be US MIL-C-39012-compatible type N male or 50-ohm BNC male.

2-21. Operating Environment

2-22. The operating environment should be within the following limitations:

Temperature	0°C to +55°C
Humidity	<95% relative
Altitude	<4570 m (15,000 ft)

2-23. Bench Operation

2-24. The instrument cabinet has plastic feet and a fold-away tilt stand for convenience in bench operation. (The plastic feet are shaped to ensure self-aligning of the instruments when stacked.) The tilt stand raises the front of the instrument for easier viewing of the control panel.

2-25. Rack Mounting

2-26. Instruments that are narrower than full rack width may be rack mounted using Hewlett-Packard sub-module cabinets. If it is desired to rack mount one Power Meter by itself, order half-module kit, HP Part Number 5061-0057. If it is desired to rack mount two Power Meters side by side, order the following items:

Rack Mounting (cont'd)

a. Rack Mount Flange Kit (two provided) HP Part Number 5020-8862.

b. Front Horizontal Lock Links (four provided) HP Part Number 0050-0515.

c. Rear Horizontal Lock Links (two provided) HP Part Number 0050-0516.

2-27. In addition to the rack mounting hardware, a front handle assembly (two provided) is also available for the Power Meter. The part number is HP 5060-9899.

2-28. STORAGE AND SHIPMENT

2-29. Environment

2-30. The instrument should be stored in a clean dry environment. The following environmental limitations apply to both storage and shipment:

Temperature . . . . −40° C to +75° C
Humidity . . . . <95% relative
Altitude . . . . <7620 m (25,000 ft)

2-31. Packaging

2-32. Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also mark the container FRAGILE to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

2-33. Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

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

b. Use a strong shipping container. A double-wall carton made of 275-lb test material is adequate.

c. Use enough shock-absorbing material (3 to 4-inch layer) around all sides of instrument to provide firm cushion and prevent movement in the container. Protect the control panel with cardboard.

d. Seal the shipping container securely.

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

Table 2-1. Circuit Options

<table>
<tr><th>Assembly</th><th>Service Sheet</th><th>Jumper Functions</th></tr>
<tr><td>A-D Converter Assembly A3</td><td>8</td><td>The factory-installed jumpers provide a filtered dc RECORDER OUTPUT which corresponds to the average power input to the Power Sensor. If external filtering is desired, reconnect the jumpers to provide the optional unfiltered dc RECORDER OUTPUT as shown on Service Sheet 8.</td></tr>
<tr><td>BCD Interface Control Assembly A6 (Option 024)</td><td>13</td><td>The factory-installed jumper enables the SENSOR ZERO function to be programmed only when the REMOTE ENABLE input to the Power Meter is low. If it is desired to program the SENSOR ZERO function independently of the remote enable input, reconnect the jumper to provide +5V to U12C-9 as shown on Service Sheet 8.</td></tr>
<tr><td>Hewlett-Packard Interface Bus Control Assembly A6 (Option 022)</td><td>11</td><td>The factory installed jumpers select TALK address M and LISTEN address — (minus sign) for the Power Meter. As shown on Service Sheet 11, either of these addresses causes a high enable output at U2C-10. If it is desired to change these addresses, refer to Service Sheet 11 and Table 2-2 and reconnect the jumpers to decode the appropriate ASCII characters. For example, to change to TALK address E and LISTEN address %, the jumpers would be reconnected as follows.

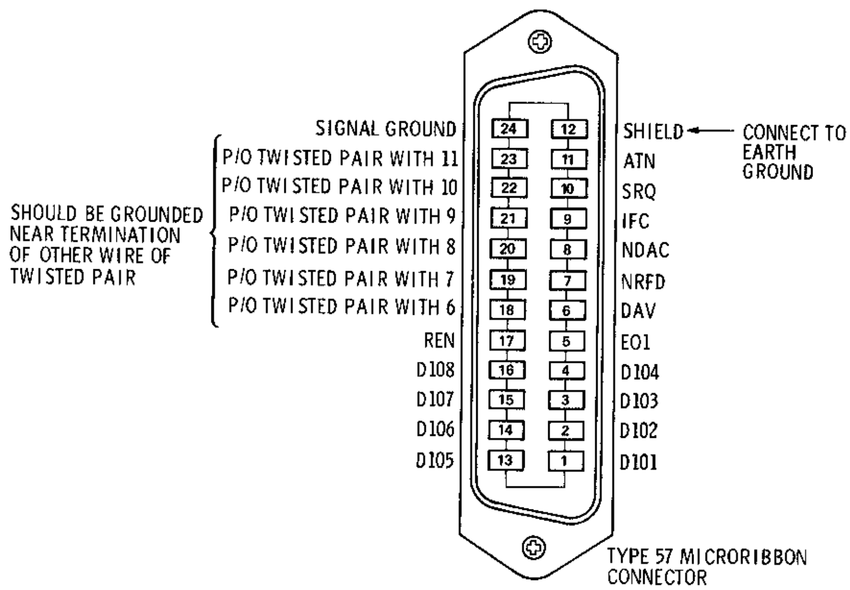
ASCII code (logic 1–0V)
<table>
<tr><td></td><td>DI07</td><td>DI06</td><td>DI05</td><td>DI04</td><td>DI03</td><td>DI02</td><td>DI01</td><td></td></tr>
<tr><td>M</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td rowspan="2">Note: DI07 and DI06 must always be 1 and 0, respectively, for TALK address.</td></tr>
<tr><td>E</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>—</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td rowspan="2">Note: DI07 and DI06 must always be 0 and 1, respectively, for LISTEN address.</td></tr>
<tr><td>%</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
</table>
Jumpers
<table>
<tr><td>M</td><td>U1B-13</td><td>HI01</td><td rowspan="2">E, % , Disconnect jumper from HI04 and reconnect to LI04.</td></tr>
<tr><td>—</td><td>U1B-12</td><td>LI02</td></tr>
<tr><td></td><td>U1B-10</td><td>HI03</td><td></td></tr>
<tr><td></td><td>U1B- 9</td><td>HI04</td><td></td></tr>
<tr><td></td><td>U2C- 9</td><td>HI05</td><td></td></tr>
</table>
</td></tr>
</table>

Table 2-2. USA Standard Code for Information Interchange (ASCII)

BITS b7 b6 b5 →					0_{0_0}	0_{0_1}	0_{1_0}	0_{1_1}	1_{0_0}	1_{0_1}	1_{1_0}	1_{1_1}
b4 ↓	b3 ↓	b2 ↓	b1 ↓	Column→ / Row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	–	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

NOTE 3 (bits b7 b6 b5 and b4–b1); NOTE 1 (columns 2–3); NOTE 2 (columns 4–5)

NOTE 1: HP-IB valid LISTEN addresses
NOTE 2: HP-IB valid TALK addresses
NOTE 3: Logic 1 = 0V



Logic Levels

The Hewlett-Packard Interface Bus logic levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to 0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format

Refer to Section III, Operation.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

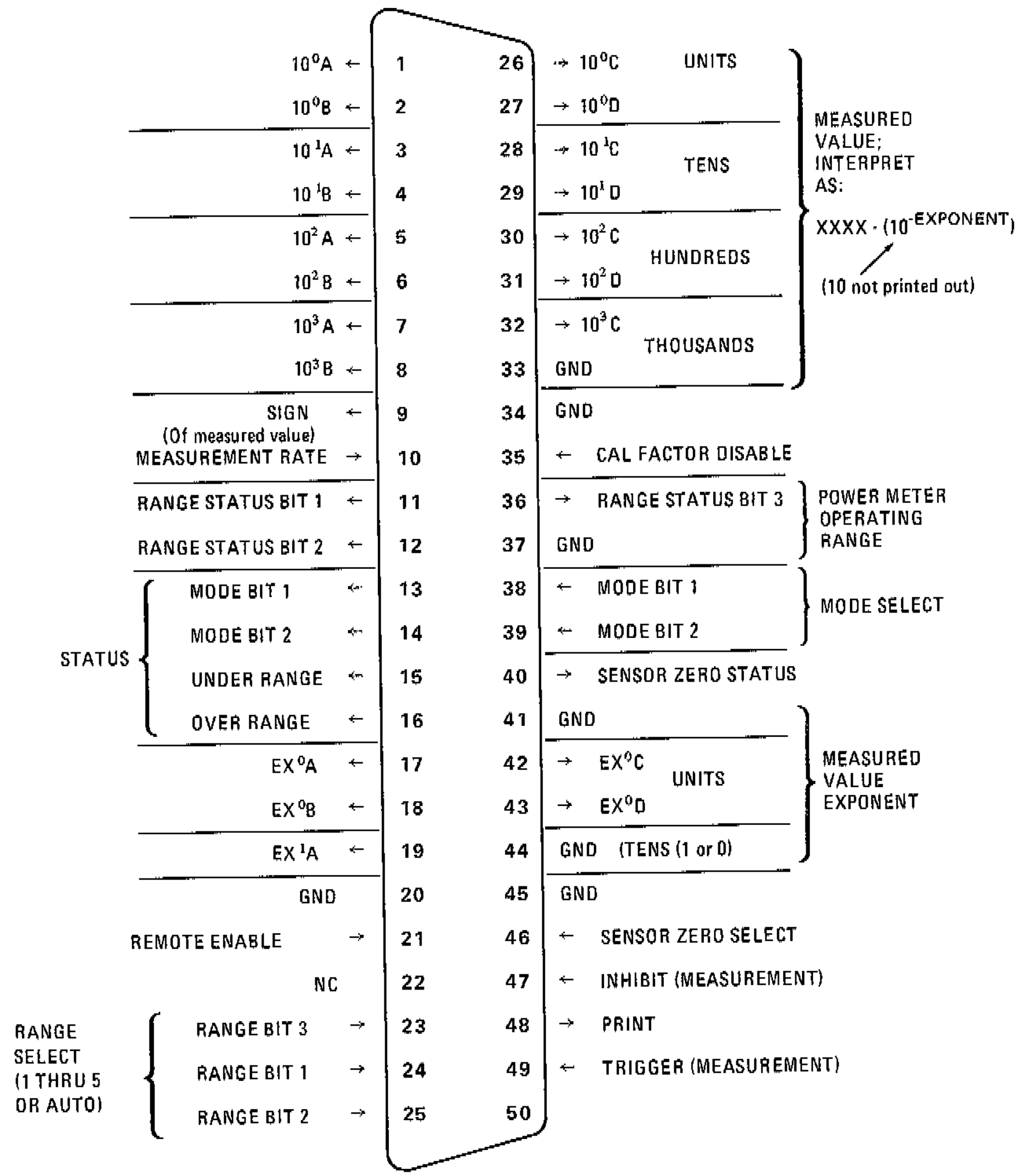
Mating Cables Available

HP 10631A, 0.9 metres (3 ft.), HP 10631A, 1.8 metres (6 ft.)
HP 10631C, 3.7 metres (12 ft.)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus System may contain no more than 1.8 metres (6 ft.) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus System is 20.0 metres (65.6 ft.)

Figure 2-3. Hewlett-Packard Interface Bus Connection



Logic Levels
The BCD Interface logic levels are TTL compatible, i.e., the true state is 0.0 Vdc to 0.4 Vdc and the false state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format
Refer to Section III, Operation
Mating Connectors — HP 1251-0086
Mating Cables Available — HP 562A-16C for 5055A Printer

Figure 2-4. BCD Interface Connection

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section provides complete operating information for the Power Meter. Included in the section are a description of all front- and rear-panel controls, connectors, and indicators (panel features), operator's checks, operating instructions, power measurement accuracy considerations, and operator's maintenance.

3-3. Since the power Meter can be operated locally as well as remotely via Hewlett-Packard Interface Bus Option 022 or BCD Remote Interface Option 024, respectively, the information in this section is arranged accordingly. All information unique to a particular operating configuration is designated as such; where no distinction is made, the information is applicable to both standard and optional instrument operation.

3-4. PANEL FEATURES

3-5. Front and rear panel features of the Power Meter are described in Figure 3-1. This figure contains a detailed description of the controls, connectors and indicators.

3-6. OPERATOR'S MAINTENANCE

3-7. The only maintenance the operator should normally perform is replacement of the primary power fuse located within Line Module Assembly A11. For instructions on how to change the fuse, refer to Section II, Line Voltage Selection.

CAUTION

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse-holders must be avoided.

3-8. OPERATOR'S CHECKS

3-9. A procedure for verifying the major functions of the Power Meter is provided in Figure 3-2. The procedure is divided into three parts: Local Operation, Remote BCD Operation, and Remote Hewlett-Packard Interface Bus Operation. For a standard instrument it is only necessary to perform the Local Operation procedure. For units equipped with either of the remote options, the Local Operation procedure should be performed first to establish a reference against which remote operation can be verified. Information covering remote programming of the Power Meter is provided in the following paragraphs, and a Hewlett-Packard Interface Bus Verification Program is provided in Section VIII, Service.

3-10. LOCAL OPERATING INSTRUCTIONS

3-11. Figure 3-3 provides general instructions for operating the Power Meter via the front-panel controls.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

FRONT AND REAR PANEL FEATURES

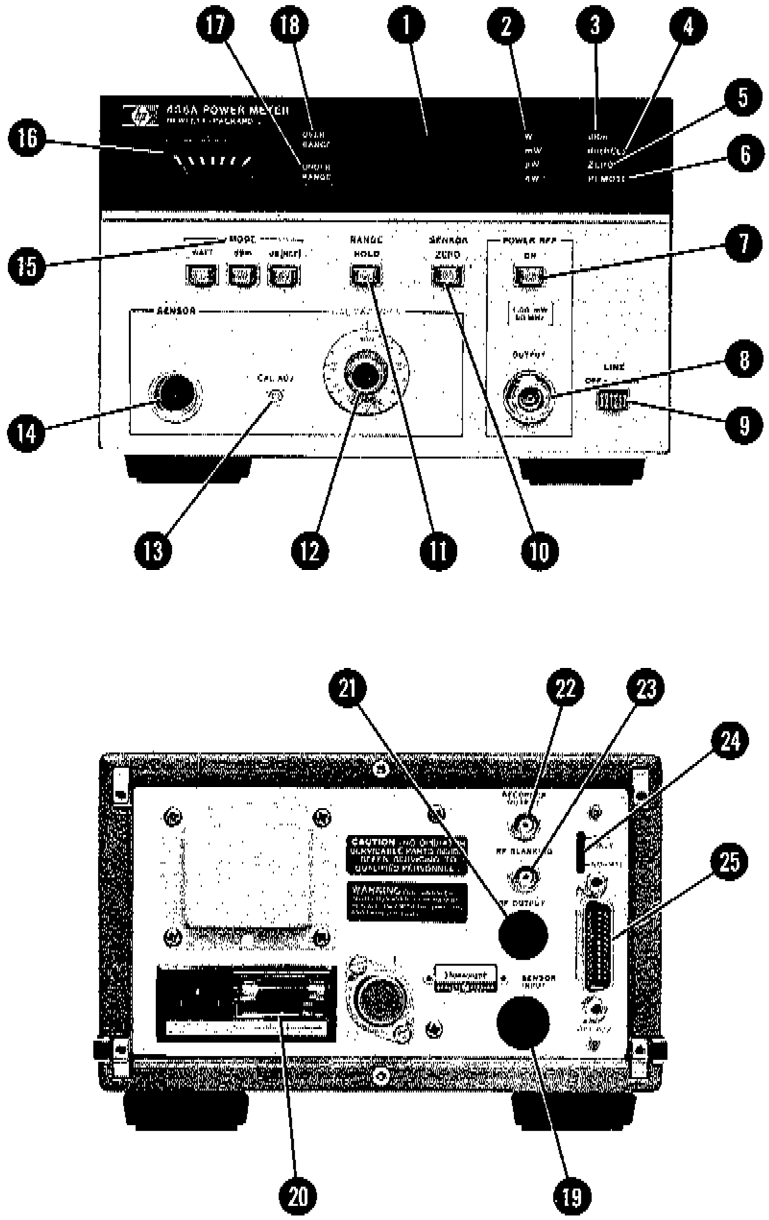


Figure 3-1. Front and Rear Panel Controls, Connectors, and Indicators (1 of 4)

FRONT PANEL FEATURES

❶ **Digital Readout:** Indicates sign and decimal value of RF input power in Watts, dBm, or in dB relative to a stored reference.

❷ **Range Lamps (W,mW, μW, nW):** Enabled in WATT MODE. Light to indicate level of Digital Readout indication.

❸ **dBm:** Lights to indicate that dBm MODE is selected and Digital Readout indication is in dBm.

❹ **dB (REL):** Lights to indicate that dB RELATIVE MODE is selected and Digital Readout indication is in dB with respect to stored reference level.

❺ **ZERO:** Lights to indicate that power sensor auto-zero circuit is enabled and ㉓ RF BLANKING output is active.

❻ **REMOTE:** Associated with BCD Option 024 and Hewlett-Packard Interface Bus Option 022. Lights to indicate that front-panel switches are disabled and power meter operation is being controlled via remote interface.

❼ **POWER REF ON:** Alternate action pushbutton switch. When set to ON (in), enables ❽ POWER REF OUTPUT.

❽ **POWER REF OUTPUT:** Enabled when ❼ POWER REF switch is set to ON. Provides RF output of 1.00 mW ± 0.70% for system calibration.

❾ **LINE ON-OFF:** Alternate action pushbutton switch. Applies ac line power to Power Meter when set to ON (in).

❿ **SENSOR ZERO:** Spring-loaded pushbutton switch. When pressed, enables Power Sensor auto zero loop for a period of approximately 4 seconds (❺ ZERO lamp remains lit for the duration of this period).

NOTE

In order to auto-zero the Power Sensor, no RF input power may be applied while the ❺ ZERO lamp is lit. If any RF input power is applied, it will introduce an offset that will affect all subsequent measurements.

⓫ **RANGE HOLD:** Alternate action pushbutton switch. When set to off (out) allows Power Meter to auto-range as required to track changes in RF input power level. When set to on (in), locks Power Meter in last range enabled during autoranging.

⓬ **CAL FACTOR %:** Rotary switch which changes the gain of the Power Meter amplifier circuits to compensate for mismatch losses and effective efficiency of the Power Sensor. A chart of CAL FACTOR % versus frequency is printed on each Power Sensor.

⓭ **CAL ADJ:** Screwdriver adjustment for calibrating the Power Meter and any Power Sensor to a known standard.

⓮ **SENSOR:** Provides input connection for Power Sensor via Power Sensor Cable.

⓯ **MODE:** Interlocking pushbutton switches which configure the Power Meter to indicate average RF input power in watts, in dBm, or in dB with respect to a stored reference.

WATT: Alternate action pushbutton switch. When set to on (in), selects WATT Mode. (Power Meter is configured to indicate RF input power in watts, milliwatts, microwatts, or nanowatts.

dBm: Alternate action pushbutton switch. When set to on (in), selects dBm Mode. (Power Meter is configured to indicate RF input power in dBm.)

dB [REF]: Spring-loaded pushbutton switch. When pressed, selects dB Relative Mode. (RF input power level displayed on ❶ Digital Readout is stored as dB reference and ❶, Digital Readout changes to 0. Then Power Meter is configured to indicate changes in RF input level in dB with respect to stored reference.)

NOTE

When the dBm relative mode is selected, the WATT Mode or dBm Mode can be selected by pressing the ⓯ WATT MODE or dBm Mode switch and the power applied to the Sensor is displayed on the ❶ Digital

(continued)

Figure 3-1. Front and Rear Panel Controls, Connectors, and Indicators (2 of 4)

FRONT AND REAR PANEL FEATURES

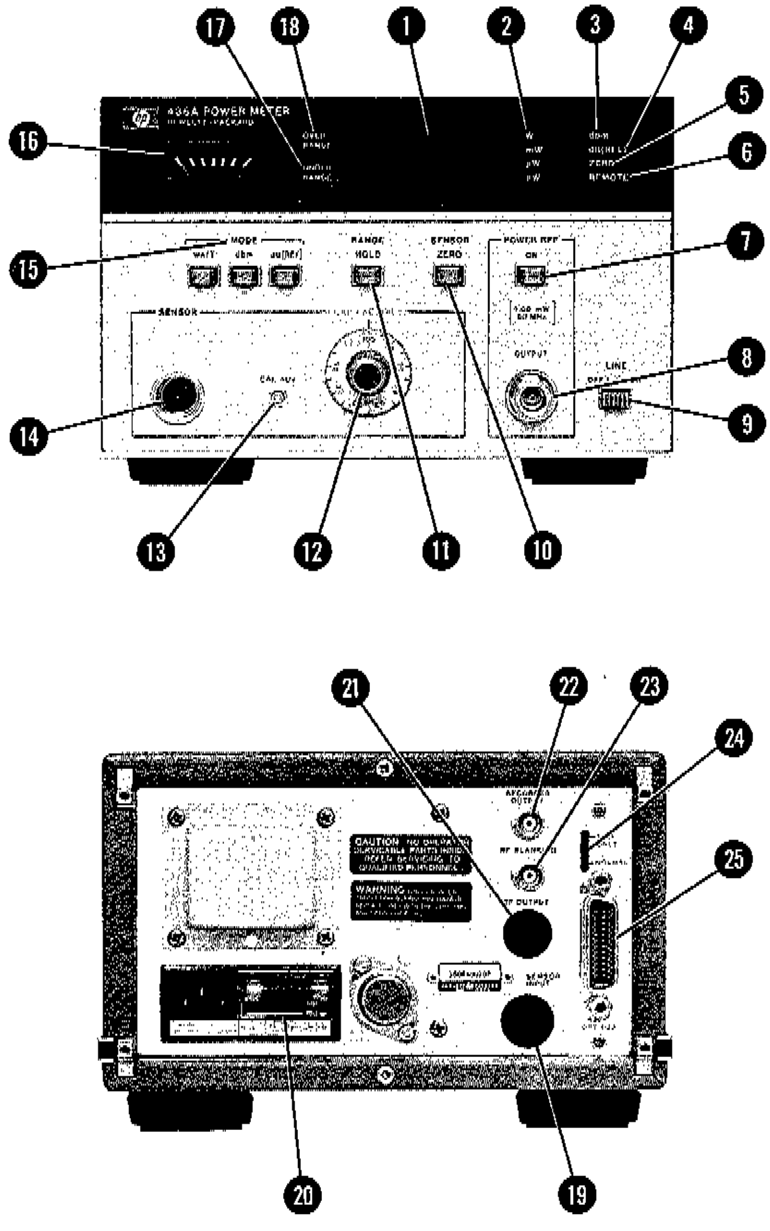


Figure 3-1. Front and Rear Panel Controls, Connectors, and Indicators (3 of 4)

FRONT PANEL FEATURES (cont'd)

(Note cont'd)

Readout. To return to the dB Relative Mode without changing the stored reference, press the (15) WATT MODE or dBm MODE switch just enough to release the previously selected MODE switch. Do not press the (15) dB [REF] MODE switch or a new reference will be entered.

(16) **Auxiliary Meter:** Provides a linear display with respect to RF input power. For any given range, a full-scale meter indication corresponds to the highest indication that can be obtained on the Digital Display.

(17) **UNDER RANGE:** Lights to indicate that RF input power level is too small to be measured on selected range (autoranging disabled), or on Power Meter lowest range (autoranging enabled).

(18) **OVER RANGE:** Lights to indicate that RF input power level is too large to be measured on selected range (autoranging disabled), or on Power Meter highest range (autoranging enabled).

REAR PANEL FEATURES

(19) **SENSOR INPUT:** Available only with Options 002 or 003. Option 002 has a rear panel input connector wired in parallel with the front panel (14) SENSOR connector. In Option 003, this rear panel input connector replaces the (14) SENSOR front panel connector.

(20) **Line Power Module:** Permits operation from 100, 120, 220, or 240 Vac. The number visible in window indicates nominal line voltage to which instrument must be connected (see Figure 2-1). Protective grounding conductor connects to the instrument through this module.

WARNING

Any interruption of the protective (grounding) conductor inside or outside the instrument or disconnecting of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited. (See Section II.)

(21) **POWER REF OUTPUT:** Takes the place of the front panel (8) POWER REF OUTPUT connector (Option 003 only).

(22) **RECORDER OUTPUT:** Provides a linear output with respect to the input power. +1.00 Vdc corresponds to a full scale (1) Digital Readout indication on the range selected (refer to Table 1-1). The minimum load which may be coupled to the output is 1 MΩ.

(23) **RF BLANKING:** Contact closure to ground when (10) SENSOR ZERO switch is pressed. May be used to remove RF input signal during automatic zeroing operation.

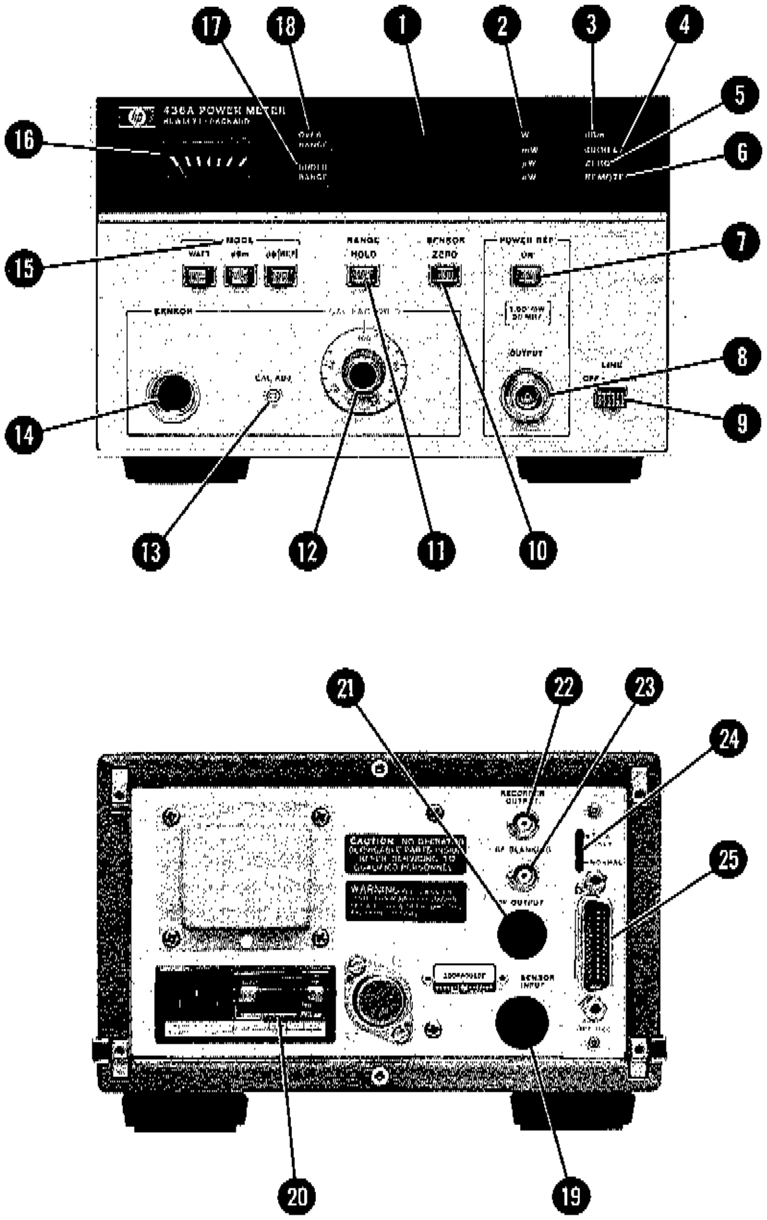
(24) **TALK ONLY/NORMAL:** Associated with Hewlett-Packard Interface Bus Option 022 only. NORMAL position configures the Power Meter as a basic talker. TALK ONLY position is normally used only when there is no controller connected to the interface bus (e.g., when Power Meter is interconnected with an HP 5150A recorder).

(25) **Interface Connector:** For Power Meter connection to remote interface Options 022 and 024.

Figure 3-1. Front and Rear Panel Controls, Connectors, and Indicators (4 of 4)

OPERATOR'S CHECKS

LOCAL OPERATION



CAUTIONS

BEFORE CONNECTING LINE POWER TO THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

Figure 3-2. Operator's Checks (1 of 10)

OPERATOR'S CHECKS

LOCAL OPERATION (cont'd)

1. BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the power transformer primary is matched to the available line voltage, the correct fuse is installed, and the safety precautions are taken. See Power Requirements, Line Voltage Selection, Power Cables, and associated warnings and cautions in Section II.

NOTE

If Power Meter is equipped with BCD or Hewlett-Packard Interface Bus option, unplug data bus cable from connector J7 on rear panel before performing this procedure. When data bus cable is unplugged, Power Meter is automatically configured for Local operation via front-panel controls.

2. Connect the Power Sensor to the Power Meter with the Power Sensor Cable.

3. Connect the Power Sensor to the (8) POWER REF OUTPUT connector.

4. Connect the Power Cable to the power outlet and (20) Line Power Module receptacle, and set the (9) LINE switch to ON (in).

5. Set the remaining Power Meter switches as follows:

(12) CAL FACTOR%	100
(7) POWER REF	off (out)
(15) MODE	WATT
(11) RANGE HOLD	off (out)

NOTE

Perform steps 6 through 19 only if Power Meter is connected to 8481A, 8482A, or 8483A Power Sensor. If Power Meter is connected to 8481H or 8482H Power Sensor, proceed to step 10.

6. Press and hold the (10) SENSOR ZERO switch until the digital readout stabilizes. While the switch is held depressed, verify that the (5) ZERO lamp is lit and that the (23) RF BLANKING output is 0.0±0.4V.

7. Release the (10) SENSOR ZERO switch and verify that the (5) ZERO lamp remains lit for approximately four seconds. When the (5) ZERO lamp goes out, verify that the (1) Digital Readout indicates 0.00±0.02 μW.

8. Set the (11) RANGE HOLD and (7) POWER REF switches to ON (in). Verify that the (18) OVER-RANGE lamp lights and that the (1) Digital Readout blanks (1_._μW).

NOTE

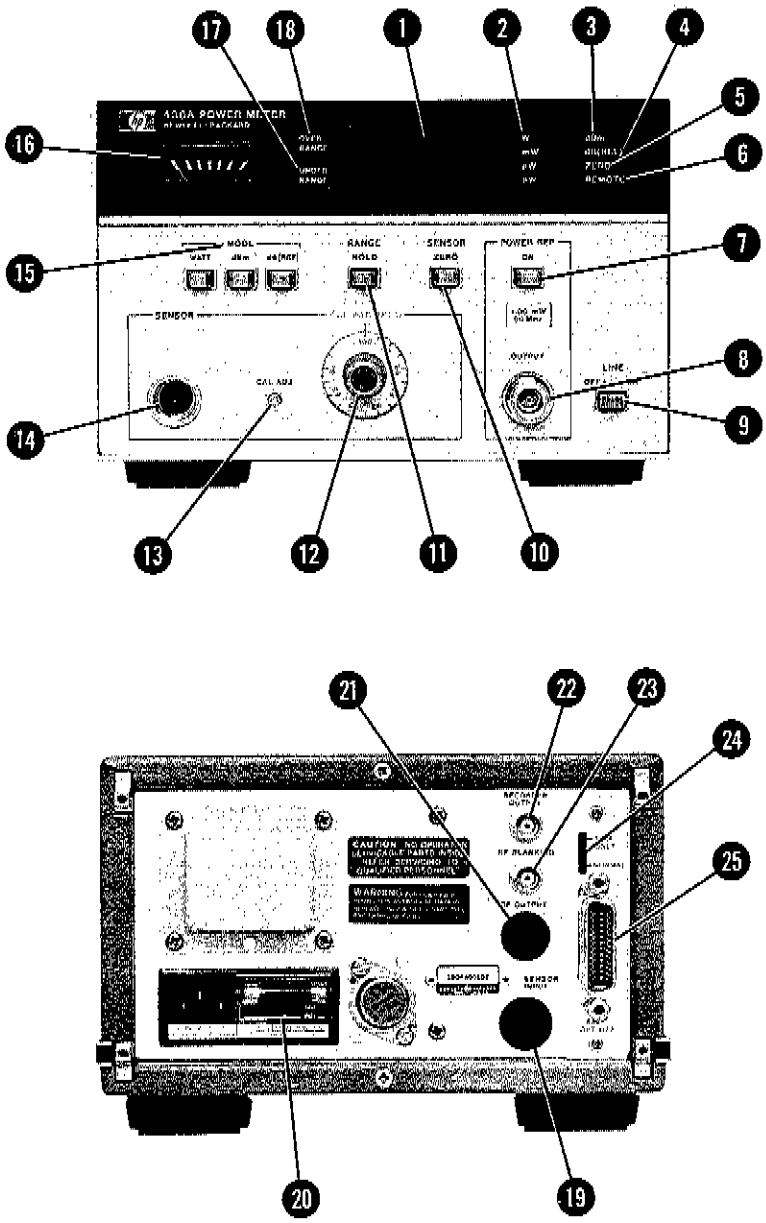
Underscore (_) indicates blanked digit.

9. Set the (11) RANGE HOLD switch to off (out). Verify that the Power Meter autoranges to the 1 mW range and that the (18) OVER RANGE lamp goes out.

Figure 3-2. Operator's Checks (2 of 10)

OPERATOR'S CHECKS

LOCAL OPERATION (cont'd)



10. Adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW. Verify that the pointer on the (16) Auxiliary Meter is aligned between the last two marks, and that the (22) RECORDER OUTPUT is approximately 1.000 Vdc.

11. Rotate the (12) CAL FACTOR % switch through its range and verify that the (1) Digital Readout indication increases slightly for each successive step. Then return the (12) CAL FACTOR % switch to 100.

Figure 3-2. Operator's Checks (3 of 10)

OPERATOR'S CHECKS

LOCAL OPERATION (cont'd)

12. Set the (15) dBm MODE switch to on (in) and verify that the (1) Digital Readout indicates —0.0 ± 0.01 dBm.

13. Set the (11) RANGE HOLD switch to on (in) and the (7) POWER REF switch to off (out). Verify that the (17) UNDER RANGE lamp lights and that the (1) Digital Readout blanks (—1_._dBm).

14. Set the (11) RANGE HOLD switch to off (out) and verify that the (1) Digital Readout blanked indication changes to —3_._. The new indication verifies that the Power Meter has autoranged to the most sensitive dBm range.

15. Set the (11) RANGE HOLD and (7) POWER REF switches to ON (in). Verify that the (18) OVER RANGE lamp lights and that the (1) Digital Readout blanked indication changes to —1_._.

16. Set the (11) RANGE HOLD switch to off (out) and verify that the (1) Digital Readout indicates —0.00 ± 0.01 dBm. This new indication verifies that the Power Meter has autoranged properly.

17. Adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates —2.00 dBm.

18. Press the (15) dB [REF] MODE switch and verify that the (3) dBm lamp goes out, the (4) dB (REL) lamp lights, and the (1) Digital Readout changes to —0.00. This step verifies that the Power Meter can store a dB reference value and indicate RF input power levels in dB with respect to the stored reference.

19. Set the (15) WATT Mode switch to on (in) and readjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW.

NOTE

Steps 20 through 28 are performed in lieu of steps 6 through 19 when the Power Meter is connected to an 8481H or an 8482H Power Sensor.

20. Press and hold the (10) SENSOR ZERO switch until the (1) Digital Readout stabilizes. While the switch is held pressed, verify that the (5) ZERO lamp is lit and that the (23) RF BLANKING output is 0.0 ± 0.4V.

21. Release the (10) SENSOR ZERO switch and verify that the (5) ZERO lamp remains lit for approximately four seconds. When the (5) ZERO lamp goes out, verify that the (1) Digital Readout indicates 0.00 ± 0.02 μW.

22. Set the (7) POWER REF switch to ON (in) and adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW. Verify that the pointer on the (16) Auxiliary Meter is aligned between the last two marks, and that the (22) RECORDER OUTPUT is approximately 1.000 Vdc.

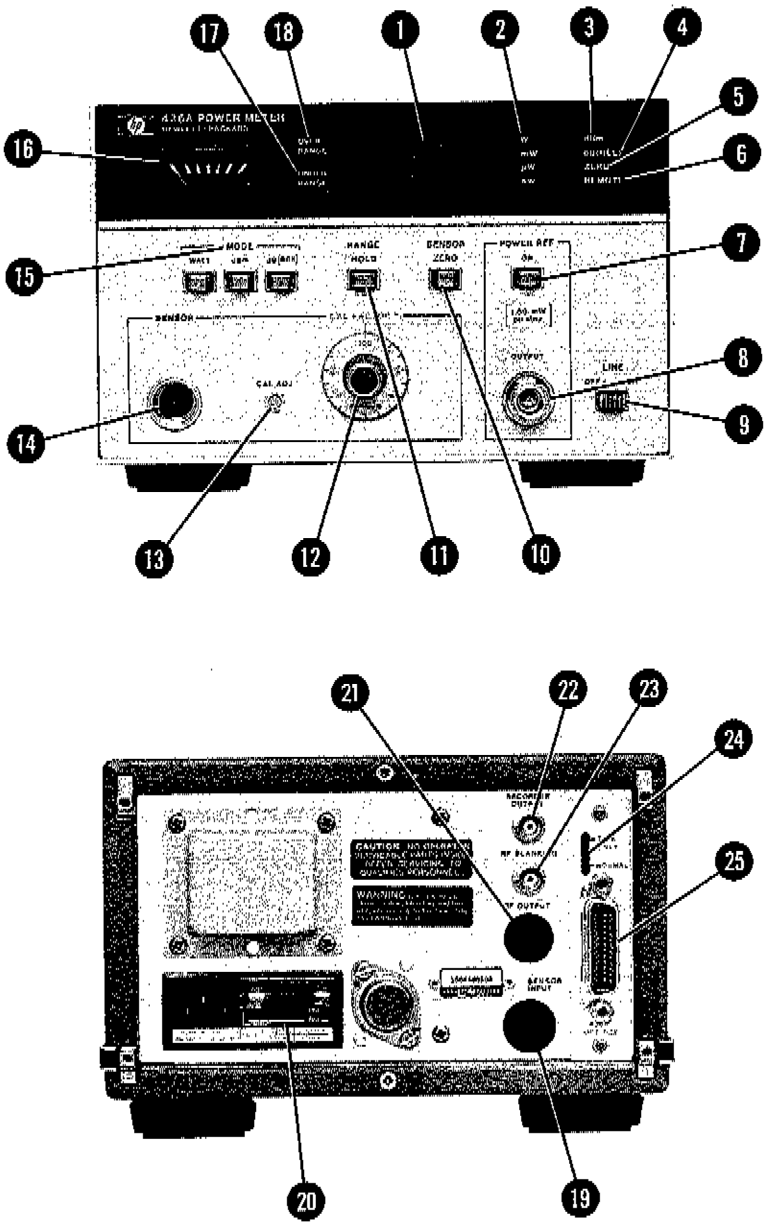
23. Rotate the (12) CAL FACTOR % switch through its range and verify that the (1) Digital Readout increases slightly for each successive step. Then return the (12) CAL FACTOR % switch to 100.

24. Set the (15) dBm MODE switch to on (in) and verify that the (1) Digital Readout indicates —0.00 ± 0.01 dBm.

Figure 3-2. Operator's Checks (4 of 10)

OPERATOR'S CHECKS

LOCAL OPERATION (cont'd)



25. Set the (7) POWER REF switch to off (out). Verify that the (17) UNDER RANGE lamp lights and that the (1) Digital Readout blanks (−1 _ . _ dBm).

26. Set the (7) POWER REF switch to ON (in) and adjust the (13) CAL ADJ control so that the (1) Digital Readout indictes −2.00 dBm.

Figure 3-2. Operator's Checks (5 of 10)

OPERATOR'S CHECKS

LOCAL OPERATION (cont'd)

27. Press the ⓯ dB [REF] Mode switch and verify that the ❸ dBm lamp goes out, the ❹ dB (REL) lamp lights, and the ❶ Digital Readout changes to −0.00. This step verifies that the Power Meter can store a dB reference value and indicate input power levels in dB with respect to the stored reference.

28. Set the ⓯ WATT Mode switch to on (in) and readjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates 1.000 mW.

REMOTE BCD OPERATION

CAUTIONS

BEFORE CONNECTING LINE POWER TO THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

1. Connect the Power Sensor to the Power Meter with the Power Sensor Cable.

2. Connect the Power Sensor to the ❽ POWER REF OUTPUT connector.

3. Connect the Power Cable to the power outlet and ⓴ Line Power Module receptacle, and set the ❾ LINE ON-OFF switch to ON (in).

4. Set the Power Meter ⓬ CAL FACTOR % switch to 100 and the ❼ POWER REF switch to off (out).

NOTE

Perform steps 5 through 20 only if Power Meter is connected to HP 8481A, 8482A, or 8483A Power Sensor. If Power Meter is connected to 8481H or 8482H Power Sensor, proceed to step 21.

5. Set the Remote Enable input to the Power Meter to logical 1 (0.0 ± 0.4V), and program the Power Meter as follows:

Mode	WATT
Range	1
❿ SENSOR ZERO	ON
⓬ CAL FACTOR %	enabled

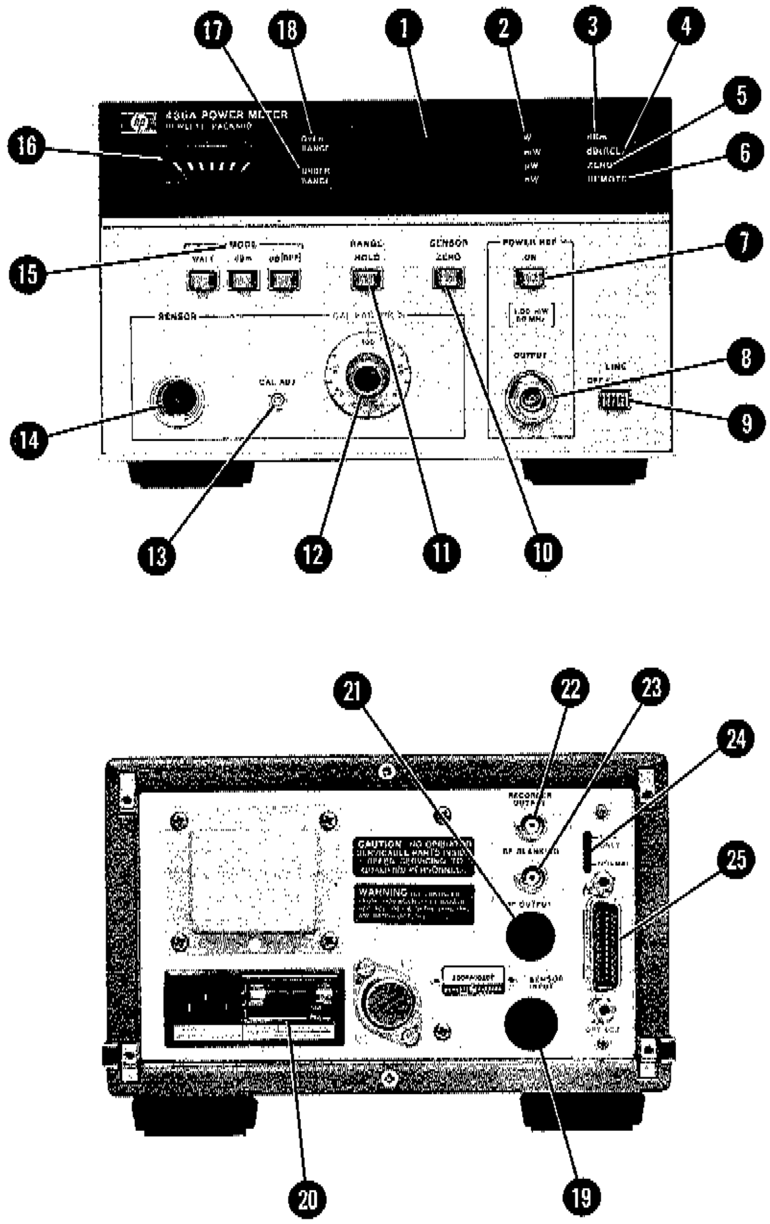
6. Verify that the Power Meter ❻ REMOTE, ❷ μW, and ❺ ZERO lamps are lit and that the ㉓ RF BLANKING output is 0.0 ± 0.4V.

7. Program the SENSOR ZERO function to off and verify that the ❺ ZERO lamp remains lit for approximately four seconds. When the ❺ ZERO lamp goes out, verify that the ❶ Digital Readout indicates 0.00 ± 0.02 μW.

Figure 3-2. Operator's Checks (6 of 10)

OPERATOR'S CHECKS

REMOTE BCD OPERATION (cont'd)



8. Set the (7) POWER REF switch to ON. Verify that the (18) OVER RANGE lamp lights and the (1) Digital Readout blanks (1 _ . _ _ μW).

NOTE

Underscore (_) indicates blanked digit.

9. Program the Power Meter to Range 3. Verify that the (2) mW lamp lights and that the (18) OVER RANGE lamp goes out.

Figure 3-2. Operator's Checks (7 of 10)

OPERATOR'S CHECKS

REMOTE BCD OPERATION (cont'd)

10. Adjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates 1.000 mW. Verify that the pointer on the ⓰ Auxiliary Meter is aligned between the last two marks, and that the ㉒ RECORDER OUTPUT is approximately 1.00 Vdc.

11. Rotate the ⓬ CAL FACTOR % switch through its range and verify that the ❶ Digital Readout increases slightly for each successive step.

12. Set the CAL FACTOR disable programming input to logical 1 (0V) and verify that the ❶ Digital Readout indication changes back to 1.000 mW.

13. Program the Power Meter to the dBm MODE and verify that the ❶ Digital Readout indicates —0.00 ± 0.01 dBm.

14. Set the ❼ POWER REF switch to off (out). Verify that the ⓱ UNDER RANGE lamp lights and that the ❶ Digital Readout blanks (—1_ . _ dBm).

15. Program the Power Meter to Range 1, and verify that the ❶ Digital Readout blanked indication changes to —3_ . _ . The new indication verifies that the Power Meter is on the most sensitive dBm range.

16. Set the ❼ POWER REF switch to ON (in). Verify that the ⓲ OVER RANGE lamp lights and that the ❶ Digital Readout blanked indication changes to —1_ . _ .

17. Program the Power Meter for Auto Ranging and verify that the ❶ Digital Readout indication changes to —0.00 ± 0.01 dBm. This new indication verifies that the Power Meter has autoranged properly.

18. Adjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates —2.00 dBm.

19. Program the Power Meter to the dB [REF] MODE. Verify that the ❸ dBm lamp goes out, the ❹ dB (REL) lamp lights, and the ❶ Digital Readout changes to —0.00. This step verifies that the Power Meter can store a dB reference value and indicate RF input power levels in dB with respect to the stored reference.

20. Program the Power Meter to the WATT MODE and readjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates 1.000 mW.

NOTE

Steps 21 through 31 are performed in lieu of steps 5 through 20 when the Power Meter is connected to an HP 8481H or an HP 8482H Power Sensor.

21. Set the Remote Enable input to the Power Meter to logical 1 (0.0 ± 0.4 Vdc) and program the Power Meter as follows:

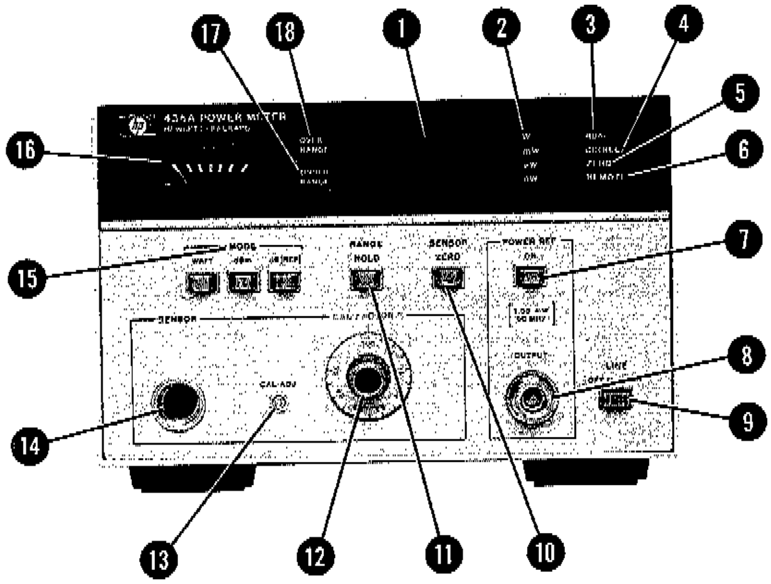
Mode	WATT
Range	AUTO
❿ SENSOR ZERO	ON
⓬ CAL FACTOR %	enabled

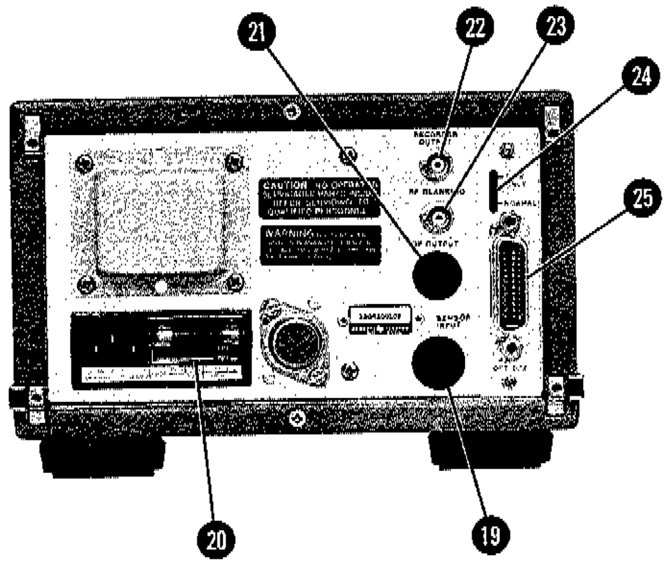
22. Verify that the Power Meter ❻ REMOTE, ❷ μW, and ❺ ZERO lamps are lit and that the ㉓ RF BLANKING output is 0.0 ± 0.4V.

Figure 3-2. Operator's Checks (8 of 10)

OPERATOR'S CHECKS

REMOTE BCD OPERATION (cont'd)





23. Program the SENSOR ZERO function to off and verify that the (5) ZERO lamp remains lit for approximately four seconds. When the (5) ZERO lamp goes out, verify that the (1) Digital Readout indicates 0.00 ± 0.02 μW.

24. Set the (7) POWER REF switch to ON (in) and adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW. Verify that the pointer on the (16) Auxiliary Meter is aligned between the last two marks and that the (22) RECORDER OUTPUT is approximately 1.000 Vdc.

Figure 3-2. Operator's Checks (9 of 10)

OPERATOR'S CHECKS

REMOTE BCD OPERATION (cont'd)

25. Rotate the ⓬ CAL FACTOR % switch through its range and verify that the ❶ Digital Readout indication increases slightly for each successive step.

26. Set the CAL FACTOR Disable programming input to logical 1 (0V) and verify that the ❶ Digital Readout indication changes back to 1.000 mW.

27. Program the Power Meter to the dBm MODE and verify that the ❶ Digital Readout indicates —0.00 ± 0.01 dBm.

28. Set the ❼ POWER REF switch to off (out). Verify that the ⓱ UNDER RANGE lamp lights and that the ❶ Digital Readout blanks (—1 _ . _ dBm).

29. Set the ❼ POWER REF switch to ON (in) and adjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates —2.00 dBm.

30. Program the Power Meter to the dB [REF] MODE and verify that the ❸ dBm lamp goes out, the ❹ dB (REL) lamp lights, and the ❶ Digital Readout changes to —0.00. This step verifies that the Power Meter can store a dB reference value and indicate input power levels in dB with respect to the stored reference.

31. Program the Power Meter to the WATT MODE and readjust the ⓭ CAL ADJ control so that the ❶ Digital Readout indicates 1.000 mW.

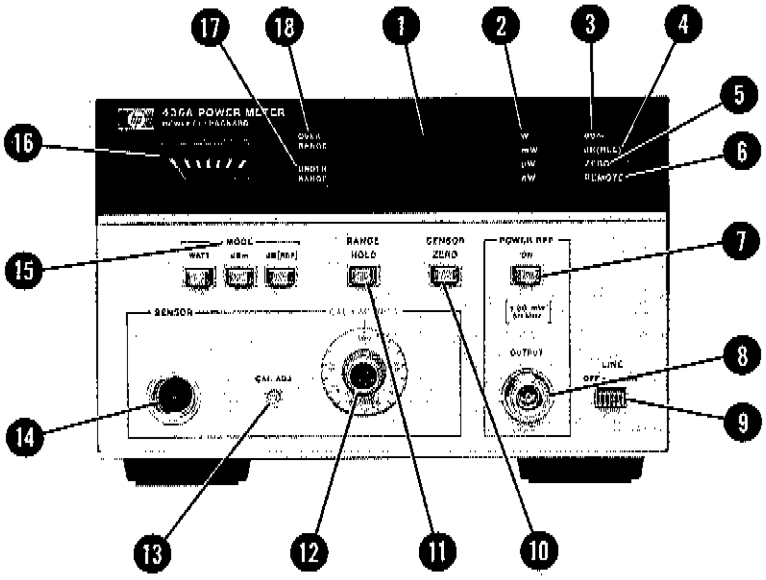
REMOTE HEWLETT-PACKARD INTERFACE BUS OPERATION

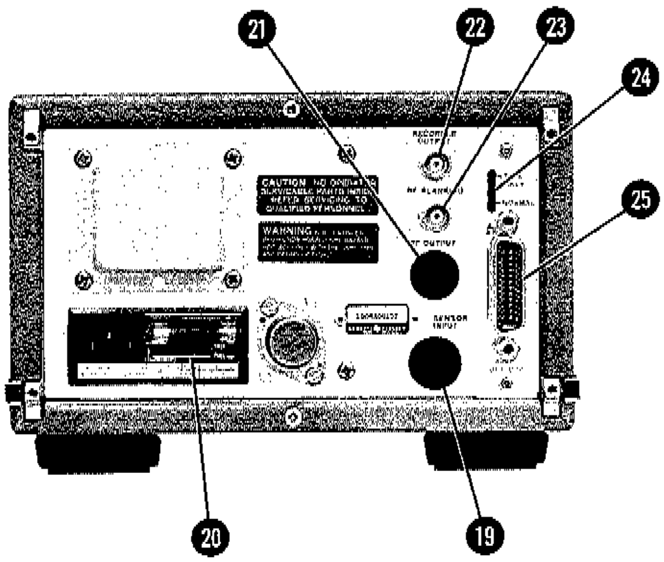
Check Power Meter operation using the verification program provided in Section VIII, SERVICE.

Figure 3-2. Operator's Checks (10 of 10)

OPERATING INSTRUCTIONS

LOCAL OPERATION





CAUTIONS

BEFORE CONNECTING LINE POWER TO THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

Figure 3-3. Operating Instructions (1 of 4)

OPERATING INSTRUCTIONS

LOCAL OPERATION (cont'd)

1. BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the power transformer primary is matched to the available line voltage, the correct fuse is installed, and safety precautions are taken. See Power Requirement, Line Voltage Selection, Power Cables, and associated warnings and cautions in Section II.

NOTE

If Power Meter is equipped with BCD or Hewlett-Packard Interface Bus Option, either unplug data bus cable from connector J7 on rear panel or program Power Meter for Local operation as described under Operating Instructions paragraph.

2. Connect the Power Sensor to the Power Meter with the Power Sensor Cable.

3. Connect the Power Cable to the power outlet and (20) Line Power Module receptacle and set the (9) LINE ON-OFF switch to ON (in).

4. Set the remaining Power Meter switches as follows:

(12) CAL FACTOR %	100
(7) POWER REF	off (out)
(15) MODE	WATT
(11) RANGE HOLD	off (out)

5. Press and hold the (10) SENSOR ZERO switch and wait for the (1) Digital Readout to stabilize. Then verify that the (5) ZERO lamp is lit and that the (1) Digital Readout indicates 0.00 ±0.02.

NOTE

When auto-zeroing the Power Sensor, no RF input power may be applied while the ZERO lamp is lit. If any RF input power is applied, it will introduce an offset that will affect subsequent measurements.

6. Release the (10) SENSOR ZERO switch and wait approximately 4 seconds for the (5) ZERO lamp to go out.

7. Connect the Power Sensor to the (8) POWER REF OUTPUT connector and set the (7) POWER REF switch to ON (in). Then adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW.

8. Set the (7) POWER REF switch to off (out) and disconnect the Power Sensor from the (8) POWER REF OUTPUT connector.

9. Locate the calibration curve on the Power Sensor cover and determine the CAL FACTOR for the measurement frequency; set the Power Meter (12) CAL FACTOR % switch accordingly.

CAUTION

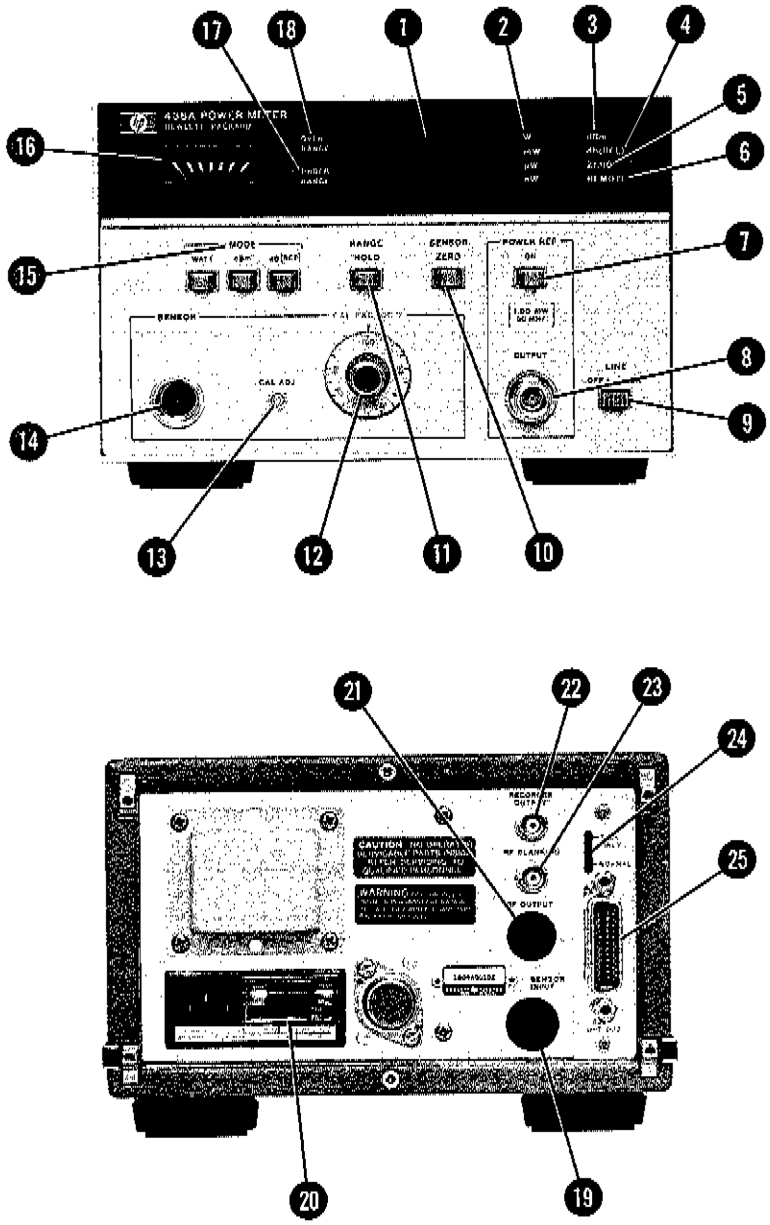
See Operating Precautions in the Power Sensor Operating and Service Manuals for maximum power levels which may be safely coupled to this system. Levels which exceed the limits may damage the Power Sensor, Power Meter or both.

10. Set the (15) MODE and (11) RANGE HOLD switches for desired operation and connect the Power Sensor to the RF source.

Figure 3-3. Operating Instructions (2 of 4)

OPERATING INSTRUCTIONS

HEWLETT-PACKARD INTERFACE BUS (HP-IB) OR BCD REMOTE OPERATION



CAUTIONS

BEFORE CONNECTING LINE POWER TO THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

Figure 3-3. Operating Instructions (3 of 4)

OPERATING INSTRUCTIONS

HP-IB OR BCD REMOTE OPERATION (cont'd)

1. BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the power transformer primary is matched to the available line voltage, the correct fuse is installed, and safety precautions are taken. See Power Requirement, Line Voltage Selection, Power Cables, and associated warnings and cautions in Section II.
2. Connect the Power Sensor to the Power Meter with the Power Sensor Cable.
3. Connect the Power Meter to the (30) Remote Interface.
4. Connect the Power Cable to the power outlet and (20) Line Power Module receptacles and set the (9) LINE ON-OFF switch to ON (in).
5. Set the Power Meter (12) CAL FACTOR % switch to 100 and the (7) POWER REF switch to off (out).
6. Set the remote enable input to the Power Meter to logical 1 (0.0 ± 0.4 Vdc) and program the Power Meter as follows:

   Mode . . . . WATT
   Range . . . . AUTO
   (10) SENSOR ZERO . . . . ON
   (12) CAL FACTOR % . . . . enabled

7. Wait for the (1) Digital Readout to stabilize, then verify that the (5) ZERO lamp is lit and that the (1) Digital Readout indicates 0.00 ± 0.02.

NOTE

When auto-zeroing the Power Sensor, no RF input power may be applied while the (5) ZERO lamp is lit. If any RF input power is applied, it will introduce an offset that will affect subsequent measurements.

8. Program the (10) SENSOR ZERO function to off and wait approximately 4 seconds for the (5) ZERO lamp to go out.
9. Connect the Power Sensor to the (8) POWER REF OUTPUT connector and set the (7) POWER REF switch to ON (in). Then adjust the (13) CAL ADJ control so that the (1) Digital Readout indicates 1.000 mW.
10. Set the (7) POWER REF switch to off (out) and disconnect the Power Sensor from the (8) POWER REF OUTPUT connector.
11. Locate the calibration curve on the Power Sensor to cover and determine the CAL FACTOR for the measurement frequency; set the Power Meter (12) CAL FACTOR % switch accordingly.

CAUTION

See Operating Precautions in the Power Sensor Operating and Service Manuals for maximum power levels which may be safely coupled to this system. Levels which exceed the limits may damage the Power Sensor, Power Meter or both.

12. Program the Power Meter to the desired Mode and Range, select the triggering most appropriate to the type of measurements anticipated, and connect the Power Sensor to the RF source.

Figure 3-3. Operating Instructions (4 of 4)

3-12. REMOTE HEWLETT-PACKARD INTERFACE BUS OPERATION

3-13. Hewlett-Packard Interface Bus Option 022 adds remote programming and digital output capability to the Power Meter. Instructions for operating the Power Meter via the Hewlett-Packard Interface Bus are provided in Figure 3-3. In order to follow these instructions, the operator must be familiar with the overall capability and operation of the Hewlett-Packard Interface Bus, and with the programming codes and data format assigned to the Power Meter. Hewlett-Packard Interface Bus operation with a calculator is described in a separate manual entitled "Hewlett-Packard Interface Bus Users Guide" (HP Part No. 59300-90001 for the HP 9820 Calculator, and 59300-90002 for the HP 9830 Calculator); Power Meter compatibility, programming, and data format is described in detail in the paragraphs which follow.

3-14. Talker Function (T3)

3-15. **Addressing and Unaddressing.** The (24) TALK ONLY/NORMAL switch enables the Power Meter to function as a basic talker or in the talk only mode. If the basic talker function is selected, the Power Meter is configured to talk when the controller places the interface bus in the command mode and outputs talk address M. The Power Meter then remains configured to talk (output data when the interface bus is in the data mode), until it is unaddressed to talk by the controller. To unaddress the Power Meter, the controller can either generate an interface clear, or it can place the interface bus in the command mode and output a new talk address, or a universal untalk command. Examples of addressing and unaddressing the Power Meter to talk are provided in Figure 8-16.

3-16. When the Power Meter functions in the Talk Only Mode, it is automatically configured to TALK when the interface bus is in the Data Mode and there is at least one listener. Since there can only be one talker per interface bus, this function is normally selected only when there is no controller connected to the system (e.g., when the Power Meter is interconnected with an HP 5150A recorder).

3-17. **Output Data Format.** The output data format of the Power Meter is shown in Figure 3-4, and described in Table 3-1.

3-18. **Data Output Time.** Figure 3-5 provides a simplified flow chart of Power Meter operation. As shown in the figure, the Power Meter operates according to a stored program and can only output data after taking a measurement. Thus, when the interface bus is placed in the data mode after the Power Meter has been addressed to talk, the time required to access the first output data character depends on where the Power Meter is in the operating program, and on how the Power Meter has been previously programmed (see Programming Codes below). Worst case access times for each of the Power Meter operating configurations are listed in Table 3-2.

3-19. After the first output character is sent, the remaining characters are sent at either a 10-kHz rate (infinitely fast listener) or at the receive rate of the slowest listener.

3-20. **Serial Polling.** The Power Meter has no capability for responding to a serial poll.

3-21. **Non-Conforming Operation.** The Power Meter fully complies with the definition of a talker as described in IEEE Document No. 488-1975.

3-22. Listener Function (L2)

3-23. The Power Meter is configured to listen when the controller places the interface bus in the command mode (ATN and REN lines low; IFC line high) and outputs listen address "–" (minus sign). The Power Meter then remains configured to listen (accept programming inputs when the interface bus is in the data mode) until it is unaddressed by the controller. To unaddress the Power Meter, the controller can either set the IFC line low or the REN line high, or it can place the interface bus in the command mode and generate a universal unlisten command.

3-24. **Data Input Format.** The Power Meter does not require any particular data input format. It is capable of responding to each of the programming codes listed in Table 3-3 on an individual basis.

3-25. **Programmability.** The Power Meter controls that can be programmed via the Hewlett-Packard Interface Bus are the MODE and SENSOR ZERO switches. The controls not programmable are the POWER REF and LINE switches. The CAL FACTOR % switch can be enabled and disabled via the interface bus but, when enabled, the calibration factor entered at the front-panel of the Power Meter is used.

Table 3-1. Hewlett-Packard Interface Bus Output Data Characters

	Definition	Character		
		ASC II	Octal	Decimal
STATUS	Measured value valid	P	120	80
	Watts Mode under Range	Q	121	81
	Over Range	R	122	82
	Under Range dBm or dB [REL] Mode	S	123	83
	Power Sensor Auto Zero Loop Enabled; Range 1 Under Range (normal for auto zeroing on Range 1)	T	124	84
	Power Sensor Auto Zero Loop Enabled; Not Range 1, Under Range (normal for auto zero-ing on Range 2-5)	U	125	85
	Power Sensor Auto Zero Loop Enabled; Over Range (error condition — RF power applied to Power Sensor; should not be)	V	126	86
RANGE	Most Sensitive 1	I	111	73
	2	J	112	74
	3	K	113	75
	4	L	114	76
	Least Sensitive 5	M	115	77
MODE	Watt	A	101	65
	dB REL	B	102	66
	dB REF (switch pressed)	C	103	67
	dBm	D	104	68
SIGN	space (+)	SP	40	32
	— (minus)	—	55	45
DIGIT	0	0	60	48
	1	1	61	49
	2	2	62	50
	3	3	63	51
	4	4	64	52
	5	5	65	53
	6	6	66	54
	7	7	67	55
	8	8	70	56
	9	9	71	57

Table 3-2. Power Meter Remote Access Time to First Output Data Character

Measurement Triggering	Mode	Worst Case Access Time to First Output Character		
		Range 1 or 2	Range 3,4 or 5	Auto Range
FREE RUN, IMMEDIATE EXTERNAL, IMMEDIATE	WATT dBm dB (REL) db [REF]	70 ms 90 ms 160 ms 160 ms	70 ms 90 ms 160 ms 160 ms	Compute measurement times from Figure 3-6 and add measurement time of each range that Power Meter steps through to delay time listed below. **From To Delay** — 1 → 2: 1070 ms; 2 → 1: 1070 ms; 2 → 3: 133 ms **From To Delay** — 3 → 2: 1070 ms; 4 → 3,5: 133 ms; 5 → 4: 133 ms Examples: Starting at block labeled "HOLD" in Figure 3-6, worst case access time for range 1—3, and range 3—1 changes with WATT MODE selected are: Range 1 70 ms; 1—2 Delay 1070 ms; Range 2 53 ms; 2—3 Delay 133 ms; Range 3 53 ms; = 1379 ms Range 3 50 ms (33+17); 3—2 Delay 1070 ms; Range 2 33 ms; 2—1 Delay 1070 ms; Range 1 33 ms; = 2256 ms
FREE RUN WITH SETTLING TIME or EXTERNAL WITH SETTLING TIME	WATT dBm dB (REL) db [REF]	1130 ms 1130 ms 1200 ms 160 ms	190 ms 190 ms 260 ms 160 ms	Compute worst case Auto Range access times from Figure 3-6. Examples: Starting at block labeled "HOLD" in Figure 3-6; worst case access times for range 1-3 and range 3-1 with WATT MODE selected are: 1 - 3 (1070 + 53, +1070 + 53 + 133 + 53) = 2432 ms 3-1 (133+33+1070+33+1070+33) = 2372 ms.

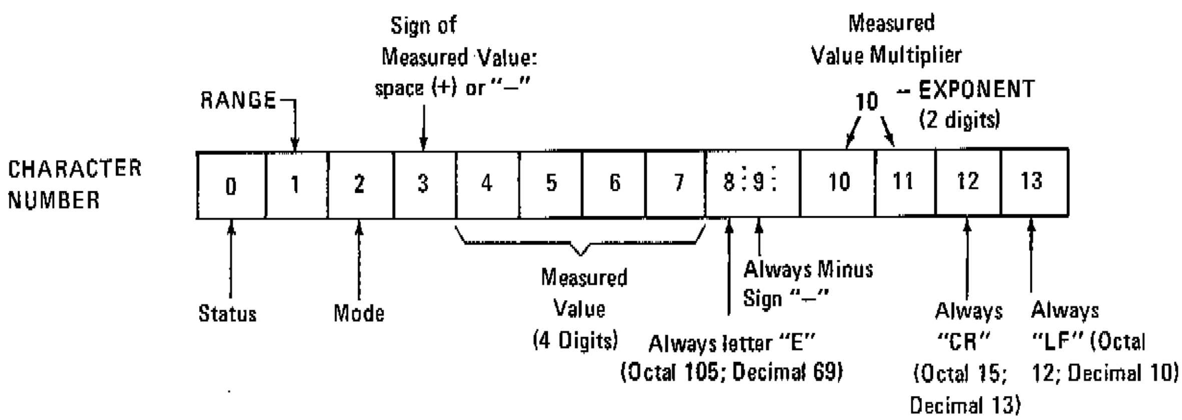
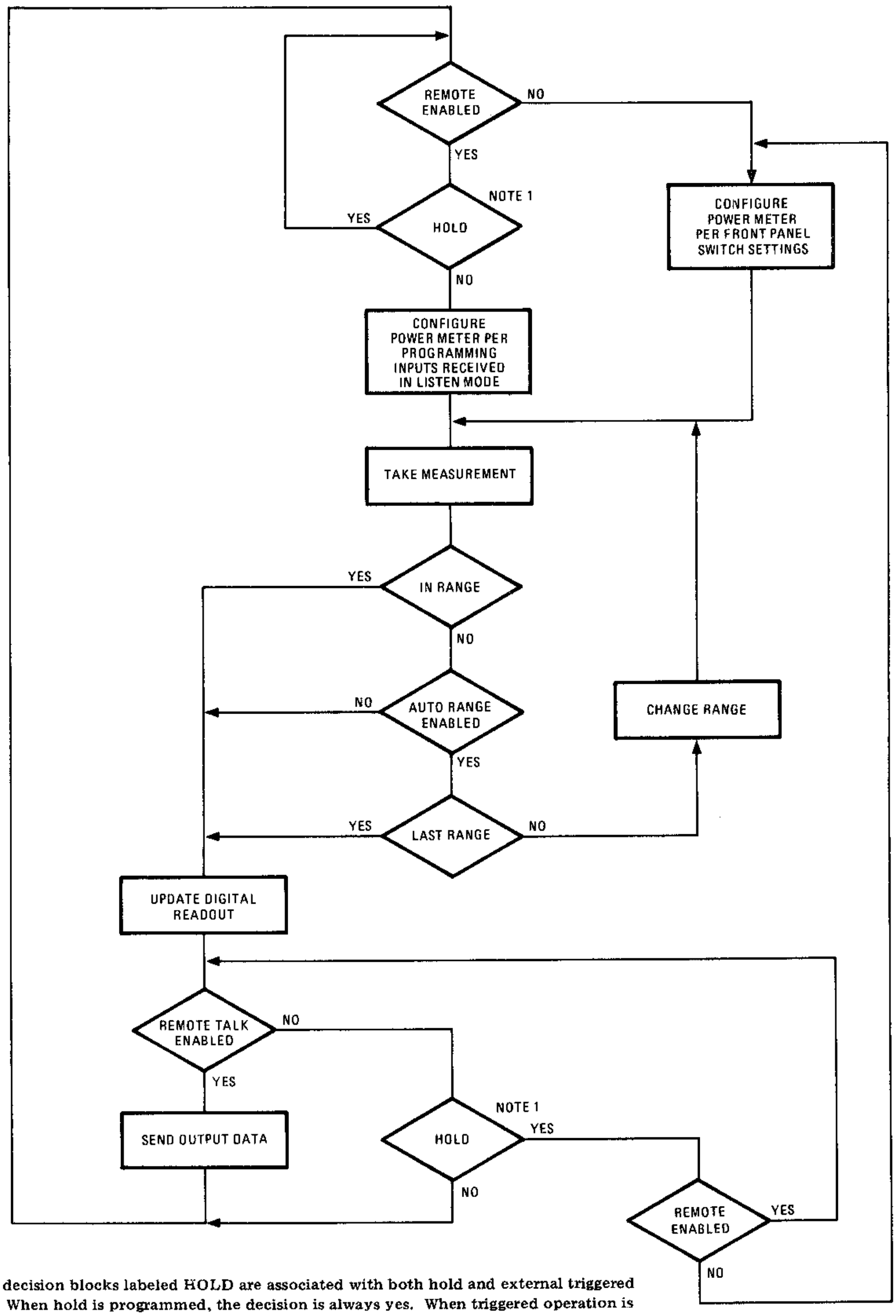


Figure 3-4. Hewlett-Packard Interface Bus Output Data Format



Note: The decision blocks labeled HOLD are associated with both hold and external triggered operation. When hold is programmed, the decision is always yes. When triggered operation is programmed, the decision is no, starting when a trigger is received and continuing unitl the digital readout is updated. The decision then reverts to yes until receipt of the next trigger. Thus, when the Power Meter is programmed for external triggering, it will provide output data only after receiving a trigger in the listen mode.

Figure 3-5. Operating Program Simplified Flow Chart

Table 3-3. Hewlett-Packard Interface Bus Input Programming Codes

Function	CODE (or Code Sequence)		
	ASC II	OCTAL	DECIMAL
RANGE			
Least sensitive	5	65	53
	4	64	52
	3	63	51
	2	62	50
Most sensitive	1	61	49
Auto	9 [1]	71	57
MODE			
Watt	A [1]	101	65
dB Rel	B [2]	102	66
dB Ref	C [2]	103	67
dBm	D	104	68
Sensor auto-zero	Z	105	69
CAL FACTOR			
Disable (100%)	+ [1]	53	43
Enable (front-panel switch)	—	55	45
MEASUREMENT RATE			
Hold	H [1]	110	72
Trigger (with settling time)	T	124	84
Trigger (immediate)	I	111	73
Free Run (at maximum rate)	R	122	82
Free Run (with settling time)	V	126	86

[1] Automatically selected when power is first turned on to Power Meter.

[2] To set reference at present input, use the following programming statement:

CMD " ? U — " , "CT"

To take first reading relative to set reference, use the following programming statement:

CMD " ? U — " , "BT"

To take additional readings relative to the reference:

CMD " ? U — " , "T"

Listener Function (L2) (cont'd)

3-26. Remote range programming is slightly different than Local range selection. For Local operation, a particular range is selected by allowing the Power Meter to auto-range to the desired range, then pressing the RANGE HOLD switch to hold the range. For Remote operation, the programming codes have provision for direct selection of the desired range as well as for selection of the auto-range function.

3-27. An additional feature that is only available via remote programming is selection of standby, triggered, or free running operation of the Power Meter. (During Local operation, the Power Meter is allowed to free run with approximately 133 milliseconds allowed for settling time between measurements.) The specific remote triggering capabilities are:

a. Hold — when the power meter is programmed to Hold, it is inhibited from taking measurements and from outputting data. Thus, it is set to a predetermined reference condition from which a measurement can be triggered synchronously to some external event.

b. Trigger Immediate — this programming command directs the Power Meter to make one measurement and output the data in the mininim possible time, then to go into Hold until the next triggering command is received. It does not allow settling time prior to the measurement.

c. Trigger with Delay — this trigger command is identical to the trigger immediate command except that it causes the Power Meter to execute a settling-time delay subroutine before taking a measurement and outputting data.

d. Free run at maximum rate — this programming command is normally used for asynchronous operation of the Power Meter. It directs the Power Meter to continuously take measurements and output data in the minimum possible time. It does not allow settling time prior to each measurement.

e. Free run with delay — this programming command is identical to the previous command except that it causes the Power Meter to execute a settling-time delay subroutine prior to each measurement.

3-28. When programming the Power Meter for synchronous triggered operation, there are two factors that the programmer must consider to ensure the validity of the output measurement data. The first factor is the time that it takes the Power Meter to respond to a full scale change in input power level. A typical Power Meter response curve is shown in Figure 3-7. By comparing this curve with the measurement timing cycle shown in Figure 3-6 and summarized in Table 3-2, the validity of the Power Meter output can be tabulated according to operating range and triggering interval — versus change in input power level. A general summary of this information is as follows:

a. When the Power Meter is programmed for trigger with settling time operation, sufficient time is provided for the Power Meter to settle to the input power level on all ranges except Range 1 (most sensitive range). On Range 1 approximately 10 seconds (9—10 measurements) are required for the Power Meter to settle to the input power level.

b. When the Power Meter is programmed for trigger immediate operation, the desired amount of settling time can be incorporated into the operating program.

3-29. The second factor that must be considered when programming the Power Meter for synchronous triggered operation is whether the first trigger is sent immediately after terminating Local operation. As illustrated in Figure 3-5, the Power Meter will not respond to the first trigger following a local to remote transistion until it completes the previously initiated measurement and display cycle. Thus, the first data output of the Power Meter may not be valid. The options available to the programmer are:

1. Send a trigger command and discount the first data output. Upon outputting the data, the Power Meter will go to Hold and operate synchronously starting with the next trigger command. A recommended programming format for the HP 9830A Calculator is as follows:

```
CMD "?U–","1"
CMD "?M5"
RDB 13→A
CMD "?U–"," program codes"
```

2. Wait approximately 2.5 seconds after placing the Power Meter in remote and sending the first program trigger command. A recommended programming format for the HP 9830A Calculator is as follows:

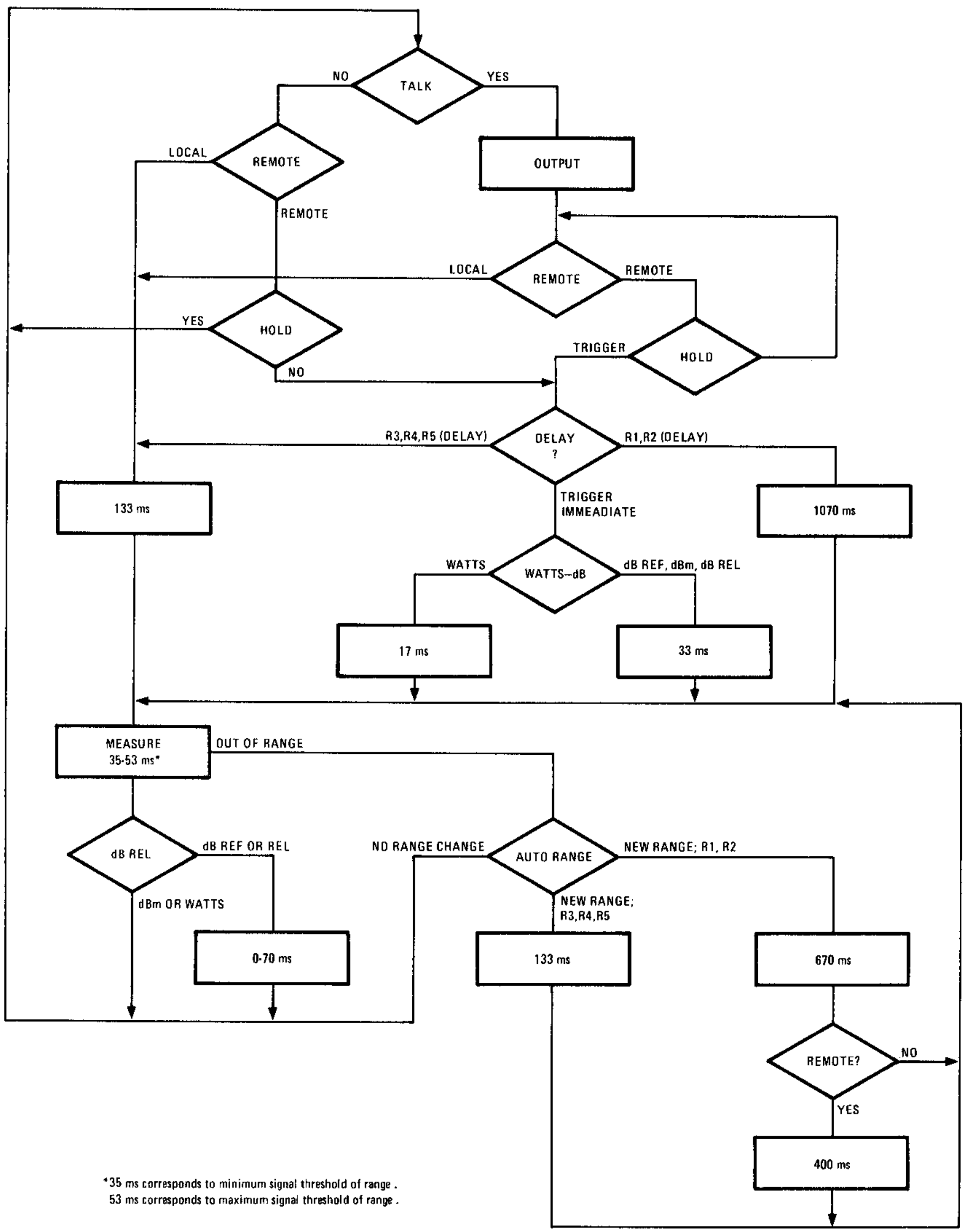


Figure 3-6. Measurement Timing Flow Chart

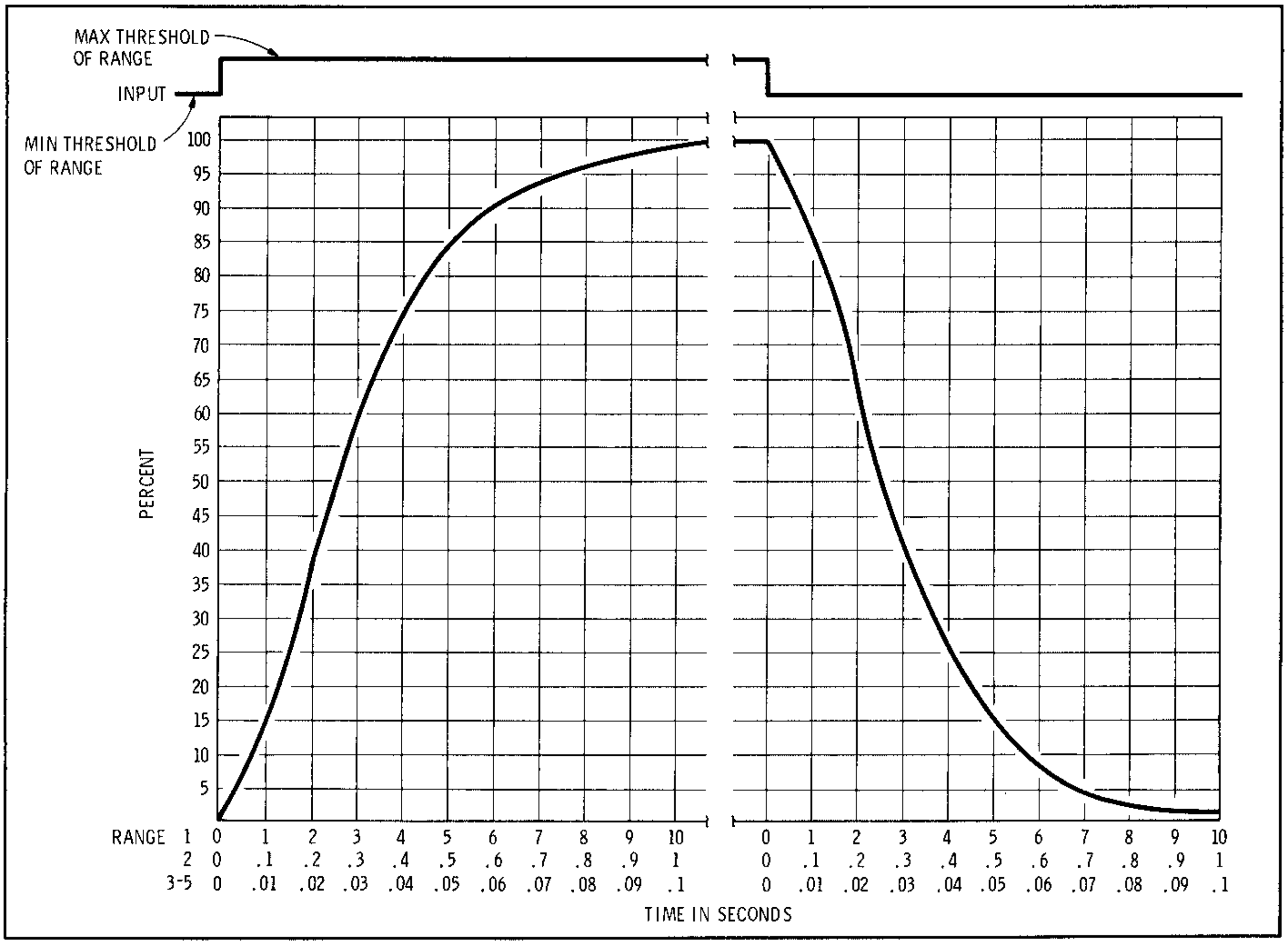


Figure 3-7. Power Meter Response Curve

Listener Function (L2) (cont'd)

CMD "?U–","H"
WAIT 2500
CMA"?U–","program codes"

3. Send a device clear command immediately after placing the Power Meter in remote. This will restart the Power Meter operating program. A recommended programming format for the HP 9830A Calculator is as follows:

CMD "?U–"
Send device clear (syntax depends on calculator used)
CMD"?U–","H"
CMD "?U–","program codes"

3-30. Programming Codes. Table 3-3 lists the programming codes that the Power Meter responds to and the functions that they enable. In the listen mode, the Power Meter can handshake in 0.5 μs. The time required for the Power Meter to respond to the programming command, however, depends on where the Power Meter is in the operating program (see Figure 3-5). The overall worst case time for Power Meter response to a programming command is 2.5 seconds, the minimum response time is approximately 100 microseconds.

NOTE

In addition to the programming codes listed in Table 3-3, Power Meter operation will be affected by all other programming codes shown in columns 2, 3, 4, and 5 of Table 2-2, except (SP!"#$%&). Thus care should be taken to address the Power Meter to unlisten before sending these programming commands to other instruments on the interface bus.*

Listener Function (L2) (cont'd)

3-31. Examples 1 and 2 below illustrate a typical format for general programming of the Power Meter, and a specific format for remotely zeroing the Power Meter. Both examples assume the use of an HP 9830A Calculator.

Example 1. The programming commands listed below select the following remote operating configuration for the Power Meter: Auto Range, Cal Factor Disable, Watt Mode, Trigger with settling time, and Talk. Ensure that the Power Meter is synchronized as described in the previous paragraph. The Power Meter will take one measurement, output the data, then go into HOLD.

```
10  FORMAT 3X, E12.0
20  CMD "?U–","9+AT","?M5"
30  ENTER (13,10)X
40  END
```

Example 2. The recommended programming format for remotely zeroing the Power Meter is listed below. Before using this format, ensure that the Power Meter is synchronized as described in the previous paragraph. The flow chart and the program for remotely zeroing the Power Meter is shown in Figure 3-8.

3-32. Non-Conforming Operation. The Power Meter fully complies with the definition of a listener as described in IEEE Standard No. 488-1975.

3-33. Service Request

3-34. The Power Meter does not have provision for requesting service.

3-35. Remote/Local Function (RL2)

3-36. Remote operation of the Power Meter is enabled when the REN line is low and local operation is enabled when the REN line is high. The Power Meter does not respond to interface bus commands LLO or GTL.

3-37. Non-Conforming Operation. The Power Meter fully complies with the requirements for remote/local operation as described in IEEE Standard No. 488-1975.

3-38. Parallel Poll

3-39. The Power Meter has no provision for responding to a parallel poll.

3-40. Device Clear Function

3-41. The Power Meter has provision for responding to the DCL bus command but not the SDC bus command. Upon receipt of the DCL command, the Power Meter operating program is reset causing the Power Meter to enter the Hold state shown at the top of Figure 3-5, and the HP-IB circuits are configured to provide Watt Mode, Auto Range, and Cal Factor Disable outputs.

3-42. Non-Conforming Operation. The Power Meter fully complies with the requirements for device clear operation as described in IEEE Standard No. 488-1975.

3-43. Device Trigger Function

3-44. The Power Meter has no provision responding to bus command GET.

3-45. Controller Function

3-46. The Power Meter has no provision for operation as a controller.

3-47. REMOTE BCD INTERFACE OPERATION

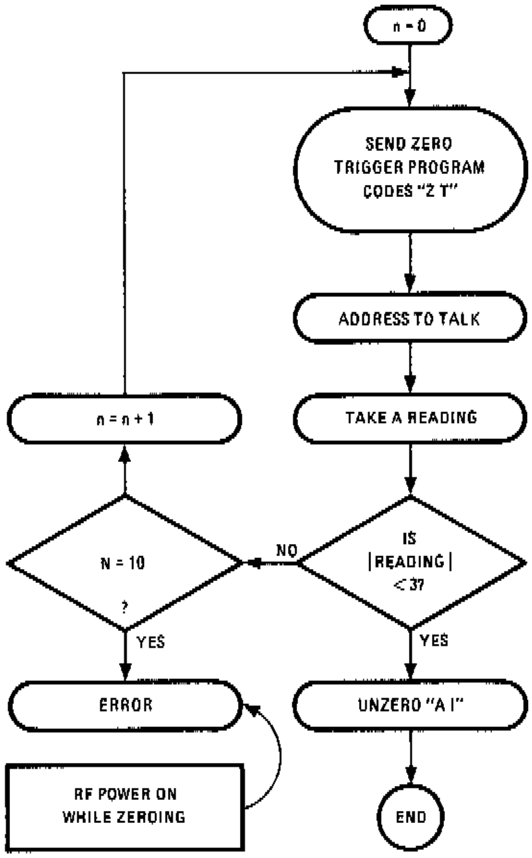
3-48. BCD Option 024 adds remote programming and digital output capability to the Power Meter. There are two basic methods for operating the Power Meter with this option. It can be operated locally with an external instrument used to record output data, or it can be operated remotely by sending remote programming inputs to the Power Meter.

3-49. Figure 3-3 provides instructions for operating the Power Meter with the BCD option installed. In order to follow these instructions, the operator must be familiar with Power Meter programming and output data format. This information is provided in detail in the paragraphs which follows.

NOTE

The Power Meter BCD option is designed to interface directly with an HP 5055A Digital Recorder. When it is used with this recorder, it can only be operated in the Local mode (unless a special cable is fabricated), as the BCD interface bus lines that are normally used to program the Power Meter, are used instead to preset the digital recorder print format. In the paragraphs which follow, differences in

(cont'd)




```
10 FORMAT 3B,F9.0
15 T=1
20 CMD "?U-","Z1T"
30 CMD "?M5"
40 T=T+1
50 ENTER (13,10)S,R,M,D
55 PRINT S,R,M,D
60 IF T=12 THEN 100
70 IF ABS(D*10↑8)>1.5 THEN 20
80 CMD "?U-","AI"
90 END
100 PRINT "ERROR"
```

Figure 3-8. Flow Chart and Program for Remotely Zeroing the Power Meter

REMOTE BCD INTERFACE OPERATION (cont'd)

(Note cont'd)
Power Meter output data format for digital recorder and "universal" interfacing are noted as applicable.

3-50. Output Data Format

3-51. When the Power Meter is interfaced with an HP 5055A Digital Recorder, the output data printout is as described in Table 3-4. When the Power Meter is interfaced with other controller or recorder instruments, data format is selected by the user. Refer to Table 3-5 for a descripition of the function and coding of the Power Meter output data lines.

3-52. BCD Remote Programming

3-53. Remote programming of the Power Meter is enabled when a 0.0 to +0.4 Vdc level is applied to remote enable input line J7-21. The Power Meter controls that can be programmed remotely are the MODE and SENSOR ZERO switches. The controls not programmable are the POWER REF and LINE switches. The CAL FACTOR % switch can be enabled and disabled via the remote interface but, when enabled, the calibration factor entered at the front panel of the Power Meter is used.

NOTE

Jumper options are provided to enable remote programming of the SENSOR ZERO switch when the remote enable input is high (+2.5 to +5.0V level is applied to J7-21). See Section II, Installation.

3-54. Remote range programming is slightly different than Local Range selection. For Local operation, a particular range is selected by allowing the Power Meter to autorange to the desired range, then pressing the RANGE HOLD switch to hold the range. For Remote operation, the programming codes have provision for direct selection of the desired range as well as selection of the autorange function.

3-55. An additional feature that is only available via remote programming is selection of standby, triggered, or free running operation of the Power Meter. (During Local operation, the Power Meter is allowed to free run with approximately 133 milliseconds allowed for settling time between measurements.) The specific remote triggering capabilities are:

a. Hold — when the power meter is programmed to Hold, it is inhibited from taking

Table 3-4. Power Meter Output Data Printout for HP 5055A Digital Recorder

Column	Interpretation	
1 (right)	Units Digit	Measured Value
2	Tens Digit	Measured Value
3	Hundreds Digit	Measured Value
4	Thousands Digit	Measured Value
5	Sign	
6	Range*	
7	Mode**	
8	Status***	
9	Exponent Units Digit	
10 (left)	Exponent Tens Digit	

Interpret measured value as $XXXX \cdot 10^{-EXPONENT}$

*Range Code	1 = Range 1 (most sensitive)
	2 = Range 2
	3 = Range 3
	4 = Range 4
	5 = Range 5 (least sensitive)
**Mode Decode	V = dB [REF]
	A = dB (REL)
	Ω = Watts
	* = dBm
***Status	0 = In Range
	1 = Underrange (WATT Mode)
	2 = Overrange
	3 = Underrange (dBm Mode)
	4 = ZERO Mode

BCD Remote Programming (cont'd)

measurements and from outputting data. Thus, it is set to a predetermined reference condition from which a measurement can be triggered synchrously to some external event.

b. Trigger Immediate — this programming command directs the Power Meter to make one measurement and output the data in the minimum possible time, then to go into Hold until the next Triggering command is recieved. It does not allow settling time prior to the measurement.

c. Trigger with Delay — this trigger command is identical to the trigger immediate command except that it causes the Power Meter to execute a settling-time delay subroutine before taking a measurement and outputting data.

d. Free run at maximum rate — this programming command is normally used for asynchronous operation of the Power Meter. It directs the Power Meter to continuously take measurements and output data in the minimum possible time. It does not allow settling time prior to each measurement.

e. Free run with Delay — this programming command is identical to the previous command except that it causes the Power Meter to execute a settling-time delay subroutine prior to each measurement.

3-56. When programming the Power Meter for synchronous triggered operation, there are two factors that the programmer must consider to ensure the idity of the output measurement data. The first factor is the time that it takes the Power Meter to respond to a full scale change in input power level. A typical Power Meter response curve is shown in Figure 3-7. By comparing this curve with the measurement timing cycle shown in Figure 3-6 and summarized in Table 3-2, the validity of the Power Meter output can be tabulated according to operating range and triggering interval — versus change in input power level. A general summay of this information is as follows:

a. When the Power Meter is programmed for trigger with settling time operation, sufficient time is provided for the Power Meter to settle to the input power level on all ranges except range 1. On range 1 approximately 10 seconds (0—10 measurements) are required for the Power Meter to settle to the input power level.

b. When the Power Meter is programmed for trigger immediate operation, the desired amount of settling time can be incorporated into the operating program.

3-57. The programming codes that the Power Meter will respond to are listed in Table 3-5.

3-58. POWER MEASUREMENT ACCURACY

3-59. A power measurement is never free from error or uncertainty. Any RF system has RF losses, mismatch losses, mismatch uncertainty, instrumentation uncertainty and calibration uncertainty. Measurement errors as high as 50% are not only possible, they are highly likely unless the error sources are understood and, as much as possible, eliminated.

3-60. Sources of Error and Measurement Uncertainty

3-61. RF Losses. Some of the RF power that enters the Power Sensor is not dissipated in the power sensing elements. This RF loss is caused by dissipation in the walls of waveguide power sensors, in the center conductor of coaxial power sensors, in the dielectric of capacitors, connections within the sensor, and radiation losses.

3-62. Mismatch. The result of mismatched impedances between the device under test and the power sensor is that some of the power fed to the sensor is reflected before it is dissipated in the load. Mismatches affect the measurement in two ways. First, the initial reflection is a simple loss and is called mismatch loss. Second, the power reflected from the sensor mismatch travels back up the transmission line until it reaches the source. There, most of it is dissipated in the source impedance, but some of its re-reflected by the source mismatch. The re-reflected power returns to the power sensor and adds to, or subtracts from, the incident power. For all practical purposes, the effect the re-reflected power has upon the power measurement is unpredictable. This effect is called mismatch uncertainty.

3-63. Instrumentation Uncertainty. Instrumentation uncertainty describes the ability of the metering circuits to accurately measure the dc output from the Power Sensor's power sensing device. In the Power Meter this error is ± 0.5% for Ranges 1 through 5. It is important to realize, however, that these uncertainty specifications do not indicate overall measurement accuracy.

Sources of Error and Measurement Uncertainty (cont'd)

3-64. Power Reference Uncertainty. The output level of the Power Reference Oscillator is factory set to 1 mW ± 0.70% at 50 MHz. This reference is normally used to calibrate the system, and is, therefore, a part of the system's total measurement uncertainty.

3-65. Cal Factor Switch Resolution Error. The resolution of the CAL FACTOR % switch contributes a significant error to the total measurement because the switch has 2% steps. The maximum error possible in each position is ±0.5%.

3-66. Corrections for Error

3-67. The two correction factors basic to power meters are calibration factor and effective efficiency. Effective efficiency is the correction factor for RF losses within the Power Sensor. Calibration factor takes into account the effective efficiency and mismatch losses.

3-68. Calibration factor is expressed as a percentage with 100% meaning the power sensor has no losses. Normally the calibration factor will be 100% at 50 MHz, the operating frequency of the internal reference oscillator.

3-69. The Power Sensors used with the Power Meter have individually calibrated calibration factor curves placed on their covers. To correct for RF and mismatch losses, simply find the Power Sensor's calibration factor at the measurement frequency from the curve or the table that is supplied with the Power Sensor and set the CAL FACTOR % switch to this value. The measurement error due to this error is now minimized.

3-70. The CAL FACTOR % switch resolution error of ±0.5% may be reduced by one of the following methods:

a. Leave the CAL FACTOR % switch on 100% after calibration, then make the measurement and record the reading. Use the reflection coefficient, magnitude and phase angle from the table supplied with the Power Sensor to calculate the corrected power level.

b. Set the CAL FACTOR % switch to the nearest position above and below the correction factor given on the table. Interpolating between the power levels measured provides the corrected power level.

3-71. Calculating Total Uncertainty

3-72. Certain errors in calculating the total measurement uncertainty have been ignored in this discussion because they are beyond the scope of this manual. Application Note AN-64, "*Microwave Power Measurement*", delves deeper into the calculation of power measurement uncertainties. It is available, on request, from your nearest HP office.

3-73. Known Uncertainties. The known uncertainties which account for part of the total power measurement uncertainty are:

a. Instrumentation uncertainty ±0.5% or ±0.02 dB (Range 1 through 5).

b. Power reference uncertainty ±0.7% or ±0.03 dB.

c. CAL FACTOR switch resolution ±0.5% or ±0.02 dB.

The total uncertainty from these sources is ±1.7% or ±0.07 dB.

3-74. Calculating Mismatch Uncertainty. Mismatch uncertainty is the result of the source mismatch interacting with the Power Sensor mismatch. The magnitude of uncertainty is related to the magnitudes of the source and Power Sensor reflection coefficients, which can be calculated from SWR. Figure 3-9 shows how the calculations are to be made and Figure 3-10 illustrates mismatch uncertainty and total calculated uncertainty for two cases. In the first case, the Power Sensor's SWR = 1.5, and in the second case, the Power Sensor's SWR = 1.26. In both cases the source has a SWR of 2.0. The example shows the effect on power measurement accuracy a poorly matched power sensor will have as compared to one with low mismatch.

3-75. A faster, easier way to find mismatch uncertainty is to use the HP Mismatch Error (uncertainty) Limits/Reflectometer Calculator. The calculator may be obtained, on request, from your nearest Hewlett-Packard office by using HP Part Number 5952-0448.

3-76. The method of calculating measurement uncertainty from the uncertainty in dB is shown by Figure 3-11. This method would be used when the initial uncertainty calculations were made with the Mismatch Error/Reflectometer Calculator.

NOTE

The BCD output data levels are TTL compatible. A false (0) state is defined as 0.0 to +0.4 Vdc and a true state is defined as +2.5 to +5.0 Vdc

Table 3-5. BCD Output Data Codes (1 of 2)

Function			Code	
MEASURED VALUE — The Power Meter format for outputting the measured value is SIGN, Four BCD DIGITS, and a negative EXPONENT. It is interpreted as: $\pm XXXX \cdot (10)^{-\text{EXPONENT}}$ (10) *not printed*			**NOTES** *Pin numbers refer to connector J7 on the rear panel.* *When used with 5055A, a four line format is established by the following pins:* *34 (ground)* *10 (measurement rate; floats high)* *35 (cal factor disable; floats high)*	
Sign space (+) —			PIN 9 0 1	
Digits			Weight	Pin Number
	Units	10^0 A	1	1
		10^0 B	2	2
		10^0 C	4	26
		10^0 D	8	27
	Tens	10^1 A	1	3
		10^1 B	2	4
		10^1 C	4	28
		10^1 D	8	29
	Hundreds	10^2 A	1	5
		10^2 B	2	6
		10^2 C	4	30
		10^2 D	8	31
	Thousands	10^3 A	1	7
		10^3 B	2	8
		10^3 C	4	32
		10^3 D	8	33

Table 3-5. BCD Output Data Codes (2 of 2)

Function	Code		
STATUS OUTPUTS	Pin 40	Pin 16	Pin 15
In Range	0	0	0
Underrange (WATT Mode)	0	0	1
Overrange	0	1	0
Underrange (dBm Mode)	0	1	1
Zero Mode	1	0	0
RANGE — indicates range on which last measurement made.	Pin 36	Pin 12	Pin 11
1 (most sensitive)	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5 (least sensitive)	1	0	1
EXPONENT	Weight	Pin	
Units EX^0A	1	17	
EX^0B	2	18	
EX^0C	4	42	
EX^0D	8	43	
Tens EX^1A	1	19	
	Note: *when used with 5055A, four line format is established by following pins: 20 (ground) 44 (ground) 45 (ground)*		
MODE	Pin 14	Pin 13	
dB [REF]	0	0	
dB (REL)	0	1	
WATT	1	0	
dBM	1	1	
	Note: *when used with 5055A, four line format is established by following pins: 38 (floats high) 39 (floats high)*		
PRINT	High to low transition on pin 48 when output data is valid.		

Table 3-6. BCD Programming Commands

<table>
<tr><th>Commands</th><th>Input Pin</th><th>Function</th></tr>
<tr><td>Remote enable</td><td>J7-21</td><td>When high, enables local operation of Power Meter via front-panel controls. When low, enables remote operation of Power Meter via programming commands listed below.

NOTE

When equipped with the BCD Option 024, the Power Meter generates a Print command and provides valid output data after each measurement for both Local and Remote operation.</td></tr>
<tr><td>Range Bit 1
Range Bit 2
Range Bit 3</td><td>J7-24
J7-25
J7-23</td><td>Select Power Meter measurement range when Remote Enable input is low.
<table>
<tr><th>Range</th><th>Pin 24</th><th>Pin 25</th><th>Pin 23</th></tr>
<tr><td>0*</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>2</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>3</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>5</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>Auto</td><td>1</td><td>1</td><td>X (0 or 1)</td></tr>
</table>
*Standby range: Power Meter operating program is held at Power Up address 000_8.</td></tr>
<tr><td>Rate
Inhibit</td><td>J7-10
J7-47</td><td>Selects Power Meter triggering when remote enable input is low
<table>
<tr><th></th><th>Pin 10</th><th>Pin 47</th><th>Pin 49</th></tr>
<tr><td>Hold</td><td>X (0 or 1)</td><td>0</td><td>X (0 or 1)</td></tr>
<tr><td>Trigger Intermediate</td><td>0</td><td>0</td><td rowspan="2">Positive-to-negative transition</td></tr>
<tr><td>Trigger with Delay</td><td>1</td><td>0</td></tr>
<tr><td>Free Run Fast</td><td>0</td><td>1</td><td>X (0 or 1)</td></tr>
<tr><td>Free Run with Delay</td><td>1</td><td>1</td><td>X (0 or 1)</td></tr>
</table></td></tr>
<tr><td>Cal Factor Disable</td><td>J7-35</td><td>When low disables front-panel CAL FACTOR % switch (same as 100% position). When high, enables switch.</td></tr>
<tr><td>Mode Bit 1
Mode Bit 2</td><td>J7-38
J7-39</td><td>Select mode when remote enable input is low.
<table>
<tr><th>Mode</th><th>Pin 38</th><th>Pin 39</th></tr>
<tr><td>dB [REF]</td><td>0</td><td>0</td></tr>
<tr><td>dB (REL)</td><td>1</td><td>0</td></tr>
<tr><td>WATT</td><td>0</td><td>1</td></tr>
<tr><td>dBm</td><td>1</td><td>1</td></tr>
</table></td></tr>
<tr><td>SENSOR Zero Select</td><td>J7-46</td><td>When low, enables power sensor auto zero circuit.

NOTE

When programming this function, allow the circuit about 7 seconds to settle before applying input power to Power Sensor. If RF input power is applied while ZERO lamp is on, it will introduce an offset that will affect future measurements.</td></tr>
</table>

CALCULATING MEASUREMENT UNCERTAINTY

1. Calculate the reflection coefficient from the given SWR.

$$\rho = \frac{SWR - 1}{SWR + 1}$$

Power Sensor #1	Power Sensor #2	Power Source
$\rho_1 = \frac{1.5 - 1}{1.5 + 1}$	$\rho_2 = \frac{1.25 - 1}{1.25 + 1}$	$\rho_s = \frac{2.0 - 1}{2.0 + 1}$
$= \frac{0.5}{2.5}$	$= \frac{0.25}{2.25}$	$= \frac{1.0}{3.0}$
$= 0.2$	$= 0.111$	$= 0.333$

2. Calculate the relative power and percentage power mismatch uncertainties from the reflection coefficients. An initial reference level of 1 is assumed.

Relative Power Uncertainty

$PU = [1 \pm (\rho_n \rho_s)]^2$ where P_n = SWR of Power Sensor # n, P_s = SWR of Power Source

$$PU_1 = \left\{1 \pm [(0.2)(0.333)]\right\}^2 = \left\{1 \pm 0.067\right\}^2 = \left\{1.067\right\}^2 \text{ and } \left\{0.933\right\}^2 = 1.138 \text{ and } 0.870$$

$$PU_2 = \left\{1 \pm [(0.111)(0.333)]\right\}^2 = \left\{1 \pm 0.037\right\}^2 = \left\{1.037\right\}^2 \text{ and } \left\{0.963\right\}^2 = 1.073 \text{ and } 0.938$$

Percentage Power Uncertainty

$\%PU$	=	$(PU - 1)\ 100\%$ for $PU > 1$	and	$-(1 - PU)\ 100\%$ for $PU < 1$
$\%PU_1$	=	$(1.138 - 1)\ 100\%$	and	$-(1 - 0.870)\ 100\%$
	=	$(0.138)\ 100\%$	and	$-(0.130)\ 100\%$
	=	13.8%	and	−13.0%
$\%PU_2$	=	$(1.073 - 1)\ 100\%$	and	$-(1 - 0.928)\ 100\%$
	=	$(0.073)\ 100\%$	and	$-(0.072)\ 100\%$
	=	7.3%	and	−7.2%

Figure 3-9. Calculating Measurement Uncertainties (1 of 2)

CALCULATING MEASUREMENT UNCERTAINTY

3. Calculate the Measurement Uncertainty in dB.

$$MU = 10\left[\log_{10}\left(\frac{P_1}{P_0}\right)\right] \text{ dB for } \frac{P_1}{P_0} > 1$$

$$= 10\left[\log\left(\frac{10P_1}{10P_0}\right)\right] \text{ dB}$$

$$= 10\ [\log(10P_1) - \log(10P_0)] \text{ dB for } \frac{P_1}{P_0} < 1$$

MU_1	$= 10\left[\log\left(\frac{1.138}{1}\right)\right]$	and	$10\ [\log(10)(0.870) - \log(10)(1)]$
	$= 10\ [0.056]$	and	$10\ [\log(8.70) - \log(10)]$
		and	$10\ [0.94 - 1]$
		and	$10\ [-0.060]$
	$= +0.56$ dB	and	-0.60 dB
MU_2	$= 10\left[\log\left(\frac{1.073}{1}\right)\right]$	and	$10\ [\log(10)(0.928) - \log(10)(1)]$
	$= 10\ [0.031]$	and	$10\ [\log(9.28) - \log(10)]$
		and	$10\ [0.968 - 1]$
		and	$10\ [-0.032]$
	$= +0.31$ dB	and	-0.32 dB

Figure 3-9. Calculating Measurement Uncertainties (2 of 2)

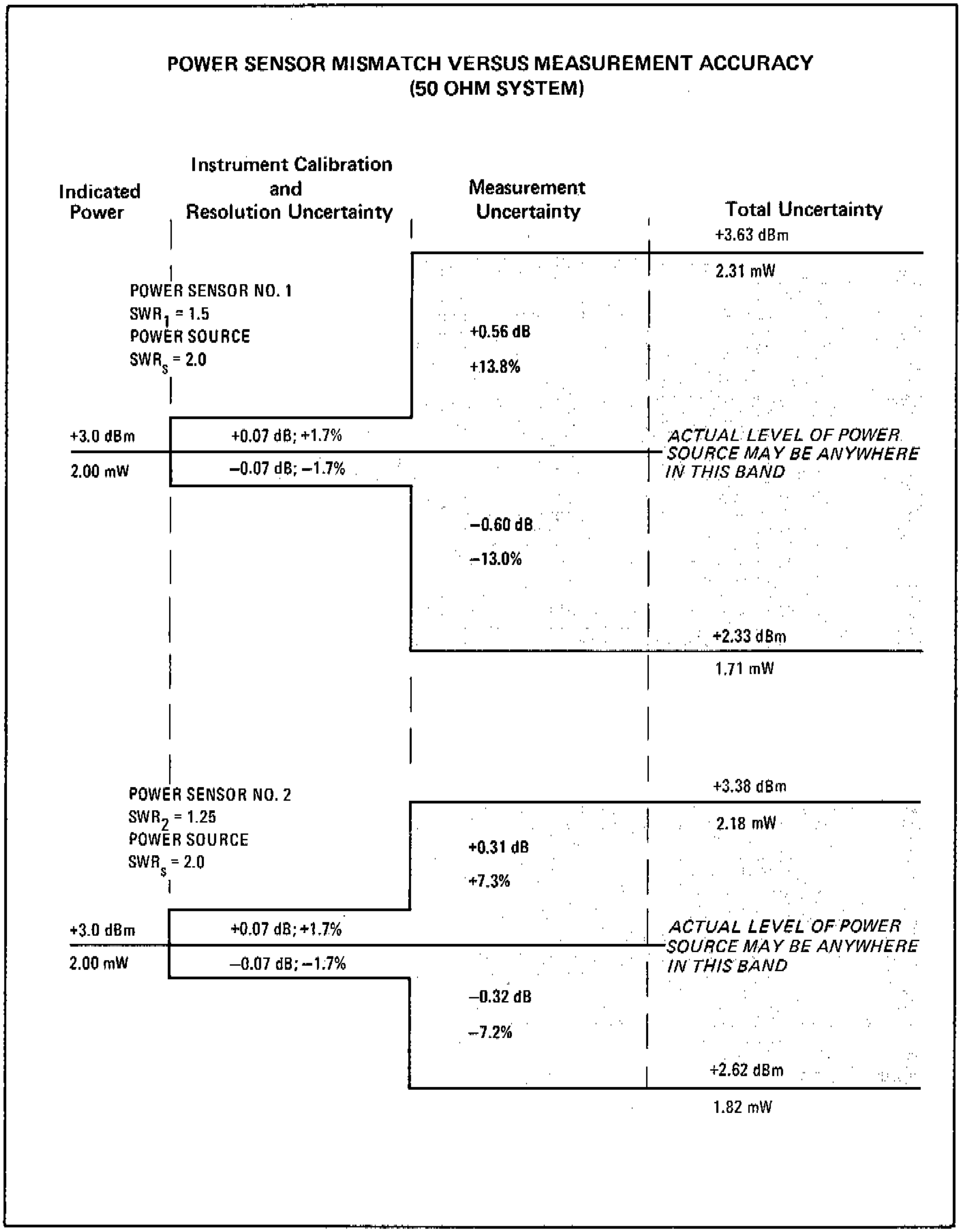


Figure 3-10. The Effect of Power Sensor Mismatch on Measurement Accuracy

CALCULATING MEASUREMENT UNCERTAINTY

1. For this example the known values are: source SWR, 2.2 and power sensor SWR, 1.16. From the Mismatch Error Calculator the mismatch uncertainty is found to be +0.24, −0.25 dB.

2. Add the known uncertainties from paragraph 3-73, (± 0.10 dB). Our total measurement uncertainty is +0.34, −0.35 dB.

3. Calculate the relative measurement uncertainty from the following formula:

$$dB = 10 \log \left(\frac{P_1}{P_0}\right)$$

$$\frac{dB}{10} = \log \left(\frac{P_1}{P_0}\right)$$

$$\frac{P_1}{P_0} = \log^{-1} \left(\frac{dB}{10}\right)$$

If dB is positive then:
$P_1 > P_0$; let $P_0 = 1$

$$MU = P_1 = \log^{-1}\left(\frac{dB}{10}\right) = \log^{-1}\left(\frac{0.34}{10}\right) = 1.081$$

If dB is negative then:
$P_1 < P_0$; let $P_1 = 1$

$$MU = P_0 = \frac{1}{\log^{-1}\left(\frac{dB}{10}\right)} = \frac{1}{\log^{-1}\left(\frac{0.35}{10}\right)} = \frac{1}{1.082} = 0.923$$

4. Calculate the percentage Measurement Uncertainty.

For $P_1 > P_0$

$$\%MU = (P_1 - P_0)\,100 = (1.081 - 1)\,100 = +8.1\%$$

For $P_1 < P_0$

$$\%MU = -(P_1 - P_0)\,100 = -(1 - 0.923)\,100 = -7.7\%$$

Figure 3-11. Calculating Measurement Uncertainty (Uncertainty in dB Known)