Operating and Service Manual

HP 438A Power Meter

SERIAL NUMBERS

Attached to the rear panel of the instrument is a serial number plate. The serial number is in the form: 0000A00000 and 0000U00000. The first four digits and the letter are the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument.

This manual applies to instruments with serial numbers prefixed 3008A or 3017U and above. For additional important information about serial numbers, see "Instruments Covered By This Manual" in Chapter 1.

This manual does not contain any backdating information, If backdating information is required for operating or repairing your HP 438A with serial prefix 2822A or 2839U and below, you must purchase manual part number 00438-90015.

HEWLETT PACKARD

HP Part No. 00438-90039

Station Road, West Lothian, Scotland, EH30 9TG.
Printed in UK

NOTICE

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This is to certify that this equipment is in accordance with the Radio Interference Requirements of Directive FTZ 1046/1984. The German Bundespost was notified that this equipment was put into circulation, and has been granted the right to check the equipment type for compliance with these requirements.

Note: If test and measurement equipment is operated with unshielded cables and/or used for measurements in open setups, the user must ensure that under these operating conditions, the radio frequency interference limits are me at the border of his premises.

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Tables

Safety Considerations

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

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

Before Applying Power

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

Safety Earth Ground

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

Warning

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

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

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

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

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

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

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

Safety Symbols

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

Indicates hazardous voltages.

Indicates earth (ground) terminal.

Warning

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

Caution

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

1

General Information

Introduction

This manual contains information required to install, operate, test, and service the Hewlett-Packard 438A Power Meter. The power meter is shown in FIGURE 1-1 with all of its externally supplied accessories. This manual also documents Option 002 which adds the capability of rear panel sensor inputs and a second reference oscillator output.

This section of the manual covers the instrument description, options, accessories, specifications, and other basic information. The remaining sections cover the following information.

Section 2 Installation
Section 3 Operation
Section 4 Performance Tests
Section 5 Adjustments
Section 6 Replaceable Parts
Section 7 Manual Changes
Section 8 Service

Two copies of the operating information are supplied with the power meter. One copy is in the form of an Operating Manual and is simply a copy of the first three sections of the Operating and Service Manual. It should remain with the instrument for use by the operator. The other copy provided is the Operating and Service Manual which should be retained by the technicians responsible for the periodic servicing of the instrument. Additional copies of either manual may be ordered through your nearest Hewlett-Packard sales office. The part numbers are listed on the title page of this manual.

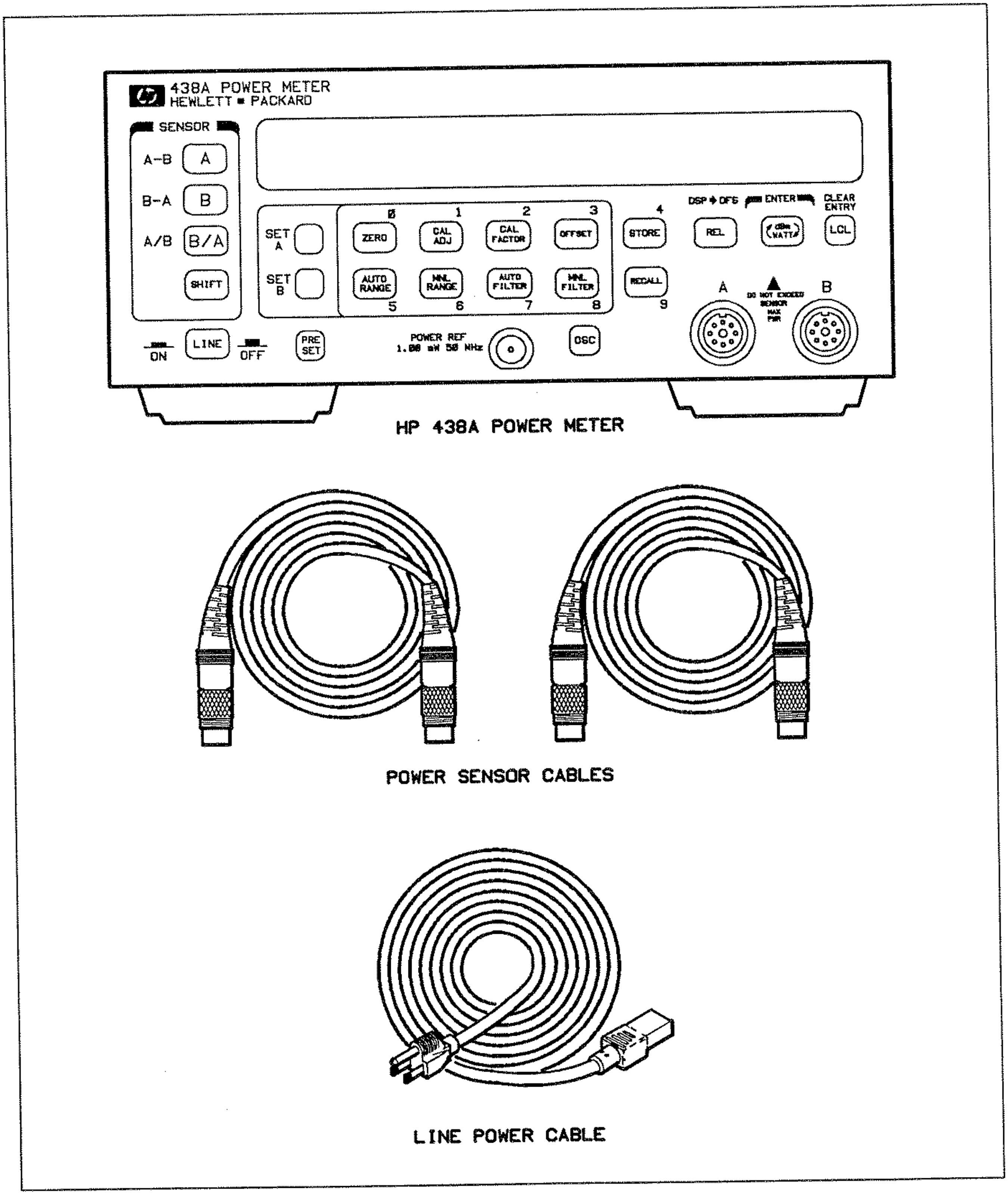


Figure 1-1. HP 438A Power Meter with Accessories Supplied.

1-2. Specifications

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested. Supplemental characteristics are listed in Table 1-2. Supplemental characteristics are not warranted specifications, but are typical characteristics included as additional information for the user.

1-3. Safety Considerations

This product is a Safety Class I instrument, that is, one provided with a protective earth terminal. The power meter and all related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the "Safety Considerations" page found at the beginning of this manual for a summary of the safety information. Safety information for installation, performance testing, adjustment, and service will be found in appropriate places throughout this manual.

1-4. Instruments Covered by this Manual

Attached to the rear panel of the instrument is a serial number plate. The serial number is in the form: 0000A00000 and 0000U00000. The first four digits and the letter constitute the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix however, is assigned sequentially and is different for each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) listed under Serial Numbers on the title page.

1-5. Manual Changes Supplement

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates that the instrument is different from those documented in the manual. If manual changes are needed, the manual for this newer instrument is accompanied by a yellow Manual Changes supplement. The supplement contains "change information" that explains how to adapt this manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. The supplement is identified with the manual print date and part number, both of which appear on the manual title page.

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

1-6. Description

The HP 438A Power Meter is a microprocessor controlled dual channel (A and B multiplexed) meter. It measures power in the range of −70 to +44 dBm over the frequency range of 100 kHz to 26.5 GHz using the existing Hewlett-Packard 8480 series power sensors. A 1.00 mW 50 MHz POWER REF (reference) is available for calibrating the meter to the sensor's sensitivity.

The meter displays power in the following modes; dBm, dB Rel (relative), watts and % Rel (per cent relative). The measured ratio and difference of two inputs can be displayed. The power ratio is displayed in either dB or % while the power difference is displayed in either watts or dBm. The ratio or difference power readings of a single sensor input are displayed relative to a stored reference. Also displayed are the possible error states of the meter.

Zeroing, calibration, and offsets are capabilities of the meter that can be set either locally by the front panel keys or remotely over the Hewlett Packard Interface Bus (HP-IB). When these routines are finished the meter resumes measuring and displaying the input power.

The meter has both manual and automatic ranging. In the AUTO RANGE mode the meter automatically switches through its five ranges and in the MNL RANGE (manual range) mode one of the five ranges can be selected.

Memory capacity for saving up to 19 front panel settings is built into the meter and can be accessed by using [STORE] and [RECALL].

1-6. Options

1-7. Electrical Options

Option 002 provides the additional capability of having two power input connectors on the rear panel in parallel with the front panel inputs and a rear panel connector for an additional power reference oscillator. If Option 002 was not initially ordered with the power meter, the option can be added by ordering the Option 002 retrofit kit HP part number 00438-60044.

Option 004 deletes the two HP 11730A Sensor Cables normally supplied with the power meter. Refer to paragraph "1-12. Cables" in this section for other cables available.

1-8. Mechanical Option

A mechanical option kit is available containing hardware and installation instructions for adding handles to the meter. To obtain front handle kit Option 907 order HP part number 5061-9688.

1-9. Accessories Supplied

The accessories supplied with the power meter are shown in Figure 1-1. The line power cable will be supplied in one of several configurations, depending upon the country of destination for the original shipment from the factory. Refer to "Power Cables" in section 2 of this manual. Two power sensor cables, HP part number 11730A, are supplied.

1-10. Accessories Available

1-11. Rack Mounting Kits

These kits are very useful when the power meter is to be rack mounted. It permits access to internal circuits and components, and access to the rear panel is possible without removing the instrument from the rack.

Rack mounting one power meter. Order HP part number 5062-3972. This kit includes one rack flange and one extension adapter.

Rack mounting two power meters. Order the following: HP part number 5062-3974 two rack flanges, and HP part number 5061-9694 cabinet locking hardware.

Rack mounting one power meter with slides. Order the following: HP part number 5062-3996 support shelf, HP part number 1494-0064 two slides, and HP part number 5062-4022 filler panel.

Rack mounting two power meters with slides. Order the following: HP part number 5062-3966 support shelf, and HP part number 1494-0064 two slides.

1-12. Cables

Power sensor cables of various lengths are available. The model numbers and lengths are listed below.

HP 11730A 1.5m (5ft)
HP 11730B 3.0m (10ft)
HP 11730C 6.1m (20 ft)
HP 11730D 15.2m (50 ft)
HP 11730E 30.5m (100ft)
HP 11730F 61.0m (200ft)

1-13. Recommended Test Equipment

Table 1-3 lists the test equipment recommended for use in testing, adjusting, and servicing the power meter. If any of the recommended equipment is not available, instruments with equivalent critical specifications may be substituted.

Table 1-1 lists the power meter's performance specifications. The following conditions apply to all specifications:

a. The power meter must have a one-half hour warm-up for all specifications.
b. The line voltage for all instruments must be 100, 120, 220, or 240 Vac +5%, −10%, and the line frequency must be 48 to 66 Hz.
c. The ambient temperature must be 0° to 55°C.

Table 1-1. Specifications

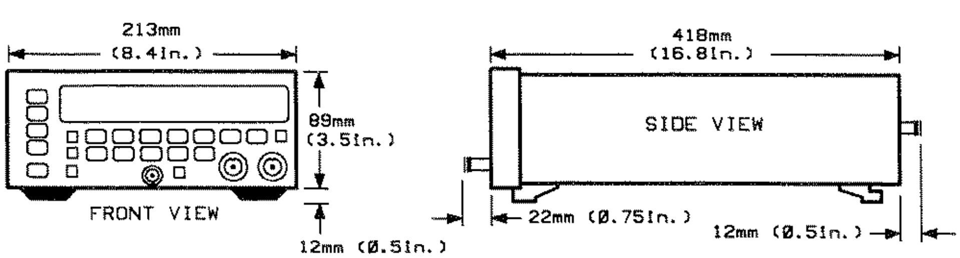
Electrical Characteristics	Performance Limits	Conditions
Meter		
Frequency range	100 kHz to 26.5 GHz	Sensor dependent
Power range	−70 dBm to +44 dBm (100 pW to 25W)	Sensor dependent
Dynamic range	50 dB total range	5 ranges of 10 dB steps for 50 dB total
Inputs	Channel A and B	Multiplexed dual sensors
Rear panel output	0–1 volt analog	Without digital filtering 1kΩ output impedance BNC connector
Measurement modes	A, B, A−B, B−A, A/B, B/A	Normal or relative all modes
Display units	Watts or dBm	Absolute A, B, A−B, B−A
	Percent or dB	Ratio A/B, B/A
	Percent or dB	Relative
Resolution		
Normal	0.1% full scale (0.01 dB)	Auto filter watts or percent
	0.01 dB	dBm or dB
High	0.01% full scale	Manual filter watts or percent
	0.001dB	dBm or dB
Accuracy		
Instrumentation, includes sensor linearity[1]		
Single channel mode:	±0.02 dB	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode:[2] (ratio or difference)	Multiply single channel specifications by 2	
Zero set (digital settability of zero)	±0.5% full scale	Most sensitive range. Decrease percentage by a factor of 10 for each higher range ± one count.
	±2% full scale	If using the HP 8484A, 8481D, 8485D, 8486D, or 8487D Power Sensors
EMI	Radiated and Conducted Emissions and Radiated and Conducted Susceptibility are within the requirements of RE02, CE03, RS01/03 and CS01/02 called out in MIL-STD-461C, and within the requirements of VDE 0871 and CISPR Publication 11.	

1 When operating in Range 5, add the corresponding sensor power linearity percentage.

2 Accuracy does not depend on the meter being in Normal or Relative mode.

Table 1-1. Specifications (continued)

Electrical Characteristics	Performance Limits	Conditions
Power reference	1.00 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards.
Power reference accuracy	±1.2%	Worst case
	±0.9%	RSS for one year.
General		
Operating temperature range	0° C to 55° C	
Power Requirements	65 VA, 35 watts	Maximum
Line Voltage	100, 120, 220, or 240 Vac, +5% to −10%	
Line Frequency	48 to 66 Hz	All specified line voltages may be used.
	360 to 440 Hz	Limited to line voltages of 100 or 120 Vac.
Power Dissipation	<10 VA (8 watts max)	
Remote Operation	HP-IB	All functions except power switch, clear entry, HP-IB address
Compatibility	HP-IB interface	SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT1, C0
Memory	Non-volatile	Contains complete meter operating state of both channels plus contents of store/recall registers
Operating and non-operating environment	Temperature, humidity, shock, and vibration type tested to MIL-T-28800B Class V requirements.	
Safety	Meets requirements of IEC 348	
Net weight	5.9 kg (13 lbs.)	
Dimensions	89mm H × 213mm W × 418mm D (3.5 H × 8.4 W × 16.8 inches D) (3.5 H × 8.4 W × 16.8 inches D)	EIA and IEC racking standards: 3.5 H × 0.5 W × 17 D



Note: For ordering cabinet accessories, the module sizes are 3-1/2H, 1/2MW, and 17D.

Table 1-2. Supplemental Characteristics

Zero drift of sensors As a % of full scale, 1 hour, at constant temperature after 24 hours warmup. Decrease percentage by a factor of 10 for each higher range.	
Sensors:	
HP 8481A, 8481B, 8481H, 8482A, 8482B, 8482H, 8483A, 8485A, R8486A, Q8486A, W8486A, and 8487A:	<±0.1% of full scale on range 1.
Sensors:	
HP 8484A, 8481D, 8485D, 8486D, and 8487D:	<±2.0% of full scale on range 1.
Measurement speed	
Over HP-IB and free running trigger.	
Single channel	20 readings per second
Dual channel	2 readings per second
Channel switching delay	200 ms
Power reference	
Frequency	50 MHz nominal
SWR	1.05 maximum
Connector	Type N female
Meter adjustments:	
CAL FACTOR	Key pad entry or programmable. Sets calibration factor for the meter. Overrides current value. Range: 1–150% in 0.1% increments.
ZERO	Key pad entry or programmable. Zeros all 5 ranges, reference oscillator automatically switched off during zeroing.
CAL ADJ	Automatic, key pad entry or programmable. Calibrates meter using internal 1.00 mW reference or external reference oscillator. Reference Cal Factor settable from 50.0% to 120.0%.
OFFSET	Key pad entry or programmable. Range: −99.99 to +99.99 dB in 0.01 dB increments.
Digital Filter Length	Keypad entry or programmable. Averages power readings from 1 to 512 successive values in increments by factors of 2 (1, 2, 4, ... 256, 512).
High/Low Power Limits	Programmable only. Activates Service Request and flashing front panel indicator. Individual channel values from −299.99 to +299.99 dBm in 0.001 dB increments.
STORE/RECALL Registers	Nineteen registers to store complete operating state of meter for later recall.
REL	Key pad entry or programmable. Displays all successive measurements relative to the last displayed value when activated. Units are in dB or %.

Table 1-3. Additional Supplemental Characteristics

Meter Noise

As a % of full scale, with constant temperature, range 1, measured over a one minute interval, and two standard deviations.

Decrease noise by a factor of 10 for each higher range for all sensors and all filters.

Sensors:

HP 8481A, 8481B, 8481H, 8482A, 8482B, 8482H, 8483A, 8485A, R8486A, Q8486A, W8486A, and 8487A:

Filter Number	Noise (%)
0	6.0
1	2.4
2	1.8
3	0.9
4	0.7
5	0.5
6	0.4
7	0.3
8	0.2
9	0.15

Sensors:

HP 8484A, 8481D, 8485D, and 8487D:
Multiply noise levels by 4 for all filters.

Sensors:

HP R/Q8486D:
Multiply noise levels by 6 for all filters.

Settling Time

0 to 99% settled readings over the bus. AUTO filter, range hold, 10 dB decreasing power step.

Single channel

Range	Settling Time
1	<3.0 s
2	<1.0 s
3	<150 ms
4-5	<100 ms

Manual filter, range hold, 10 dB decreasing power step.

Single channel

Filter Number	Response Time(s)
0	0.10
1	0.15
2	0.25
3	1.0
4	1.4
5	2.2
6	3.7
7	6.9
8	14.0
9	27.0

Dual channel (ratio or difference mode):

Approximately the sum of the individual response times of each channel, plus channel switching delay.

Table 1-4. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use[1]
Digital Voltmeter	Range 0 to 20 Vdc Resolution: 0.01 Volt	HP 3456A	P, A, T
Oscilloscope	>200 MHz bandwidth	HP 1725A	T
Range Calibrator	Calibration uncertainty ±0.25%	HP 11683A	P, A, T
Signature Multimeter	Qualified Signiture Analysis	HP 5005B	T
Frequency Counter	Range: 10 Hz to 50 MHz Resolution: 1 Hz	HP 5328A Option 031	P, A, T
Power Splitter	Frequency: 50 Mhz Impedance: 50 Ohms Connectors: Type N	HP 11667A	O
Power Meter	Range: 1 mW Transfer Accuracy: 0.2% (Input to output)	HP 432A	P, A, T
Thermistor Mount	SWR: 1.05 at 50 MHz Accuracy: ±0.5% at 50 MHz	HP 478A-H75 HP 478A-H76[2]	P, A

1 *P=Performance Tests, A=Adjustments, T=Troubleshooting.

2 Calibrated by the National Institute of Standards and Technology (NIST) for this accuracy.

Table 1-5. Service Accessories

Accessory[1]	Specification	Suggested Model
Open-end wrench (SMC connectors)	1/4-inch	Utica Tool Co.[2], Open End Standard, Model No. OP82, 1/4-inch
Extender Board	36 contacts (2 x 18)	HP 08684-60018
Foam Pad	Conductive polyurethane foam, 12 × 12 × 0.25 inches	HP 4208-0094

1 Refer to section 8, "Service" for applications.

2 Utica Tool Company, Inc. Orangeburg, SC 29115 or the nearest Utica Tool Company distributor.

2

Installation

2-1. Introduction

This section provides the information needed to install the power meter. Included is information pertinent to the initial inspection, power requirements, line voltage and fuse selection, operating environment, instrument mounting, storage, and shipment.

2-2. Initial Inspection

Warning

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

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 procedures for checking electrical performance are given in section 4, "Performance Tests". If the contents are incomplete, if there is a mechanical defect, or if the instrument does not pass the performance tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning shows signs of stress, notify the carrier and the Hewlett-Packard office. Keep the shipping material for the carrier's inspection.

2-3. Preparation for Use

2-4. Power Requirements

Warning

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

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

If this instrument is to be energized via an external autotransformer (for voltage reduction), make sure the common terminal is connected to neutral (that is, the grounded side of the line (Mains) supply).

The power meter requires a power source of any voltage between 90 and 126 Vac or between 198 and 252 Vac, 48 to 66 Hz, single phase. The power meter has the additional capability of operating with line frequencies of 360 to 440 Hz. However, operation at line frequencies greater than 66 Hz is limited to a line voltage of 90 to 126 Vac. The power consumption is less than 65 VA using either source.

2-5. Installation Checklist

Before plugging the power meter into the line (Mains) voltage, ensure the following steps are taken:

1. Check the line (Mains) voltage to ensure compatibility with the power meter requirements. (See paragraph "2-4. Power Requirements").
2. Check the line voltage switches on the power meter's rear panel to ensure proper selection for the line (Mains) voltage. (See paragraph "2-6. Line Voltage and Fuse Selection").
3. Ensure that the fuse rating is appropriate for the line voltage used. Fuse ratings are listed in Table 2-1.
4. Ensure that the power cable to be used is the required type. (See paragraph "2-7. Power Cable").

Caution

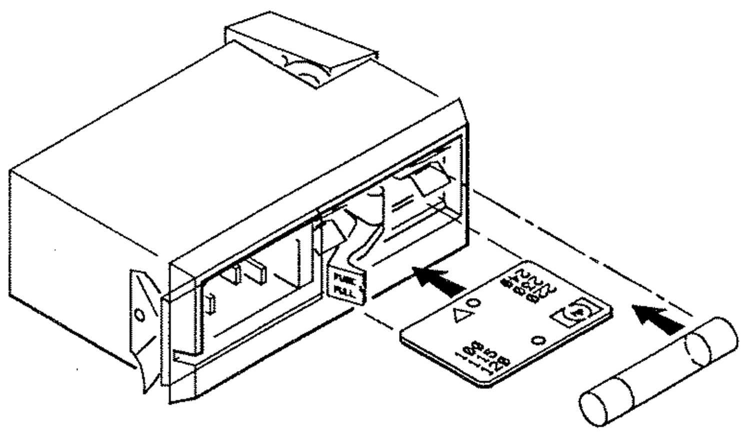
BEFORE PLUGGING THIS INSTRUMENT into the line (Mains) voltage, ensure that the correct voltage and fuse have been selected.

5. Plug in the power cable.

2-6. Line Voltage and Fuse Selection

Caution BEFORE PLUGGING THIS INSTRUMENT into the Mains (line) voltage, be sure that the correct operating voltage and fuse have been selected.

A rear-panel line-power module permits operation from 90 to 126 Vac sources or from 198 to 252 Vac sources. The number visible in the window on the module indicates the nominal line voltage (100, 120, 220 or 240 Vac) to which the instrument must be connected. Verify that the line voltage selection card and the fuse are matched to the power source to be used. Refer to Figure 2-1, Line Voltage and Fuse Selection. Table 2-1 lists the ratings and HP part numbers for the replaceable fuses.



Selection of Operating Voltage

1. Slide cover and rotate FUSE PULL to left.
2. Select line (Mains) voltage by orienting PC board with desired voltage on 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 and Fuse Selection

Warning For protection against fire hazards, the line fuse should be a 250V normal-blow fuse with the correct current rating.

Table 2-1. Fuse Ratings and Part Numbers

Line Voltage	Rating	Part Number
100/120V	1.0A, 250 V	2110-0001
220/240V	0.375 A, 250 V	2110-0421

2-7. Power Cable

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

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 is determined by the country of destination. Refer to Figure 2-2 for the part numbers of these power cables. Cables are available in different lengths and some with right angle plugs to the instrument. Check with you nearest HP service center for descriptions and part numbers for these cables.

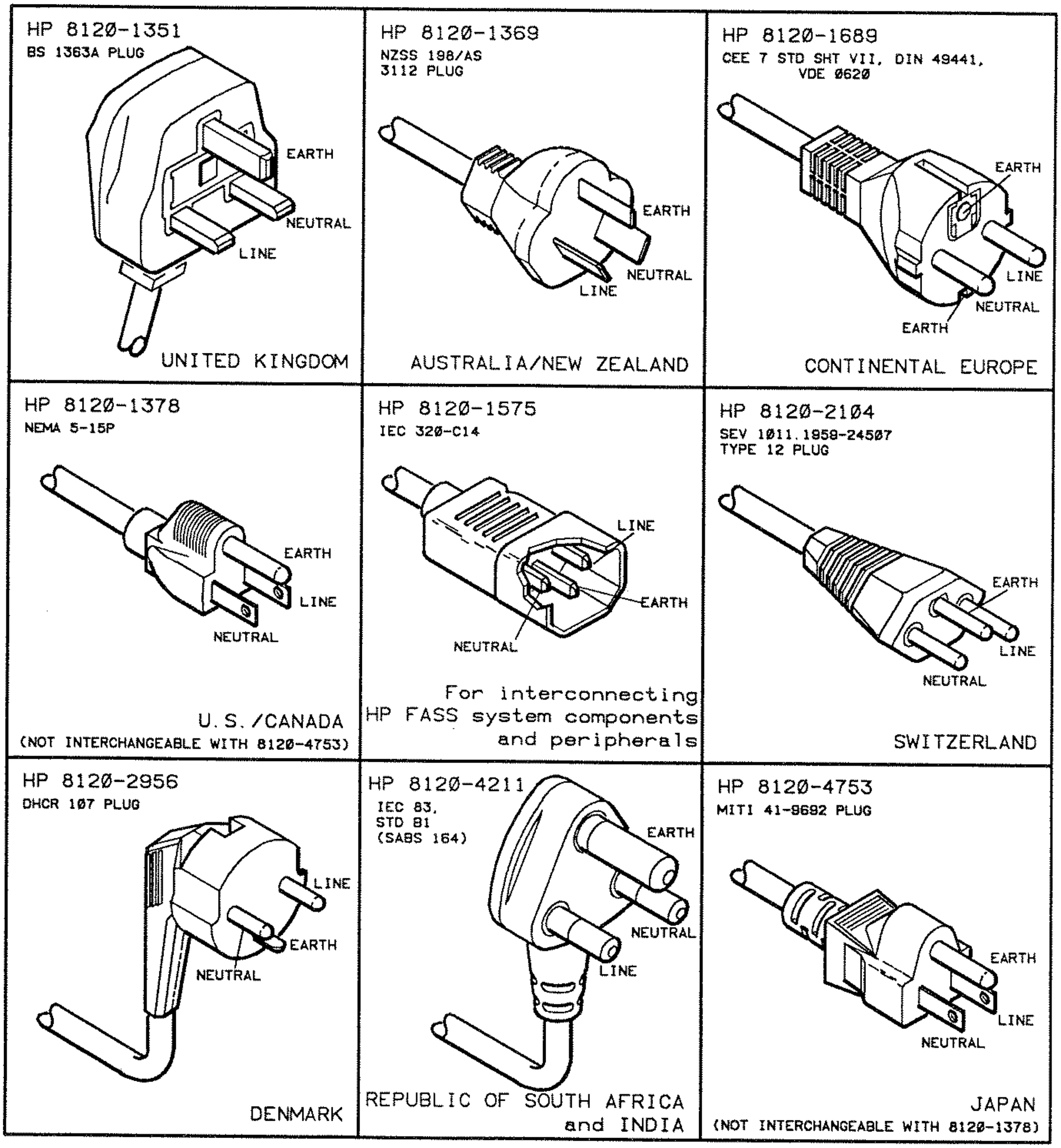


Figure 2-2. Power Cable and Line (Mains) Plug Part Numbers

2-8. HP-IB Address Selection and Configuring

The address can be selected from the front panel and stored in RAM. When shipped from the factory the address of the instrument is 13.

When an address is stored in RAM and not lost, changing the internal HP-IB switch will have no effect. The address that is stored in RAM can be viewed on the front panel display by pressing (LCL) (local) and will be the valid address unless memory is lost. Memory lost is indicated by a RCL FAIL ERROR message.

HP-IB addresses from 00 to 30 can be used. A list of allowable addresses is given in Table 2-2. Table 2-2 shows the ASCII address codes to decimal equivalents.

Table 2-2. Allowable HP-IB Addresses

ASCII Address Codes		Decimal Equivalents[1]
LISTEN	TALK	
SP	@	00
!	A	01
’	B	02
_	C	03
$	D	04
%	E	05
&	F	06
’	G	07
(	H	08
)	I	09
*	J	10
+	K	11
,	L	12
-	M	13[2]
.	N	14
/	O	15
0	P	16
1	Q	17
2	R	18
3	S	19
4	T	20
5	U	21
6	V	22
7	W	23
8	X	24
9	Y	25
:	Z	26
;	[	27
<	}	28
=	]	29
>		30

1 Decimal values are equivalent to the last five bits of both talk and listen addresses.

2 Decimal 13 is the factory set HP 437b address.

Use the following procedure to set the HP-IB address:

1. Turn the instrument off.
2. Press and hold the (LCL) (local) key while turning the instrument on.
3. Wait for the Ent (enter) address message.
4. Release the (LCL) key.
5. Key in the address using the keys representing the numbers.

2-9. Interconnections

The connection from meter to power sensor is made through HP 11730 series sensor cables having circular 12 contact male mating connectors. The two front panel connectors (Sensor A and Sensor B), and the two rear panel Option 002 connectors (SENSORS A,B) require this mating connector.

The rear panel interface connector for the Hewlett Packard Interface Bus is a 24 pin connector. The HP-IB mating connector is shown in Figure 2-3. Part numbers for mating connectors are included in the figure. Note the two securing screws are metric.

2-10. Mating Connectors

Coaxial Connectors. The front-panel output POWER REF 1.00mW 50 MHz and the rear-panel Option 002 OSC (power reference oscillator) output connectors require 50-ohm type N male mating connectors. The rear panel RCDR (recorder) output signal connector requires a 50-ohm BNC male mating connector. Both types must be compatible with the specifications of US MIL-C-39012. The power reference oscillator connectors are designed to be used with power sensors that have Type N connectors.

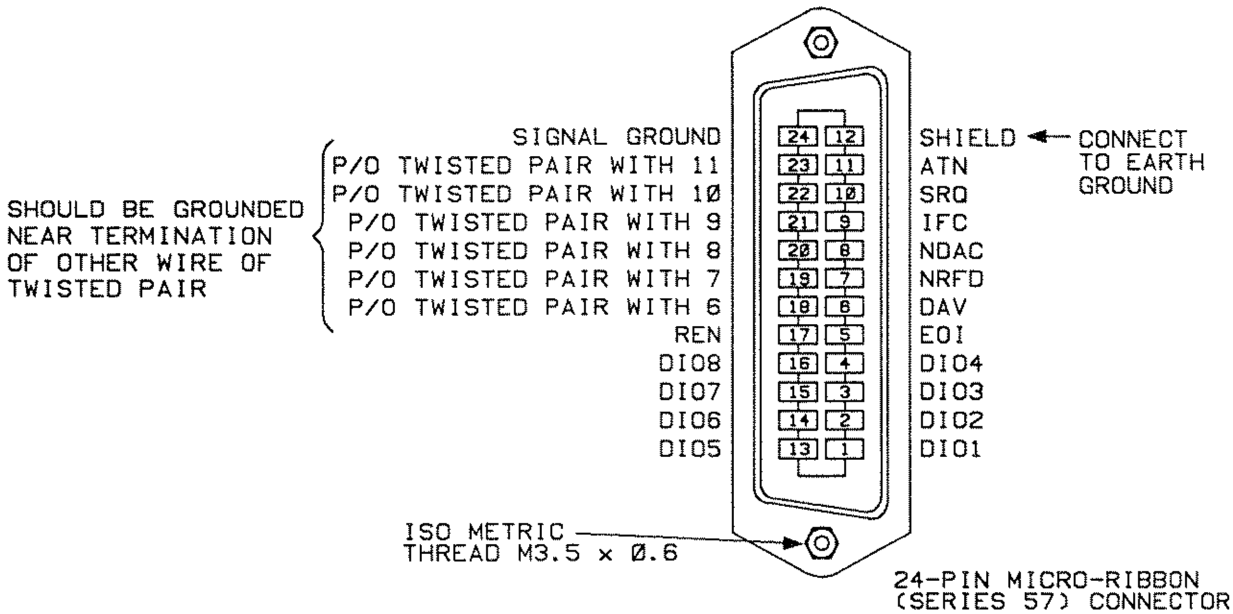
2-11. Operating Environment

The operating environment is specified to be within the following limitations:

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

2-12. Bench Operation

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. The plastic feet are designed to ensure proper stacking with other instruments in similar housings, and the tilt stands raise the front of the power meter for easier viewing of the front panel.



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.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

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

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-3. Hewlett-Packard Interface Bus Connection

2-13. Rack Mounting

The power meter 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 5062-3972. If it is desired to rack mount two power meters or another HP product with the same physical dimensions, side by side, order the following items:

1. Lock Link Kit, HP part number 5062-3994
2. Rack Mounting Flange Kit, HP part number 5062-3974

When rack mounting with a support shelf and slide kit order:

1. Shelf, HP part number 5062-3996
2. Slide Kit, HP part number 1494-0064

In addition to the rack mounting hardware, a front handle assembly (two provided) is also available for the power meter. Order front handle kit Option 907 HP part number 5061-9688.

Rack mounting information is provided with the rack mounting kits. If a kit was not ordered as an option or an accessory with the power meter, it may be purchased through the nearest Hewlett-Packard office. Refer to "Mechanical Options" or "Mechanical Equipment Available" in section 1.

2-14. Storage and Shipment

2-15. Environment

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

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

2-16. Packaging

Tagging for Service. If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument.

To minimize repair time, be as specific as possible when describing the failure. Keep the following two items in mind when describing the failure:

1. Describe what makes you think the instrument is failing. An example might be "Power meter displays NO SENSOR when a power sensor is connected to the input port".
2. If the failure only occurs under certain conditions, explain how to duplicate the failure. An example might be "Power meter will not make measurements in ranges 4 and 5."

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. Mark the container "FRAGILE" to encourage careful handling. In any correspondence, refer to the instrument by model number and full serial number.

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

1. Wrap the instrument in heavy paper or plastic. If shipping to a Hewlett-Packard office or service center, complete one of the blue tags mentioned above and attach it to the instrument.
2. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.
3. Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) around all sides of the instrument to provide a firm cushion and prevent movement in the container. Protect the front panel with an appropriate type of cushioning material to prevent damage during shipment.
4. Seal the shipping container securely.
5. Mark the shipping container "FRAGILE" to encourage careful handling.

3

Operation

3-1. Introduction

This section provides operating information for the power meter. Included in this section are general and detailed operating instructions, descriptions of the front and rear panel, local and remote operator's instructions, and operator's maintenance procedures.

3-2. Operating Characteristics

Table 3-1 briefly summarizes the major operating characteristics of the power meter. This table is not intended to be an in-depth listing of all operations and ranges but gives an idea of the instrument's capabilities. For more information on the power meter's capabilities refer to Table 1-1, Specifications and Table 1-2, Supplemental Characteristics. For information on HP-IB capabilities, refer to the summary contained in Table 3-3, HP-IB Message Reference Table.

3-3. Local Operation

Initial Turn-On Information. Instructions relating to the power meter's turn-on procedure are presented to acquaint the user with the general operation of the instrument.

Information covering front panel operation of the power meter is given in the sections described below. To rapidly learn the operation of the instrument, begin with Major Operating Characteristics and Operator's Checks.

Panel Features. Front and rear panel features are described in Figure 3-1 and Figure 3-2. The front panel has different colored keys and lettering for different operating modes. The (SHIFT) key has yellow lettering and relates to the shifted capability of the (A), (B), and (B/A) keys as shown by the yellow lettering next to these keys. Blue keys, blue numbers and all blue lettering are related and set the power meter into its entry mode. When a blue key is pressed the display will show that a Ent (enter) response is required. Also some of the keys have a two letter mnemonic near them. This two letter mnemonic will be used in remote programming of the power meter.

Simplified Operating Instructions. The instructions located on the foldout provide a quick introduction to front panel operation of the power meter. These instructions are designed to rapidly acquaint the new user with basic operating procedures and therefore are not an exhaustive listing of all power meter functions.

Detailed Operating Instructions. The detailed operating instructions provide the operating reference information for the power meter user.

3-4. Remote Operation HP-IB

The power meter is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Instructions pertinent to HP-IB operation cover considerations and instructions specific to remote operation including capabilities, addressing, input and output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes.

3-5. Operator's Maintenance

Warning

For continued protection against fire hazard, replace the line fuse with a 250V fuse of the same rating only. Do not use repaired fuses or short-circuited fuseholders.

Operator's maintenance consists of replacing defective fuses. The primary power fuse is located within the tine Power Module Assembly. Refer to Figure 2-1 for instructions on how to change the fuse.

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue tags located at the end of this manual and attach it to the instrument. Refer to section 2 for packaging instructions.

Table 3-1. Major Operating Characteristics

Power Range (Sensor Dependant)	−70 dBm to +44 dBm Auto or Manual 1 through 5 ranges, the power range of each sensor is divided into five parts.
	Power Sensor — **Range**
	HP8481B — 0 to +44 dBm (1 mW to 25 W)
	HP8482B — 0 to +44 dBm (1 mW to 25 W)
	HP8481H — −10 to +35 dBm (100 μW to 3 W)
	HP8482H — −10 to +35 dBm (100 μW to 3 W)
	HP8481A — −30 to +20 dBm (1 μW to 100 mW)
	HP8482A — −30 to +20 dBm (1 μW to 100 mW)
	HP8485A — −30 to +20 dBm (1 μW to 100 mW)
	HP8483A (75 Ω)[1] — −30 to +20 dBm (1 μW to 100 mW)
	HP R/Q8486A — −30 to +20 dBm (1 μW to 100 mW)
	HP8481D — −70 to −20 dBm (100 pW to 10 μW)
	HP8484A — −70 to −20 dBm (100 pW to 10 μW)
	HP8485D — −70 to −20 dBm (100 pW to 10 μW)
	HP R/Q8486D — −70 to −20 dBm (100 pW to 10 μW)
	HP8487D — −70 to −20 dBm (100 pW to 10 μW)
Frequency Range (Sensor Dependent)	100 kHz to 33.0 GHz
Zeroing	Calibration of the power meter to power sensor sensitivity
Calibration Factor[1]	Compensation for mismatch and effective efficiency
Power Reference	1 mW at 50 MHz
Power Display	dBm, dB Relative, Watts, and % Relative
Ratio and Difference	Dual Inputs Ratio in dB or % Difference in dBm or Watts
Offset	Compensation for gains or losses in test system
Digital Filtering	Auto or Manual filters 0 through 9 A filter length or number of readings is determined by two being raised to some power where that exponent is the filter number.
Memory	19 registers for store and recall of front panel information. A twentieth register is used for recall of power down information .

1 When using an older HP 8483A that specifies adjusting to 0.96 mW note that the following procedure should be used:
1. Set REF CF to 0.96 times the Ref Cal Factor on the label.
2. The power meter will automatically adjust to 1.000 mW. Note that the cal factor value for 50 MHz power measurements should be read for the plotted data on the sensor body. No special procedure is necessary for these measurements.

SIMPLIFIED FRONT PANEL FEATURES

SET A (±)

Sets the power meter into the enter A mode for parameter changes.

SET B (•)

Set the power meter into the enter B mode for parameter changes.

ZERO (0)

Initiates a routine that zeros the power meter sensor combination.

CAL FACTOR (2)

The power meter enters the calibration factor entry mode and a cal factor printed on the sensor can be entered.

MNL FILTER (8)

Numeric entry mode becomes active and the user can now enter a new filter for the selected channel. Filter numbers range from zero through nine.

A (A-B)

Selects channel A as the single sensor active channel and initiates the command to put the meter in the display channel A power mode.

CAL ADJ (1)

The power meter enters the calibration mode and a reference calibration factor can be entered prior to being calibrated to the 1 mW power reference.

OFFSET (3)

Enters the offset entry mode and the user can enter an offset for the channel selected. The range of offsets is -99.99 to +99.99 dB in 0.01 db increments.

STORE (4)

Enters the store instrument state numeric entry mode becomes active and the user can enter a storage register location in the range of one to nineteen.

B (B-A)

Selects channel B as the single sensor active channel and initiates the command to put the meter in the display channel B power mode.

REL (DSP → OFS)

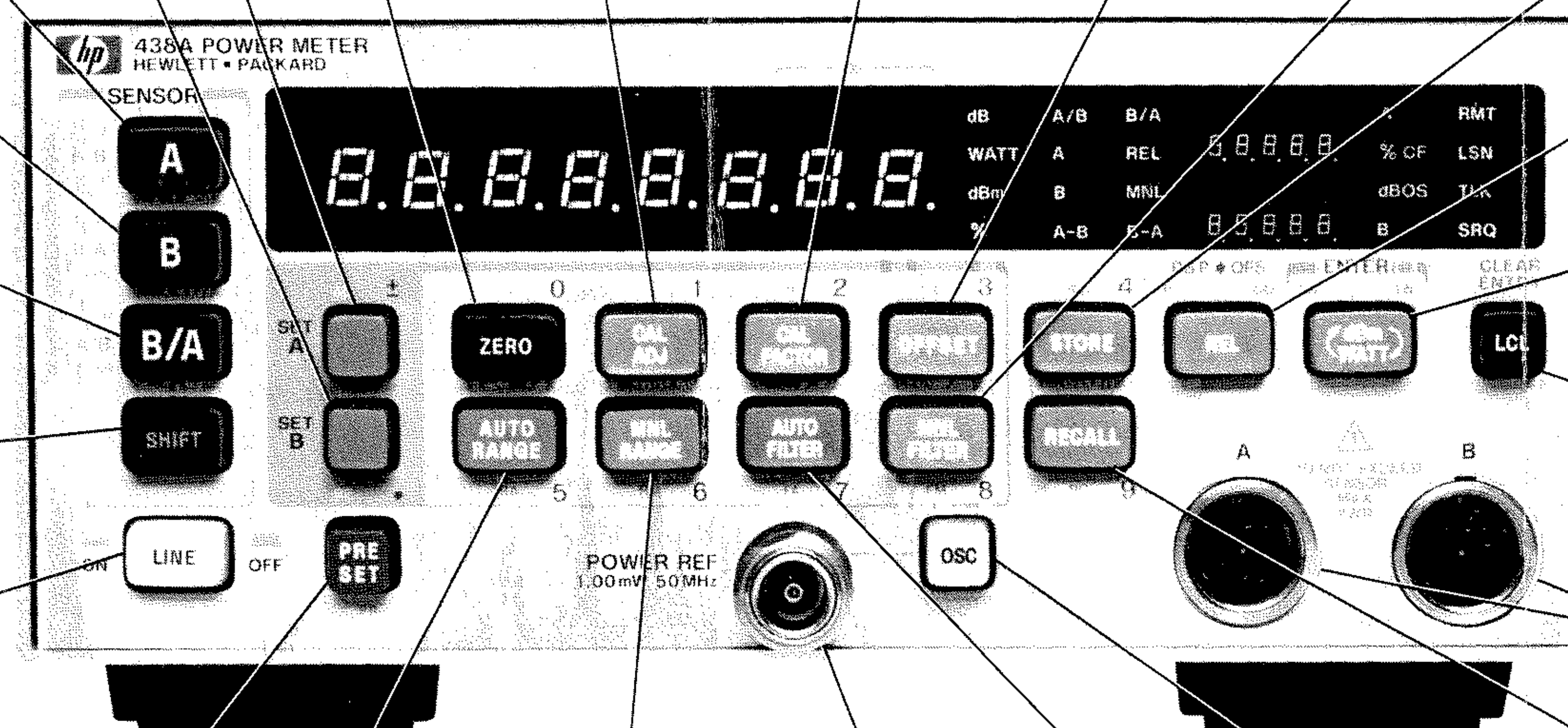
The rel (relative) mode is enabled and power levels relative to some other power level is measured.

B/A (A/B)

Sets the power meter to the double sensor mode and initiates the command to display the ratio of the power readings. The active entry channel is B and the ratio order is B/A.

↑ dBm WATT ↓ (ENTER)

This command toggles the measurement units depending on the user wanting a linear or logarithmic display.



SHIFT

Enables a shifted function of the A, B, and B/A keys. This allows for ratio (A/B) and the difference of two power levels to be measured.

LCL (CLEAR ENTRY)

Returns the power meter to the local mode if not in local lockout from a bus command.

LINE

Primary power to the meter is switched on and off.

⚠ A and B

The inputs to channel A and B are through female 12 contact audio connectors.

In places where key cap labels are followed by letters or symbols in parentheses the keys have a secondary function to the one in the simplified explanation. When the data entry mode is active the keys are SET A for + and − signs, SET B for the decimal point, various keys for numeric inputs 0 through 9, REL where a calculated offset is displayed DSP → OFS, ↑ dBm WATT ↓ when information in the display is entered ENTER, and LCL for cancelling the entry mode CLEAR ENTRY.

RECALL (9)

Information in storage register locations zero through nineteen can be recalled and displayed.

AUTO RANGE (5)

Causes the selected channel to enter an auto range mode.

POWER REF

The power reference output is a 50 ohm type N connector and the signal is 1 mW at 50 MHz used for calibrating the sensor meter combination.

OSC

Turns the power reference oscillator on and off. When Option 002 is installed this key turns both reference oscillators on and off.

PRESET

The power meter is put into a preset state and the parameters for channel A and B are set to default conditions.

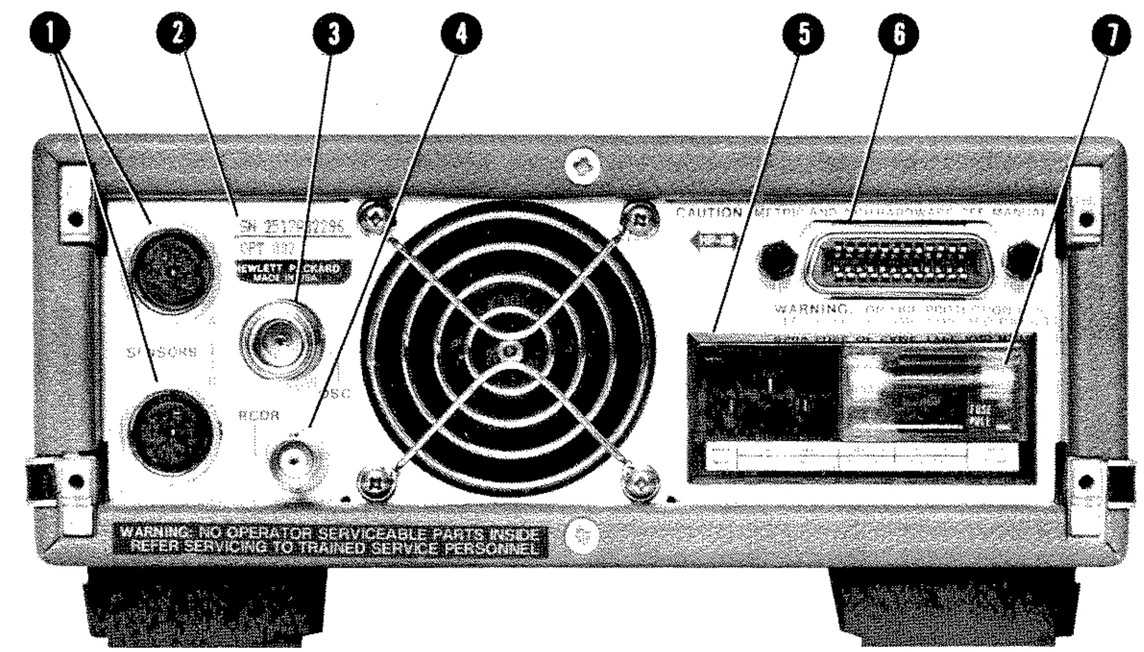
MNL RANGE (6)

The numeric entry mode becomes active and the user can enter a power range of one through five.

AUTO FILTER (7)

The selected channel enters the auto filter mode and one of nine filters is automatically selected.

Figure 3-1. Simplified Front Panel Features



❶ SENSORS A B

Option 002 rear panel inputs to channel A and B are through 12 contact female audio connectors. Inputs are in parallel with front panel channel A and B.

❷ Serial Number Plate

First four digits and letter constitute the prefix which defines the instrument configuration. The last five digits form a sequential suffix that is unique to each instrument. The plate also indicates any options supplied with the instrument.

❸ OSC

Option 002 rear panel 1 mW power reference output from the added oscillator. Output connector is a 50 ohm type N.

❹ RCDR

BNC connector with an analog 0 to 1 volt signal that is related to power level measured by the meter. Output impedance is 1k ohm.

❺ Line Power Module

Permits operation from 100, 120, 220, or 240 Vac. The number visible in the window indicates nominal line voltage to which the instrument must be connected. The center conductor is safety earth ground.

❻ HP-IB Connector

Female connector with 24 contacts used to connect the power meter to Hewlett-Packard Interface Bus (HP-IB) for remote operation.

❼ Fuse

1.0A 250V for 100/120 Vac operation and 375 mA 250V for 220/240 Vac operation. Ordering information is presented in Section II, Installation.

Figure 3-2. Rear Panel Features

PRESET

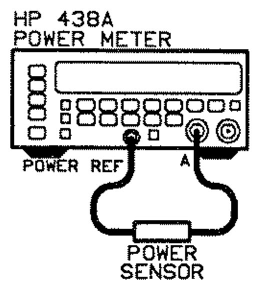
Press (PRESET) to set the Power Meter to the following conditions:

Measurement Mode = Sensor A
Reference Oscillator = Off
Active Entry Channel = A
Measurement Units = Watts
REL Mode = Off
Measurement Parameters (set for Sensor A and Sensor B)
  Cal Factor = 100.0%
  Cal Adj = 100.0%
  Offset = 0.00 dB
  Auto Filter
  Auto Range

In addition, default conditions are set for some remote-only functions. Refer to Table 3-5, Response to Clear Message (and PRESET).

CALIBRATION

Connect the power sensor as shown.



Press (ZERO) to zero the Power Meter. Each sensor must be zeroed seperately for dual sensor operation.

CAL ADJ is used only during calibration for entering the sensor's calibration factor at 50 MHz (that is, the reference calibration factor). For example, to calibrate the Power Meter to the sensor with a reference cal factor of 98%, press (CAL/ADJ) (RECALL) (MNL/FILTER) (dBm/WATT)

MEASUREMENT MODES

The Power Meter can display single sensor (A or B), dual sensor ratio (A/B or B/A) or dual sensor difference (A-B or B-A) power measurements. In addition, measurements can be displayed relative to a reference measurement.

SENSOR

To display the Sensor A power measurement on the front panel, press (A).

Single sensor measurements are display in dBm or Watts.

To display the ratio of Sensor A divided by Sensor B, press (SHIFT) A/B (B/A).

Ratio measurements are displayed in dB or %.

To display the difference between Sensor A and Sensor B, press (SHIFT) A-B (A).

Difference measurements are displayed in dBm or Watts.

REL

Press (REL) to enter and exit relative mode.

Once relative mode has been entered, the first power reading is saved as a reference. Successive measurements are displayed relative to the reference.

The REL annunciator in the front panel display lights when the Power Meter is in relative mode.

MEASUREMENT PARAMETERS

Measurement parameter can be set for each sensor. Blue keys indicate parameters that have selectable values. Values are selected in a Blue Key-Data-ENTER format. Data consists of digits 0 through 9, ±, and the decimal point. Pressing any blue key activates the data functions of the corresponding keys.

SET A and SET B

SET A and SET B allow measurement parameters to be entered for Sensor A and Sensor B. For example, to designate channel A as the active entry channel, press SET A ( ).

Any measurement parameters that are entered will apply to Sensor A only, regardless of the measurement mode displayed on the front panel.

CAL FACTOR

The calibration factor is the frequency response of the sensor relative to 50 MHz. For example, to enter a calibration factor of 100%, press (CAL/FACTOR) (CAL/ADJ) (ZERO) (ZERO) (dBm/WATT).

FILTER

A digital filter averages measurement readings to reduced jitter. A filter number (0 through 9) is entered to set the filter length. The filter length is the number of readings averaged and is equal to 2 to the power of the filter number (that is, from 1 to 512 in powers of 2).

(AUTO/FILTER) selects the optimum filter length automatically.

Because of speed, resolution, and display considerations, the filter can be set manually. Measurements with higher filter numbers are slower and more settled; measurements with lower filter numbers are faster and have more jitter. For example, to manually set the filter to 7 (filter length of 128), press (MNL/FILTER) (AUTO/FILTER) (dBm/WATT)

RANGE

The Power Meter divides the sensor's power range into five ranges of 10 dB each. Range 5 may be less that 10 dB if the sensor has a power range of less than 50 dB. Range 1 is the most sensitive, and range 5 is the least sensitive.

(AUTO/RANGE) sets the correct range automatically for the current measurement.

Manual range is used primarily with the rear panel recorder output or when faster readings are required. For example, to set range manually to Range 3, press (MNL/RANGE) (OFFSET) (dBm/WATT).

OFFSET

Offsets can be added to measurements to compensate for gain or loss in the measurement system. For example, to add an offset of 20 dB, press (OFFSET) (CAL/FACTOR) (ZERO) (dBm/WATT)

MEASUREMENT UNITS

Single sensor and difference measurements are displayed in units of Watts or dBm. Ratio and relative measurements are displayed in either percent of dB. Press (dBm/WATT) to toggle from one measurement unit to another.

STORE and RECALL

The Power Meter can store up to 19 instrument configurations for recall at a later time. For example, to store an instrument configuration in storage register 10, press (STORE) (CAL/ADJ) (ZERO) (dBm/WATT)

(RECALL) (OFFSET) (dBm/WATT) recalls an intrument configuration stored in register 3 and changes the Power Meter to the recalled parameters.

3-6. Turn-On Instructions

Warning

Before the instrument is switched on, all protective earth terminals, extension cords, autotransformers and devices connected to it should be connected to a protective earth grounded socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

Only 250V normal blow fuses with the required rated current should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

Caution

Before the instrument is switched on, it must be set to the voltage of the power source or damage to the instrument may result.

3-7. Turn-On

Turn-On Procedure. If the power meter is already plugged in, set the LINE switch to ON.

If the power cable is not plugged in, follow these instructions.

On the rear panel:

1. Check the line voltage switch for correct voltage selection.
2. Check that the fuse rating is appropriate for the line voltage used (see Figure 2-1). Fuse ratings are printed on the rear panel.
3. Plug in the power cable.

   On the front panel, press the LINE switch to ON.

Note

Turn-On Configuration. The power meter turns on to the same control settings it had before line power was removed. An exception to this is that it always turns on in the local mode. In addition some HP-IB default conditions are enabled. Refer to "Turn on Default Conditions" later in this section.

When the power meter is turned on, it will execute a power up sequence which will be followed by an automatic RECALL 0. The power up sequence will run some self test routines to verify the operation of ROM, RAM, and display circuits. If any self test failures occur an error message will be reported to the user on the front panel display. If, for some reason, RAM content was lost this error will be reported and all storage registers initialized to put the power meter into the PRESET state. Storage location 0 is also set to the PRESET state when a RAM error occurs. This means the power meter will be in the PRESET state when it begins operation. The internal HP-IB address switch is read only when the memory content is lost. In all other cases the HP-IB address that is entered from the front panel is the one saved in RAM.

Note

An internal battery is used to retain data in RAM during off periods. The data restores the last control setup that was saved in storage location zero and the other nineteen storage registers.

3-8. Error Messages

Power up error message numbers as well as other error messages displayed on the front panel are listed and explained in Table 3-8, Error Messages. As an example, if a ROM or RAM failure occurs, the power meter will display an error code number in the range of 61 through 66 depending on the location in memory that has a problem.

3-9. Power Reference and Calibration

A POWER REF of 1.00 mW at 50 MHz (factory set at ±0.7% and traceable to the National Institute of Standards and Technology (NIST)) is available at the front panel for calibrating the power meter to the sensor.

Note

There are two buttons on the front panel dealing with calibration: (CAL ADJ) and (CAL FACTOR). (CAL ADJ) is pressed when entering the reference calibration factor for your power sensor and should not need to be reset until another sensor is used. (CAL FACTOR) is pressed when frequency changes. To verify calibration on the power meter front panel, (CAL ADJ) and (CAL FACTOR) must be the same value.

Procedure

The Calibration Procedure which may appear on the power sensor label does not apply to the HP 438A Power Meter.

Some sensors come with attenuators which may or may not need to be connected for calibration.

Power Sensor	Attenuator
HP 8481B	disconnected
HP 8482B	disconnected
HP 8481D	connected
HP 8484A	(HP 11708A) connected
HP 8485D	connected
HP R/Q8486D	connected
HP 8487D	connected

1. To calibrate the power sensor to the meter, first connect the sensor to the POWER REF output. To see if your sensor requires an attenuator for calibration see the list above.
2. Press the (ZERO) key and wait for the zeroing routine to finish.
3. Press (CAL ADJ) and enter the reference calibration factor (Ref. CF) which is printed on the sensor label. (If you have a power sensor that does not specify the reference calibration factor, assume it to be 100%)
4. Press (ENTER) and wait for the calibration routine to finish. The sensor is now calibrated.

5. To see the results of the calibration, first make sure the OSC light is on, then press (CAL FACTOR) and enter the same reference calibration factor (Ref. CF) that you entered for CAL ADJ.

   Press (ENTER). The display should now read 1 mW (0 dBm), except for the following sensors:

Power Sensor	Display
HP 8481B	1 W
HP 8482B	1 W
HP 8481D	1 μW
HP 8484A	1 μW
HP 8485D	1 μW
HP R/Q8486D	1 μW
HP 8487D	1 μW

3-10. Operator's Checks

Operator's Checks are procedures designed to verify the proper operation of the power meter's main capabilities. Two procedures are provided as described below.

Basic Functional Checks

This procedure requires power sensors, cables, and a power splitter. It assures the operator that most front panel controlled features are being properly executed by the power meter.

HP-IB Functional Checks

These procedures require an HP-IB compatible computing controller, an HP-IB interface, and connecting cable. The procedures check the applicable bus messages summarized in Table 3-2. The HP-IB Checks assume that front panel operation has been verified by performing the Basic Front Panel Checks.

3-11. Basic Functional Checks

The functions of the power meter are checked using power sensors, sensor cables, and a power splitter. These checks provide reasonable assurance that most of the front panel controlled functions are being executed by the power meter.

Equipment

Power Sensors (2) .... HP 8480 Series
Sensor Cables (2) .... HP 11730 Series
Power Splitter .... HP 11667A
Adapter N(m) to N(m) .... HP 1250-1528
Adapter APC-3.5(f) to N(m) .... HP 1250-1744

Procedure

The following procedure was developed using power sensors HP 8485A and HP 8481A. Using other sensors such as the HP 8481B will result in different displays.

Turn on the power meter and observe the power up routine with no power sensor connected to the inputs. During power up the diagnostics stored in ROM are executed under microprocessor control and turn on all the display segments and annunciators. This is followed by a shorter flash of all dashes.

When the self-test is finished, the power meter will display no CH A or B, WATT A or B, Error 31 or 32, and flashing A or B. Since the power meter stores the last active parameters in storage location 0 this stored information is what will be recalled and displayed during power up. This is the reason for the "A" or "B" information being displayed.

1. Verify that the power up internal diagnostics are exercised without any error messages other than no CH A, ERROR 31 or no CH B, ERROR 32 depending on which channel was active during power down.
2. Press (PRESET). This sets the parameters for channel A and B to:

   Cal Factor = 100.0%
   Offset = 0.00 dB
   Low Limit = 0.00 dB
   High Limit = 0.00 dB
   Auto Filter
   Auto Range

3. Set the power meter to the following conditions:

   Measurement Mode....................................Sensor A
   Reference Oscillator....................................OFF
   Active Entry Channel....................................A
   Measurement Units....................................Watt
   Limits Checking....................................OFF
   Rel Mode....................................OFF
   Group Execute Trigger Mode..........Trigger with Delay (GT2)
   Trigger Mode....................................Free Run

4. Connect a power sensor with associated cable to channel A input as shown in Figure 3-3. The error message should disappear and display will show either a power level, or PLEASE 0, and Error 15. Annunciators WATT A, 100% CF, and A on.

5. Connect the power sensor to 1 mW POWER REF. Display will show a power level.

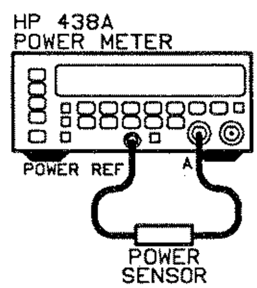


Figure 3-3. Front Panel Checks Setup (1)

6. Press (ZERO). Wait approximately 15 seconds for the zeroing routine to finish. Verify that display shows - - - - - -, with a walking decimal point. Observe that the POWER REF OSC LED is off during this routine.

7. Press (CAL ADJ). The power meter will display Ent - - - - -, and annunciators %, 100.0% CF A, and rcF are on. Enter the REF CAL FACTOR shown on the power sensor using blue numeric keys and the (SET B) key for a decimal point.

   Press (ENTER). The power meter will display - - - - -, with a walking decimal point and annunciators A, A. Wait approximately 5 seconds for the CAL ADJ routine. Observe that during CAL ADJ the POWER REF OSC LED will be turned off and on.

8. Press (CAL FACTOR). The power meter will display Ent - - - - -, %, 100.0% CF A, and 1–150. Enter the CAL FACTOR at 50 MHz. Press (ENTER). The CF displayed will be the one used in the measurments.

9. Turn on POWER REF OSC. The display will now read 1.000 −3, with annunciators WATT, A, 100.0% CF, and A on.

10. Press (dBm WATT). Display will change to 0.00 dBm.

11. Press (B). Repeat steps 4 through 10 for channel B inputs.
12. Remove sensor from POWER REF OSC. Connect the equipment as shown in FIGURE 3-4.
13. The power meter will display a power level. Annunciators WATT B, 100.0% CF and B are on.
14. Press (dBm WATT) to display dBm. The power meter will now display the loss through the power splitter. This number will be used as an offset to get the power level displayed back to 1 mW. Annunciators B, MNL, 100.0% CF, and B are on.
15. Press (OFFSET.) The power meter display reads Ent - - - - -, annunciators show dB, 0.00 B, and ≤99.99.

    Key in a number equivalent to power loss through power splitter using the blue keys representing the numbers and the (SET B) key for the decimal point. Press (ENTER).

    An alternative is to just press (REL) which is (DSP→OFS) in the blue key mode. This takes the loss in dB through the splitter and uses it as the offset to return to a display of 1 mW.

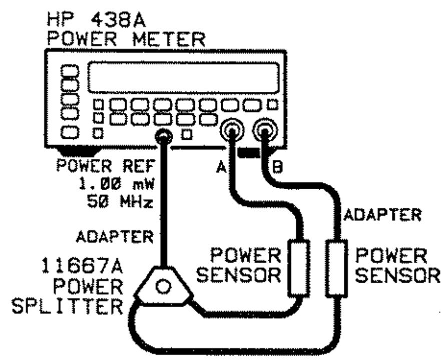


Figure 3-4. Front Panel Checks Setup (2)

16. Press (A) to return to channel A as the active channel. Repeat step 15 for channel A.
17. Press (B/A). Press (dBm WATT) to display the ratio in %.
18. The above checks have been using the AUTO RANGE and AUTO FILTER modes.

    To check the two MNL (manual) keys for RANGE and the FILTER:

    Press (MNL RANGE). The power meter will display Ent -.
    Annunciators rng 3, 1–5, and A will be on for channel A.
    Annunciators rng 1,1–5, and B will be on for channel B.
    Press (MNL FILTER). The power meter will display Ent -
    Annunciators FLt 1, 0–9, and A will be on for channel A.
    Annunciators FLt 7, 0–9, and B will be on for channel B.

19. Observe the **rng** and **FLt** number difference because of the sensor being used.

Note

Several combinations of keys can be exercised at this time to further familiarize yourself with the front panel operation.

3-12. HP-IB Checks

Description

These procedures check the power meter's ability to process or send the HP-IB messages described in Table 3-2. Only the power meter, a power sensor, a controller, and an HP-IB interface are needed to perform these checks.

These procedures do not check that all the power meter program codes are being properly interpreted and executed by the instrument. However, if the power-up sequence and front panel operation are good, the program codes, in all likelihood, will be correctly implemented.

The validity of these checks is based on the following assumptions:

1. The power meter performs properly when operated via the front panel keys (that is, in local mode). This can be verified by the "Basic Functional Checks" in this section.
2. The bus controller properly executes HP-IB operations.
3. The bus controller's interface properly executes the HP-IB operations.

If the power meter appears to fail any of these HP-IB checks, the validity of the above assumptions should be confirmed before attempting to service the instrument.

The select code of the controller's HP-IB interface is assumed to be 7. The address of the power meter is assumed to be 13 (its address set at the factory). This particular select code-address combination (that is, 713) is not necessary for these checks to be valid. However, the program lines presented here must be modified for any other combination.

These checks can be performed together or separately. Any special requirements for a check are described at the beginning of the check.

Initial Setup

The test setup is the same for all of the checks. Connect the equipment as shown in Figure 3-5.

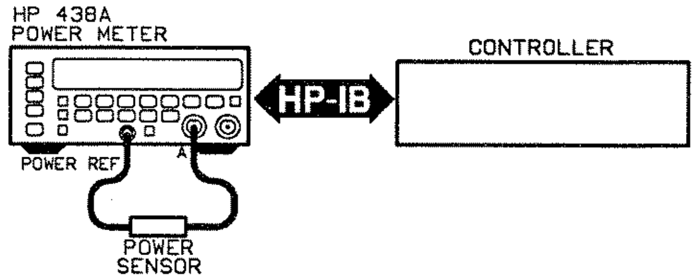


Figure 3-5. HP-IB Functional Checks Setup

Equipment

HP-IB Controller .... HP 9000 Series 200/300 (BASIC 2.0)
Power Sensor .... HP 848x series

Remote and Local Messages and LCL

This check determines whether or not the power meter properly switches from local to remote control, from remote to local control, and whether or not (LCL) key returns the instrument to local control.

Before beginning this check, set the LINE switch to OFF, then to ON.

Description	Series 200/300 (BASIC)
Send the Remote message (by setting the Remote Enable bus control line, REN, true and addressing the power meter to listen).	REMOTE 713

Check that the power meter's RMT and LSN annunciators are on.

Description	Series 200/300 (BASIC)
Send the Local message to the power meter	LOCAL 713

Check that the power meter's RMT annunciator is off but its LSN annunciator is on.

Description	Series 200/300 (BASIC)
Send the Remote message to the power meter.	REMOTE 713

Check that both the RMT and LSN annunciators are on. Press (LCL) on the power meter. Check that the RMT annunciator is now off, but that the LSN annunciator remains on.

Sending the Data Message

This check determines whether or not the power meter properly issues Data messages when addressed to talk.

Before beginning this check, set the power meter's LINE switch to OFF, then to ON. Press (LCL). (If an HP Series 200/300 controller is used, a short program is required to perform this check.)

Description	Series 200/300 (BASIC)
Address the power meter to talk and store its output in variable V.	10 V=0 20 ENTER 713;V
Display the value of V.	30 DISP V 40 END

Check that the power meter's TLK annunciator is on. The controller should display the same value as the one shown in the power meter's display. (Note that the power meter displays data using engineering notation. The controller may display the same value using a different format.)

Receiving the Data Message

This check determines whether or not the power meter properly receives Data messages.

Description	Series 200/300 (BASIC)
Send the first part of the Remote message (enabling the power meter to remote).	REMOTE 7
Address the power meter to listen (completing the Remote message), then send a Data message.	OUTPUT 713; "KB 95 EN"

Check that the power meter's RMT and LSN annunciators are on and that the display indicates the channel A cal factor is set to 95%.

Local Lockout and Clear Lockout/Set Local Messages

This check determines whether or not the power meter properly receives the Local Lockout message, disabling all front panel keys (including (LCL)). This check also determines whether or not the Clear Lockout/Set Local message is properly received and executed by the power meter.

This check assumes the power meter is in remote mode.

Description	Series 200/300 (BASIC)
Send the Local Lockout message.	LOCAL LOCKOUT 7

Check that the RMT annunciator is on. Press the power meter's (LCL) key. The RMT annunciator should remain on.

Description	Series 200/300 (BASIC)
Send the Clear Lockout/Set Local message.	LOCAL 7

Check that the power meter's RMT annunciator is off.

Description	Series 200/300 (BASIC)
Return the power meter to remote mode if the remaining checks in this section are to be performed.	REMOTE 713

Check that the power meter's RMT annunciator is on.

Clear Message

This check determines whether or not the power meter properly responds to the Clear message.

This check assumes that the power meter is in remote mode.

Description	Series 200/300 (BASIC)
Send a Data message to set the cal factor to 98.5%.	OUTPUT 713; "KB 98.5 EN"

Check that the power meter's display indicates the channel A cal factor is set to 98.5%.

Description	Series 200/300 (BASIC)
Send the Clear message (setting the cal factor to 100%.	CLEAR 713

Check that the power meter's display indicates the channel A cal factor is set to 100%.

Abort Message

This check determines whether or not the power meter becomes unaddressed when it receives the Abort message.

This check assumes the power meter is in remote mode.

Description	Series 200/300 (BASIC)
Address the power meter to listen.	OUTPUT 713

Check that the power meter's LSN annunciator is on.

Description	Series 200/300 (BASIC)
Send the Abort message, unaddressing the power meter from listening.	ABORTIO 713

Check that the power meter's LSN annunciator is off.

Status Byte Message

This check determines whether or not the power meter sends the Status Byte message.

Before beginning this check, set the power meter's LINE switch to OFF then to ON and press (LCL).

Description	Series 200/300 (BASIC)
Place the power meter in serial-poll mode (causing it to send the Status Byte message).	SPOLL(713)

Check that the controller's display reads 0.

Require Service Message

This check determines whether or not the power meter can issue the Require Service message (set the SRQ bus control line true).

This check can be performed in either local or remote mode.

Description	Series 200/300 (BASIC)
Send a Data message to set the Service Request Mask to 4.	OUTPUT 713 USING "2A,B"; "@1",4
Send a Data message containing an entry error. This causes the Require Service message to be sent.	OUTPUT 713; "RM 15 EN"

Check that the power meter's SRQ annunciator is on.

Description	Series 200/300 (BASIC)
Read the binary status of the controller's HP-IB interface and store the data in variable V (in this step, 7 is the interface's select code, and 2 is a status register for bus control lines).	10 V=0 20 STATUS 7,2;V
Display the value of the SRQ bit (in this step, 6 is the SRQ bit for the controller, numbered from 0).	30 DISP "SRQ="; BIT(V,6) 40 END

Check that the SRQ value is 1, indicating that the power meter issued the Require Service message.

Status Bit Message

This check determines whether or not the power meter sends the Status Bit message.

This check can be performed in either local or remote mode. If the power meter's SRQ annunciator is off, perform the first part of the Require Service message check before beginning this check.

Description	Series 200/300 (BASIC)
Configure the power meter to respond to a parallel poll with positive-true logic on HP-IB data line DIO3.	SEND 7;LISTEN 13 CMD 5 SCG 10
Place the power meter in parallel poll mode (causing it to send the Status Bit message).	PPOLL(7)

Check that the SRQ annunciator is on and that the response to the parallel poll is 4, indicating that the power meter issued the Status Bit message.

Description	Series 200/300 (BASIC)
Unconfigure the power meter from responding to a parallel poll.	SEND 7; LISTEN 13 CMD 5 SCG 18
Place the power meter in parallel POLL MODE.	PPOLL(7)

Check that the SRQ annunciator is on and that the response to the parallel poll is 0, indicating that the power meter is no longer configured to respond to a parallel poll. To turn the SRQ annuciator off set the LINE switch to OFF, then to ON.

Trigger Message

This check determines whether or not the power meter responds to a Trigger message.

This check assumes that the power meter is in remote mode.

Description	Series 200/300 (BASIC)
Send a Data message to place the Power Meter in the Trigger Hold mode.	10 OUTPUT 713;"TRO"
Send the Trigger message.	20 TRIGGER 713
Address the power meter to talk and store the data in variable V.	30 V=10 40 ENTER 713;V
Display the value of V.	50 DISP V 60 END

Check that the power meter's RMT and TLK annunciators are on and that the controller displays the same value as the one shown in the power meter's display. (Note that the power meter displays data using engineering notation. The controller may display the same value using a different format.)

Table 3-2. Message Reference Table

HP-IB Message	Applicable	Response	Related Command	Interface Functions[1]
Data	Yes	All power meter operations, (except setting the LINE switch and setting the HP-IB address) and remote-only functions are bus programmable. All measurement results are available to the bus.		AH1, SH1, T5, TE0, L3, LE0
Trigger	Yes	The power meter's response to bus command GET (Group Execute Trigger) can be programmed. The default Condition is Trigger With Delay (GT2). If in remote and addressed to listen, the power meter makes a measurement according to the previously programmed setup.	GET	DT1
Clear	Yes	All HP-IB inputs and outputs are cancelled	DCL, SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. Remote mode is not entered, however, until the first time the power meter is addressed to listen. The front panel RMT annunciator lights when the instrument is actually in remote mode. When entering remote mode, no instrument settings or functions are changed but all front panel keys, except (LCL), are disabled.	REN	RL1

1 Commands, control lines, and interface functions are defined by ANSI/IEEE Standard 488.1. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve messages in the "HP-IB Message" column.

Table 3-2. Message Reference Table (continued)

HP-IB Message	Applicable	Response	Related Command	Interface Functions[1]
Local	Yes	The power meter returns to local mode (front panel control). It responds equally to the Go To Local (GTL) bus command and the front panel (LCL) key.	GTL	RL1
Local Lockout	Yes	Disables all front panel keys, including (LCL). Only the controller can return the power meter to local (front panel) control.	LLO	RL1
Clear Lockout/ Set Local	Yes	The power meter returns to local mode (front panel control). Local Lockout is cleared when the bus control line goes false.	REN	RL1
Pass Control/ Take Control	No	The power meter has no controller capability.		C0
Require Service	Yes	The power meter sets the SRQ bus control line true if one of the following conditions exists and has been enabled (via the Service Request Mask) to send the message for that condition: data ready, cal/zero completed, entry error, measurement error, or over/under limits.	SRQ	SR1

1 Commands, control lines, and interface functions are defined by ANSI/IEEE Standard 488.1. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve messages in the "HP-IB Message" column.

Table 3-2. Message Reference Table (continued)

HP-IB Message	Applicable	Response	Related Command	Interface Functions[1]
Status Byte	Yes	The power meter responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ bus control line true (issuing the Require Service message), bit position 6 in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by removing the causing condition and then reading the Status Byte or by receiving the Clear Status (CS) program code.	SPE, SPD	T5
Status Bit	Yes	The power meter responds to a Parallel Poll Enable (PPE) bus command by sending a bit on a controller selected HP-IB data line.	PPE, PPD, PPC, PPU	PP1
Abort	Yes	The power meter stops talking and listening.	IFC	T5, TE0, L3, LE0
Complete HP-IB capability as defined in ANSI/IEEE Standard 488.1 is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT1, C0				

1 Commands, control lines, and interface functions are defined by ANSI/IEEE Standard 488.1. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve messages in the "HP-IB Message" column.

3-13. Remote Operation, Hewlett-Packard Interface Bus

The power meter can be operated through the Hewlett-Packard Interface Bus (HP-IB). HP-IB is Hewlett-Packard's implementation of ANSI/IEEE Standard 488.1 and the identical ANSI Standard MC1.1. Bus compatibility, programming, and data formats are described in the following paragraphs.

All front panel functions are programmable via HP-IB except setting the LINE switch and activating the (SHIFT) key. The (SHIFT) key is not programmable because the shifted functions have their own program codes. Additional functions are available in remote operation only.

A quick test of the power meter's HP-IB interface is described in this section under HP-IB Functional Checks. These checks verify that the power meter can respond to or send each of the applicable bus messages described in Table 3-2. For more information about HP-IB, refer to ANSI/IEEE Standard 488.1 (or the identical ANSI Standard MC1.1), the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet *Improving Measurements in Engineering and Manufacturing* (HP part number 5952-0058).

3-14 HP-IB Compatibility

The power meter's complete bus compatibility as defined by IEEE Standard 488 (and the identical ANSI Standard MC1.1) is described at the end of Table 3-2. Table 3-2 also summarizes the power meter's HP-IB capabilities in terms of the twelve messages in the "HP-IB Message" column.

3-15. Remote Mode

Remote Capability. The power meter communicates on the bus in both remote and local modes. In remote, most of the power meter's front panel keys are disabled (exceptions are the LINE switch and the (LCL) key). Front panel displays, however, remain active and valid.

In remote, the power meter can be addressed to talk or listen. When addressed to listen, the power meter responds to the Data, Trigger, Clear (SDC), Remote, and Local messages. When addressed to talk, the power meter can issue the Data and Status Byte messages. Whether addressed or not, the power meter responds to the Clear (DCL), Local Lockout, Clear Lockout/Set Local, and Abort messages. In addition, the power meter may issue the Require Service and Status Bit messages.

Local-to-Remote Changes. The power meter switches to remote operation upon receipt of the Remote message. The Remote message has two parts:

a. the remote enable bus control line (REN) is set true, and,

b. the device listen address is received once (while REN is true).

When the power meter switches to remote, the front panel RMT annunciator turns on. The power meter's control settings remain unchanged with the local-to-remote transition.

3-16. Local Mode

Local Capability. In local, the power meter's front panel controls are fully operational and the instrument will respond to the Remote message. Whether it is addressed or not, it will also respond to the Clear, Local Lockout, Clear Lockout/Set Local, and Abort messages. When addressed to talk, the instrument can issue Data messages and the Status Byte message. Whether addressed or not, the instrument can issue the Require Service and Status Bit messages.

Remote-to-Local Changes. The power meter always switches from remote to local whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local message sets the remote enable bus control line [REN] false.) If not in Local Lockout mode, the power meter switches to local from remote whenever the front panel (LCL) key is pressed.

Local Lockout. A local lockout is recommended for purely automatic applications. Local lockout disables the (LCL) key and allows return-to-local only under program control.

Note

Return-to-local can also be accomplished by setting the power meter's LINE switch to OFF, then to ON. However, this technique has some disadvantages:

a. Many of the power meter's parameters are set to default states. This may cause the measured power reading to change.

b. There are several HP-IB conditions that reset to default states at turn-on.

3-17. Addressing

The power meter interprets the byte on the eight HP-IB data lines as an address or a bus command if the bus is in the command mode. The command mode is defined as the attention control line (ATN) being set true and the interface clear control line (IFC) set false. Whenever the power meter is addressed (whether in local or remote), either the talk (TLK) or listen (LSN) annunciator on the front panel turns on.

The power meter's HP-IB address is set in decimal from the front panel. HP-IB address switches (set in binary) are located inside the instrument. The only time the power meter reads the internal switches, however, is when the internal RAM contents storing the front panel address setting have been lost (for example, when the battery fails). Additional information for setting the internal switches is located in sections 2 and 8.

The power meter's HP-IB address can be set from the front panel as follows:

a. Set power meter's LINE switch from OFF to ON while pressing and holding the (LCL) key.

b. Release the (LCL) key.

c. Enter the desired HP-IB address in decimal (0–30) and then press the (ENTER) key.

d. To display the current HP-IB address setting in the front panel display, press and hold the (LCL) key.

Listen Only Mode. The power meter is placed in Listen Only mode when its HP-IB address is set to 40. The Listen Only mode is provided to allow power meter to accept programming from devices other than controllers.

Talk Only Mode. The power meter is placed in Talk Only mode when its HP-IB address is set to 50. In this mode, the instrument is configured to send data messages whenever the bus is in the data mode (attention control line [ATN] false).

3-18. Turn-on Default Conditions

Several HP-IB parameters are reset at turn-on. The parameters and their default conditions are listed below.

- HP-IB Local Mode
- Unaddressed
- Service Request Mask cleared
- Status Byte cleared
- Free Run Trigger Mode
- GT2 (Trigger with Delay) response to Trigger message
- Parallel Poll data line unassigned
- Display Enable active

3-19. Data Messages

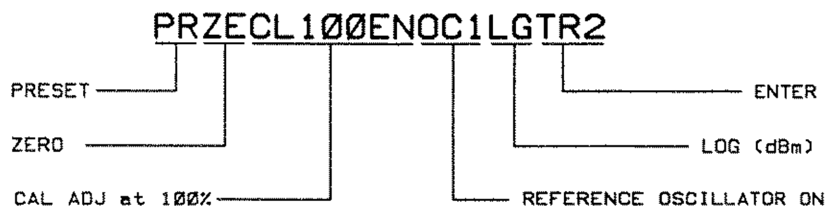
The power meter communicates on the interface bus primarily with Data messages. Data messages consist of one or more bytes sent over the bus' data lines when the bus is in the data mode (ATN bus control line false). Unless it is set to Talk Only, the power meter receives Data messages when addressed to listen. Unless it is set to Listen Only, the power meter sends Data messages or the Status Byte message when addressed to talk.

Virtually all instrument operations available in local mode can be performed in remote mode via Data messages. The only exceptions are: changing the LINE switch, activating the (SHIFT) key, or changing the HP-IB address. The power meter may also be triggered via Data messages to make measurements at a particular time.

3-20. Receiving the Data Message

The power meter responds to Data messages when it is enabled to remote (REN bus control line true) and it is addressed to listen. The instrument remains addressed to listen until it receives its talk address, an Abort message, or a universal unlisten command.

Data Input Format. The Data message string, or program string, consists of a series of ASCII codes. Each code is typically equivalent to a front panel keystroke in local mode. Thus, for a given operation, the program string syntax in remote mode is the same as the keystroke sequence in local mode. Example 1 shows a typical program string.



EXAMPLE 1: Typical Program String

Program Codes. All of the HP-IB codes normally used by the operator to control the power meter are given in Table 3-6, HP-IB Code to Parameter Summary. All front panel keys except (LCL) and (SHIFT) have corresponding program codes. Lower case alpha characters are interchangeable with upper case characters. The number "0" and the letter "O" are not interchangeable.

Numeric data can be entered in fixed, floating point, or exponential format.

Note

All measurement parameter entries must be terminated with the program code "EN". (This is equivalent to pressing the (ENTER) key in local mode.) All frequency entries must be terminated with HZ, KZ, MZ, or GZ. For DUTY CYCLE (DY), CAL FAC (KB), and CAL (CL), the percent sign (%) can be used in place of EN.

Turning Off Functions. When operating in local mode, OSC (reference oscillator) and REL (relative mode) toggle on and off with successive keystrokes. In remote mode these functions do not toggle on and off. Instead, a specific program code is required to turn off each function. Use RL0 to turn off REL mode and OC0 to turn off the reference oscillator.

Hold Range. When the power meter is addressed to listen and receives program code RH (Range Hold), it switches from auto range to manual range using the current auto range value. If the power meter is already in manual range mode no action is taken. No range number is entered with this program code.

Hold Filter. When the power meter is addressed to listen and receives program code FH (Filter Hold), it switches from auto filter mode to manual filter mode using the current auto filter value. If the power meter is already in manual filter mode no action is taken. No filter number is entered with this program code.

Limits. The limits checking function allows the power meter to monitor the power present at each sensor and indicate when that power is outside preset limits. Enabling the limits checking function and setting limit values are available only via remote programming.

To set the the limits for a sensor, address the power meter to listen and then send a Data message consisting of program code LL (limit low) or LH (limit high), a numeric value, and program code EN (ENTER). The allowable range for limit values is −299.999 to +299.999. Values entered that are outside of this range cause the limit to be set to the minimum or maximum value as appropriate. Limit values are entered in dBm and converted automatically to Watts when necessary.

The limits checking function is enabled by program code LM1 and disabled by program code LM0. When the limits checking function is enabled, it uses the last values set for the high and low limits. PRESET (and the Clear message) sets both the high and low limits for Sensors A and B to 0.000 dBm and disables the limits checking function.

If the limits checking function is enabled and the input power exceeds the high limit or is less than the low limit, the condition is indicated on the front panel as well as over the bus. The out-of-limits condition is indicated on the front panel by the flashing A and/or B annunciator. The out-of-limits condition is indicated only for the sensor(s) used by the current measurement mode. The out-of-limits condition can be indicated over the bus by setting the Service Request Mask to enable an out-of-limits condition to issue the Require Service message. This condition can also be indicated by reading the Status Message.

Display Functions. The selection of display functions is available only via remote programming. During local operation, the power meter display is enabled to indicate measurement results, error codes, entries in progress, and instrument status. In remote mode, two additional display functions are allowed: display disable and display all.

Display Enable (DE). This function is identical to local operation and is the function in effect when no other display function has been selected. This is the display function at turn-on. This condition is also established by PRESET and the Clear message.

Display Disable (DD). This function blanks out the front panel display. All readings over the bus remain valid. This function is cleared by sending another display function program code (DA or DE), by PRESET, or by the Power Meter receiving the Clear message.

Display All (DA). This function causes the power meter to turn on all front panel display LED segments. It is used to verify that all display segments are working properly. This function is cleared by sending another display function program code (DE or DD), by PRESET, or by the power meter receiving the Clear message. (At turn-on, all the display segments light momentarily before the display enable becomes active.)

Triggering Measurements with the Data Message. A feature that is only available via remote programming is the selection of free run, standby, or triggered operation of the power meter. During local operation the power meter is allowed to free run, outputting data to the display as each measurement is completed. In remote, three additional operating modes are allowed: hold, trigger immediate, and trigger with delay.

Hold (TR0). This mode is used to set up triggered measurements (initiated by program codes TR1, TR2, and the Trigger message). In trigger hold mode, internal settings can be altered by the instrument itself or by the user via the bus. The instrument, however, is inhibited from outputting any data to the front panel display or to the HP-IB except as follows. The instrument will issue the Status Byte message if serial polled.

The power meter leaves hold mode when it receives either the free run, trigger immediate, or trigger with delay program codes, or the Trigger message, or when it returns to local mode via the (LCL) key. Upon leaving hold, the front panel display is updated as the new measurement cycle begins. The Status Byte will be affected by the events that occur during the new measurement cycle.

Trigger Immediate (TR1). When the power meter receives the trigger immediate program code, it makes one measurement in the shortest possible time. The instrument then waits for the measurement results to be read. While waiting, the instrument can process most bus commands without losing the measurement results. However, if the instrument receives GET (Group Execute Trigger), a new measurement cycle will be executed. Once the measurement results are read onto the bus, the power meter reverts to the hold mode. Measurement results obtained via trigger immediate are normally valid only when the instrument is in a steady, settled state.

Trigger with Delay (TR2). Triggering with delay is identical to trigger immediate except the power meter inserts a settling-time delay before taking the requested measurement. This settling time is a function of the selected range and filter and is sufficient to produce valid, accurate measurement results.

Free Run (TR3). This mode is identical to local operation and is the mode of operation in effect when no other trigger mode has been selected. The measurement result data available to the bus is constantly being updated as rapidly as the power meter can make measurements. Entry into remote from local via the (LCL) key sets the power meter to the free run mode. (A local command from the controller does not return the power meter to free run mode.)

Program Order Considerations. Although program string syntax is virtually identical to keystroke order, some program order considerations need highlighting.

Trigger Immediate and Trigger with Delay. When either of the trigger program codes TR1 or TR2 is received by the power meter, a measurement is immediately initiated. Once the measurement is completed, some bus commands can be processed without aborting the measurement. However, any HP-IB program code sent to the power meter before the triggered measurement results have been completed will abort the trigger. Thus, trigger codes should always appear at the end of a program string, and the triggered measurement results must be completed before any additional program codes that affect measurement are sent.

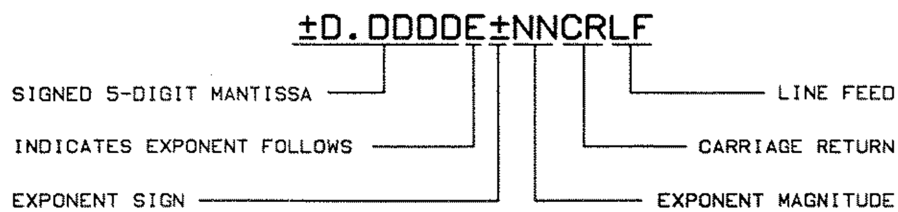
ZERO and CAL ADJUST. Zero the power meter before performing a calibration adjustment to avoid inaccurate measurement results.

OFFSET and Display Offset. The display offset program code (DO) is only valid when it immediately follows the program code for OFFSET (OS). When the Power Meter is addressed to listen and receives the program string "OS DO EN" (a Data message), the offset that causes the power meter display to read 0 dB or dBm, 1.000 mW, or 100% (depending on the measurement units and measurement mode) is entered.

3-21. Sending the Data Message

The power meter sends Data messages when addressed to talk. The instrument remains configured to talk until it is unaddressed to talk by the controller. To unaddress the power meter, the controller must send the power meter's listen address, a new talk address, an Abort message or a universal untalk command.

Data Output Format. As shown below, the output data is usually formatted as a real constant in exponential form: first the sign, then a digit, a decimal point, and four digits followed by the letter "E" and a signed power-of-ten multiplier. The string is terminated by a carriage return (CR) and line feed (LF). The power meter sends an EOI with the last byte of each output string.



When an error is output to the bus, it follows the same format described above. As long as the front panel display indicates an error condition, the Power Meter sends 9.0000E+40 as the measured data when addressed to talk. To determine the error code, it is necessary to read the Status Message. Refer to the Status Message paragraph below for additional information.

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

Learn Mode #1
Learn Mode #2
Status Message
Identification
Service Request Mask Value

Each of these five functions is enabled by first addressing the power meter to listen. Then the power meter must receive a Data message with the appropriate program code. When the power meter is addressed to talk, it will output data for the selected function. The output format for these functions is described in the following paragraphs. Service Request Mask Value is explained later under Sending the Service Request Mask Value.

Learn Modes. In addition to being able to store front panel setups in its own registers, the power meter has two learn modes that use the controller's memory. One learn mode allows the power meter to send instrument configurations to the controller's memory. The second learn mode is a subset of the first and transfers only information that can be stored in a STORE/RECALL register.

Whenever data is being transferred between controller and power meter, it must do so in uninterrupted strings. If a data string is broken or interrupted, the data could be lost or offset, and misinterpreted by the power meter. An offset of data bytes can persist until EOI is read.

Learn Mode #1. After receiving an LP1 program code (Learn Mode #1) and when addressed to talk, the power meter sends a string of up to 128 ASCII characters containing information on the instrument configuration. The last character is sent with EOI bus line true, thus terminating the message. This data can then be stored in the controller's memory for future use.

When the power meter is addressed to listen, the ASCII data string can be returned to the power meter. The power meter changes accordingly.

Table 3-3 shows the information contained in the string and the order in which it is sent.

Table 3-3. Learn Mode #1 Output Format

Parameter	Output from Power Meter[1]
Trigger Mode	TRx
Measurement Mode	AP, BP, AR, BR, AD, or BD
Sensor A Parameters	AE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	HL sxxx.xxx EN
Sensor B Parameters	BE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	HL sxxx.xxx EN
Active Entry Channel	AE or BE
Measurement Units	LG or LN
Reference Oscillator Status	OC0 or OC1
Group Trigger Mode	GTx
Limits Checking Status	LM0 or LM1
Carriage Return Line Feed	EOI

1 "s" indicates sign; "x" indicates a single digit

Learn Mode #2. After receiving the program code LP2 (Learn Mode #2) and when addressed to talk, the power meter sends 2 ASCII characters, @ and 2, followed by a string of 28 8-bit binary bytes. The last byte is sent with EOI bus line true, thus terminating the message. This binary data can then be stored in the controller's memory.

The most straight-forward way to program the system controller is to use a loop to read 30 binary characters and store them in an array. Learn Mode #2 requires a controller that can transfer information in binary form.

This string contains the following information:

Measurement mode
REL mode status (on or off)
Reference oscillator status (on or off)
Current reference value if in REL mode
Measurement units (Log or Lin)
Cal Factor for each sensor
Offset for each sensor
Range for each sensor
Filter for each sensor

When the power meter is addressed to listen, the binary data can be returned to the power meter. The power meter changes accordingly.

Status Message. This function enables the power meter's current state to be read under program control. After receiving an SM program code (Status Message) and when addressed to talk, the power meter sends a string of 23 ASCII characters followed by carriage return (CR), line feed (LF), and EOI. The Status Message is updated only after a measurement. The Status Message can be interpreted with the information shown in Figure 3-6.

Note

In order to obtain Measurement Units (E) in % and dB, enter the following program:

```
10  DIM Units$[7]
20  DIM Sm$[25]
30  PM=713
40  ENTER Pm;Dummy            !Update Status Message
50  OUTPUT Pm;"SM"
60  ENTER PM;Sm$              !Read Status Message
70  !
80  !  Check for Rel Mode or two channel operation
90  !
100 IF Sm$[18,18]="1" OR (VAL(Sm$[6,6])>1 AND VAL(Sm$[6,6])<6) THEN
110    SELECT Sm$[15,15]      ! Check for Log or Linear Mode
120       CASE "0"
130          Units$="   %"
140       CASE "1"
150          Units$="  dB"
160       CASE ELSE
170          Units$="    "
180    END SELECT
190    IF Sm$[18,18]="1" THEN Units$=Units$&" Rel"
200 ELSE                      ! Not Rel mode or two channel operation
210    SELECT Sm$[15,15]      ! Check for Log or Linear Mode
220       CASE "0"
230          Units$="WATTS"
240       CASE "1"
250          Units$="  dBm"
260    END SELECT
270 END IF
280 END
```

Identification. This function is used to identify the the power meter's model number and the firmware version. After receiving program code ?ID and when addressed to talk, the power meter sends the following string: HP438A,VERX.XX. Where HP438A is the instrument model number and VERX.XX is the firmware version number.

3-22. Receiving the Clear Message

The power meter responds to the Clear message by assuming the same conditions as established by PRESET. Refer to Table 3-4. The power meter responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not.

3-23. Receiving the Trigger Message

When in remote and addressed to listen, the power meter responds to a Trigger message (the Group Execute Trigger bus command [GET]) by executing one of the pre-programmed codes shown in Table 3-5. If none of the codes has been preprogrammed (via a Data message), the power meter responds to the Trigger message by executing one settled-measurement cycle (GT2), which is the default condition at turn-on. Refer to Triggering Measurements with the Data Message, discussed earlier in this section.

Note

Hardware Errors NOT available via the Status Message

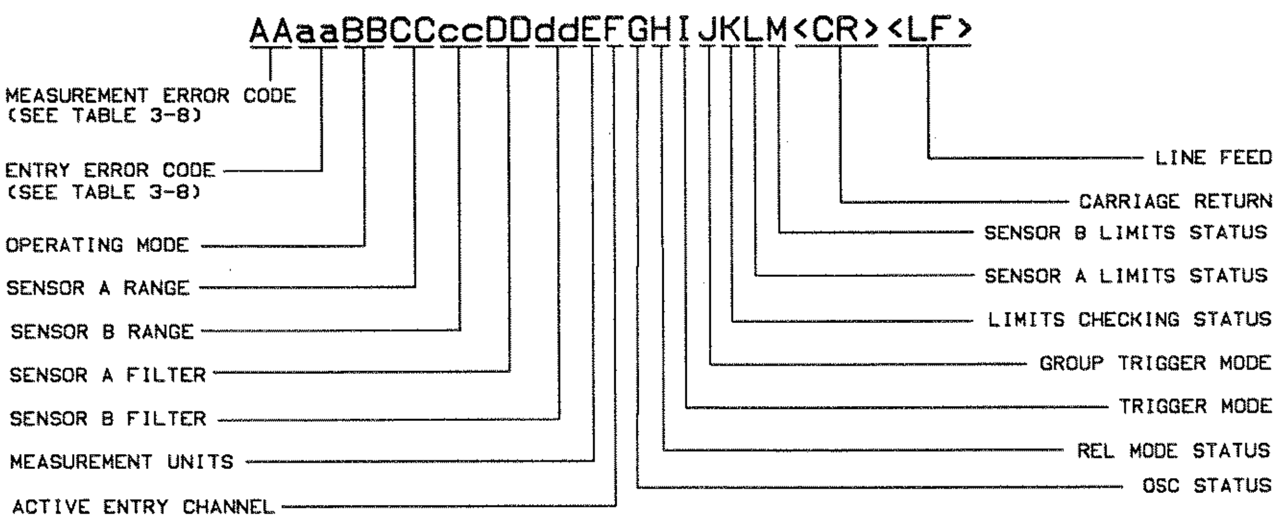


Figure 3-6. Status Message Output Format

Codes Used in Status Message

BB	CC cc	DD dd	E	F	G	H	I	J	K	LM
Operating Mode	**Range**	**Filter**	**Measurement Units**	**Active Entry Channel**	**Osc Status**	**REL Mode Status**	**Trigger Mode**	**Group Trigger Mode**	**Limits Checking Status**	**Sensor A & B Limits Status**
00=Sensor A	Manual	Manual								
01=Sensor B	Range	Filter	0=Watts	A=A	0=Off	0=Off	0=Free	0=GTO	0=Disabled	0=In limits
02=A/B	01=1	00=1	00=0	1=dBm	B=B	1=On	Run			1=Over
03=B/A	02=2	01=1					1=Hold	1=GT1	1=Enabled	high limit
04=A-B	03=3	02=2								
05=B-A	04=4	03=3						2=GT2		2=Under
06=Zeroing	05=5	04=4								low limit
A		05=5								3=Over
		06=6								high limit
07=Zeroing	Auto	07=7								and under
B	Range	08=8								low limit
08=Cal A	11=1	09=9								
09=Cal B	12=2	Auto								
10=Ext Cal A	13=3	Filter								
11=Ext Cal B	14=4	10=0								
	15=5	11=1								
		12=2								
		13=3								
		14=4								
		15=5								
		16=6								
		17=7								
		18=8								
		19=9								

Table 3-4. Response to a Clear Message (and PRESET)

Parameter	Condition
Sensor A	
CAL ADJ	100.0%
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Sensor B	
CAL ADJ	100.0%
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Display	Sensor A
OSC	Off
Entry Channel	SET A
Measurement Units	WATT
Limits Checking	Off
REL	Off
Trigger Mode	Free Run
Group Execute Trigger Mode	GT2
Display Function	Display Enable

Table 3-5. Response to a Trigger Message

Program/Code	Power Meter Response
GT0	Ignore Group Execute Trigger
GT1	Trigger Immediate (TR1)
GT2	Trigger with Delay (TR2)

3-24. Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REM) is held true, then the device listen address is sent by the controller. These two actions combine to place the power meter in remote mode. Thus, the power meter is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote. When actually in remote, the power meter lights the front panel RMT annunciator.

3-25. Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the power meter returns to front panel control when it receives the Local message. If the instrument was in local lockout when the Local message was received, front panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout/Set Local message, the power meter will return to local lockout the next time it goes to remote. No instrument settings are changed by the transition from remote to local.

When the power meter goes to local mode, the front panel RMT annunciator turns off. However, when the power meter is being addressed (whether in local or remote), its front panel LSN or TLK annunciator lights.

3-26. Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote, the power meter responds to the Local Lockout message by disabling the front panel LCL key. The local lockout mode prevents loss of system control due to someone accidentally pressing front panel keys. If, while in local, the power meter is enabled to remote (that is, REN set true) and it receives the Local Lockout message, it will switch to remote mode with local lock-out the first time it is addressed to listen. When in local lockout, the power meter can be returned to local only by the controller (using Local or Clear Lockout/Set Local messages) or by setting the LINE switch to OFF and back to ON or by removing the bus cable.

3-27. Receiving the Clear Lockout/Set Local Message

The Clear Lockout/Set Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The power meter returns to local mode (full front panel control) when it receives the Clear Lockout/Set Local message. When the power meter goes to local mode, the front panel RMT annunciator turns off.

3-28. Receiving the Pass Control Message

The power meter does not respond to the Pass Control message because it cannot act as a controller.

3-29. Sending the Require Service Message

The power meter sends the Require Service message by setting the Service Request (SRQ) bus control line true. The instrument can send the Require Service message in either local or remote mode. When the power meter is sending the Require Service message, the front panel SRQ annunciator lights. The Require Service message is cleared when a serial poll is executed by the controller or when a "CS" (clear status) program code is received via a Data message.

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

Data Ready: When the power meter has a data point requested by a trigger command.

Cal/Zero Completed: When the power meter has completed a calibration or zeroing cycle.

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

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

Over/Under Limits: When the limits checking function is enabled and the measured power is greater than the high limit or lower than the low limit.

Service Request Mask. The Service Request Mask determines which bits can set the Status Byte's RQS bit true (see Table 3-6). When the RQS bit is true, the SRQ bus line is also true.

The Service Request Mask is set by the program code "@1" followed by an 8-bit byte (a Data message). The value of the byte is determined by summing the weight of each bit to be checked. Each bit, if true, enables the corresponding condition to set the RQS bit true. At turn-on, the Service Request Mask is cleared (that is, set to 0).

Sending the Service Request Mask Value (a Data Message). After receiving an RV program code (Service Request Mask value) and when addressed to talk, the Power Meter will send a single binary word (8 bits) that describes the present state of the mask. The bit pattern can be interpreted with the information in Table 3-6.

Note

This byte is sent with the bus EOI line true, thus terminating the message.

3-30. Sending the Status Byte Message

After receiving a Serial Poll Enable (SPE) bus command and when addressed to talk, the power meter sends the Status Byte message. The Status Byte message consists of one 8-bit byte in which five of the bits are set according to the conditions described under Sending the Require Service Message. The bit pattern of the Status Byte is shown in Table 3-6. Note that bits 6 and 8 are always set to 0. The remaining bit is the RQS bit.

If one or more of the five conditions described above is both present and enabled by the Service Request Mask, the bits corresponding to the conditions and also bit 7, the RQS bit, are set true (and the Require Service message is sent). If one or more of the five conditions occurs but has not been enabled by the Service Request Mask, the corresponding bits are still set true. However, if a condition has not been enabled by the mask, it cannot cause the RQS bit to be set true.

Once the power meter receives the serial poll enable (SPE) bus command, it is no longer able to alter the status byte. If a bit has been enabled and that condition occurs after the RQS bit has been set true, the bit is stored in a buffer and is read the next time the power meter receives the SPE bus command.

Table 3-6. The Status Byte and Service Request Mask

Bit	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Condition	0	RQS Bit Require Service	0	Over/Under Limit	Measurement Error	Entry Error	Cal/Zero Complete	Data Ready

After the Status Byte message has been sent, it will be cleared if the Serial Poll Disable (SPD) bus command is received, if the Abort message is received, or if the power meter is unaddressed to talk. Bits stored in the buffer waiting to be read, however, are not cleared. Regardless of whether or not the Status Byte message has been sent, the Status Byte and any Require Service message pending will be cleared if a Clear Status (CS) program code is received by the Power Meter.

3-31. Sending the Status Bit Message

The power meter sends the Status Bit message (if configured to do so) as part of the interface's response to the Parallel Poll Enable (PPE) bus command. In order for the power meter to respond to a PPE bus command, the instrument must be assigned a single HP-IB data line on which to respond by the controller. The controller also assigns the logic sense of the bit. Both tasks are accomplished by the Parallel Poll Configure (PPC) bus command. If the power meter is sending the Require Service message, it will set its assigned status bit true. The power meter can send the Status Bit message without being addressed to talk.

The data line on which the power meter is assigned to respond is cleared by sending the Parallel Poll Unconfigure (PPU) bus command. At turn-on, the data line is unassigned.

3-32. Receiving the Abort Message

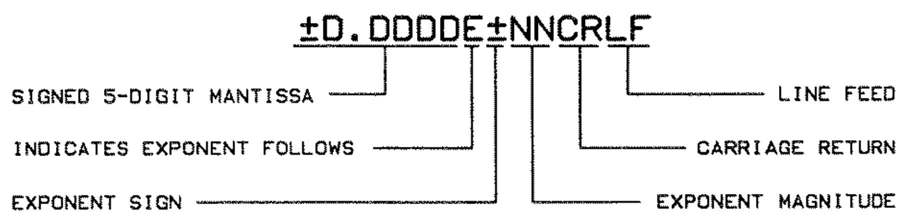
The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Power Meter becomes unaddressed and stops talking and listening.

3-33. HP-IB Syntax and Characteristics Summary

Address. Set in decimal from the front panel. Set the LINE switch to ON while pressing the LCL key. Release the LCL key, enter the desired address, and press the ENTER key. Factory set to 13.

Data input Format. Typically the same as front panel keystrokes in local mode. All numeric entries sent over the HP-IB must be terminated with program code "EN" (for ENTER).

Data Output Format. Output format when no other talk mode has been defined:



Output format for Learn Mode #1 (program code LP1). Up to 128 ASCII characters [EOI]

Output format for Learn Mode #2 (program code LP2). 30 bytes [EOI]

Output format for identification (program code 71 D). HP438AVERx.xx [EOI]

Output format for Status Message (program code SM). 23 ASCII characters [EOI]

Output format for Service Request Mask Value (program code RV). 1 byte [EOI]

Return to Local. Front panel LCL key if not locked out.

Status Byte

Bit	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Service Request Condition	0	RQS Bit Require Service	0	Over/Under Limit	Measurement Error	Entry Error	Cal/Zero Complete	Data Ready

Notes:
The condition indicated in bits 1–5 must be enabled by the Service Request Mask to cause a Service Request Condition. The mask is set with the @1 program code followed by an 8-bit byte. The value of the byte is determined by summing the weight of each bit to be checked.

The RQS bit (bit 7) is true when any of the conditions of bits 1–5 are enabled and occur. Bits remain set until the Status Byte is cleared.

Complete HP-IB capability (as described in IEEE Std 488-1978 and ANSI Std MC1.1):
SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, C0.

Table 3-7. HP-IB Codes to Parameter Summary

HP-IB Code	Parameter
AD	Sensor A minus Sensor B measurement
AE	SET A
AP	Sensor A measurement
AR	A/B ratio measurement
BD	Sensor B minus Sensor A measurement
BE	SET B
BP	Channel B measurement
BR	B/A ratio measurement
CL[1,2]	CAL ADJ
CS[1]	Clear Status Byte
DA[1]	Display All
DD[1]	Display Disable
DE[1]	Display Enable
DO	DSP → OFS
EN[1]	ENTER
FA	AUTO FILTER
FH	Filter Hold
FM[1,2]	MNL FILTER
GT0[1]	Ignore Group Execute Trigger (GET) bus command
GT1[1]	Trigger Immediate response to Group Execute Trigger
GT2[1]	Trigger with Delay response to Group Execute Trigger
KB[1,2]	CAL FACTOR
LG[1]	Log (dB or dBm)
LH[1,2]	High Limit
LL[1,2]	Low Limit
LM0[1]	Disable limits checking function
LM1[1]	Enable limits checking function
LN[1]	Linear (Watts or %)
LP1	Learn Mode #1
LP2	Learn Mode #2
OC0[1]	Reference Oscillator off
OC1[1]	Reference Oscillator on
OS[1,2]	OFFSET
PR[1]	PRESET
RA[1]	AUTO RANGE
RC[1,2]	RECALL
RH[1]	Range Hold
RL0[1]	Exit REL mode
RL1[1]	Enter REL mode
RM[1,2]	MNL RANGE
RV[1]	Service Request Mask Value
SM[1]	Status Message
ST[1,2]	STORE
TR0[1]	Trigger Hold
TR1[1]	Trigger Immediate
TR2[1]	Trigger with Delay
TR3[1]	Trigger - Free Run
ZE[1]	ZERO
@1[1]	Prefix for Service Request Mask
?ID[1]	Identification

1 These commands are fully compatable with the HP 437B Power Meter HP-IB command codes.

2 Requires numeric entry followed by program code EN.

Cal Adj

Description

CAL ADJ is used to calibrate the power meter and any compatible power sensor to a known reference. During the calibration cycle, the gain of the power meter is adjusted so that the front panel display reads 1.000−3 (1 mW) when the sensor is connected to a 1.00 mW reference oscillator.

Pressing the (CAL ADJ) key enables entry of the reference calibration factor for the active entry channel. The reference calibration factor is the sensor's calibration factor at 50 MHz. The allowable range of values for CAL ADJ is 50.0 to 120.0%.

The power meter calibrates to an external reference source if the entered reference calibration factor is negative. If the entered reference calibration factor is positive, the power meter calibrates to the 1.00 mW internal reference oscillator.

Procedure

Connect the sensor to either channel A or channel B via a power sensor cable, and set the active entry channel accordingly. Press (ZERO). (Be sure that no RF power is applied to the sensor during the zero routine.) When the power meter has finished zeroing, connect the sensor to the 1.00 mW reference oscillator. Press (CAL ADJ). Enter the reference calibration factor in percent. Press (ENTER).

Both channels must be calibrated with their own sensors for dual sensor measurements.

Example

To calibrate a sensor to the power meter with a reference cal factor of 98.5%:

LOCAL (Keystrokes)	Function: (CAL ADJ) — Data: (RECALL) 9, (MNL FILTER) 8, SET B ( ), (AUTO RANGE) 5 — Enter: (dBm/WATT)
HP-IB (program codes)	CL98.5EN — Function: CL; Data: 98.5; Enter: EN

Program Codes

Parameter	Program Code
CAL ADJ	CL
ENTER	EN

Indications

After the (CAL ADJ) key has been pressed, the power meter will display "ENT _ _ _ _". Once the reference cal factor has been entered, the instrument goes through its calibration routine, and the display shows eight dashes and a moving decimal point.

Comments

The reference calibration factor, which is entered via CAL ADJ, is used only during calibration. Calibration factors entered via CAL FACTOR are used for actual measurements.

Zero the active entry channel before entering the reference calibration factor.

The reference calibration factor can be found on the body of the sensor.

A calibration should be performed whenever the power meter changes power sensors or whenever the ambient temperature changes by more than 5°C.

PRESET sets CAL ADJ to 100%. The gain of the power meter, however, does not change until a new calibration is performed.

Pressing (CAL ADJ) and then (ENTER) without entering any data causes the power meter to initiate a calibration using the last entered value for CAL ADJ.

Any command received during the calibration process aborts the calibration and executes the function of the command received. The number entered for CAL ADJ, however, is stored as the last entered value.

When using an older HP 8483A Power Sensor, enter a reference calibration factor of 96%, even though 100% may be indicated on the sensor's cal factor label. Using this CAL ADJ value compensates for mismatch between the 75-ohm sensor and the 50-ohm reference oscillator Newer HP 8483A Power Sensors have the correct reference cal factor (96%) or less printed on the label and should be used.

If an HP 8484A Power Sensor with its associated HP 11708A Reference Attenuator is used, the front panel display reads 1.000-6 instead of 1.000-3.

Offset settings are ignored during calibration.

Error 57 occurs when the instrument is turned on and the internal RAM contents have been lost. This is generally due to battery failure, but may also occur when the power meter is powered down during calibration or zeroing. The error is cleared after two seconds or by selecting any other function. Once the error is cleared, the power meter is configured to the PRESET state and the HP-IB address is read from the internal address switch.

Because of the variety of sensor power ranges, the power meter always auto ranges during calibration. After calibration the previous range setting is restored.

If the CAL ADJ entry is positive, the power meter first checks that the sensor is connected to the reference oscillator by turning the oscillator on and off and watching for a power level change on the sensor. If the sensor is connected, the reference oscillator is turned on for the calibration and returned to its former state upon completion of the calibration.

Related Section

CAL FACTOR
Error Messages
SET A and SET B
PRESET
ZERO

Cal Factor

Description

The calibration factor compensates for mismatch losses and effective efficiency over the frequency range of the power sensor.

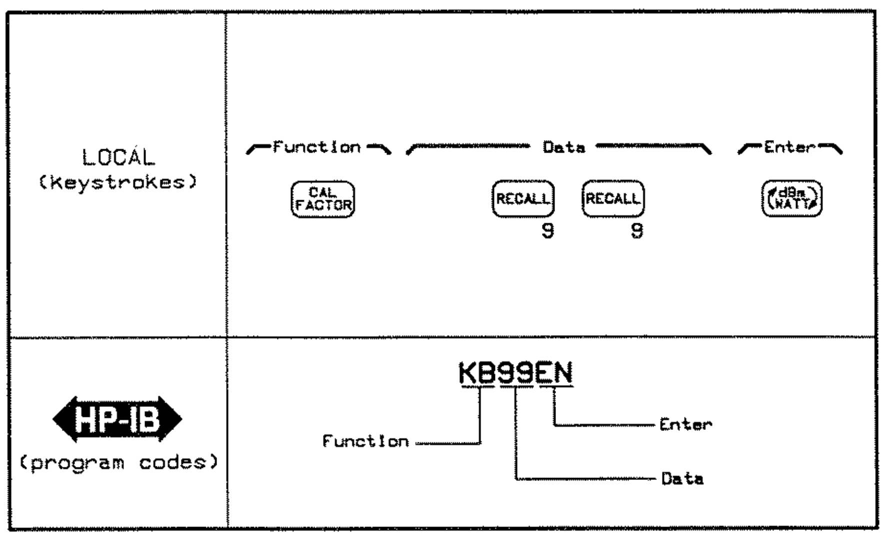
Pressing the (CAL FACTOR) key enables entry of the calibration factor for the sensor connected to the active entry channel. (A chart of CAL FACTOR % versus Frequency is printed on each sensor and an accompanying data sheet.) Calibration factor is entered in percent. Valid entries for CAL FACTOR range from 1.0 to 150.0%. Front panel numeric entry allows up to 4 digits. After the first four digits are entered, succeeding digits are ignored. Only one digit to the right of the decimal point is accepted. Data entered over the bus (in remote mode) is rounded to the required resolution.

Procedure

Cal factor is entered separately for sensor A or sensor B. To enter the cal factor for the active entry channel, press (CAL FACTOR), enter the cal factor in percent, and then press (ENTER).

Example

To enter a cal factor of 99%:



Program Codes

Parameter	Program Code
CAL FACTOR	KB
ENTER	EN

Indications

When the (CAL FACTOR) key is pressed, the front panel display shows "EHT_ _ _". After a number has been entered and the (ENTER) key has been pressed, the display returns to its previous mode.

The front panel displays the value of the calibration factor(s) used in the current measurement.

Comments

During actual measurements, calibration factors entered via CAL FACTOR are used. The reference calibration factor, which is entered via CAL ADJ, is used only during the calibration cycle.

Pressing (CAL FACTOR) and then (ENTER) without entering any data sets the calibration factor to 100%.

PRESET sets the calibration factor of both sensor A and sensor B to 100%.

Related Sections

CAL ADJ
PRESET
SET A and SET B
STORE and RECALL

dBm/WATT (Logarithmic/Linear Units)

Description

The (dBm/WATT) key can be used to express measurement results in logarithmic or linear units. The following table shows which units are applicable to the individual measurement modes.

Measurement Mode	REL Off[1]		REL on[1]	
	Lin	Log	Lin	Log
Single Sensor	Watt	dBm	%	dB
Ratio	%	dB	%	dB
Difference	Watt	dBm	%	dB

1 When REL (relative mode) is on, the measurement is compared to a reference value. The reference value is the first value read when REL is activated.

The (dBm/WATT) key allows any measurement result to be viewed in logarithmic or linear format.

Procedure

Pressing the (dBm/WATT) key alternates the display between the logarithmic and the linear functions. When the measurement mode is changed, the logarithmic or linear setting of the (dBm/WATT) key remains the same.

Example

If the power meter display reads 1.000 mW, to display this value in dBm:

LOCAL (Keystrokes)	(dBm/WATT)
HP-IB (program codes)	LG

Program Codes

Parameter	Program Code
Logarithmic Units (dBm or dB)	LG
Linear Units (Watts or %)	LN

Indications

The status of the (dBm/WATT) key can be determined by observing the current measurement mode, the measurement unit annunciators, and the table above.

Comments

Logarithmic units cannot be used with a measured value that is zero or negative. If the value is zero or negative, Error 27 (illegal logarithmic operation) will be displayed.

With REL mode off, logarithmic units cannot be used to display A−B difference measurements where the SENSOR A power level is less than the SENSOR B power level. Likewise (with REL mode off), logarithmic units cannot be used to display B-A difference measurements where the SENSOR B power level is less than the SENSOR A power level.

PRESET sets the measurement units to Watts (linear units).

With no power applied to the sensor, the displayed power in single sensor measurement mode dirfts both negative and positive (about zero). If the power meter is in logarithmic mode, negative drift results in a log error (Error 27). This is normal and does not require corrective action.

Related Sections

Error Messages
PRESET
REL (Relative Measurements)
SENSOR A−B and SENSOR B−A

Error Messages

Description

The power meter generates error messages to indicate operating problems, incorrect keyboard or HP-IB entries, and service related problems.

Error messages are grouped as follows:

Errors 01 through 49. These are measurement errors, which indicate that not all conditions have been met to assure a calibrated measurement. Measurement errors can usually be cleared by readjusting the front panel controls or changing the equipment setup.

Errors 60 through 59 and 90 through 99. These are entry errors, which indicate that an invalid keyboard or HP-IB entry has been made. These errors require that a new entry or function selection be made.

Errors 60 through 69. These are service errors, which provide service-related information. Service errors are discussed in section 8 of the manual.

Error Displays

Errors are indicated on the front panel. The left side of the display shows a brief message (eight characters or less) indicating the nature of the problem. The right side of the display indicates the error code. In addition, the channel on which the error occurs is indicated in the right side of the display for some errors.

HP-IB Output Format

As long as the front panel display indicates an error condition, the instrument sends 9.0000E+40 as the measured data when addressed to talk.

If an error condition generates SRQ, the status byte and status message latch the error until the status message (program code SM) has been read by the HP-IB controller. Once the status message has been read, the status byte and status message are cleared if the error condition no longer exists. If multiple errors occur, the status message indicates the most recent error.

If an error condition does not generate SRQ (for example, the Service Request Mask has been set such that measurement or entry errors do not set the status byte's RQS bit true), the status byte and status message latch all entry errors. Measurement errors, however, are latched only if 9.0000E+40 has been sent over the HP-IB. The status byte and status message are cleared by removing the cause of the error and then reading the status message over the HP-IB.

Error Messages

Table 3-8, Error Messages, describes all measurement and entry errors. The error code, front panel error display, message, and action typically required to remove the error causing condition are given.

Table 3-8. Error Messages

Error Code	Error Display	Message	Action Required
		Measurement Errors	
01	Cannot 0	Power meter cannot zero sensor A	Ensure that no RF power is being applied to sensor A.
02	Cannot 0	Power meter cannot zero sensor B	Ensure that no RF power is being applied to sensor B.
03	no rEF	Sensor A is not connected to reference oscillator during calibration	Connect sensor A to reference oscillator. Enter a negative reference cal factor if an external reference source is used. If error persists, check ouput of reference oscillator.
04	no rEF	Sensor B is not connected to reference oscillator during calibration	Connect sensor B to reference oscillator. Enter a negative reference cal factor if an external reference source is used. If error persists, check ouput of reference oscillator.
05	Cal-Err	Power meter cannot calibrate sensor A	Check sensor A connection to reference oscillator. Reference must be 1 mW.
06	Cal-Err	Power meter cannot calibrate sensor B	Check sensor B connection to reference oscillator. Reference must be 1 mW.
11	inPut-OL	Input overload on sensor A	Reduce input power to sensor A.[1]
12	inPut-OL	Input overload on sensor B	Reduce input power to sensor B.[1]
15	PLEASE 0	Sensor A's zero reference has drifted negative	Zero sensor A. If error persists, check input power.
16	PLEASE 0	Sensor B's zero reference has drifted negative	Zero sensor B. If error persists, check input power.
17	uP rng	Input power on sensor A is too high for current range	Select a higher range or reduce input power to sensor A.[2]
18	uP rng	Input power on sensor B is too high for current range	Select a higher range or reduce input power to sensor B.[2]
25	CALC OF	Overflow error	Change either the input power, offset, cal factor or measurement mode.[3]

1 This error occurs when the input power exceeds 120% of the full-scale power for range 5 and only when the power meter is on range 5.

2 This error occurs when the power meter is on manual range and the input power exceeds 120% of full-scale for ranges 1,2,3, and 4.

3 Power calculations result in a value that is too large to calculate or display. The combination of input power, offset, cal factor and measurement mode results in a value whose absolute value is greater than 3.4028E+38.

Table 3-8. Error Messages (continued)

Error Code	Error Display	Message	Action Required
Measurement Errors (continued)			
26	CALC UF	Underflow error	Change either the input power, offset, cal factor or measurement mode.[1]
27	LOf Err	Illegal logarithmic operation	Change to linear measurement units, zero the power meter with no RF input power, or increase input power to greater than 0 Watts.
28	rEL Err	Invalid or missing reference value	Exit REL mode.[2]
31	no Ch a	Channel A does not have a sensor connected to it	Connect a sensor to channel A or change channels (assuming a sensor is connected to channel B).
32	no Ch b	Channel B does not have a sensor connected to it	Connect a sensor to channel B or change channels (assuming a sensor is connected to channel A).
33	2 inPuts	Both front and rear sensor A inputs have sensors connected (Option 002 only)	Remove one of the 2 sensors connected to sensor A input.
34	2 inPuts	Both front and rear sensor B inputs have sensors connected (Option 002 only)	Remove one of the 2 sensors connected to sensor B input.

1 Power calculations result in a value that is too small to calculate or display. The combination of input power, offset, cal factor and measurement mode results in a value whose absolute value is greater than 1.1755E-38.

2 This error is cleared after two seconds or by selection of any other function.

Table 3-8. Error Messages (continued)

Error Code	Error Display	Message	Action Required
Entry Errors			
50	CF Error	Entered cal factor is out of range	Re-enter value between 1.0 and 150.0[1]
51	OS Error	Entered offset is out of range	Re-enter value between −99.99 and +99.99[1]
52	rg Error	Entered range number is out of range	Re-enter range number between 1 and 5[1]
53	FL Error	Entered filter number is out of range	Re-enter filter number between 0 and 9.[1]
54	rc Error	Entered recall register number is out of range	Re-enter register number between 0 and 19.[1]
55	st Error	Entered storage register number is out of range	Re-enter register number between 1 and 19[1]
56	rCF Err	Entered reference cal factor is out of range	Re-enter CAL ADJ value between 50.0 and 120.0[1]
57	rCL FaiL	Continuous memory failure	Refer to footnote below[2]
58	Ad Error	Entered HP-IB address is out of range	Re-enter HP-IB address between range 0–30, 40–49, or 50–59.[1]
90		HP-IB data without valid prefix	Check, then re-enter valid prefix with data.
91		Invalid HP-IB code	Check, then re-enter correct HP-IB code.
Hardware Errors			
61–69		Service-related errors	Refer to Service-Related Errors in section 8, "Service"

1 This error indication is cleared after two seconds or by selecting any function. (The selected function will be executed.) When the error is cleared, the parameter that caused the error remains unchanged from its previous value.

2 Error 57 occurs when the instrument is turned on and the internal RAM contents have been lost. This is generally due to battery failure, but may also occur when the power meter is powered down during the end of a zero or calibration sequence. The error indication is cleared after two seconds or by selecting another function. (The selected function will be executed). Once the error indication is cleared, the power meter is configured in the PRESET state and the HP- IB address is taken from the value defined on the internal address switch.

Note Hardware Errors NOT reported via SRQ.

Filters

(Includes AUTO FILTER and MNL Filter)

Description

The purpose of filtering is to reduce jitter in the display. Measured values are averaged iii with previous values before being displayed.

The power meter uses a variable digital filter to average power readings. The value shown in the display is the average of the last 2^N readings, where 2^N is the filter length and N is the filter number. The filter length can range from 1 (2^0) to 512 (2^9).

When a new power measurement is input to the filter, it is saved and the oldest reading is discarded. If the power meter's configuration changes such that the values in the filter are no longer valid (for example, a change in measurement mode, range or filter setting), the filter contents are set to zero. The filter starts filling up again, and the power meter displays the average of the accumulated power readings.

The filter length can be selected automatically (via AUTO FILTER) or manually (via MNL FILTER). For most applications, auto filter is the best mode of operation. Manual filter mode is useful mainly in specialized applications requiring high resolution or fast settling times.

In auto filter mode, the power meter automatically sets the filter length to satisfy the filtering requirements for most power measurements. The filter length depends solely upon the power range in which the power meter is currently operating. The following table lists the filter length and filter number for each range when the power meter is in auto filter mode.

Auto Filter Setting for Each Range		
Range	**Filter Length**	**Filter Number**
1	128	7
2	8	3
3	2	1
4	1	0
5	1	0

When the filtering is selected automatically, the resolution is four significant digits for measurements displayed in Watts or percent. The resolution is 0.01 dB for measurements displayed in dB or dBm.

In manual filter mode, the filter length is selected by entering a filter number between 0 and 9. Refer to the following table to cross-reference filter numbers to filter lengths.

Filter Number	Filter Length
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

Note The filter length is independent of the measurement power range when the filter length is set manually.

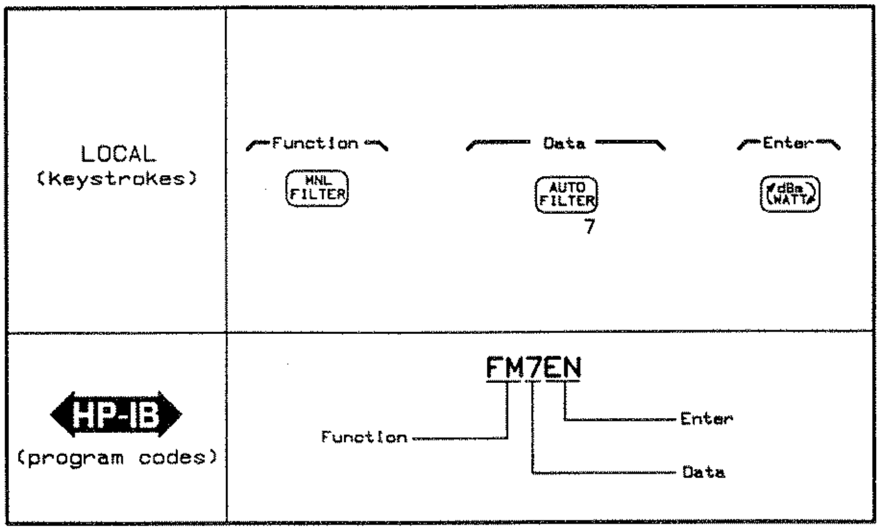
An additional feature of the power meter is the hold filter mode. Hold filter mode provides a means of switching from auto filter mode to manual filter mode while retaining the auto filter setting.

Procedure

The filter length is set for the active entry channel. For dual sensor measurements, the filter length should be set for each sensor. To automatically select the filter length, press (AUTO FILTER). To manually select the filter length, press (MNL FILTER), enter a number (0–9), and then press (ENTER). (The filter length is the result of 2 being raised to the power of the filter number.) To select hold filter mode, press (MNL FILTER) and then (ENTER).

Example

To manually set the filter length to 128 (filter number=7):



Program Codes

Parameter	Program Code
AUTO FILTER	FA
MNL FILTER	FM
Hold filter	FH
ENTER	EN

Indications

The MNL annunciator on the front panel display lights when the power meter is in manual filter or manual range mode. There is no front panel indication when the power meter is in auto filter mode.

Comments

By manually selecting a filter length that is significantly longer than the auto filter mode default length, the resolution of the display can be extended to five digits in Watts or to 0.001 in dBm on some power ranges. The range setting and filter number required for high resolution is defined in the following table.

Range	Filter Number Required for High Resolution
1	High resolution not available
2	8, 9
3	5, 6, 7, 8, 9
4	4, 5, 6, 7, 8, 9
5	3, 4, 5, 6, 7, 8, 9

In auto filter mode, the average of the last four values entered into the filter is compared to the average of the entire filter. If the difference between the two averages is greater than 12.5%, the contents of the digital filter are set to zero. The filter then starts storing new measurement values, and power meter displays the average of accumulated power readings. This feature shortens the settling time of the power meter when the input power changes substantially.

Only one digit is allowed for MNL FILTER data entries. If a second digit is entered, it replaces the one that is already there. The (.) (decimal point) and (±) keys are ignored.

PRESET sets both sensor A and sensor B to auto filter mode.

Related Sections

PRESET
Range
SET A and SET B
STORE and RECALL

Limits

Description

The limits checking function allows the power meter to monitor the power level on each sensor and to indicate when that power is outside preset limits. High and low limits can be set, and the limits checking function is enabled only via remote programming.

Limit values are entered in dBm and need not be the same for each sensor. Allowable values range from −299.999 to +299.999 dBm. Values entered outside this range cause the limit to be set to the minimum or maximum value as appropriate.

When the limits checking function is enabled, the power meter uses the last high and low limit values set for each sensor.

Procedure

To set a high limit or a low limit for the active entry channel:

a. Address the power meter to listen.

b. Send a program string (in a Data message) consisting of program code LL (limit low) or LH (limit high), a numeric value, and program code EN (ENTER).

To enable the limits checking function, address the power meter to listen and then send a Data message with program code LM1. The limits checking function is disabled by program code LM0.

Example

To set sensor A's low limit to +10 dBm and high limit to +20 dBm, and to enable the limits checking function:

LOCAL (keystrokes)	(not available in local)
HP-IB (program codes)	AELL10ENLH20ENLM1 AE: SET A LL10EN: Low Limit LH20EN: High Limit LM1: Enable Limits Checking

Program Codes

Parameter	Program Code
Low Limit	LL
High Limit	LH
Enable Limits Checking	LM1
Disable Limits checking	LM0

Indications

If the limits checking function is enabled and the input power exceeds the high limit or is less than the low limit, the out-of-limits condition is indicated on the front panel by a flashing A or B annunciator, depending on the measurement mode. The out-of-limits condition is indicated only for sensors used in the current measurement. For dual sensor measurements, the out-of-limits condition is indicated for the sensor(s) out of limits.

The out-of-limits condition can be indicated over the bus by setting the Service Request Mask to enable an out-of-limits condition to issue the Require Service Message, thus lighting the SRQ annunciator on the front panel.

Comments

PRESET sets both the high and low limits for each sensor to 0.000 dBm and disables the limits checking function.

Limits are checked against measured power plus offsets.

By setting the low limit to a value greater than the high limit (or setting the high limit to a value less than the low limit), a region can be defined. An out-of-limits condition occurs anytime displayed power drifts into this region (assuming the limits checking function is enabled).

If the limits checking function is enabled in remote mode and then the Power Meter is switched to local operation, the limits checking function remains enabled.

High and low limits cannot be stored or recalled.

Related Sections

PRESET
Remote Operation, HP-IB
SET A and SET B
STORE and RECALL

Offset

Description

Offset values can be entered to each channel to compensate for gain or loss. The offset is added to the measured power before the result is displayed.

Offsets are entered in dB. The allowable range of values is −99.99 to +99.99dB in 0.01dB increments. Use positive values for gain and negative values for loss. Pressing the (OFFSET) key and then the (ENTER) key (without entering any data) sets the offset of the active entry channel to 0.00dB.

The display offset function provides another method for entering offset values. Pressing (OFFSET), (DSP → OFS), and then (ENTER) automatically enters the offset necessary for the power meter's display to indicate 0.00 dB or dBm for logarithmic units, or 100% or 1.00 mW for linear units, depending on the measurement mode. Existing offsets are taken into account in the calculation of the display offset value.

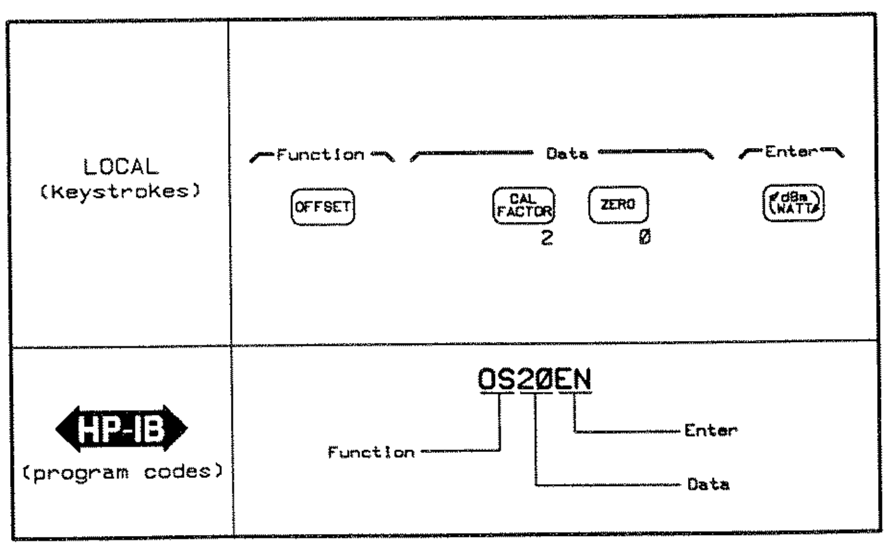
Procedure

To enter an offset for the active entry channel, press (OFFSET), enter a value between −99.99 and +99.99dB and then press (ENTER).

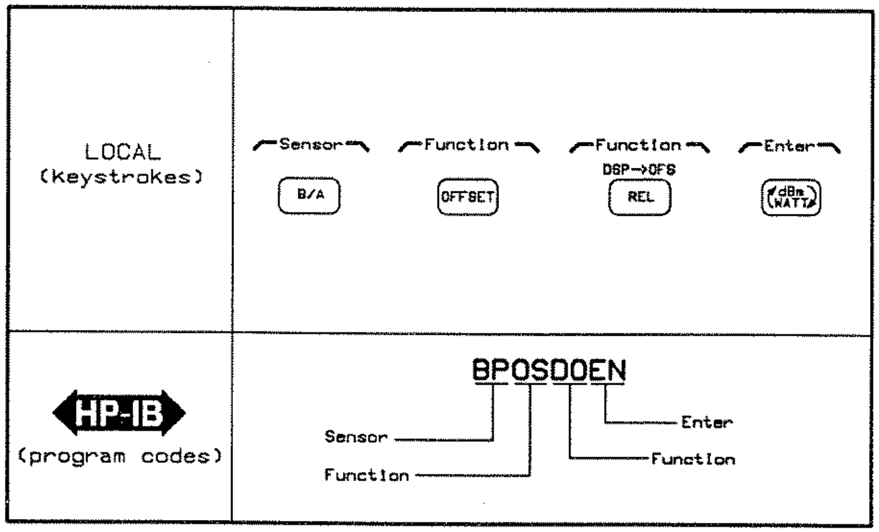
To enter the offset necessary for the power meter to display 0.00dB or dBm, 100%, or 1.00 mW (depending on the measurement mode), press (OFFSET), (DSP→OFS), and then (ENTER).

Examples

To add a 20dB offset to channel B (assuming that channel B is the active entry channel):



The next example uses the display offset function to compensate for the coupling factor of a directional coupler. Connect sensor A to the coupler's test port, and connect sensor B to the coupler's incident port. To enter the correct offset for sensor B to read the power emerging from the directional coupler (correcting for any main line insertion loss as well as coupling factor):



Program Codes

Parameter	Program Code
OFFSET	OS
Display Offset	DO
ENTER	EN

Indications

When an offset is added to a measurement, the front panel displays the value of the offset and the "dBOS" annunciator lights.

Comments

A dB offset can be added to a sensor whose display is in Watts. The power meter automatically converts the dB offset to Watts and adds that value to the sensor's measured power.

The following equations are used to calculate the value that is entered for the display offset function.

For measurement modes A−B or A/B:

Display Offset of active entry channel =

a. Current OFFSET (active entry channel)
$- 10 * \mathrm{LOG} \left[\frac{Power(B)+OFFSET(B)}{Power(A)+OFFSET(A)}\right].$

b. Current OFFSET (active entry channel)
$+ 10 * \mathrm{LOG} \left[\frac{Power(B)+OFFSET(B)}{Power(A)+OFFSET(A)}\right].$

c. Current OFFSET (active entry channel)
− 10 ∗ LOG [Power (active entry channel)].

If the display OFFSET value as calculated above results in an illegal OFFSET entry value, the number 999.9 will be displayed. The power meter generates Error 51 (OFFSET entry error) if an attempt to enter the illegal value is made.

Display offset function ignores REL mode when calculating the offset value.

PRESET sets both the sensor A and sensor B offset values to 0.00dB.

The DSP→OFS function is only active when it is preceeded by OFFSET.

Related Sections

dBm/WATT (Logarithmic/Linear Units)
Error Messages
PRESET
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

Preset

Description

The (PRESET) key sets the power meter to a known state. Preset conditions are shown in Table 3-9.

Table 3-9. PRESET Conditions

Parameter	Condition
Sensor A and B	
CAL ADJ	100.0%
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Measurement Mode	Sensor A
Reference Oscillator (OSC)	Off
Active Entry Channel	A
Measurement Units	Watts
REL	Off
Remote Only Functions	
Sensors A and B	
Low Limit	0.000 dBm
High Limit	0.000 dBm
Limits checking	Disabled
Trigger Mode	Free Run
Group Trigger Mode	Trigger with Delay
Display Function	Display Enable

Procedure

To set the power meter to the conditions indicated in Table 3-9, press the (PRESET) key.

Program Codes

The program code for PRESET is PR.

Comments

PRESET does not affect zero and calibration information stored for each sensor. Although PRESET sets the CAL ADJ value to 100.0%, it does not initiate a calibration using the new value for CAL ADJ.

PRESET produces the same results as the Device Clear command over the HP-IB.

Storage register 0 is set to the preset condition when a continuous memory error (Error 57) occurs.

Related Sections

CAL ADJ
CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
Range
REL (Relative Measurements)
STORE and RECALL

Range

(Includes AUTO RANGE and MNL RANGE)

Description

The power meter divides each sensor's power range into 5 ranges of 10dB each. Range 1 is the most sensitive (lowest power levels), and Range 5 is the least sensitive (highest power levels). Range 5 can be less than 10 dB if the sensor's power range is less than 50 dB. The range can be set either automatically or manually for the active entry channel.

AUTO RANGE automatically selects the correct range for the current measurement.

MNL RANGE enables the range to be selected manually. Valid range numbers are 1 through 5. Only one digit is permitted for range entries. If a second digit is entered, it replaces the first digit.

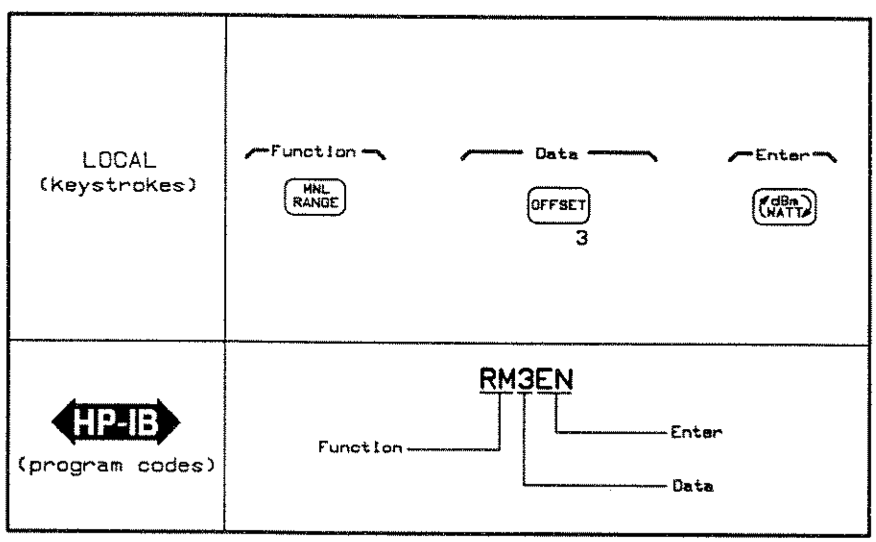
Another feature of the power meter is the hold range mode. Hold range provides a means of switching from auto range to manual range while retaining the current auto range setting.

Procedure

To select auto range, press (AUTO RANGE). To select manual range, press (MNL RANGE), enter a numeric value and then press (ENTER). To select hold range mode, press the (MNL RANGE) key and then the (ENTER) key.

Example

To select range 3 manually:



Program Codes

Parameter	Program Code
AUTO RANGE	RA
MNL RANGE	RM
Hold Range	RH
ENTER	EN

Indications

The MNL annunciator on the front panel display lights when the power meter is in manual or hold range mode, or manual or hold filter mode. There is no front panel indication when the power meter is auto ranging.

Comments

PRESET sets both sensor A and sensor B to AUTO RANGE.

If you are only interested in power readings in one range, manual range can be used for faster readings.

Use manual range when using the rear panel RCDR output so that the power meter does not change ranges while outputting data. The recorder output provides a 0 to 1 Vdc output for each range.

Pressing the (AUTO RANGE) key when the power meter is already in auto range mode causes the instrument to step down one range, if possible. (There is a 20% overlap on ranges.) If the power reading can be displayed on either range, the power meter stays on the lower range. In linear mode, this provides a means for down ranging to obtain greater resolution in borderline situations. For example, with an HP 8481A power sensor measuring a power level of 1.153 mW, the range could be either range 4 (1 to 10 mW) or range 3 (0.1 to 1.2 mW with 20% overrange). The display in range 4 would read 1.15 mW, but in range 3 would read 1.153 mW.

Related Sections

Error Messages
PRESET
Recorder Output
SET A and SET B

Recorder Output

Description

The rear panel RCDR output produces a dc voltage that corresponds to the power level in Watts of sensor A or sensor B, depending on the measurement mode. Only single sensor power measurements produce a valid dc output voltage at the RCDR output. The RCDR output is disabled (OV) during dual sensor and relative measurements. This dc voltage ranges from 0 to +1.0 Vdc. For each of the Power Meter's five ranges, +1.0 Vdc corresponds to a full-scale indication. The output impedance is 1 kõ.

Some uses of the RCDR output include recording swept measurements on an X-Y recorder, leveling input for external ALC, or monitoring output power on a strip chart recorder. A setup for recording swept measurements is shown in Figure 3-7.

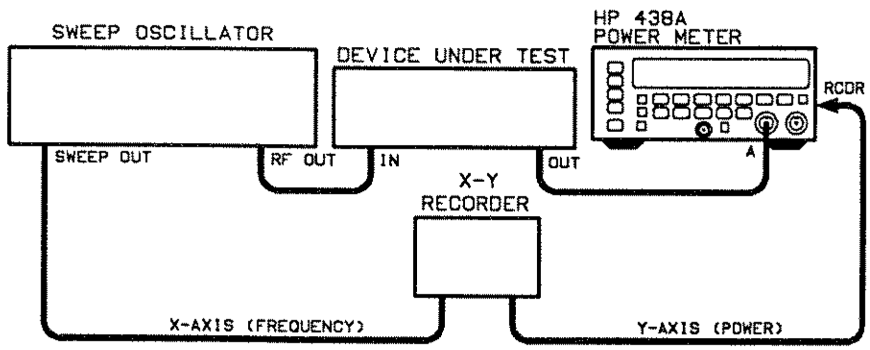


Figure 3-7. Test Setup For Recording Swept Measurements

Comments

Cal factor and offsets have no effect on the recorder output.

The most stable results are obtained on ranges 3, 4, and 5.

Use MNL RANGE when using the RCDR output to prevent the power meter from changing ranges while outputting data.

Related Sections

Range
REL (Relative Measurements)
SENSOR A and SENSOR B

Rel

(Relative Measurements)

Description

Relative mode permits any measurement result to be compared in dB or % to a reference value. Pressing the REL key enters or exits relative mode. Once relative mode has been entered, the first reading is saved as a reference value. Successive measurements are displayed relative to the reference value.

If a new measurement mode is selected while relative mode is enabled, REL is disabled and the reference value is lost.

Procedure

Press (REL) to toggle in and out of relative mode.

Press (dBm/WATT) to alternate between dB and percent.

Example

To enter relative mode and make relative measurements (assuming that the Power Meter is not in relative mode):

LOCAL (keystrokes)	(REL)
HP-IB (program codes)	RL1

Program Codes

Parameter	Program Code
Enter REL Mode	RL1
Exit REL Mode	RL0

Indications

When the power meter is displaying a relative measurement, the REL annunciator on the front panel display lights. The displayed value is the measurement result relative to the reference in dB or %.

Comments

Relative measurements cannot be output via the rear panel RCDR output.

If the reference is zero or negative power, the measurement result can be displayed in dB as long as the measured power does not change signs (that is, positive to negative or vice versa) while REL mode is on. If the measured power does change signs while displaying dB in REL mode, Error 27 (illegal logarithmic operation) occurs.

If a negative reference is used, the ratio indication (%) will be displayed in absolute value.

The reference value is stored if the power meter is in REL mode when the instrument configuration is saved.

The reference value, once set, cannot be read.

Related Sections

dBm/WATT (Logarithmic/Linear Measurement Units)
SENSOR A and SENSOR B
SENSOR A−B and SENSOR B−A
SENSOR A/B and SENSOR B/A
STORE and RECALL

Sensor A and Sensor B

(Single Sensor Measurements)

Description

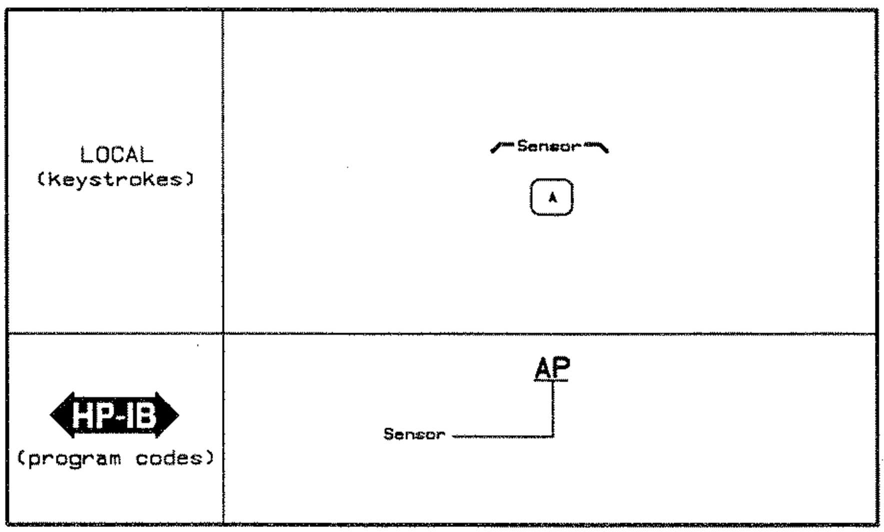
SENSOR A and SENSOR B cause the power meter to make single sensor measurements. Absolute power is displayed for the selected sensor in either dBm or Watts. In addition, SENSOR A sets the active entry channel to A, and SENSOR B sets the active entry channel to B.

Procedure

To select a single sensor measurement mode, press (SENSOR A) or (SENSOR B).

Example

To select SENSOR A as the measurement mode:



Program Codes

Parameter	Program Code
SENSOR A	AP
SENSOR B	BP

Indications

The middle block of annunciators on the front panel display indicate the measurement mode and the measurement units. The cal factor and offset (if any) for the selected sensor are also indicated in the front panel display.

Comments

Filter, range, offset, cal factor, and limits can be set for the selected sensor.

PRESET sets the measurement mode to SENSOR A.

Single sensor measurements can be displayed relative to a stored reference. In REL mode readings are dislayed in either dB or percent.

Changing the measurement mode causes the contents of the digital filter to be discarded.

Related Sections

CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Filters
OFFSET
PRESET
Range
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

Sensor A−B and Sensor B−A

(Dual Sensor Difference Measurements)

Description

SENSOR A−B and SENSOR B−A cause the power meter to make dual sensor difference measurements. The power meter displays the numerical difference of the power values of both sensors. The power values for sensors A and B include all offsets and cal factors that have been set for each individual channel. Measurement results are displayed in either dBm or Watts. In addition, A−B sets A as the active entry channel, and B−A sets B as the active entry channel.

Procedure

To make a difference measurement, press the (SHIFT) key and then select A−B or B−A, as desired.

Example

To select B−A measurement mode:

LOCAL (Keystrokes)	(SHIFT) (B)
HP-IB (program codes)	BD (Sensor)

Program Codes

Parameter	Program Code
SENSOR A−B	AD
SENSOR B− A	BD

Indications

The middle block of annunciators on the front panel display indicate the measurement mode (either A–B or B–A) and the measurement units (either dBm or Watts).

Comments

Cal factor, offset, range, limits, and filter are set separately for each sensor.

Logarithmic units (dBm) cannot be used in A–B difference measurements where the sensor A power level is less than the sensor B power level. Likewise, logarithmic units cannot be used in B–A difference measurements where the sensor B power level is less than the sensor A power level.

Difference measurements can be displayed relative to a stored reference. In REL mode, readings are displayed in either dB or percent,

Changing the measurement mode causes the contents of the digital filter to be discarded. The filter buffer then starts filling up with values from the new measurement mode. The power meter displays the average of the accumulated readings.

Related Sections

Cal Factor
dBm/Watt (Logarithmic/Linear Measurement Units)
Filters
Limits
OFFSET PRESET
PRESET
Range
REL (Relative Measurements)
SET A and SET B
STORE and RECALL

Sensor A/B and Sensor B/A

(Dual Sensor Ratio Measurements)

Description

SENSOR A/B and SENSOR B/A cause the power meter to make dual sensor ratio measurements. The power meter displays the ratio of the sensors' power values in either dB or percent. The power value of each sensor includes offsets and cal factors in addition to measured power. Also, A/B sets A as the active entry channel, and B/A sets B as the active entry channel.

Procedure

To make B/A ratio measurements, press (B/A). To make A/B ratio measurements, press the (SHIFT) key and then (B/A).

Example

To make B/A ratio measurements:

LOCAL (keystrokes)	(B/A)
HP-IB (program codes)	BR (Sensor)

Program Codes

Parameter	Program Code
SENSOR A/B	AR
SENSOR B/A	BR

Indications

The middle block of annunciators on the front panel display indicate the measurement mode (A/B or B/A) and the measurement units (dB or %).

Comments

Cal factor, range, filter, limits, and offset are set separately for each sensor.

Ratio measurements can be displayed relative to a stored reference. In REL mode, readings are displayed in either dB or percent.

Changing the measurement mode causes the contents of the digital filter to be discarded. The filter buffer then starts filling up with values from the new measurement mode. The power meter displays the average of the accumulated readings.

Ratios where the denominator is equal to zero cause Error 27 (log error) to be displayed.

Logarithmic measurement units (dB) cannot be used if the ratio is negative. To do so would cause Error 27 (log error) to be displayed.

Related Sections

CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
Range
REL
SET A and SET B
STORE and RECALL

Set A and Set B

Description

SET A and SET B are used to select the channel on which measurement parameter changes are to be made. Measurement parameters consist of the following:

Cal Adj (reference calibration factor)
Cal Factor
Filters
Limits
Offset
Range
Zero

SET A and SET B allow measurement parameters to be set for one channel while working in any measurement mode.

Selecting measurement mode SENSOR A, A−B, or A/B automatically sets the active entry channel to channel A. Selecting measurement mode SENSOR B, B−A, or B/A automatically sets the active entry channel to channel B.

Procedure

To select the active entry channel, press (SET A) for channel A or (SET B) for channel B.

Example

To designate channel B as the active entry channel:

LOCAL (keystrokes)	SET B ▢
HP-IB (program codes)	BE

Program Codes

Parameter	Program Code
SET A	AE
SET B	BE

Indications

When a measurement parameter is being entered, an annunciator on the right side of the display lights to indicate the active entry channel.

Comments

PRESET sets the active entry channel to A.

Related Sections

CAL ADJ
Cal Factor
Filters
Limits
OFFSET
PRESET
Range
SENSOR A and SENSOR B
SENSOR A–B and SENSOR B–A
SENSOR A/B and SENSOR B/A

Store and Recall

Description

The power meter can store instrument configurations for recall at a later time. The following information can be stored in the power meter's internal registers:

- Measurement Mode
- REL mode status (on or off)
- Reference value if in REL mode
- Reference Oscillator status (on or off)
- Active entry channel (A or B)
- Measurement units (logarithmic or linear)
- Cal factor for each sensor
- Offset for each sensor
- Range for each sensor
- Filter for each sensor
- Cal Adj value for each sensor

Registers 1 through 19 are available for storing instrument configurations. Registers 0 through 19 are available for recall. Register 0 always contains the previous power meter configuration. Thus, RECALL 0 provides a way to recover from an entry error.

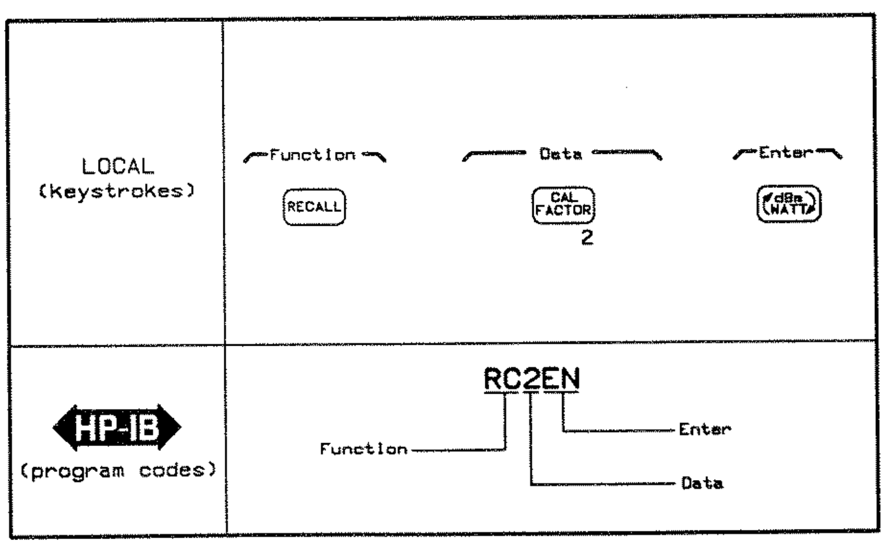
Procedure

To store an instrument configuration, press (STORE), enter a number from 1 to 19, and then press (ENTER).

To recall an instrument configuration, press (RECALL), enter a number from 0 to 19, and then press (ENTER).

Example

To recall an instrument configuration that has been stored in register 2:



Program Codes

Parameter	Program Code
RECALL	RC
STORE	ST
ENTER	EN

Indications

When the stored contents of a register are recalled, the power meter changes to the recalled parameter values.

The power meter executes a RECALL 0 at power-up. This places the power meter in the same state that it was in when power was removed.

The Cal Adj value (reference calibration factor) for each sensor can be stored and recalled but the internal calibration settings are not stored.

PRESET has no effect on the storage registers 1 through 19. Register 0, however, is set to the PRESET conditions when the (PRESET) key is pressed.

Storage register 0 is set to the PRESET state when a continuous memory error (Error 57) occurs.

High and low limits cannot be stored.

Related Sections

CAL ADJ
CAL FACTOR
dBm/WATT (Logarithmic/Linear Units)
Error Messages
Filters
Limits
OFFSET
PRESET
Range
REL (Relative Measurements)
SET A and SET B

Zero

Description

ZERO is used to adjust the power meter's internal circuitry for a 0 power indication when no power is applied to the sensor. Pressing the (ZERO) key automatically zeroes all five of the power meter's ranges. For dual sensor measurements, each channel of the power meter must be zeroed separately.

Note

Be sure that no power is applied to the sensor while the power meter is zeroing. Any applied RF input power introduces an offset that affects all subsequent measurements.

Procedure

To zero the power meter to the sensor connected to the active entry channel, press (ZERO).

Example

To zero the power meter:

LOCAL (keystrokes)	(ZERO)
HP-IB (program codes)	ZE

Program Codes

Parameter	Program Code
ZERO	ZE

Indications

The power meter display shows eight dashes and a moving decimal point while zeroing. When the zeroing is completed, new zero values are stored and the instrument is returned to its previous state.

Comments

Zero the power meter before entering the reference calibration factor.

The power meter's internal reference oscillator automatically turns off during zeroing. If the reference oscillator was on before the zeroing was initiated it will be returned to the on state when zeroing is completed.

To determine whether or not the power meter needs to be zeroed, remove any power to the sensor and then read the front panel display. If the display does not indicate 0 power, the power meter needs to be zeroed. Any residual nonzero reading, if not corrected, will be added to all subsequent measurements, resulting in an error. This error may be insignificant when measuring moderate to high power values, but it can be unacceptable when measuring low power values.

Error 57 (recall fail) occurs when the power meter is turned on and the internal RAM contents have been lost. This is generally due to battery failure but may also occur when the instrument is powered down while zeroing.

For best accuracy, HP 8484A Power Sensors should be connected to a device with the RF power off before zeroing.

Zeroing data cannot be stored and recalled, but it is remembered when the instrument is turned off.

PLEASE 0 (Error 15 or 16, sensor dependent) is displayed when the zero reference drifts negative.

Related Sections

CAL ADJ
Error Messages
Range
STORE and RECALL

Performance Tests

4-1. Introduction

The procedures in this section test the instrument's electrical performance using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in section 3 under "Basic Functional Checks".

Note

If the performance tests are to be considered valid, the following conditions must be met:

a. The power meter must have a 1 hour warm-up for all specifications.

b. The line voltage for all instruments must be 100, 120, 220, or 240 Vac +5%, −10%; and the line frequency must be 48 to 66 Hz. The power meter has the additional capability of operating on line frequencies of 360 to 440 Hz, but the line voltage is limited to a nominal 100 or 120 Vac.

c. The ambient temperature must be 0°C to 55°C.

4-2. Equipment Required

Equipment required for the performance tests is listed in Table 1-3, "Recommended Test Equipment". Any equipment that satisfies the critical specifications given in the table may be substituted.

4-3. Performance Test Record

Results of the performance test may be tabulated in Table 4-1, Performance Test Record. The Performance Test Record lists all of the performance test specifications and the acceptable limits for each specification. If performance test results are recorded during an incoming inspection of the instrument, they can be used for comparison during periodic maintenance or troubleshooting procedures. The test results may also prove useful in verifying proper adjustments after repairs are made.

4-4. Performance Tests

The performance tests given in this section are suitable for incoming inspection, troubleshooting, or preventive maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify published instrument specifications. Perform the tests in the order given and record the data on the test card and/or in the data spaces provided at the end of each procedure.

4-5. Calibration Cycle

This instrument requires periodic verification of performance to ensure that it is operating within specified tolerances. The performance tests described in this section should be performed at least once each year; under conditions of heavy usage or severe operating environments, the tests should be more frequent. Adjustments that may be required are described in section 5, "Adjustments".

4-6. Abbreviated Performance Test

Refer to section 3, "Operation", for a Basic Functional Checks test.

4-7. Test Procedures

It is assumed that the person performing the following tests understands how to operate the specified test equipment. Equipment settings, other than those for the power meter, are stated in general terms. It is also assumed that the technician will select the power sensor, cables, adapters and probes required for test setups illustrated in this section.

4-8. Zero Carryover Test

Specification

Electrical Characteristics	Performance Limits	Conditions
Accuracy: Zero set (Digital settability of zero)	±0.5% full scale	Most sensitive range.Decrease percentage by factor of 10 for each higher range ±1 count.

Description

After the power meter is initially zeroed, the change in the digital readout is monitored as the power meter is stepped through its ranges. This test also takes drift and noise into account, since drift, noise and zero carryover readings cannot be separated.

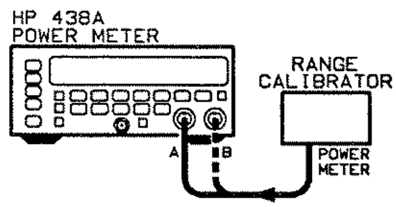


Figure 4-1. Zero Carryover Test Setup

Equipment

Range .... HP 11683A
Power Sensor .... HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-1.
2. Set the power meter controls as follows:

   LINE .... ON
   PRESS .... PRESET

3. Set the range calibrator switches as follows:

   FUNCTION .... STANDBY
   LINE .... ON

4. Press the power meter's [ZERO] switch and wait (approximately 15 to 17 seconds) for the display to reappear and stabilize. Verify that the reading is 0.00 ±0.06.

Note The power meter is now zeroed on range 1 (most sensitive).

5. Press (MNL RANGE), 1, (ENTER).
6. After the power meter reading has stabilized, verify that the indication is within the limits shown.

Power Meter Range	Min	Actual Results A	Actual Results B	Max
1	−0.06 μW	________	________	0.06 μW
2	−0.1 μW	________	________	0.1 μW
3	−0.001 mW	________	________	0.001 mW
4	−0.01 mW	________	________	0.01 mW
5	−0.1 mW	________	________	0.1 mW

7. Repeat steps 5 and 6 by entering 2, then 3, then 4, and 5.
8. Repeat steps 2 through 7 for Channel B by pressing (B) in step 2.
9. Repeat steps 2 through 7 for Channel A and B when rear panel Option 002 inputs are installed.

4-9. Instrument Accuracy Test

Specification

Electrical Characteristics	Performance Limits	Conditions
Accuracy:		
Instrumentation, includes sensor linearity.[1]		
Single channel mode	±0.2%	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode (Ratio or difference)	Multiply single channel specification by 2	

1 When operating in range 5 add the corresponding sensor power linearity percentage.

Description

After the power meter is initially calibrated on the 1 mW range, the readout is monitored as the range calibrator is switched to provide reference inputs corresponding to each of the power meter operating ranges.

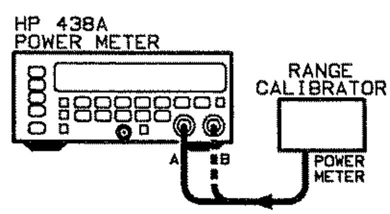


Figure 4-2. Instrument Accuracy Test Setup

Equipment

Range Calibrator .... HP 11683A
Power Sensor Cable .... HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-2.
2. Set the power meter controls as follows:

   LINE .... ON
   SENSOR .... A
   PRESS .... PRESET

3. Set the range calibrator switches as follows:

   FUNCTION .... STANDBY
   POLARITY .... NORMAL
   RANGE .... 1 mW
   LINE .... ON

4. Press the power meter (ZERO) key, and wait for the readout to reappear. Verify that the reading is 0.00 ±0.06 μW.
5. Set the range calibrator FUNCTION switch to CALIBRATE.
6. Press the power meter (CAL ADJ) key, then press the (±) key to get a minus (−) sign, then press 100, (ENTER). The minus sign indicates use of an external reference source. If the minus sign is not used there will be a NO REF error on the display.
7. Verify that the power meter display reads 1.000 ±0.006 mW.

Note

The range calibrator output level is adjustable in 5dB increments. Thus, the 3 μW, 30 μW, 300 μW, 3 mW, and 30 mW legends on the RANGE switch are approximations. The true values for these settings are 3.16, 31.6, and 316 μW, 3.16 mW and 31.6 mW. It may be necessary to re-zero the meter before each measurement.

8. Set the range calibrator RANGE switch to the positions shown in the following table. For each setting, verify that the power meter autoranges properly, and that the display is within the limits shown.
9. Set the range calibrator RANGE switch to STANDBY. Connect the calibrator to channel B.
10. Press the power meter channel (k) and repeat steps 4 through 6 to test channel B.
11. Set the power meter dBm/WATT switch to the dBm position and verify that the display changes to the dBm mode, and that the indication is within 20.00 ±0.04 dBm.

    19.96 dBm__________20.04 dBm

12. Set the range calibrator RANGE switch to −10 dBm.
13. Verify that the power meter displays −10.00 ±0.04 dBm.

    −9.96 dBm__________−10.04 dBm

14. Press the power meter (REL) key and verify that the display indicates 0.00 ±0.01dB.

Range Calibrator Setting	Min	Actual Results	Max
3 μW	3.13 μW	________	3.19 μW
10 μW	9.90 μW	________	10.10 μW
30 μW	31.3 μW	________	31.9 μW
100 μW	99.0 μW	________	101.0 μW
300 μW	0.314 mW	________	0.318 mW
1 mW	0.995 mW	________	1.005 mW
3 mW	3.13 mW	________	3.19 mW
10 mW	9.90 mW	________	10.10 mW
30 mW	31.3 mW	________	31.9 mW
100 mW	99.0 mW	________	101.0 mW

Note

It is not necessary to check instrument accuracy in dBm. The power meter uses the same internal circuitry to measure power and mathematically converts watts to dBm.

4-10. Power Reference Level Test

Specification

Electrical Characteristics	Performance Limits	Characteristics
Power reference	1.0 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards.
Power reference	±1.2%	Worst case.
Accuracy	±0.9%	RSS for one year.

Description

The power reference oscillator output is factory adjusted to 1 mW ±0.7%. To achieve this accuracy, Hewlett-Packard employs a special measurement system accurate to 0.5% (traceable to the National Bureau of Standards) and allows for a transfer error of ±0.2% in making the adjustment. If an equivalent measurement system is employed for verification, the power reference oscillator output can be verified to 1 mW ±1.9% (±1.2% accuracy plus ±0.5% verification system error plus ±0.2% transfer error=1.9% maximum error).
The power reference oscillator can be set to ±0.7% using the same equipment and following the adjustment procedure. To ensure maximum accuracy in verifying the power reference oscillator output, the following procedure provides step by step instructions for using specified Hewlett-Packard test instruments of known capability. If equivalent test instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the instruments.

Note

The power meter may be returned to the nearest Hewlett-Packard office to have the power reference oscillator checked and/or adjusted. Refer to section 2, "Packaging".

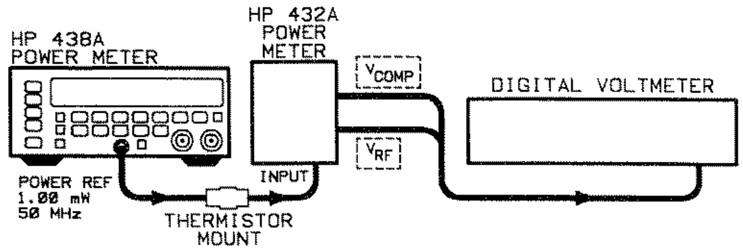


Figure 4-3. Power Reference Level Test Setup

Equipment

Test Power Meter .... HP 432A
Thermistor Mount .... HP 478A Option H75/H76
Digital Voltmeter (DVM) .... HP 3456A

Procedure

1. Set the DVM to measure resistance. Connect the DVM between the Vrf connector on the rear panel of the test power meter, and pin 1 on the thermistor mount end of the test power meter interconnect cable.
2. Round the DVM reading to two decimal places. Record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

R__________

3. Connect the test power meter to the power meter as shown in Figure 4-3.
4. Set the power meter LINE switch to ON and the OSC switch off (LED off).

Note

Wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.

5. Set the test power meter RANGE switch to Coarse Zero and adjust the front panel Coarse Zero control to obtain a zero meter indication.
6. Fine Zero the test power meter on the most sensitive range, then set the test power meter RANGE switch to 1 mW.

Note

Ensure that DVM input leads are isolated from chassis ground when performing the next step.

7. Set the DVM to measure microvolts. Connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.

8. Observe the reading on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter Fine Zero switch and adjust the Coarse Zero control so that the DVM indicates 200 microvolts or less. Then release the Fine Zero switch and proceed to the next step.

9. Round the DVM reading to the nearest microvolt. Record this value as V0.

V0____________

10. Set the power meter OSC switch to ON (LED on). Record the reading observed on the DVM as V1.

V1____________

11. Disconnect the DVM negative input lead from the Vrf connector on the test power meter. Reconnect it to test power meter chassis ground.

   Observe the DVM reading. Record the reading as Vcomp.

V comp____________

12. Calculate the power reference oscillator output level (Prf) from the following formula:

$$\frac{Prf = 2V_{comp}(V_1 - V_0) + V_0^2 - V_1^2}{4R(Calibration Factor)}$$

   Where:
   Prf=power reference oscillator output level
   Vcomp=previously recorded value
   V1=previously recorded value
   V0=previously recorded value
   R=previously recorded value
   Calibration Factor=value for thermistor mount at 50 MHz (traceable to the National Bureau of Standards).

13. Verify that Prf is within the limits shown in the following table. Record the reading.

Min	Actual	Max
0.981 mW	____________	1.019 mW

Table 4-1. Performance Test Record

Hewlett-Packard Company

Tested by ______________________

Model HP 438A
Power Meter

Serial Number ______________________ Date ______________________

Paragraph Number	Test	Minimum Result	Actual Result	Maximum Result
4-8.	**Zero Carryover**			
	Power Meter Range			
	1	−0.06 μW	______	0.06 μW
	2	−0.1 μW	______	0.1 μW
	3	−0.001mW	______	0.001 mW
	4	−0.01 mW	______	0.01 mW
	5	−0.1 mW	______	0.1 mW
4-9.	**Instrument Accuracy**			
	Watt Mode			
	3 μW	3.13 μW	______	3.19 μW
	10 μW	9.90 μW	______	10.10 μW
	30 μW	31.3 μW	______	31.9 μW
	100 μW	99.0 μW	______	101.0 μW
	300 μW	0.313 mW	______	0.319 mW
	1 mW	0.995 mW	______	1.005 mW
	3 mW	3.13 mW	______	3.19 mW
	10 mW	9.90 mW	______	10.10 mW
	30 mW	31.3 mW	______	31.9 mW
	100 mW	99.0 mW	______	101.0 mW
	dBm Mode			
	20 dBm	19.96 dBm	______	20.04 dBm
	−10 dBm	−9.96 dBm	______	−10.04 dBm
	Rel Mode	−0.01 dBm	______	+0.01 dBm
4-10.	**Power Reference**			
	Prf	0.981 mW	______	1.019 mW

5

Adjustments

5-1. Introduction

This section contains adjustments and checks that ensure proper performance of the power meter. Adjustments are not required on any fixed periodic basis, and normally are performed only after a performance test has indicated that some parameters are out of specification. Performance tests should be completed after any repairs that may have altered the characteristics of the instrument. The test results will make it possible to determine whether or not adjustments are required. Allow 60 minutes for the power meter to warm up, and then remove the top and bottom covers, also loosen the screws holding the A3 CPU Assembly and A5 Main Amplifier Assembly for access to the test and adjustment points.

To determine which performance tests and adjustments to perform after a repair, refer to paragraph "5-6. Post-Repair Adjustments".

5-2. Safety Considerations

This section contains a warning that must be followed for your protection and to avoid damage to the equipment being used.

Warning

Adjustments described in this section are performed with power applied to the instrument and with protective covers removed. Maintenance should be performed only by trained personnel who are aware of the hazards involved. When the maintenance procedure can be performed without power, the power should be removed.

5-3. Equipment Required

Most of the adjustment procedures include a list of recommended test equipment, and the test equipment is also identified on the test setup diagrams. If substitutions must be made, the equipment used must meet the critical specification listed in Table 1-3 in section 1.

5-4. Factory Selected Components

Factory selected components are identified on the schematics and parts lists by an asterisk(*) which follows the reference designator. The nominal value of the selected component is shown. Table 5-1 lists the reference designator, the service sheet where the component is shown, the value range, and the basis for selecting a particular value.

5-5. Interrelated Adjustments

The −15V adjustment on the A9 Regulator Assembly should be the first item checked during any adjustment procedure. The −15V source and the +15V source are such that they are equal but opposite in sign. The +5V (D) digital is measured and adjusted second before the other adjustment procedures are started.

Note

Make adjustments only in the order specified.

5-6. Post-Repair Adjustments

Table 5-2 lists the adjustments related to repairs or replacement of any of the assemblies.

Table 5-1. Factory Selected Components

Reference Designator	Service Sheet	Range of Values	Basis of Selection
G1A1R2 G1A1VR2 combination (G2A1R2 G2A1VR2 Option 002)	11	825Ω with 5.11 V Zener or 1470Ω with 8.25 V Zener	If the reference power is outside the range of 1.000 ±0.0007 mW between 0°C and 55°C, and if the G1A1R2, G1A2VR2 combination is 825Ω 5.11 V then change the G1A1R2, G1A1VR2 combination to 1470Ω 8.25 V. However, if the G1A1R2, G1A1VR2 combination is already 1470Ω 8.25 V, then a problem exists elsewhere.

Table 5-2. Post-Repair Adjustments, Tests, and Checks

Assembly Repaired	Related Adjustment or Performance Test	Reference Service Sheet
A1 Keyboard	None	1
A2 Display	None	5
A3 Central Processing Unit	5-7, 5-8, 5-9	1, 2, 3, 4
A4 Input Amplifier	5-7, 5-8, 5-10, 5-11	6
AS Main Amplifier	5-7, 5-8, 5-9	7, 8
A8 Rectifier	4-10, 4-11, 4-12, 4-13, 5-7, 5-8	9
A9 Regulator	4-8, 4-9, 5-7, 5-8	9, 10
G1 50 MHz Reference Oscillator	5-7, 5-8, 5-12, 5-13	11

5-7. ±15 Volt Power Supply Adjustment

Reference Service Sheet 10

Description The +15 volt supply is measured, then the −15 volt supply is measured and adjusted so that the supplies are equal in amplitude but of opposite sign.

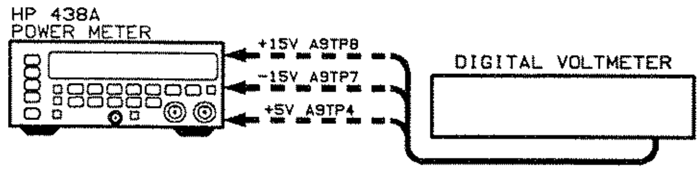


Figure 5-1. Power Supply Adjustments Setup

Equipment Digital Voltmeter (DVM) .... HP 3456A

Procedure

1. Remove the top and bottom covers of the power meter. Loosen the screws that secure the A3 CPU Assembly. Turn the instrument ON and allow for warm-up.
2. Connect the DVM between the +15V testpoint A9TP8 and chassis ground. Measure and record the value of the +15 volts. The voltage should be between 14.25 and 15.75 Vdc.

   +15 V__________

3. Connect the DVM between the −15V testpoint A9TP7 and chassis ground. Adjust −15V, A9R16, until the DVM reading is within 0.05 Vdc of the numerical value from step 2. Ignore the difference in sign for this adjustment.

5-8. +5 Volt Power Supply Adjustment

Reference Service Sheet 9

Description The +5 volt supply is measured and adjusted.

Equipment Digital Voltmeter (DVM) .... HP 3456A

Procedure

1. See Figure 5-1. Connect the DVM between the +5V testpoint A9TP4 and ground. Adjust +5V, A9F3 until the DVM reads 5.00 ±0.05 volts.

5-9. Analog to Digital Converter Slope Adjustment

Reference Service Sheet 8

Description The Analog to Digital Converter is adjusted for a central reading.

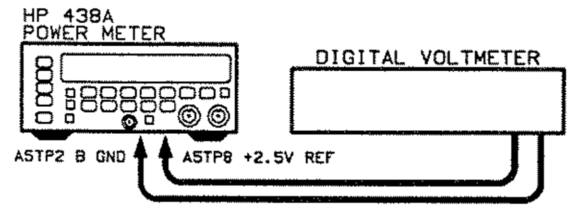


Figure 5-2. Analog to Digital Converter Slope Adjustment Setup

Equipment

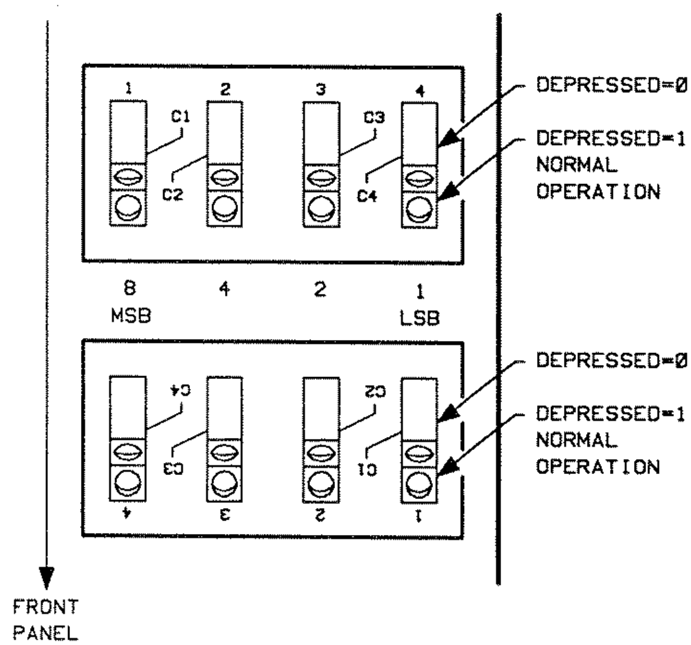
Digital Voltmeter (DVM) .... HP 3456A

Procedure

1. Turn the power meter OFF. Place all 4 switches of A3S1 to the test position. This would be positions where the switches are all opposite to the normal operating position.

Note

A3S1 can be loaded on the printed circuit board so that it has one of the two orientations shown.



2. Turn the power meter ON. The instrument should now display -- -- -- -- --. Connect the DVM between B-GND A5TP2 and +2.5V REF A5TP8 testpoints on A5. Read the DVM.

   ____

3. Enter the reading to 5 digits (4 decimal places) into the power meter by entering the numbers into the keyboard, then pressing (ENTER).
4. Adjust the ADC SLOPE, A5R61, so that the display reading is centered about zero. (The reading may be from +5.00 to −5.00, try to get as close to zero as possible.)
5. Turn the power meter OFF. Return A3S1 to its original position.

5-10. 220 Hz Frequency Adjustment

Reference Service Sheet 6

Description The 220 Hz is adjusted for maximum power meter readout.

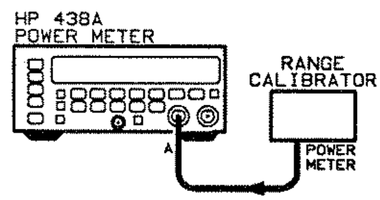


Figure 5-3. 220 Hz Frequency Adjustment Setup

Equipment Range Calibrator .... HP 11683A

Procedure

1. Turn both the power meter and the range calibrator ON. Set the range calibrator controls as follows:

   LINE .... ON
   RANGE .... 1 mW
   FUNCTION .... STANDBY
   POLARITY .... NORMAL

2. Connect the range calibrator output to channel A using the sensor cable. Press (PRESET) on the power meter then press (ZERO), and allow time (approximately 15 to 17 seconds) for the power meter zeroing process.
3. Set the range calibrator function switch to calibrate.
4. On the power meter press (CAL ADJ), (−), (100), then (ENTER). This procedure allows the power meter to calibrate using an external reference, the range calibrator output.
5. Adjust 220 Hz, A4R43, for the maximum front panel reading.

5-11. Ranges 4 and 5 Shaper Adjustment, Channel A and B

Reference Service Sheet 6

Description Ranges 4 and 5 Shaper circuits are adjusted for proper gain.

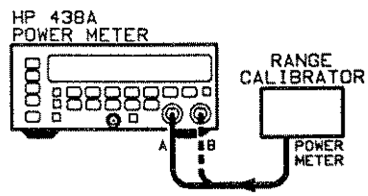


Figure 5-4. Ranges 4 and 5 Shaper Adjustment Setup

Equipment Range Calibrator .... HP 11683A

Procedure

1. Connect range calibrator to channel A input connector.
2. Set the range calibrator controls as follows:

   LINE .... ON
   RANGE .... 1 mW
   FUNCTION .... STANDBY
   POLARITY .... NORMAL

3. Turn the power meter ON. Press (PRESET). After zeroing the power meter, set the range calibrator to calibrate, then press (CAL ADJ), (−), (100), and (ENTER) on the power meter.
4. Set the range calibrator range to 10 mW.
5. Adjust RNG 4, A4R26, until the power meter reads 10.00 ±0.01 mW.
6. Set the range calibrator range to 100 mW.
7. Adjust RNG 5, A4R34, until the power meter reads 100.0 ±0.1 mW.
8. Repeat steps 4 through 7 to check that interaction between steps has not caused a shift in settings.
9. Repeat the procedure for channel B of the power meter by making connection to channel B from the range calibrator.
10. Repeat the above procedure, starting with step 3, except press (B) on the power meter. Adjust RNG 4 SHP, A4R27, and RNG 5 SHP, A4R35, as in steps 5 and 7 above.

5-12. Power Reference Oscillator Frequency Adjustment

Note

Adjustment of the Power Reference Oscillator frequency may also affect the output level of the oscillator. Thus after the frequency is adjusted 50.0 ±0.5 MHz, the output level should be checked as described in section 4. A procedure for adjusting the output to the specified level is provided in the next paragraph.

Reference Service Sheet 11

Description Variable inductor G1A1L1 is adjusted to set the power reference oscillator output frequency to 50.0 ±0.5 MHz.

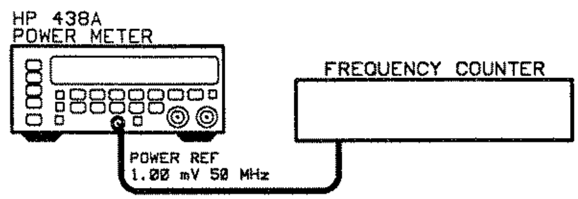


Figure 5-5. Power Reference Oscillator Frequency Adjustment Setup

Equipment Frequency Counter .... HP 5328A Option 031

Procedure

1. Connect the equipment as shown in Figure 5-5 and set up the counter to measure frequency.
2. Set the power meter LINE switch to ON (in) and the POWER REF OSC switch to off (LED off).
3. Set the power meter POWER REF OSC switch to on (LED on) and observe the indication on the counter. If the counter display reads 50.0 ±0.5 MHz, no adjustment of the power reference oscillator frequency is necessary. If it is not within these limits, adjust the power reference oscillator frequency as described in steps 4 and 5.
4. Remove the power meter top cover, and loosen the screws holding the A3 CPU Assembly. Swing the assembly out. The screwdriver adjustment is accessible through a hole in the deck.
5. Adjust G1A1L1 to obtain a 50.00 ±0.5 MHz indication on the counter.

5-13. Power Reference Oscillator Level Adjustment

Reference Service Sheet 11

Description The power reference oscillator is factory-adjusted to 1.0 mW ±0.7% using a special measurement system accurate to 0.5% (traceable to the National Institute of Standards and Technology) and allowing for a 0.2% transfer error. To ensure maximum accuracy in readjusting the power reference oscillator, the following procedure provides step-by-step instructions for using specified Hewlett-Packard instruments of known capability. If equivalent instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the equipment.

Note The power meter may be returned to the nearest HP office to have the power reference oscillator checked and/or adjusted. Refer to section 2, "Packaging".

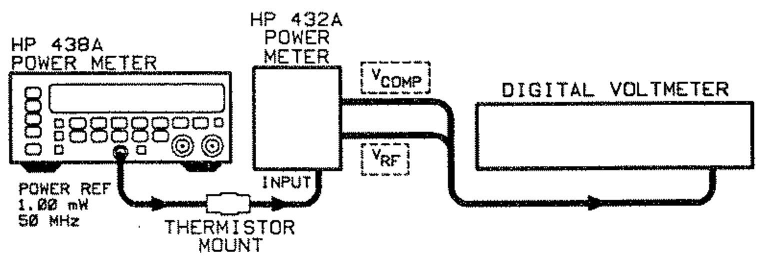


Figure 5-6. Power Reference Oscillator Level Adjustment Setup

Equipment

Test Power Meter .... HP 432A
Thermistor Mount .... HP 478A-H75/H76
Digital Voltmeter (DVM) .... HP 3456A

Procedure

1. Set the DVM to measure resistance and connect the DVM between the Vrf connector on the rear panel of the test power meter and pin 1 on the thermistor mount end of the test power meter interconnect cable.
2. Round the DVM reading to two decimal places. Record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

   R (Internal Bridge Resistance)__________

3. Connect the test power meter to the power meter as shown in Figure 5-5.

4. Set the power meter LINE switch to ON and the POWER REF OSC switch to OFF. Wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.
5. Set the test power meter range switch to coarse zero. Adjust the front panel coarse zero control to obtain a zero meter indication.
6. Fine zero the test power meter on the most sensitive range, then set the test power meter range switch to 1 mW.

Note

Ensure that the DVM input leads are isolated from chassis ground when performing the next step.

7. Set the DVM to measure microvolts. Connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.
8. Observe the reading on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter fine zero switch and adjust the coarse zero control so that the DVM reads 200 microvolts or less. Then release the fine zero switch and proceed to the next step.
9. Round the DVM reading to the nearest microvolt. Record this value as V0.

V0__________

10. Disconnect the DVM negative input lead from the Vrf connector on the test power meter. Reconnect the lead to chassis ground.
11. Set the power meter POWER REF OSC to ON. Record the reading observed on the DVM as Vcomp.

Vcomp__________

12. Disconnect the DVM negative input lead from chassis ground. Reconnect it to the Vrf connector on the rear panel of the test power meter. The DVM is now set up to measure V1 which represents the power reference oscillator output level.
13. Calculate the value of V1 equal to 1 mW from the following equation:

$$V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - (10^{-3})(4R)(EFFECTIVE\ EFFICIENCY)}$$

Where:
V_0 = previously recorded value
V_{COMP} = previously recorded value
10^{-3} = 1 milliwatt
R = previously recorded value
EFFECTIVE EFFICIENCY = value for thermister mount at 50 MHz (traceable to the National Institute of Standards and Technology).

14. Remove the power meter top cover and adjust the LEVEL ADJUST potentiometer G1A1R4 so that the DVM reads the calculated value of V_1.

Typical Calulations

1. ACCURACY:

DVM Measurements:	(V_{COMP})	±0.018%
	($V_1 - V_0$)	±0.023%
	(R)	±0.03%
Math Assumptions:		±0.01%
EFFECTIVE EFFICIENCY CAL (NIST):		±0.5%
MISMATCH UNCERTAINTY:		±0.1%
(Source & Mount SWR ≤1.05)		≤0.7%

2. MATH ASSUMPTIONS:

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(EFFECTIVE\ EFFICIENCY)}$$

Assume:

$V_0^2 - V_1^2 = (V_1 - V_0)^2 - (V_1 - V_0)^2 = -V_1^2 + 2V_1 - V_0^2$

Want:

$V_0^2 - V_1^2$

Therefore error:

$= (V_1^2 + 2V_1V_0 - V_0^2) - (V_0^2 - V_1^2)$

$= -2V_0^2 + 2V_1V_0 = 2V_0(V_1 - V_0)$

If:

$2V_0(V_1 - V_0) << 2V_{COMP}(V_1 - V_0)$

That is:

if $V_0 << V_{COMP}$, then the error is negligible.

For example:

If $V_{COMP} \sim 4$ volts and $V_0 < 400\ \mu V$, then the error is $< 0.01\%$.

(typically V_0 can be set to $< 50\ \mu V$).

3. Derivation of the formula for $V_1 - V_0$:

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(EFFECTIVE\ EFFICIENCY)}$$

Desired $P_{RF} = 1\ mW = 10^{-3}\ W$

Therefore:

$$10^{-3} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(EFFECTIVE\ EFFICIENCY)}$$

Let

$(4R)(EFFECTIVE\ EFFICIENCY)(10^{-3}) = K$

Substitute $-(V_1 - V_0)^2$ for $V_0^2 - V_1^2$

(see Math Assumptions under Accuracy)

Then

$0 = (V_1 - V_0)^2 - 2V_{COMP}\ (V_1 - V_0) + K$

or

$$V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - K}$$

6

Replaceable Parts

6-1. Introduction

This section contains information for ordering parts. Table 6-1 ists part numbers for restored assemblies. Table 6-2 lists abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-4 contains the names and addresses that correspond to the manufacturer's code numbers.

6-2. Abbreviations

Table 6-2 lists abbreviations used in the parts list, schematics, and throughout the manual. In some cases, two forms of the abbreviation are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts list are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper case letters.

6-3. Replaceable Parts List

Table 6-3 is the list of replaceable parts and is organized as follows:

a. Electrical assemblies and their components in alphanumeric order by reference designation.

b. Chassis-mounted parts in alphanumeric order by reference designation.

c. Mechanical parts.

The information given for each part consists of the following:

a. The Hewlett-Packard part number.

b. Part number check digit (CD).

c. Total quantity (Qty) used in the instrument.

d. Part description.

e. Five-digit code that represents a typical manufacturer.

f. Manufacturers part number.

Note

The total quantity for each part is given only once, that is, at the first occurrence of the part number in the list. The total quantities for optional assemblies are totalled by assembly and not integrated into the standard list.

6-4. Factory Selected Parts (*)

Parts marked with an asterisk (*) are factory selected parts. The value listed in the parts list is the nominal value. Refer to sections 5 and 6 of this manual for information on determining what value to use for replacement.

6-5. Parts List Backdating (†)

Parts marked with a dagger (†) are different in power meters with serial number prefixes lower than the one that this manual applies to directly.

6-6. Parts List Updating (Change Sheet)

Production changes to power meters made after the publication date of this manual are accompanied by a change in the serial number prefix. Changes to the parts list are recorded by serial number prefix on a MANUAL CHANGES supplement. Also, parts list errors are noted in the ERRATA portion of the MANUAL CHANGES supplement.

6-7. Illustrated Parts Breakdown

Most mechanical parts are identified in Figure 6-1 through Figure 6-3. These figures are located at the end of the replaceable parts table.

6-8. Ordering Information

To order a part listed in the replaceable parts table, include the Hewlett-Packard part number (with the check digit), and the quantity required. Address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

Note

Within the USA, it is better to order directly from the HP Parts Center in Mountain View, California. Ask your nearest HP office for information and forms for the "Direct Mail Order System".

6-9. Recommended Spares List

Stocking spare parts for an instrument is often done to ensure quick return to service after a malfunction occurs. Hewlett-Packard prepares a "Recommended Spares" list for this instrument. The contents of the list are based on failure reports and repair data. Quantities given are for one year of parts support. A complimentary copy of the "Recommended Spares" list may be requested from your nearest Hewlett-Packard office.

When stocking parts to support more than one Signal Generator or to support a variety of Hewlett- Packard instruments, it may be more economical to work from one consolidated list rather than simply adding together stocking quantities from the individual instrument lists. Hewlett-Packard will prepare consolidated "Recommended Spares" lists for any number or combination of instruments. Contact your nearest Hewlett-Packard office for details.

6-10. Restored Assemblies

Table 6-1 lists assemblies within the instrument that may be replaced on an exchange basis, thus affording a considerable cost saving. Exchange, factory-repaired and tested assemblies are available only on a trade-in basis; therefore, the defective assemblies must be returned for credit. For this reason, assemblies required for spare parts stock must be ordered by the new assembly part number.

Table 6-1. Part Numbers for Restored Assemblies

Reference Designation	Description	Part Number[1]	
		Restored Assembly	New Assembly
A3[2]	Central Processing Unit Assembly	00438-69103	00438-60103
A5	Main Amplifier Assembly	00438-69005	00438-60005

1 When ordering extra assemblies for spare parts stock, use new assembly part number only. Restored orders require return of the defective part.

2 If you have a 00438-69003 or 00438-60003 you must order a 00438-60105 kit for replacement.

Table 6-2. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A .... assembly
AT ...... attenuator; isolator; termination
B .... fan; motor
BT .... battery
C .... capacitor
CP .... coupler
CR .... diode; diode thyristor; varactor
DC .... directional coupler
DL .... delay line
DS .... annunciator; signaling device (audible or visual); lamp; LED
E miscellaneous electrical part
F .... fuse
FL .... filter
H .... hardware
HY .... circulator
J .... electrical connector (stationary portion); jack
K .... relay
L .... coil; inductor
M .... meter
MP . miscellaneous mechanical part
P electrical connector (movable portion); plug
Q ..... transistor; SCR; triode thyristor
R .... resistor
RT .... thermistor
S .... switch
T .... transformer
TB .... terminal board
TC .... thermocouple
TP .... test point
U .... integrated circuit; microcircuit
V .... electron tube
VR .... voltage regulator; breakdown diode
W ... cable; transmission path; wire
X .... socket
Y crystal unit (piezoelectric or quartz)
Z .. tuned cavity; tuned circuit

ABBREVIATIONS

A .... ampere
ac .... alternating current
ACCESS .... accessory
ADJ .... adjustment
A/D .... analog-to-digital
AF .... audio frequency
AFC .... automatic frequency control
AGC .. automatic gain control
AL .... aluminum
ALC .. automatic level control
AM .... amplitude modulation
AMPL .... amplifier
APC . automatic phase control
ASSY .... assembly
AUX .... auxiliary
avg .... average
AWG ... American wire gauge
BAL .... balance
BCD ... binary coded decimal
BD .... board
BE CU ..... beryllium copper
BFO . beat frequency oscillator
BH .... binder head
BKDN .... breakdown
BP .... bandpass
BPF .... bandpass filter
BRS .... brass
BWO backward-wave oscillator
CAL .... calibrate
ccw .... counterclockwise
CER .... ceramic
CHAN .... channel
cm .... centimeter
CMO ..... cabinet mount only
COAX .... coaxial
COEF .... coefficient
COM .... common
COMP .... composition
COMPL .... complete
CONN .... connector
CP .... cadmium plate
CRT .... cathode-ray tube
CTL complementary transistor logic
CW .... continuous wave
cw .... clockwise
cm .... centimetre
D/A .... digital-to-analog
dB .... decibel
dBm decibel referred to 1 mW
dc .... direct current
deg ...... degree (temperature interval or difference)
... ° ... degree (plane angle)
°C degree Celsius (centigrade)
°F .... degree Fahrenheit
°K .... degree Kelvin
DEPC ...... deposited carbon
DET .... detector
diam .... diameter
DIA .. diameter (used in Parts List)
DIFF AMPL ...... differential amplifier
div .... division
DPDT .... double-pole, double-throw
DR .... drive
DSB .... double sideband
DTL .... diode transistor logic
DVM .... digital voltmeter
ECL .... emitter coupled logic
EMF ..... electromotive force
EDP electronic data processing
ELECT .... electrolytic
ENCAP .... encapsulated
EXT .... external
F .... farad
FET .... field-effect transistor
F/F .... flip-flop
FH .... flat head
FIL H .... fillister head
FM .... frequency modulation
FP .... front panel
FREQ .... frequency
FXD .... fixed
g .... gram
GE .... germanium
GHz .... gigahertz
GL .... glass
GRD .... ground(ed)
H .... henry
h .... hour
HET .... heterodyne
HEX .... hexagonal
HD .... head
HDW .... hardware
HF .... high frequency
HG .... mercury
HI .... high
HP .... Hewlett-Packard
HPF .... high-pass filter
HR .. hour (used in Parts List)
HV .... high voltage
Hz .... Hertz
IC .... integrated circuit
ID .... inside diameter
IF .... intermediate frequency
IMPG .... impregnated
in .... inch
INCD .... inncandescent
INCL .... include(s)
INP .... input
INS .... insulation
INT .... internal
kg .... kilogram
kHz .... kilohertz
kΩ .... kilohm
kV .... kilovolt
lb .... pound
LC .... inductance-capacitance
LED ..... light-emitting diode
LF .... low frequency
LG .... long
LH .... left hand
LIM .... limit
LIN linear taper (used in Parts List)
lin .... linear
LK WASH .... lock washer
LO .... low; local oscillator
LOG .. logarithmic taper (used in Parts List)
log .... logrithm(ic)
LPF .... low pass filter
LV .... low voltage
m .... metre (distance)
mA .... millampere
MAX .... maximum
MΩ .... megohm
MEG meg (10^6) (used in Parts List)
MET FLM .... metal film
MET OX ...... metallic oxide
MF .... medium frequency; microfarad (used in Parts List)
MFR .... manufacturer
mg .... milligram
MHz .... megahertz
mH .... millihenry
mho .... mho
MIN .... minimum
min .... minute (time)
... ′ ... minute (plane angle)
MINAT .... miniature
mm .... millimetre
MOD .... modulator
MOM .... momentary
MOS .... metal-oxide semiconductor
ms .... millisecond
MTG .... mounting
MTR meter (indicating device)
mV .... millivolt
mVac .... millivolt, ac
mVdc .... millivolt, dc
mVpk .... millivolt, peak
mVp-p . millivolt, peak-to-peak
mVrms .... millivolt, rms
mW .... milliwatt
MUX .... multiplex
MY .... mylar
μA .... microampere
μF .... microfarad
μH .... microhenry
μmho .... micromho
μs .... microsecond
μV .... microvolt
μVac .... microvolt, ac
μVdc .... microvolt, dc
μVpk .... microvolt, peak
μVp-p microvolt, peak-to-peak
μVrms .... microvolt, rms
μW .... microwatt

NOTE

All abbreviations in the Parts List appear in uppercase.

Table 6-2. Reference Designations and Abbreviations (2 of 2)

ABBREVIATIONS (cont'd)

nA .... nanoampere
NC .... no connection
N/C .... normally closed
NE .... neon
NEG .... negative
nF .... nanofarad
NI PL .... nickel plate
N/O .... normally open
NOM .... nominal
NORM .... normal
NPN negative-positive-negative
NPO .... negative-positive
zero .... (zero temperature coefficient)
NRFR .. not recommended for field replacement
NSR .... not separately replaceable
ns .... nanosecond
nW .... nanowatt
OBD .... order by description
OD .... outside diameter
OH .... oval head
OP AMPL .... operational amplifier
OPT .... option
OSC .... oscillator
OX .... oxide
oz .... ounce
Ω .... ohm
P ... peak (used in Parts List)
PAM .... pulse-amplitude modulation
PC .... printed circuit
PCM .. pulse-code modulation; pulse-count modulation
PDM .... pulse-duration modulation
pF .... picofarad
PH BRZ .... phosphor bronze
PHL .... Phillips
PIN .... positive-intrinsic-negative
PIV ..... peak inverse voltage
pk .... peak
PL .... phase lock
PLO ..... phase lock oscillator
PM .... phase modulation
PNP positive-negative-positive
P/O .... part of
POLY .... polystyrene
PORC .... porcelain
POS positive; position(s) (used in Parts List)
POSN .... position
POT .... potentiometer
p-p .... peak-to-peak
PP peak-to-peak (used in Parts List)
PPM .... pulse-position modulation
PREAMPL ...... preamplifier
PRF pulse-repetition frequency
PRR .... pulse repetition rate
ps .... picosecond
PT .... point
PTM .. pulse-time modulation
PWM . pulse-width modulation
PWV ... peak working voltage
RC .... resistance-capacitance
RECT .... rectifier
REF .... reference
REG .... regulated
REPL .... replaceable
RF .... radio frequency
RFI .... radio frequency interference
RH ... round head; right hand
RLC ... resistance-inductance-capacitance
RMO .... rack mount only
rms .... root-mean-square
RND .... round
RAM .. random-access memory
ROM ...... read-only memory
R&P .... rack and panel
RWV . reverse working voltage
S .... scattering parameter
s .... second (time)
... " ... second (plane angle)
S-B .... slow-blow (fuse) (used in Parts List)
SCR silicon controlled rectifier; screw
SE .... selenium
SECT .... sections
SEMICON ..... semiconductor
SHF .... super-high frequency
SI .... silicon
SIL .... silver
SL .... slide
SNR ..... signal-to-noise ratio
SPDT .... single-pole, double-throw
SPG .... spring
SR .... split ring
SPST single-pole, single-throw
SSB .... single sideband
SST .... stainless steel
STL .... steel
SQ .... square
SWR ..... standing-wave ratio
SYNC .... synchronize
T ..... timed (slow-blow fuse)
TA .... tantalum
TC temperature compensating
TD .... time delay
TERM .... terminal
TFT ...... thin-film transistor
TGL .... toggle
THD .... thread
THRU .... through
TI .... titanium
TOL .... tolerance
TRIM .... trimmer
TSTR .... transistor
TTL transistor-transistor logic
TV .... television
TVI .... television interference
TWT .... traveling wave tube
U .... micro (10^{-6}) (used in Parts List)
UF . microfarad (used in Parts List)
UHF .... ultra-high frequency
UNREG .... unregulated
V .... volt
VA .... voltampere
Vac .... volts, ac
VAR .... variable
VCO .... voltage-controlled oscillator
Vdc .... volts, dc
VDCW ..... volts, dc, working (used in Parts List)
V(F) .... volts, filtered
VFO ...... variable-frequency oscillator
VHF ..... very-high frequency
Vpk .... volts, peak
Vp-p ..... volts, peak-to-peak
Vrms .... volts, rms
VSWR . voltage standing-wave ratio
VTO . voltage-tuned oscillator
VTVM vacuum-tube voltmeter
V(X) .... volts, switched
W .... watt
W/ .... with
WIV .. working inverse voltage
WW .... wirewound
W/O .... without
YIG ...... yttrium-iron-garnet
Z_o ... characteristic impedance

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

NOTE

All abbreviations in the Parts List appear in uppercase.

Table 6-3. Replaceable Parts

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A1	00438-60001	1	1	BD AY KEY	28480	00438-60001
A1J1	1200-0507	9	1	SOCKET-IC-DIP 16-CONT DIP-SLDR	02194	ICN-163B-S3-G30
A1MP1	5041-2839	0	1	KEY A	28480	5041-2839
A1MP2	5041-2840	3	1	KEY B	28480	5041-2840
A1MP3	5041-2842	5	1	KEY B/A	28480	5041-2842
A1MP4	5041-0309	5	1	KEY 1/4 (BLANK)	28480	5041-0309
A1MP5	5041-2841	4	1	KEY ZERO	28480	5041-2841
A1MP6	5041-2850	5	1	KEY CAL ADJ	28480	5041-2850
A1MP7	5041-2851	6	1	KEY FACTOR	28480	5041-2851
A1MP8	5041-2854	9	1	KEY OFFSET MNL	28480	5041-2854
A1MP9	5041-2844	7	1	KEY STORE	28480	5041-2844
A1MP10	5041-2849	2	1	KEY REL	28480	5041-2849
A1MP11	5041-2848	1	1	KEY DBM WATT	28480	5041-2848
A1MP12	5041-2886	7	1	KEY LCL	28480	5041-2886
A1MP13	5041-2838	9	1	KEY SHIFT	28480	5041-2838
A1MP14	5041-0309	5	1	KEY 1/4 (BLANK)	28480	5041-0309
A1MP15	5041-2846	9	1	KEY AUTO RANGE	28480	5041-2846
A1MP16	5041-2852	7	1	KEY RANGE	28480	5041-2852
A1MP17	5041-2847	0	1	KEY FILTER	28480	5041-2847
A1MP18	5041-2853	8	1	KEY MNL FILTER	28480	5041-2853
A1MP19	5041-2845	8	1	KEY RECALL	28480	5041-2845
A1MP20	5041-2855	0	1	KEY PRE SET	28480	5041-2855
A1MP21	5041-2843	6	1	KEY OSC	28480	5041-2843
A1S1	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S2	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S3	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S4	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S5	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S6	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S7	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S8	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S9	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S10	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S11	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S12	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S13	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S14	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S15	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S16	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S17	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A1S18	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S19	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S20	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1S21	5060-9436	7	1	SWITCH-PB SPST-NO MOM	04486	5560-9436
A1W4	00438-60033	9	1	CABLE AY KEY BD	28480	00438-60033
A2	00438-60002	2	1	BD AY DISPLAY	28480	00438-60002
A2DS1	1990-1076	2	1	DISPLAY-SOL-STA RED	01542	HDSP-3533/HLMP-2620
A2DS12	1990-0587	8	1	DISPLAY-NUM-SEG 5-CHAR .11-H	01542	5082-7415
A2DS13	1990-0587	8	1	DISPLAY-NUM-SEG 5-CHAR .11-H	01542	5082-7415
A2DS16	1990-0665	3	1	LED-LAMP LUM-INT=1MCD IF=30MA-MAX BVR=5V	01542	
A2J1	1252-0242	8	1	CONN-POST TYPE .100-PIN-SPCG 34-CONT	04726	3431-6202
A2MP1	0380-0059	5	4	SPACER-RVT-ON .25-IN-LG .152-IN-ID	01461	
A2MP2	00438-80006	8	1	LABEL-INFO	28480	00438-80006
A2W5	00438-60031	7	1	CBL AY DISPLAY	28480	00438-60031
A2XA1	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA2	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA3	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA4	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA5	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA6	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA7	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA8	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA9	1200-1616	3	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	06665	SEP-20363-01
A2XA10	1200-1616	3	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	06665	SEP-20363-01
A2XA11	1200-1616	3	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	06665	SEP-20363-01
A2XA12	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA13	1200-1617	4	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	06665	ICS-314-HGT
A2XA14	1200-1616	3	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	06665	SEP-20363-01
A2XA15	1200-1616	3	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	06665	SEP-20363-01
A3	00438-60103	4	1	MICROPROCR BD AY	28480	00438-60103
A3BT1	1420-0314	2	1	BATTERY 3V .16A-HR LITHIUM POLYCARBON	08709	BR-2325
A3C1	0180-2815	1	1	CAP-FXD 100uF +-20% 10 V TA	04200	199D1147
A3C2	0180-2620	6	1	CAP-FXD 2.2uF +-10% 50 V TA	04200	199D1134
A3C3	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C4	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C5	0180-1745	4	1	CAP-FXD 1.5uF +-10% 20 V TA	04200	150D155X9020A2-DYS
A3C6	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C7	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C8	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C9	0160-0574	3	1	CAP-FXD 0.022uF +-20% 100 V CER X7R	02010	SR201C223MAAH
A3C10	0180-2617	1	1	CAP-FXD 6.8uF +-10% 35 V TA	04200	199D1131

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A3C11	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C12	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C13	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C14	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C15	0160-3455	5	1	CAP-FXD 470pF +-10% 1 kV CER X5E	09538	838-546 X5E 471K
A3C16	0180-0374	3	1	CAP-FXD 10uF +-10% 20 V TA	04200	150D106X9020B2-DYS
A3C17	0160-3874	2	1	CAP-FXD 10pF +-5% 200 V CER C0G	06352	FD12C0G2D100D
A3C18	0180-2620	6	1	CAP-FXD 2.2uF +-10% 50 V TA	04200	199D1134
A3C19	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C20	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C21	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C22	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C23	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C24	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C25	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C26	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C27	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C28	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C29	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C30	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C31	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C32	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C33	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C34	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C35	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C36	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C37	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C38	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C39	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C40	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C41	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C42	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C43	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3C44	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A3CR1	1901-0376	6	1	DIODE-GEN PRP 35V 50MA DO-35	00046	S303
A3CR2	1901-1085	6	1	DIODE-SCHOTTKY SM SIG	02062	5082-2835
A3CR3	1901-0539	3	1	DIODE-SCHOTTKY SM SIG	02062	50825510
A3CR6	1906-0275	4	1	DIODE-ARRAY	04200	TND908
A3CR7	1906-0275	4	1	DIODE-ARRAY	04200	TND908
A3CR8	1906-0275	4	1	DIODE-ARRAY	04200	TND908
A3DS1	1990-0933	8	1	LED-LAMP ARRAY LUM-INT=500UCD	01542	HLMP-6204
A3DS2	1990-0933	8	1	LED-LAMP ARRAY LUM-INT=500UCD	01542	HLMP-6204
A3J1	1252-1276	0	1	CONN-POST TYPE .100-PIN-SPCG 24-CONT	01380	499345-5

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A3J2	1252-3489	1	1	CONN-POST TYPE .100-PIN-SPCG 3-CONT	02946	87499-102
A3J3	1251-8106	7	1	CONN-POST TYPE .100-PIN-SPCG 20-CONT	04726	3592-6002
A3J4	1200-1205	6	1	SOCKET-IC-DIP 16-CONT DIP DIP-SLDR	01380	2-641610-2
A3J5	1251-8601	7	1	CONN-POST TYPE .100-PIN-SPCG 34-CONT	04726	3594-6002
A3J6	1251-8935	0	1	CONN-POST TYPE .100-PIN-SPCG 2-CONT	02946	65806-077
A3MP1	1400-1210	7	1	HOLDER-BAT 1-WD	10476	BH906
A3MP2	1200-0638	7	1	SOCKET-IC-DIP 14-CONT DIP DIP-SLDR	02414	DILB14P-308T
A3MP3	1200-0654	7	2	SOCKET-IC-DIP 40-CONT DIP DIP-SLDR	02414	DILB40P-308T
A3MP4	0340-0944	3	1	INSULATOR-IC NYLON BLACK	03724	814-060
A3MP5	1200-0567	1	3	SOCKET-IC-DIP 28-CONT DIP DIP-SLDR	02414	DILB28P-308T
A3MP6	00438-20029	9	3	HINGE RIVETED	28480	00438-20029
A3MP7	0403-0179	0	3	BUMPER FOOT-ADH MTG	04726	SJ 5012 BLK
A3MP8	2190-0731	9	3	WASHER-FL NM NO. 4 .115-IN-ID .26-IN-OD	02648	
A3MP9	3050-0891	7	3	WASHER-FL MTLC 3.0 3.3-MM-ID 6.85-MM-OD	06691	
A3MP10	0515-0168	4	3	SCREW-MACHINE ASSEMBLY M3.5 X 0.6 6MM-LG	01125	
A3MP11	0361-0009	5	3	RIVET-SEMITUB OVH .123DIA .188LG	02531	R-4012
A3Q1	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q2	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q3	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q4	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q5	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q6	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q7	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q8	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q9	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q10	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q11	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q12	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q13	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q14	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q15	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q16	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q17	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q18	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q19	1853-0281	9	1	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	02037	2N2907A
A3Q20	1854-0477	7	1	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	02037	2N2222A
A3R1	1810-0280	8	1	NETWORK-RES 10-SIP 10.0K OHM X 9	05524	MSP10A01
A3R2	1810-0280	8	1	NETWORK-RES 10-SIP 10.0K OHM X 9	05524	MSP10A01
A3R3	0698-7283	4	1	RESISTOR 90.9K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R4	0698-7268	5	1	RESISTOR 21.5K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R5	0698-7268	5	1	RESISTOR 21.5K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R6	0698-7212	9	1	RESISTOR 100 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R7	0698-7212	9	1	RESISTOR 100 +-1% .05W TF TC=0+-100	05524	CMF-50-2

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A3R8	0698-7236	7	1	RESISTOR 1K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R9	1810-0280	8	1	NETWORK-RES 10-SIP 10.0K OHM X 9	05524	MSP10A01
A3R10	0698-7268	5	1	RESISTOR 21.5K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R11	0698-7268	5	1	RESISTOR 21.5K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R12	0698-7268	5	1	RESISTOR 21.5K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R13	0698-7269	6	1	RESISTOR 23.7K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R14	0698-3460	1	1	RESISTOR 422K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R15	0698-7236	7	1	RESISTOR 1K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R16	0698-7212	9	1	RESISTOR 100 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R17	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R18	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R19	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R20	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R21	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R22	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R23	0698-7253	8	1	RESISTOR 5.11K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R24	0757-0317	7	1	RESISTOR 1.33K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R25	0698-7260	7	1	RESISTOR 10K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R26	0698-7260	7	1	RESISTOR 10K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R27	0698-7236	7	1	RESISTOR 1K +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R28	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R29	0698-7212	9	1	RESISTOR 100 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R30	1810-0273	9	1	NETWORK-RES 10-SIP 470.0 OHM X 9	05524	MSP10A01
A3R31	1810-0265	9	1	NETWORK-RES 16-DIP 680.0 OHM X 8	03744	4116R-001-681
A3R32	1810-0265	9	1	NETWORK-RES 16-DIP 680.0 OHM X 8	03744	4116R-001-681
A3R33	1810-0247	7	1	NETWORK-RES 16-DIP 220.0 OHM X 8	02483	761-3-R220
A3R34	0698-7232	3	1	RESISTOR 681 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R35	1810-0247	7	1	NETWORK-RES 16-DIP 220.0 OHM X 8	02483	761-3-R220
A3R36	1810-0247	7	1	NETWORK-RES 16-DIP 220.0 OHM X 8	02483	761-3-R220
A3R37	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R38	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R39	1810-0411	7	1	NETWORK-RES 10-SIP 50.0 OHM X 9	05524	MSP10A01
A3R40	0757-0984	4	1	RESISTOR 10 +-1% .5W TF TC=0+-100	05524	CMF-65-2
A3R41	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R42	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R43	0757-0984	4	1	RESISTOR 10 +-1% .5W TF TC=0+-100	05524	CMF-65-2
A3R44	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R45	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R46	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R47	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R48	0698-3430	5	1	RESISTOR 21.5 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A3R49	1810-0273	9	1	NETWORK-RES 10-SIP 470.0 OHM X 9	05524	MSP10A01
A3R50	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A3R51	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3R52	0698-7220	9	1	RESISTOR 215 +-1% .05W TF TC=0+-100	05524	CMF-50-2
A3S1	3101-2172	0	1	SWITCH-DIP RKR 4-SPDT 0.05A 30VDC	04990	76SC04S
A3S2	3101-2761	3	1	SWITCH-DIP SL 7-1A 0.1A 30VDC	04990	90B07S
A3TP1	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP2	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP3	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP4	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP5	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP6	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP7	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP8	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP9	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP10	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP11	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3TP12	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A3U1	1820-2075	4	1	IC TRANSCEIVER TTL/LS BUS OCTL	01698	SN74LS245N
A3U2	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A3U3	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A3U4	1820-1858	9	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG COM	01698	SN74LS377N
A3U5	1820-1858	9	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG COM	01698	SN74LS377N
A3U6	1820-1858	9	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG COM	01698	SN74LS377N
A3U8	1820-2075	4	1	IC TRANSCEIVER TTL/LS BUS OCTL	01698	SN74LS245N
A3U9	00438-80036	4	1	PROM PROGRAMMED	28480	00438-80036
A3U11	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A3U13	1818-3183	2	1	IC 64K SRAM 150-NS CMOS	06347	HM6264ALP-15
A3U14	1820-1212	9	1	IC FF TTL/LS J-K NEG-EDGE-TRIG	01698	SN74LS112AN
A3U15	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A3U16	1820-3513	7	1	IC-INTERFACE XCVR MISC/UNKNOWN	03406	DS75161AN
A3U17	1820-3431	8	1	IC-INTERFACE XCVR MISC/UNKNOWN	03406	DS75160AN
A3U18	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A3U19	1820-2624	9	1	IC-MPU; CLK FREQ=2 MHZ, ENHANCED 6800	02037	MC68B09P
A3U20	1820-2705	7	1	IC-8-BIT/16-BIT SYSTEM TIMING CONTROLLER	03794	AM9513APC
A3U21	1820-2983	3	1	IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	02037	MC68B21P
A3U22	1820-2983	3	1	IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	02037	MC68B21P
A3U23	1820-1427	8	1	IC DCDR TTL/LS BIN 2-TO-4-LINE DUAL	01698	SN74LS156N
A3U24	1820-0668	7	1	IC DRVR TTL BUS HEX	01698	SN7407N
A3U25	1820-0668	7	1	IC DRVR TTL BUS HEX	01698	SN7407N
A3U26	1820-0668	7	1	IC DRVR TTL BUS HEX	01698	SN7407N
A3U27	1820-1216	3	1	IC DCDR TTL/LS BIN 3-TO-8-LINE 3-INP	01698	SN74LS138N
A3U28	00438-80013	7	1	PAL PROGRAMMED	28480	00438-80013
A3U29	1820-2549	7	1	IC-GPIB TALKER/LISTENER	03811	P8291A SELECTED
A3U30	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A3U31	1820-1729	3	1	IC LCH TTL/LS ADDRESSABLE 8-BIT	02037	SN74LS259N
A3U32	1820-1729	3	1	IC LCH TTL/LS ADDRESSABLE 8-BIT	02037	SN74LS259N
A3U33	1820-1281	2	1	IC DCDR TTL/LS BIN 2-TO-4-LINE DUAL	01698	SN74LS139AN
A3U34	1820-1753	3	1	IC FF CMOS D-TYPE POS-EDGE-TRIG	03406	MM74C74N
A3U35	1826-0175	3	1	IC COMPARATOR GP DUAL 14 PIN DIP-P	03406	LM319N
A3U36	1820-1197	9	1	IC GATE TTL/LS NAND QUAD 2-INP	01698	SN74LS00N
A3U37	1820-1199	1	1	IC INV TTL/LS HEX 1-INP	01698	SN74LS04N
A3U38	1820-1212	9	1	IC FF TTL/LS J-K NEG-EDGE-TRIG	01698	SN74LS112AN
A3U39	1820-2075	4	1	IC TRANSCEIVER TTL/LS BUS OCTL	01698	SN74LS245N
A3U40	1820-1858	9	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG COM	01698	SN74LS377N
A3U41	1820-0668	7	1	IC DRVR TTL BUS HEX	01698	SN7407N
A3U42	1820-0668	7	1	IC DRVR TTL BUS HEX	01698	SN7407N
A3U43	1820-1851	2	1	IC ENCDR TTL/LS PRIORITY 8-TO-3-LINE	01698	SN74LS148N
A3U44	1820-2130	2	1	IC SWITCH CUR QUAD 16 PIN DIP-P	13307	ULN-2074B
A3U45	1820-2130	2	1	IC SWITCH CUR QUAD 16 PIN DIP-P	13307	ULN-2074B
A3U46	1820-2130	2	1	IC SWITCH CUR QUAD 16 PIN DIP-P	13307	ULN-2074B
A3W6	00438-60034	0	1	CABLE AY MICRO	28480	00438-60034
A3Y1	1813-0130	3	1	CLOCK-OSCILLATOR-XTAL 16.0-MHZ 0.05%	01417	HS-102-16.000MHZ
A4	00438-60004	4	1	BD AY AMPL INPUT	28480	00438-60004
A4C1	0180-2139	2	1	CAP-FXD 10uF +-20% 60 V WT-SLG-TA-ELCTLT	04200	109D106X0060C2-DYP
A4C2	0180-2139	2	1	CAP-FXD 10uF +-20% 60 V WT-SLG-TA-ELCTLT	04200	109D106X0060C2-DYP
A4C4	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A4C6	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A4C7	0180-2139	2	1	CAP-FXD 10uF +-20% 60 V WT-SLG-TA-ELCTLT	04200	109D106X0060C2-DYP
A4C8	0180-2139	2	1	CAP-FXD 10uF +-20% 60 V WT-SLG-TA-ELCTLT	04200	109D106X0060C2-DYP
A4C9	0180-2206	4	1	CAP-FXD 60uF +-10% 6 V TA	04200	150D606X9006B2-DYS
A4C10	0180-2206	4	1	CAP-FXD 60uF +-10% 6 V TA	04200	150D606X9006B2-DYS
A4C11	0160-0160	3	1	CAP-FXD 8200pF +-10% 200 V POLYE-FL	05176	HEW238T
A4C12	0160-0160	3	1	CAP-FXD 8200pF +-10% 200 V POLYE-FL	05176	HEW238T
A4C13	0180-0228	6	1	CAP-FXD 22uF +-10% 15 V TA	04200	150D226X9015B2-DYS
A4C14	0180-0228	6	1	CAP-FXD 22uF +-10% 15 V TA	04200	150D226X9015B2-DYS
A4C15	0180-0228	6	1	CAP-FXD 22uF +-10% 15 V TA	04200	150D226X9015B2-DYS
A4C16	0180-0228	6	1	CAP-FXD 22uF +-10% 15 V TA	04200	150D226X9015B2-DYS
A4C17	0180-0374	3	1	CAP-FXD 10uF +-10% 20 V TA	04200	150D106X9020B2-DYS
A4C18	0180-0374	3	1	CAP-FXD 10uF +-10% 20 V TA	04200	150D106X9020B2-DYS
A4C19	0180-0229	7	1	CAP-FXD 33uF +-10% 10 V TA	04200	150D336X9010B2-DYS
A4C20	0160-3439	5	1	CAP-FXD 0.039uF +-5% 200 V POLYC-MET	05176	HEW-249
A4C21	0160-3439	5	1	CAP-FXD 0.039uF +-5% 200 V POLYC-MET	05176	HEW-249
A4C22	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A4CR1	1901-0895	4	1	DIODE-SCHOTTKY SM SIG	02062	QSCH1186
A4CR2	1901-0895	4	1	DIODE-SCHOTTKY SM SIG	02062	QSCH1186
A4CR3	1901-0895	4	1	DIODE-SCHOTTKY SM SIG	02062	QSCH1186

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A4CR4	1901-0895	4	1	DIODE-SCHOTTKY SM SIG	02062	QSCH1186
A4J1	1252-3487	9	1	CONN-POST TYPE .100-PIN-SPCG 5-CONT	02946	87499-104
A4J2	1252-3489	1	1	CONN-POST TYPE .100-PIN-SPCG 3-CONT	02946	87499-102
A4J3	1252-3488	0	1	CONN-POST TYPE .100-PIN-SPCG 4-CONT	02946	87499-103
A4J4	1252-3488	0	1	CONN-POST TYPE .100-PIN-SPCG 4-CONT	02946	87499-103
A4J5	1252-3487	9	1	CONN-POST TYPE .100-PIN-SPCG 5-CONT	02946	87499-104
A4J6	1250-1255	1	1	CONNECTOR-RF SMB M PC 50-OHM	05769	51-051-0000
A4J7	1252-3487	9	1	CONN-POST TYPE .100-PIN-SPCG 5-CONT	02946	87499-104
A4J8	1252-3488	0	1	CONN-POST TYPE .100-PIN-SPCG 4-CONT	02946	87499-103
A4J9	1252-3488	0	1	CONN-POST TYPE .100-PIN-SPCG 4-CONT	02946	87499-103
A4J10	1251-8248	8	1	CONN-POST TYPE .100-PIN-SPCG 26-CONT	04726	3593-6002
A4J11	1252-3487	9	1	CONN-POST TYPE .100-PIN-SPCG 5-CONT	02946	87499-104
A4J12	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A4J13	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A4J14	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A4J15	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A4L1	9100-3922	4	1	INDUCTOR-FIXED Z > 1200 OHMS 120 TO 650	03259	14067
A4L2	9100-3922	4	1	INDUCTOR-FIXED Z > 1200 OHMS 120 TO 650	03259	14067
A4L3	9100-2247	4	1	INDUCTOR RF-CH-MLD 100NH +-10%	03273	10M100K
A4L4	9100-3922	4	1	INDUCTOR-FIXED Z > 1200 OHMS 120 TO 650	03259	14067
A4L5	9100-3922	4	1	INDUCTOR-FIXED Z > 1200 OHMS 120 TO 650	03259	14067
A4Q1	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
A4Q2	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
A4Q3	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
A4Q4	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A4Q5	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A4R1	0811-1557	5	1	RESISTOR 15 +-5% 3W PWI TC=0+-20	05524	RS-2B
A4R2	0757-0346	2	1	RESISTOR 10 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R3	0757-0346	2	1	RESISTOR 10 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R4	0698-3447	4	1	RESISTOR 422 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R5	0757-0346	2	1	RESISTOR 10 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R6	0757-0346	2	1	RESISTOR 10 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R7	0698-3447	4	1	RESISTOR 422 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R8	0698-3450	9	1	RESISTOR 42.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R9	0698-3450	9	1	RESISTOR 42.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R10	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R11	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R12	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R13	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R14	0757-0459	8	1	RESISTOR 56.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R15	0757-0459	8	1	RESISTOR 56.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R16	0698-3159	5	1	RESISTOR 26.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R17	0698-3159	5	1	RESISTOR 26.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A4R18	0698-3450	9	1	RESISTOR 42.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R19	0698-3450	9	1	RESISTOR 42.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R20	0757-0444	1	1	RESISTOR 12.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R21	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R22	0757-0444	1	1	RESISTOR 12.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R23	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R24	0757-0463	4	1	RESISTOR 82.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R25	0757-0463	4	1	RESISTOR 82.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R26	2100-2655	1	1	RESISTOR-TRMR 100K 10% TKF TOP-ADJ 1-TRN	04568	82PR100K
A4R27	2100-2655	1	1	RESISTOR-TRMR 100K 10% TKF TOP-ADJ 1-TRN	04568	82PR100K
A4R28	0698-3451	0	1	RESISTOR 133K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R29	0698-3451	0	1	RESISTOR 133K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R30	0698-3160	8	1	RESISTOR 31.6K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R31	0698-3160	8	1	RESISTOR 31.6K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R32	0698-0083	8	1	RESISTOR 1.96K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R33	0698-0083	8	1	RESISTOR 1.96K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R34	2100-2655	1	1	RESISTOR-TRMR 100K 10% TKF TOP-ADJ 1-TRN	04568	82PR100K
A4R35	2100-2655	1	1	RESISTOR-TRMR 100K 10% TKF TOP-ADJ 1-TRN	04568	82PR100K
A4R36	0698-0084	9	1	RESISTOR 2.15K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R37	0698-0084	9	1	RESISTOR 2.15K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R38	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R39	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R40	0698-3154	0	1	RESISTOR 4.22K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R41	0757-0200	7	1	RESISTOR 5.62K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R42	0757-0460	1	1	RESISTOR 61.9K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R43	2100-2030	6	1	RESISTOR-TRMR 20K 10% TKF TOP-ADJ 1-TRN	04568	82PR20K
A4R44	0757-0460	1	1	RESISTOR 61.9K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R45	0698-3154	0	1	RESISTOR 4.22K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R46	0757-0200	7	1	RESISTOR 5.62K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R47	0757-0279	0	1	RESISTOR 3.16K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R48	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R49	0757-0422	5	1	RESISTOR 909 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R50	0698-3446	3	1	RESISTOR 383 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R51	0699-2624	9	1	RESISTOR 2.61K +-0.1% .125W TF TC=0+-25	05524	CMF-55-1
A4R52	0699-2623	8	1	RESISTOR 2.58K +-0.1% .125W TF TC=0+-25	05524	CMF-55-1
A4R53	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R54	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R55	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4R56	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A4TP1	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP2	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP3	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP4	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A4TP5	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP6	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP7	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP8	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP9	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4TP10	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A4U1	1826-0547	3	1	IC OP AMP LOW-BIAS-H-IMPD DUAL 8 PIN	01698	TL072ACP
A4U2	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A4U3	1826-0547	3	1	IC OP AMP LOW-BIAS-H-IMPD DUAL 8 PIN	01698	TL072ACP
A4U4	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A4U5	1826-0600	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14 PIN	01698	TL074ACN
A4VR1	1902-3002	3	1	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	02037	
A4VR2	1902-3002	3	1	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	02037	
A4VR3	1902-3002	3	1	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	02037	
A4VR4	1902-3002	3	1	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	02037	
A4W1	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W2	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W3	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W4	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W5	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W6	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W9	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W10	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W11	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W12	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A4W13	00438-60040	8	1	CABLE AY AMP SIG	28480	00438-60040
A5	00438-60005	5	1	BD AY MAIN AMPL	28480	00438-60005
A5C1	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A5C2	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A5C3	0180-0197	8	1	CAP-FXD 2.2uF +-10% 20 V TA	04200	150D225X9020A2-DYS
A5C4	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A5C5	0160-6294	6	1	CAP-FXD 1000pF +-5% 50 V CER C0G	06352	DA13C0G1H102J
A5C6	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A5C8	0160-0127	2	1	CAP-FXD 1uF +-20% 50 V CER Z5U	02010	SR835E105MAAH
A5C9	0160-2290	4	1	CAP-FXD 0.15uF +-10% 80 V POLYE-FL	05176	HEW-238T
A5C10	0160-3336	1	1	CAP-FXD 100pF +-10% 50 V CER X7R	02010	SA102A101KAAH
A5C11	0160-3336	1	1	CAP-FXD 100pF +-10% 50 V CER X7R	02010	SA102A101KAAH
A5C12	0160-3336	1	1	CAP-FXD 100pF +-10% 50 V CER X7R	02010	SA102A101KAAH
A5C13	0180-0197	8	1	CAP-FXD 2.2uF +-10% 20 V TA	04200	150D225X9020A2-DYS
A5C14	0180-0197	8	1	CAP-FXD 2.2uF +-10% 20 V TA	04200	150D225X9020A2-DYS
A5C15	0180-0197	8	1	CAP-FXD 2.2uF +-10% 20 V TA	04200	150D225X9020A2-DYS
A5C16	0180-0197	8	1	CAP-FXD 2.2uF +-10% 20 V TA	04200	150D225X9020A2-DYS

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A5C17	0160-2199	2	1	CAP-FXD 30pF +-5% 300 V MICA	02367	CD15ED300JO3
A5C18	0160-2199	2	1	CAP-FXD 30pF +-5% 300 V MICA	02367	CD15ED300JO3
A5C19	0160-3762	7	1	CAP-FXD 0.68uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C20	0160-3702	5	1	CAP-FXD 0.027uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C21	0160-3402	2	1	CAP-FXD 1uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C22	0160-3661	5	1	CAP-FXD 0.1uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C23	0180-0373	2	1	CAP-FXD 0.68uF +-10% 35 V TA	04200	150D684X9035A2-DYS
A5C24	0180-0373	2	1	CAP-FXD 0.68uF +-10% 35 V TA	04200	150D684X9035A2-DYS
A5C25	0160-4557	0	1	CAP-FXD 0.1uF +-20% 50 V CER X7R	02010	SA305C104MAAH
A5C26	0160-3402	2	1	CAP-FXD 1uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C27	0160-3439	5	1	CAP-FXD 0.039uF +-5% 200 V POLYC-MET	05176	HEW-249
A5C28	0160-3661	5	1	CAP-FXD 0.1uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C29	0160-0160	3	1	CAP-FXD 8200pF +-10% 200 V POLYE-FL	05176	HEW238T
A5C30	0160-4325	0	1	CAP-FXD 0.33uF +-5% 50 V POLYC-MET	05176	HEW-249
A5C31	0160-0161	4	1	CAP-FXD 0.01uF +-10% 200 V POLYE-FL	05176	HEW238T
A5C32	0160-0168	1	1	CAP-FXD 0.1uF +-10% 200 V POLYE-FL	05176	HEW238T
A5C33	0160-0155	6	1	CAP-FXD 3300pF +-10% 200 V POLYE-FL	05176	HEW238T
A5C34	0160-2291	5	1	CAP-FXD 0.18uF +-10% 80 V POLYE-FL	05176	HEW-238T
A5C35	0160-7136	7	1	CAP-FXD 0.1uF +-1% 100 V POLYP-FL	05176	HEW860
A5C36	0160-2199	2	1	CAP-FXD 30pF +-5% 300 V MICA	02367	CD15ED300JO3
A5CR1	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	03406	
A5J1	1251-8935	0	1	CONN-POST TYPE .100-PIN-SPCG 2-CONT	02946	65806-077
A5J2	1251-8106	7	1	CONN-POST TYPE .100-PIN-SPCG 20-CONT	04726	3592-6002
A5J3	1251-8248	8	1	CONN-POST TYPE .100-PIN-SPCG 26-CONT	04726	3593-6002
A5J4	1250-1377	8	1	CONNECTOR-RF SMB M PC 50-OHM	02788	5164-5003-09
A5L1	9140-0210	1	1	INDUCTOR RF-CH-MLD 100UH +-5%	05826	1537-76
A5MP1	0361-0009	5	2	RIVET-SEMITUB OVH .123DIA .188LG	02531	R-4012
A5MP2	00438-20029	9	2	HINGE RIVETED	28480	00438-20029
A5Q1	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A5Q2	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A5Q3	1855-0420	2	1	TRANSISTOR J-FET 2N4391 N-CHAN D-MODE	02883	2N4391
A5Q4	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A5Q5	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
A5Q6	1853-0459	3	1	TRANSISTOR PNP SI PD=625MW FT=200MHZ	02037	
A5Q7	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
A5Q8	1855-0414	4	1	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	02883	2N4393
A5Q9	1853-0314	9	1	TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	02037	2N2905A
A5R1	1810-0280	8	1	NETWORK-RES 10-SIP 10.0K OHM X 9	05524	MSP10A01
A5R2	0757-0279	0	1	RESISTOR 3.16K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R3	1810-0280	8	1	NETWORK-RES 10-SIP 10.0K OHM X 9	05524	MSP10A01
A5R4	0699-0842	9	1	RESISTOR 6.19K +-0.1% .125W TF TC=0+-25	01074	H8
A5R5	0698-3444	1	1	RESISTOR 316 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R6	0757-0274	5	1	RESISTOR 1.21K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A5R7	0757-0439	4	1	RESISTOR 6.81K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R8	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R9	0757-0123	3	1	RESISTOR 34.8K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R10	0757-0279	0	1	RESISTOR 3.16K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R11	0698-8638	5	1	RESISTOR 3.16K +-0.1% .125W TF TC=0+-25	05524	CMF-55-1
A5R12	0698-8638	5	1	RESISTOR 3.16K +-0.1% .125W TF TC=0+-25	05524	CMF-55-1
A5R13	0699-0842	9	1	RESISTOR 6.19K +-0.1% .125W TF TC=0+-25	01074	H8
A5R14	0757-0420	3	1	RESISTOR 750 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R15	0699-0148	8	1	RESISTOR 31.6K +-0.1% .1W TF TC=0+-15	05524	PTF-56-7
A5R16	0757-0290	5	1	RESISTOR 6.19K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R17	0699-0924	8	1	RESISTOR 11K +-0.1% .125W TF TC=0+-25	01074	H8
A5R18	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R19	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R20	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R21	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R22	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R23	0811-3351	1	1	RESISTOR 11K +-0.025% .05W PN TC=0+-10	03123	140
A5R24	0811-3348	6	1	RESISTOR 111.11 +-0.025% .05W PN	03123	140
A5R25	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R26	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R27	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R28	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R29	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R30	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R31	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R32	0698-3158	4	1	RESISTOR 23.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R33	0698-3158	4	1	RESISTOR 23.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R34	0698-3158	4	1	RESISTOR 23.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R35	0698-3158	4	1	RESISTOR 23.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R36	0698-3442	9	1	RESISTOR 237 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R37	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R38	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R39	0698-3441	8	1	RESISTOR 215 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R40	0757-1094	9	1	RESISTOR 1.47K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R41	0757-0461	2	1	RESISTOR 68.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R42	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R43	0757-0463	4	1	RESISTOR 82.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R44	0698-3453	2	1	RESISTOR 196K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R45	0757-0470	3	1	RESISTOR 162K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R46	0757-0288	1	1	RESISTOR 9.09K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R47	0698-3157	3	1	RESISTOR 19.6K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R48	0698-3161	9	1	RESISTOR 38.3K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R49	0757-0462	3	1	RESISTOR 75K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A5R50	0757-0444	1	1	RESISTOR 12.1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R51	0698-3162	0	1	RESISTOR 46.4K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R52	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R53	0811-3350	0	1	RESISTOR 10K +-0.025% .05W PN TC=0+-10	03123	140
A5R54	0811-3349	7	1	RESISTOR 1K +-0.025% .05W PN TC=0+-10	03123	140
A5R55	0811-3348	6	1	RESISTOR 111.11 +-0.025% .05W PN	03123	140
A5R56	0698-3455	4	1	RESISTOR 261K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R57	0757-0274	5	1	RESISTOR 1.21K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R58	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R59	0698-6360	6	1	RESISTOR 10K +-0.1% .125W TF TC=0+-25	05524	CMF-55-1, T-9
A5R60	0757-0199	3	1	RESISTOR 21.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R61	2100-3109	2	1	RESISTOR-TRMR 2K 10% TKF SIDE-ADJ 17-TRN	04568	89PR2K
A5R62	0757-0440	7	1	RESISTOR 7.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R63	0757-0123	3	1	RESISTOR 34.8K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R64	0699-0148	8	1	RESISTOR 31.6K +-0.1% .1W TF TC=0+-15	05524	PTF-56-7
A5R65	0699-1172	0	1	RESISTOR 200K +-0.1% .1W TF TC=+50+-5	02499	MTR5-+50PPM/DEG C-200K-0.1%
A5R66	0698-3160	8	1	RESISTOR 31.6K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R67	0698-3136	8	1	RESISTOR 17.8K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R68	0698-3450	9	1	RESISTOR 42.2K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R69	0757-0278	9	1	RESISTOR 1.78K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R70	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R71	0699-0148	8	1	RESISTOR 31.6K +-0.1% .1W TF TC=0+-15	05524	PTF-56-7
A5R72	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R73	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R74	0698-3449	6	1	RESISTOR 28.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R75	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R76	0757-0441	8	1	RESISTOR 8.25K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R77	0698-3150	6	1	RESISTOR 2.37K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R79	0757-0419	0	1	RESISTOR 681 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R80	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R81	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R82	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R83	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5R84	0698-3156	2	1	RESISTOR 14.7K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A5TP1	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP2	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP3	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP4	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP5	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP6	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP7	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP8	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP9	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A5TP10	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP11	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP12	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP13	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP14	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP15	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP16	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP17	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP18	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP19	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5TP20	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A5U1	1826-1460	1	1	IC OP AMP GP 8 PIN DIP-P	04078	LM201AN
A5U2	1826-0471	2	1	IC OP AMP LOW-DRIFT 8 PIN TO-99	02180	OP-07CJ SELECTED
A5U3	1826-0921	7	1	D/A 10-BIT 16-CBRZ CMOS	03285	AD7533CD
A5U4	1820-1997	7	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG PRL-IN	03406	DM74LS374N
A5U5	1820-1934	2	1	D/A 8-BIT 16-CERDIP BPLR	02180	DAC-08EQ
A5U6	1820-1997	7	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG PRL-IN	03406	DM74LS374N
A5U7	1826-0098	9	1	IC COMPARATOR PRCN 8 PIN TO-99	03406	LM211H
A5U8	1826-0026	3	1	IC COMPARATOR PRCN 8 PIN TO-99	03406	LM311H
A5U9	1826-0471	2	1	IC OP AMP LOW-DRIFT 8 PIN TO-99	02180	OP-07CJ SELECTED
A5U10	1820-1934	2	1	D/A 8-BIT 16-CERDIP BPLR	02180	DAC-08EQ
A5U11	1820-1997	7	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG PRL-IN	03406	DM74LS374N
A5U12	1826-0544	0	1	IC V RGLTR-V-REF-FXD 2.5V 8-DIP-C PKG	02037	
A5U13	1820-1199	1	1	IC INV TTL/LS HEX 1-INP	01698	SN74LS04N
A5U14	1820-1997	7	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG PRL-IN	03406	DM74LS374N
A5U15	1820-1216	3	1	IC DCDR TTL/LS BIN 3-TO-8-LINE 3-INP	01698	SN74LS138N
A5U16	1820-1997	7	1	IC FF TTL/LS D-TYPE POS-EDGE-TRIG PRL-IN	03406	DM74LS374N
A5U17	1826-0574	6	1	IC OP AMP LOW-DRIFT 8 PIN TO-99	03406	OP07DJ
A5U18	1820-2024	3	1	IC DRVR TTL/LS BUS OCTL	01698	SN74LS244N
A5U19	1826-1021	0	1	ANALOG MULTIPLEXER CHNL 16 -DIP-P	02883	DG508ACJ
A5U20	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A5U21	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A5U22	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A5U23	1826-0600	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14 PIN	01698	TL074ACN
A5U24	1826-0600	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14 PIN	01698	TL074ACN
A5U25	1826-1019	6	1	ANALOG SWITCH 4 SPST 16 -CERDIP	02883	DG201ABK
A5U26	1826-1460	1	1	IC OP AMP GP 8 PIN DIP-P	04078	LM201AN
A5U27	1826-1460	1	1	IC OP AMP GP 8 PIN DIP-P	04078	LM201AN
A5U28	1826-0471	2	1	IC OP AMP LOW-DRIFT 8 PIN TO-99	02180	OP-07CJ SELECTED
A5VR1	1902-0680	7	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	02037	1N827
A5VR2	1902-0947	9	1	DIODE-ZNR 3.6V 5% DO-35 PD=.4W TC=-.036%	02037	
A5VR3	1902-0680	7	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	02037	1N827
A5W11	00438-60035	1	1	CBL AY ANALG INP	28480	00438-60035

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A8	00438-60008	8	1	BD AY RECTIFIER	28480	00438-60008
A8C1	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A8C2	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A8C3	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A8CR1	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A8CR2	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A8CR3	1906-0231	2	1	DIODE-CT-RECT 200V 15A	12928	R712
A8MP1	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP2	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP3	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP4	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP5	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP6	0515-1087	8	1	SCREW-MACH M3 X 0.5 14MM-LG PAN-HD	01711	
A8MP7	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP8	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP9	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP10	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP11	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP12	0590-1076	3	1	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	03981	KFS2-M3
A8MP13	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP14	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP15	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP16	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP17	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP18	1200-0081	4	1	INSULATOR-FLG-BSHG NYLON	03380	974 307
A8MP19	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP20	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP21	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP22	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP23	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP24	1251-2313	6	1	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	01380	3-332070-5
A8MP25	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP26	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP27	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP28	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP29	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP30	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A8MP31	00438-20021	1	1	HEATSINK RECT.	28480	00438-20021
A8MP32	6040-0239	9		HEAT SINK COMPOUND SIL	02123	120
A8R1	0698-3438	3	1	RESISTOR 147 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A8U1	1826-0423	4	1	IC V RGLTR-ADJ-POS 1.2/37V TO-3 PKG	03406	LM317K
A8U2	1826-0677	0	1	IC V RGLTR-ADJ-POS 1.2/32V TO-3 PKG	03406	LM338K

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A9	00438-60009	9	1	BD AY REGULATOR	28480	00438-60009
A9C1	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A9C2	0160-0163	6	1	CAP-FXD 0.033uF +-10% 200 V POLYE-FL	05176	HEW238T
A9C3	0160-0161	4	1	CAP-FXD 0.01uF +-10% 200 V POLYE-FL	05176	HEW238T
A9C4	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A9C5	0160-0161	4	1	CAP-FXD 0.01uF +-10% 200 V POLYE-FL	05176	HEW238T
A9C6	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A9C7	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A9C8	0160-0127	2	1	CAP-FXD 1uF +-20% 50 V CER Z5U	02010	SR835E105MAAH
A9C9	0160-3638	6	1	CAP-FXD 0.22uF +80% -20% 200 V CER X5V	02010	SR402E224ZAAH
A9C10	0160-6437	9	1	CAP-FXD 1uF +-10% 50 V CER Y5R	06352	FD41Y5R1H105K
A9C11	0180-0491	5	1	CAP-FXD 10uF +-20% 25 V TA	04200	199D1112
A9C12	0180-1743	2	1	CAP-FXD 0.1uF +-10% 35 V TA	04200	150D104X9035A2-DYS
A9C13	0180-0291	3	1	CAP-FXD 1uF +-10% 35 V TA	04200	150D105X9035A2-DYS
A9CR1	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR2	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR3	1901-0418	7	1	DIODE-PWR RECT 400V 1.5A	02037	
A9CR4	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR5	1901-0418	7	1	DIODE-PWR RECT 400V 1.5A	02037	
A9CR6	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR7	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR8	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	03406	
A9CR9	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	03406	
A9CR10	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A9CR11	1901-0418	7	1	DIODE-PWR RECT 400V 1.5A	02037	
A9DS1	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	01542	HLMP-1301
A9DS2	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	01542	HLMP-1301
A9DS3	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	01542	HLMP-1301
A9DS4	1990-0486	6	1	LED-LAMP LUM-INT=2MCD IF=25MA-MAX BVR=5V	01542	HLMP-1301
A9MP1	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP2	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP3	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP4	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP5	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP6	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP7	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP8	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A9MP9	0515-0925	1	1	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	09908	
A9MP10	0515-0925	1	1	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	09908	
A9MP11	0535-0004	9	1	NUT-HEX DBL-CHAM M3 X 0.5 2.9MM-THK	06691	
A9MP12	0535-0004	9	1	NUT-HEX DBL-CHAM M3 X 0.5 2.9MM-THK	06691	
A9MP13	1205-0011	0	1	HEAT SINK TO-5/TO-39-CS	05792	TXBF-032-025B
A9MP14	1205-0353	3	1	HEAT SINK SGL PLSTC-PWR-CS	02608	6073B

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A9MP15	1205-0353	3	1	HEAT SINK SGL PLSTC-PWR-CS	02608	6073B
A9MP16	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A9MP17	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A9MP18	3050-0105	6	1	WASHER-FL MTLC NO. 4 .125-IN-ID	04821	
A9MP19	3050-0105	6	1	WASHER-FL MTLC NO. 4 .125-IN-ID	04821	
A9MP20	5000-9043	6	1	PIN	28480	5000-9043
A9MP21	5040-6843	2	1	EXTRACTOR	28480	5040-6843
A9MP22	08673-20063	2	2	BUSHING	28480	08673-20063
A9MP23	6040-0239	9		HEAT SINK COMPOUND SIL	02123	120
A9Q1	1884-0244	9	1	THYRISTOR-SCR VRRM=400	28480	1884-0244
A9Q2	1884-0244	9	1	THYRISTOR-SCR VRRM=400	28480	1884-0244
A9R1	0757-1094	9	1	RESISTOR 1.47K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R2	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R3	2100-2633	5	1	RESISTOR-TRMR 1K 10% TKF SIDE-ADJ 1-TRN	04568	82PAR1K
A9R4	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R5	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R6	0757-0418	9	1	RESISTOR 619 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R7	0757-0397	3	1	RESISTOR 68.1 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R8	0757-0288	1	1	RESISTOR 9.09K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R9	0698-3447	4	1	RESISTOR 422 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R10	0698-3447	4	1	RESISTOR 422 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R11	0698-3154	0	1	RESISTOR 4.22K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R12	0698-3444	1	1	RESISTOR 316 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R13	0757-0440	7	1	RESISTOR 7.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R14	0757-0440	7	1	RESISTOR 7.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R15	0757-0398	4	1	RESISTOR 75 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R16	2100-2633	5	1	RESISTOR-TRMR 1K 10% TKF SIDE-ADJ 1-TRN	04568	82PAR1K
A9R17	0757-1094	9	1	RESISTOR 1.47K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9R18	0757-1094	9	1	RESISTOR 1.47K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
A9U1	1826-0607	6	1	IC V RGLTR-FXD-POS 14.7/15.3V TO-220 PKG	03406	LM340AT-15
A9U2	1826-0527	9	1	IC V RGLTR-ADJ-NEG 1.2/37V 3-TO-220 PKG	03406	LM337T
A9VR1	1902-0952	6	1	DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	02037	SZ30035-10RL
A9VR2	1902-0176	6	1	DIODE-ZNR 47V 5% PD=1W IR=5UA	02037	
A10	00438-60006	6	1	BD AY MOTHER	28480	00438-60006
A10C1	0180-3286	2	1	CAP-FXD +75% -10% 15 V AL-ELCTLT	04200	36DE183G015EA2P
A10C2	0180-3283	9	1	CAP-FXD 2200uF +75% -10% 50 V AL-ELCTLT	04200	36DE1056
A10C3	0180-3282	8	1	CAP-FXD 680uF +100% -10% 50 V AL-ELCTLT	04200	674D183
A10C4	0160-3638	6	1	CAP-FXD 0.22uF +80% -20% 200 V CER X5V	02010	SR402E224ZAAH
A10C5	0180-1743	2	1	CAP-FXD 0.1uF +-10% 35 V TA	04200	150D104X9035A2-DYS
A10C6	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A10C7	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A10C8	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
A10C9	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
A10CR1	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A10CR2	1901-0028	5	1	DIODE-PWR RECT 400V 750MA DO-29	02664	SS5117
A10J1	1252-3491	5	1	CONN-POST TYPE .100-PIN-SPCG 8-CONT	02946	87800-107
A10J2	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A10J3	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
A10J4	1251-3638	0	1	CONN-POST TYPE .156-PIN-SPCG 6-CONT	03418	26-60-1060
A10MP1	0515-0925	1	1	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	09908	
A10MP2	0535-0004	9	1	NUT-HEX DBL-CHAM M3 X 0.5 2.9MM-THK	06691	
A10MP3	1205-0353	3	1	HEAT SINK SGL PLSTC-PWR-CS	02608	6073B
A10MP6	2190-0003	8	1	WASHER-LK HLCL NO. 4 .115-IN-ID	04939	
A10MP7	2200-0103	2	1	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	04771	
A10MP8	3050-0105	6	1	WASHER-FL MTLC NO. 4 .125-IN-ID	04821	
A10MP9	5040-0170	6	1	SUPPORT BOARD	28480	5040-0170
A10MP10	08673-20063	2	1	BUSHING	28480	08673-20063
A10MP11	6040-0239	9		HEAT SINK COMPOUND SIL	02123	120
A10TP1	0360-0535	0	1	CONNECTOR-SGL CONT TML-TS-PT	04055	
A10U1	1826-0147	9	1	IC V RGLTR-FXD-POS 11.5/12.5V TO-220 PKG	02037	UA7812UC
A10W1	8159-0005	0	1	RESISTOR 0 CWM	01339	L-2007-1
A10XA8	1251-8116	9	1	CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	04068	252-18-50-123
A10XA9	1251-8116	9	1	CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	04068	252-18-50-123
G1	00438-60010	2	1	50MHZ OSC BD AY	28480	00438-60010
G1A1	00436-60011	1	1	BD AY 50MHZ OSC	28480	00436-60011
G1A1C1	0160-3879	7	1	CAP-FXD 0.01uF +-20% 100 V CER X7R	02010	SR201C103MAAH
G1A1C4	0160-3879	7	1	CAP-FXD 0.01uF +-20% 100 V CER X7R	02010	SR201C103MAAH
G1A1C5	0160-3879	7	1	CAP-FXD 0.01uF +-20% 100 V CER X7R	02010	SR201C103MAAH
G1A1C6	0160-2027	5	1	CAP-FXD 300pF +-5% 500 V MICA	02367	CD15FD301JO3
G1A1C7	0160-3070	0	1	CAP-FXD 100pF +-5% 300 V MICA	02367	CD15FD101JO3
G1A1C8	0180-0100	3	1	CAP-FXD 4.7uF +-10% 35 V TA	04200	150D475X9035B2-DYS
G1A1C9	0160-2255	1	1	CAP-FXD 8.2pF +-3.05% 500 V CER C0G	09538	301-000-COH0-829C
G1A1C10	0160-3878	6	1	CAP-FXD 1000pF +-20% 100 V CER X7R	02010	SR201C102MAAH
G1A1C11	0160-0179	4	1	CAP-FXD 33pF +-5% 300 V MICA	02367	CD15ED330JO3
G1A1C12	0160-3879	7	1	CAP-FXD 0.01uF +-20% 100 V CER X7R	02010	SR201C103MAAH
G1A1C13	0160-7088	8	1	CAP-FXD 36pF +-2% 300 V GL	02010	TY06-360G
G1A1C14	0160-7087	7	1	CAP-FXD 200pF +-2% 300 V GL	02010	CY06C201G
G1A1CR1	1901-0518	8	1	DIODE-SCHOTTKY SM SIG	02062	5082-5509
G1A1CR2	1901-0518	8	1	DIODE-SCHOTTKY SM SIG	02062	5082-5509
G1A1CR3	0122-0299	9	1	DIODE-VVC 82PF 5% C 2/C20-MIN=2	02037	
G1A1J1	1250-1220	0	1	CONNECTOR-RF SMC M PC 50-OHM	05769	050-051-0109-220
G1A1L1	00436-80001	1	1	COIL VARIABLE	28480	00436-80001
G1A1L2	9140-0144	0	1	INDUCTOR RF-CH-MLD 4.7UH +-10%	05826	1025-36
G1A1L3	00436-80002	2	1	COIL 3 1/2 TURNS	28480	00436-80002

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
G1A1Q1	1854-0247	9	1	TRANSISTOR NPN SI TO-39 PD=1W FT=800MHZ	02037	
G1A1Q2	1854-0810	2	1	TRANSISTOR NPN SI PD=625MW FT=200MHZ	02037	
G1A1R1	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R2*	0757-1094	9	1	RESISTOR 1.47K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R3	0811-3234	9	1	RESISTOR 10K +-1% .05W PN TC=0+-10	03123	140
G1A1R4	2100-3109	2	1	RESISTOR-TRMR 2K 10% TKF SIDE-ADJ 17-TRN	04568	89PR2K
G1A1R5	0811-3682	1	1	RESISTOR 6.8K +-1% .05W PN TC=0+-10	03123	140
G1A1R6	0757-0440	7	1	RESISTOR 7.5K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R7	0698-7284	5	1	RESISTOR 100K +-1% .05W TF TC=0+-100	05524	CMF-50-2
G1A1R8	0757-0465	6	1	RESISTOR 100K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R9	0698-7284	5	1	RESISTOR 100K +-1% .05W TF TC=0+-100	05524	CMF-50-2
G1A1R10	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R11	0757-0280	3	1	RESISTOR 1K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R12	0757-0442	9	1	RESISTOR 10K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R13	0757-0438	3	1	RESISTOR 5.11K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R14	0757-0398	4	1	RESISTOR 75 +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R15	0757-0317	7	1	RESISTOR 1.33K +-1% .125W TF TC=0+-100	05524	CCF-55-1, T-1
G1A1R16	0698-6364	0	1	RESISTOR 50 +-0.1% .125W TF TC=0+-25	05524	CMF-55-1, T-9
G1A1TP1	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
G1A1TP2	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	03418	16-06-0034
G1A1U1	1826-0013	8	1	IC OP AMP LOW-NOISE 8 PIN TO-99	03285	AD741CH
G1A1U2	1820-0223	0	1	IC OP AMP GP 8 PIN TO-99	03406	LM301AH
G1A1VR1	1902-0680	7	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	02037	1N827
G1A1VR2*	1902-0956	0	1	DIODE-ZNR 8.2V 5% DO-35 PD=.4W TC=+.065%	02037	
G1C2	0160-3036	8	1	CAP-FXD 5000pF +80% -20% 0 V CER X5V	03746	54-713-011-X5V-502Z
G1C3	0160-3036	8	1	CAP-FXD 5000pF +80% -20% 0 V CER X5V	03746	54-713-011-X5V-502Z
G1MP2	2190-0009	4	2	WASHER-LK INTL T NO. 8 .168-IN-ID	02440	820-BC
G1MP3	2190-0124	4	1	WASHER-LK INTL T NO. 10 .195-IN-ID	05769	3002-26
G1MP5	2580-0002	4	2	NUT-HEX-DBL-CHAM 8-32-THD .085-IN-THK	04939	
G1MP6	2950-0078	9	1	NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	04637	500220
G1MP8	7100-1204	9	1	CAN-RECT .72-IN-DP-OUT 1.959-IN-WD-OUT	01932	
G2	00438-60010	2	1	50MHZ OSC BD AY (OPTION 002 ONLY)	28480	00438-60010
B1	00438-60047	5	1	FAN ASSY	28480	00438-60047
C1	0160-4065	5	1	CAP-FXD 0.1UF +-20% 250VAC(RMS) (PART OF S1)	28480	0160-4065
C2	0160-4554	7	1	CAP-FXD 0.01uF +-20% 50 V CER X7R	02010	SA105C103MAAH
F1	2110-0001	8	1	FUSE 1A 250V NTD 1.25X.25 UL (PART OF S1)	75915	312001
F2	2110-0421	6	1	FUSE (INCH) .375A 250V TD FE UL	02805	MDL-3/8
J7	1250-0083	1	1	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	05879	31-221-1020
MP1	5021-8413	6	1	FRAME-FRT,88.1H	28480	5021-8413
MP2	00438-00018	4	1	PANEL-FRONT	28480	00438-00018
MP3	00438-20035	7	1	FRAME-REAR	28480	00438-20035
MP4	5041-8803	0	1	TRIM STRIP	28480	5041-8803
MP5	5001-0538	8	2	TRIM SIDE 3 1/2	28480	5001-0538

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
MP6	5062-3914	8	1	COVER-UTOP,PRF	28480	5062-3914
MP7	5062-3864	7	1	COVER-BTM,U TOP	28480	5062-3864
MP13	1460-1345	5	2	TILT STAND SST	00359	
MP14	00438-00019	5	1	REAR PANEL	28480	00438-00019
MP15	5041-8801	8	4	FOOT FULL-1/2MOD	28480	5041-8801
MP16	3160-0483	6	1	FAN GRILLE	10938	08147
MP17	0624-0458	6	4	SCREW-TPG 8-16 .375-IN-LG PAN-HD-POZI	05610	PLASTITE
MP21	2190-0016	3	1	WASHER-LK INTL T 3/8 IN .377-IN-ID	04805	1920-02
MP22	2950-0043	8	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	04605	28200-10-101
MP23	6960-0133	2	1	PLUG-HOLE TR-HD FOR .438-D-HOLE BRS	04507	BS-51043-K1105
MP24	6960-0024	0	2	PLUG-HOLE TR-HD FOR .688-D-HOLE NYL	03480	2673 (BLACK)
MP25	5021-5831	6	2	SIDE STRUT	28480	5021-5831
MP33	00438-00012	8	1	SUPPORT CABLE	28480	00438-00012
MP36	00438-00017	3	1	PANEL-SUB	28480	00438-00017
MP37	00438-20020	0	1	SCREEN RFI	28480	00438-20020
MP38	00438-20023	3	1	WINDOW	28480	00438-20023
MP39	5040-6889	6	1	LIGHT PIPE 19MM	28480	5040-6889
MP41	00438-20036	8	1	SUPPRT-BOT S PNL	28480	00438-20036
MP42	00438-20037	9	1	SUPPRT-TOP S PNL	28480	00438-20037
MP43	00438-00012	8	1	SUPPORT CABLE	28480	00438-00012
MP44	2190-0104	0	1	WASHER-LK INTL T 7/16 IN .439-IN-ID	04805	1922-04
MP45	2950-0132	6	2	NUT-HEX-DBL-CHAM 7/16-28-THD .094-IN-THK	04604	76500NP
MP46	00436-20014	0	2	WASHR MOUNT CONN	28480	00436-20014
MP47	1251-3362	7	2	NUT-AUDIO CONN	05879	91-T-422-6-9
MP48	0510-1148	2	5	RETAINER-PUSH-ON KB-TO-SHFT EXT	11544	669
MP49	7120-3104	4	2	WIRE MARKER SGL-LTR=A PLSTC-SPR-CLP PVC	02154	C8P-LETTER A
MP50	7120-3105	5	2	WIRE MARKER SGL-LTR=B PLSTC-SPR-CLP PVC	02154	C8P-LETTER B
MP52	2200-0164	5	1	SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG	04771	
MP53	2200-0166	7	8	SCREW-MACH 4-40 .312-IN-LG 82 DEG	04771	
MP54	5041-1682	9	1	KEY CAP LINE	28480	5041-1682
MP55	0362-0227	1	2	CONNECTOR-SGL CONT SKT 1.14-MM-BSC-SZ SQ	27264	02-05-5223
MP57	0360-1190	5	1	TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	04880	720-.380H
MP75	00438-00001	5	1	DECK	28480	00438-00001
MP76	00438-20031	3	1	BOARD SUPPORT	28480	00438-20031
MP77	00438-20026	6	1	PUSHROD (SWITCH)	28480	00438-20026
MP78	00438-20025	5	1	CLIP PUSHROD	28480	00438-20025
MP79	00438-00009	3	1	SUPPORT AMPLIFER	28480	00438-00009
MP81	7120-4163	7	1	LABEL-WARNING .5-IN-WD 1-IN-LG AL	22670	
MP82	00438-00002	6	1	SHIELD INPUT AMP	28480	00438-00002
MP85	0515-0886	3	4	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	09908	
MP91	2200-0164	5	1	SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG	04771	
MP100	1400-0249	0	2	CABLE TIE .062-.625-DIA .091-WD NYL	04225	TY-23M-8
S1	00438-60041	9	1	SWITCH PUSHBUTTON LINE ON OFF KIT	28480	00438-60041

Table 6-3. Replaceable Parts (continued)

Reference Designation	HP Part No.	C D	Qty	Description	Mfr Code	Manufacturer Part Number
T1	9100-4342	4	1	TRANSFORMER	28480	9100-4342
U1	0960-0443	1	1	LINE MODULE-FILTERED (PART OF S1)	28480	0960-0443
W1	00438-60050	0	1	CABLE AY-FRONT	28480	00438-60050
W2	00438-60050	0	1	CABLE AY-FRONT	28480	00438-60050
W3	00438-60026	0	1	CBL AY REF OSC	28480	00438-60026
W4				SEE A1W4		
W5				SEE A2W5		
W6				SEE A3W6		
W7	00438-60046	4	1	CABLE ASSY-HP IB	28480	00438-60046
W8	00438-60038	4	1	LINE SWITCH AY	28480	00438-60038
W9	00438-60052	2	1	WIRING HARNESS	28480	00438-60052
W10				SEE A4W13		
W11				SEE A5W11		
W12	8120-1378	1	1	OPT-903 18-AWG 3-COND 90-IN-LG	02805	CH7081
W13	00438-60051	1	1	CABLE AY-REAR (OPTION 002 ONLY)	28480	00438-60051
W14	00438-60051	1	1	CABLE AY-REAR (OPTION 002 ONLY)	28480	00438-60051
W15	00438-60026	0	1	CBL AY REF OSC (OPTION 002 ONLY)	28480	00438-60026
W16	00438-60048	6	1	WIRING HARNESS	28480	00438-60048
W17,W18	11730A		2	POWER SENSOR CABLE (5 FT.) (DELETED WITH OPTION 004)	28480	11730A

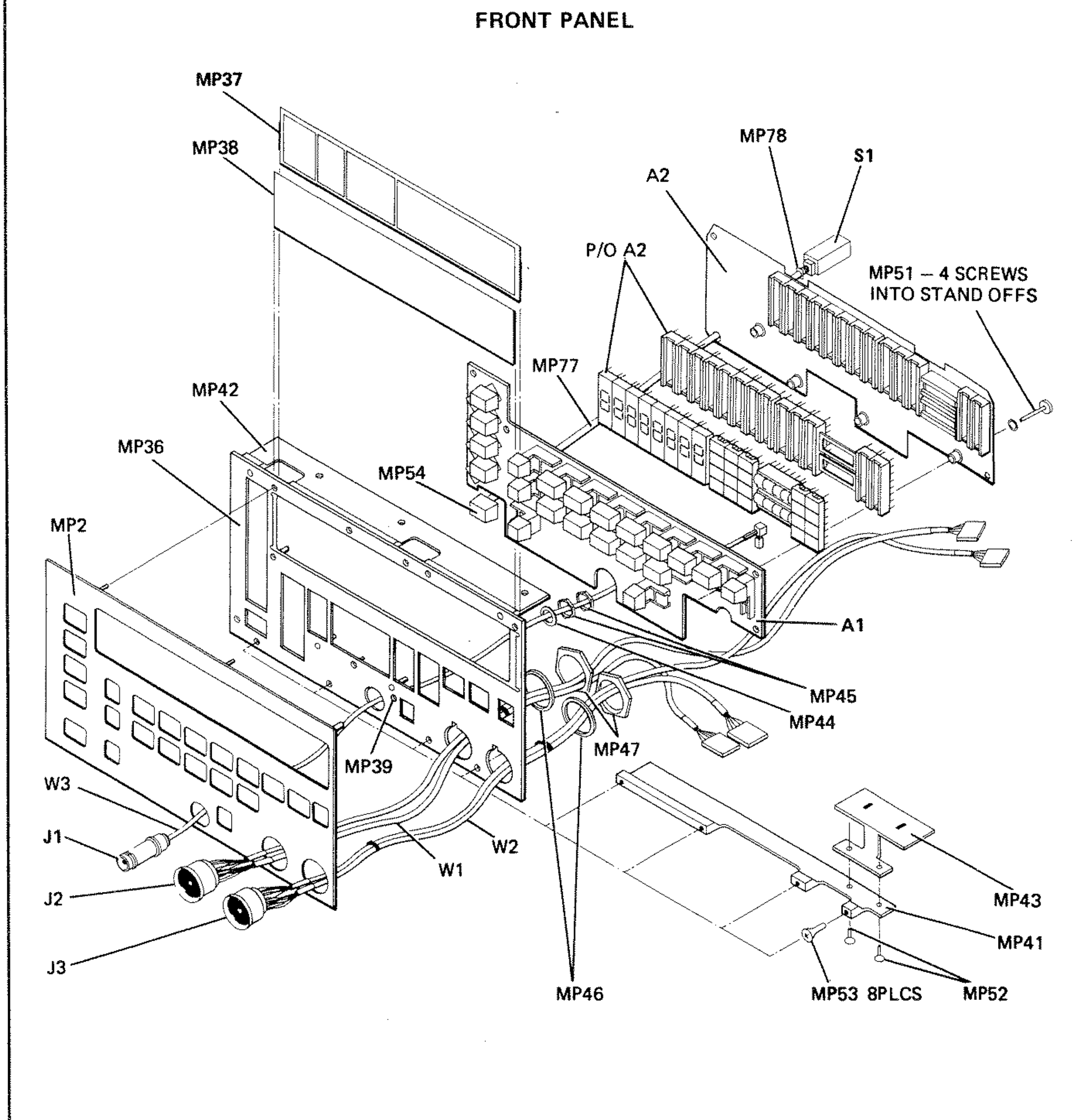


Figure 6-1. Front Panel Illustrated Parts Breakdown

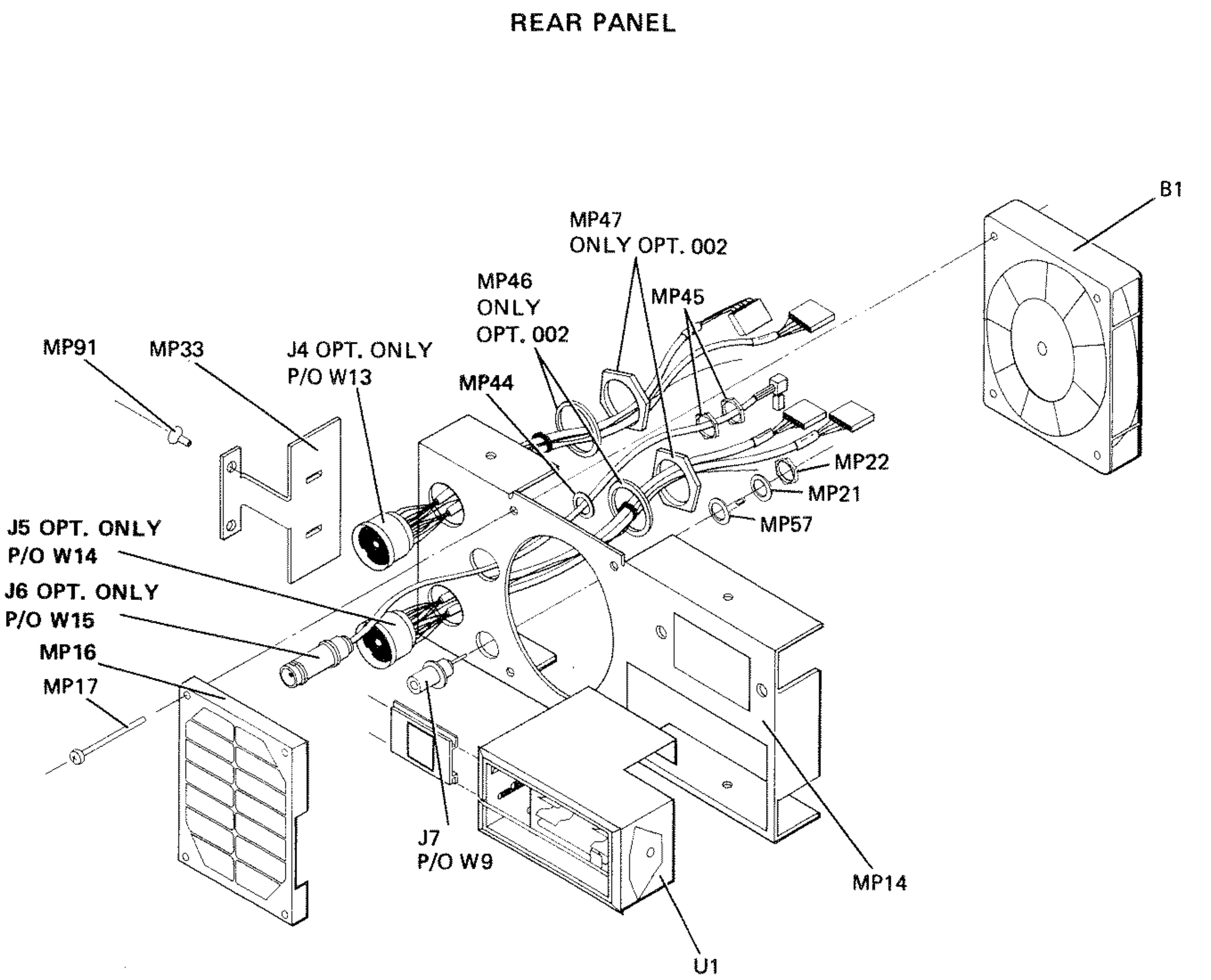


Figure 6-2. Rear Panel Illustrated Parts Breakdown

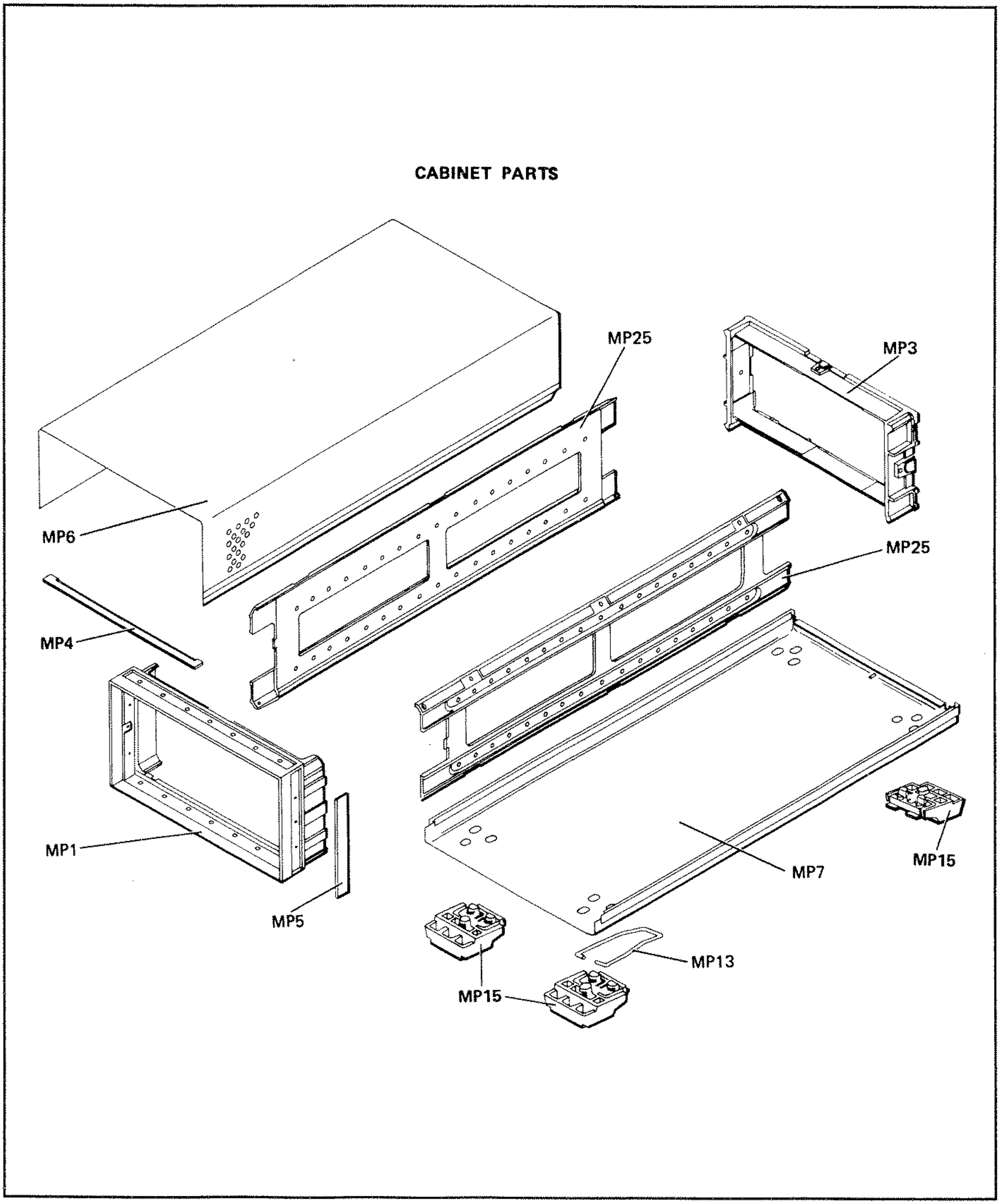


Figure 6-3. Cabinet Parts

Table 6-4. Code list of Manufacturers

Mfr Code	Manufacturer Name	Address	Zip Code
D3976	BUEHLER GEBR NACHFOLGER GMBH	NURNBERG GM	7750
S0545	NIPPON ELECTRIC CO	TOKYO JP	
00000	ANY SATISFACTORY SUPPLIER		
01121	ALLEN-BRADLEY CO INC	EL PASO TX US	79935
01295	TI INC SEMICOND COMPONENTS DIV	DALLAS TX	75222
02111	SPECTROL ELECTRONICS CORP	CITY OF IND CA	91745
03127	CHEMCENTRAL	CHICAGO IL US	60638
03888	K D I PYROFILM	WHIPPANY NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX AZ	85008
04729	UNICORP	ORANGE NJ	07050
05820	EG & G WAKEFIELD ENGR INC	WAKEFIELD MA US	01880
06001	MEPCO/ELECTRA INC	MORRISTOWN NJ US	07960
06229	ELECTROVERT INC	ELMFORD NY	10553
06383	PANDUIT CORP	TINLEY PARK IL	60477
06665	PRECISION MONOLITHICS INC.	SANTA CLARA CA	95050
07263	FAIRCHILD CORP	MOUNTAIN VIEW CA US	94042
10960	T D R ELECTRONICS INC	BRISTOL RI	02809
13103	THERMALLOY CO	DALLAS TX	75234
13606	SPRAGUE ELECTRIC SEMICON DIV	CONCORD NH	03301
16299	CORNING ELECTRONICS	RALEIGH NC US	27604
19701	MEPCO/ELECTRA INC	MINERAL WELLS TX US	76067
20940	MICRO-OHM CORP	EL MONTE CA	91731
24046	TRANSITRON ELECTRONIC CORP	WAKEFIELD MA	01880
24546	CORNING ELECTRONICS	SANTA CLARA CA US	95050
25088	SIEMENS CORP	ISELIN NJ	08830
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA	95051
28480	HEWLETT-PACKARD CO CORP HQ	PALO ALTO CA	94304
31585	RCA CORP SOLID STATE DIV	SOMERVILLE NJ	
30983	MEPCO/ELECTRA CORP	SAN DIEGO CA	92121
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247
73138	BECKMAN INDUSTRIAL CORP	FULLERTON CA US	92632
75915	LITTLEFUSE INC	DES PLAINES IL US	60016

MANUAL CHANGES

Note

This manual does not contain any backdating information. If backdating information is required for operating or repairing your HP 438A with serial prefix 2822A or 2839U and below, you must purchase manual part number 00438-90015.

8

Service

8-1. Introduction

This section contains information required for servicing the power meter. It includes block diagrams with theory and troubleshooting, schematic diagrams, schematic diagram notes, and after service safety checks.

8-2. Service Sheets

The pages in the last part of this section are called the service sheets (SS). They contain block diagrams, schematic diagrams, supplemental diagrams, and associated information.

8-3. Block Diagrams

The block diagrams and related service information are found on Service Sheets BD1, BD2 and BD3. BD1 is an overall block diagram that shows the major functional sections of the power meter. It serves as an index to the more detailed information on the succeeding service sheets and is the starting point for most troubleshooting procedures. BD2 shows the Controller Section with connections to BD3 the Amplifier Section.

8-4. Schematic Diagrams

The schematic diagrams and their associated information are presented in Service Sheets 1 through 11. These diagrams, in functional groupings, are designed to aid in understanding the principles of operation and to aid in troubleshooting the power meter. Refer to the paragraph entitled Trouble shooting for additional information.

8-5. Safety Considerations

8-6. Before Applying Power

Verify that the instrument is properly set to operate from the available line voltage and that the correct fuse is installed. An uninterrupted safety earth ground must be provided from the main power source to the instrument input wiring terminals, power cord, or supplied power cord set.

8-7. Warnings and Cautions

Pay attention to the WARNINGS and CAUTIONS. They must be followed for your protection and to avoid damage to the equipment.

Warning

Maintenance described herein must be performed with power supplied to the instrument and with protective covers removed. Such maintenance should be performed only by service trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Any interruption of the protective (grounding) conductor (inside or outside of the instrument) or disconnection of the protective earth terminal will create a potential shock hazard and could result in personal injury. Grounding one conductor of a two-conductor outlet is not sufficient. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative (that is, secured against unintended operation).

If the instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Capacitors inside the instrument may still be charged even if the instrument is disconnected from the power source.

Make sure that only 250 volt normal-blow fuses with the specified current rating are used for replacement. Do not use repaired fuses or short-circuited fuseholders. To do so could create a shock or fire hazard.

Caution

Some printed circuit boards contain devices that may be damaged if the board is removed or installed while the power is on. Verify that the LINE switch is OFF or that the power cord is unplugged before you remove or install a printed circuit board.

After removing MOS devices from sockets, store the devices with the pins in conductive foam. This will prevent accidental damage from a static discharge.

8-8. Recommended Test Equipment and Accessories

Test equipment and test accessories required to maintain the power meter are listed in Table 1-3, Recommended Test Equipment. Equipment other than that listed may be used if it meets the critical specifications listed.

8-9. Service Tools, Aids, and Information

8-10. Service Tools

Equipment recommended for use when changing components on printed circuit boards is listed in Table 8-1. The following unique service tools will make servicing of this instrument much easier.

Pozidriv Screwdrivers. Many screws in the power meter appear to be Phillips type, but they are not. To avoid damage to the screw heads, Pozidriv screwdrivers should be used. The Pozidriv No. 1 size can be ordered as HP part number 8710-0899, and the Pozidriv No. 2 size can be ordered as HP part number 8710-0900.

Tuning Tools. For adjustments requiring non-metallic tuning tools, use the blade tuning tool HP part number 8710-0033 or hex tuning tool(JFD Model No. 5284) HP part number 8710-1010. For other adjustments, an ordinary small screwdriver is sufficient. No matter which tool is used, never force any adjustment control against its stops. This is especially critical when adjusting variable inductors or capacitors.

Heat Staking Tool. The front-panel pushbutton switches have small plastic pins that protrude through the printed circuit board, and the pins are then flattened with a heated tool that softens the plastic. The heat staking tool is a standard soldering iron with a special tip attached.

8-11. Assembly Locations

Printed circuit board assemblies are numbered sequentially from front to back. For example, A1 is part of the front panel assembly.

8-12. Parts and Cable Locations

The locations of individual components on the printed circuit boards and other assemblies are shown adjacent to the schematic diagrams on the appropriate Service Sheet. The complete reference designator consists of the assembly designator plus the part designator. For example, A6R9 is resistor R9 on the A6 assembly. For specific component descriptions and ordering information, refer to Table 6-3, Replaceable Parts. Chassis, frame, and other mechanical parts are identified in Figure 6-1 through Figure 6-3.

Mechanical parts have reference designators that begin with the letters MP. Mechanical parts such as screws, washers, and nuts are listed in the replaceable parts list. To find the part number and description of a mechanical part, find the part in one of the figures in section 6 or section 8. The part in the figure will be labeled with its reference designator. Look up the reference designator in Table 6-3, Replaceable Parts.

The power meter has a mixture of Unified National (inch) and metric screws. The metric screws are defined by Industrial Fasteners publication (IFI 500) and are identified in the replaceable parts list as metric (M). Unified National screws have a dull steel gray appearance and the metric screws have a shiny silver appearance. Do not use a metric screw in a Unified National nut, thread damage will result.

8-13. Test Point and Adjustment Locations

Most test points and adjustments are indicated on individual circuit board assemblies. Test points and adjustments can also be found on the component locator diagrams adjacent to the assembly chematic diagrams.

8-14. Service Aids on Printed Circuit Boards

The service aids on the printed circuit boards include test points, indicator LEDs, reference designators, adjustment names, and assembly part numbers.

8-15. Other Service Documents

Service Notes, Manual Changes Supplements, Application Notes, and other service literature are available from Hewlett Packard. For further information, contact your nearest Hewlett Packard office.

Table 8-1. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended	HP Part No.
Soldering Tool	Soldering, Heat Staking	Wattage: 35W Tip Temp: 390–440°C (735–825°F)	Ungar No. 135 Ungar Division Eldon Ind. Corp. Compton, CA 90220	8690-0167
Soldering Tip	Soldering, Unsoldering	Shape: Chisel[1]	Ungar PL113[1]	8690-0007
Soldering Tip	Heat Staking Shape: Cupped	HP 5020-8160 or modified Ungar PL11	5020-8160	
De-Solder Aid	To remove molten solder from connection	Suction Device	Soldapullt by Edsyn Co., Van Nuys, CA 91406	8690-0060
Rosin (flux) Solvent	To remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board	Freon	8500-0232
Solder	Component replacement; Circuit board repair wiring	Rosin (flux core, high tin content (63/37 tin/lead), 18 guage (AWG) 0.040 in. diameter preferred		8090-0607

1 For working on circuit boards; for general purpose work, use No. 555 Handle (8690-0261) and No. 4037 Heating Unit $47\frac{1}{2}$–$56\frac{1}{2}$ W (HP 8690-0006); tip temperature of 850–900°F; and Ungar No. PL113 $\frac{1}{8}$" chisel tip.

8-16. Troubleshooting

8-17. Service Related Error Messages

The power meter generates error messages to indicate operating problems, incorrect keyboard entries or service related problems. The error message is generally cleared when the error condition is removed. Refer to Service Sheet 2 for further troubleshooting when a ROM or RAM error message appears.

Service error messages from the power up diagnostic are 61 through 66. These errors are displayed when a problem with ROM or RAM has been detected. A list of the errors follows:

61 A3U9 ROM address 8000H through 09FFFH
62 A3U9 ROM address 0A000H through 0BFFFH
63 A3U10 ROM address 0C000H through 0DFFFH
64 A3U10 ROM address 0E000H through 0FFFFH
65 A3U12 RAM address 800H through 0FFFH
66 A3U13 RAM address 0 through 7FFH

8-18. After Service Safety Checks

Visually inspect the interior of instrument for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence or arcing. Determine and remedy the cause of any such condition.

Using a suitable ohmmeter, check the resistance from the instrument enclosure to the ground pin on the power cord plug. The reading must be less than one ohm. Flex the power cord while making this measurement to determine whether intermittent discontinuities exist.

Check any indicated front or rear panel ground terminals that are marked, using the above procedures.

Check the resistance from the instrument enclosure to the line and neutral (tied together) with the power switch ON and the power source disconnected. The minimum acceptable resistance is two megohms. Replace any component which results in a failure.

Check the line fuse to verify that a correctly rated fuse is installed.

Table 8-2. Schematic Diagram Notes (1 of 8)

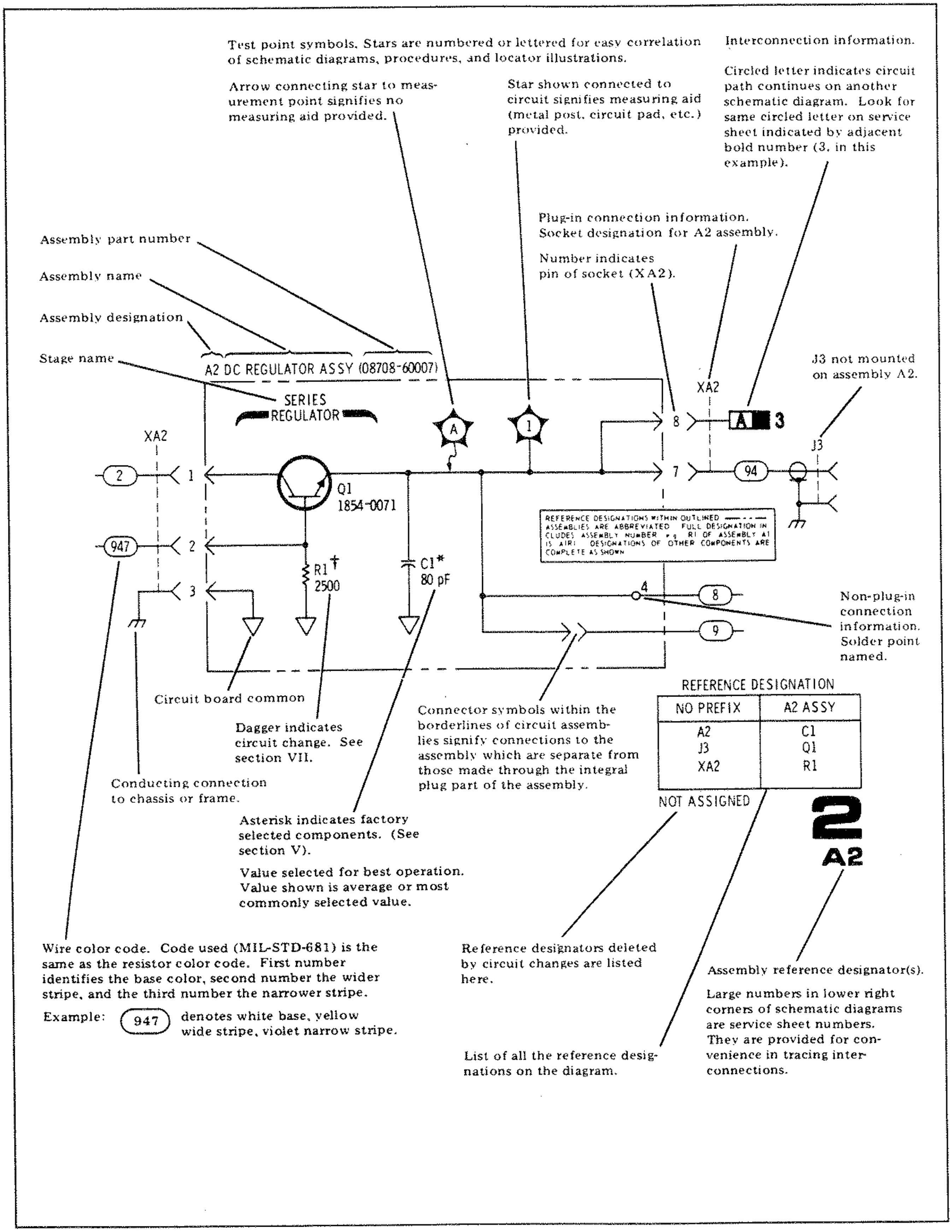


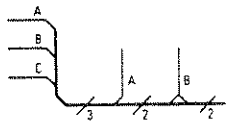
Table 8-1. Schematic Diagram Notes (2 of 8)

SCHEMATIC DIAGRAM NOTES

*	Asterisk denotes a factory-selected value. Value shown is typical.
†	Dagger indicates circuit change. See Section VII.
	Tool-aided adjustment. ○ Manual control.
	Encloses front-panel designation.
	Encloses rear-panel designation.
	Circuit assembly borderline.
	Other assembly borderline.
	Heavy line with arrows indicates path and direction of main signal.
	Heavy dashed line with arrows indicates path and direction of main feedback.
	Indicates stripline (i.e., RF transmission line above ground).
CW	Wiper moves toward cw with clockwise rotation of control (as viewed from shaft or knob).
1	Numbered Test Point measurement aid provided.
	Encloses wire or cable color code. Code used is the same as the resistor color code. First number identifies the base color, second number identifies the wider stripe, and the third number identifies the narrower stripe, e.g., denotes white base, yellow wide stripe, violet narrow stripe.
	A direct conducting connection to earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).
	A conducting connection to a chassis or frame.
	Common connections. All like-designation points are connected.
AK 12	Letters = off-page connection, e.g., AK Number = Service Sheet number for off-page connection, e.g., 12
① THIS PAGE	Number (only) = on-page connection.

Table 8-1. Schematic Diagram Notes (3 of 8)

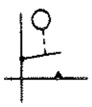
SCHEMATIC DIAGRAM NOTES



Indicates multiple paths represented by only one line. Letters or names identify individual paths. Numbers indicate number of paths represented by the line.

Coaxial or shielded cable.

Relay. Contact moves in direction of arrow when energized.



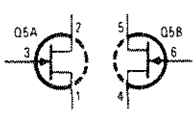
Indicates a pushbutton switch with a momentary (ON) position.

Indicates a PIN diode.

Indicates a current regulation diode.

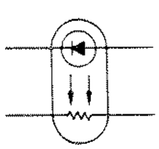
Indicates a voltage regulation diode.

Indicates a Schottky (hot-carrier) diode.



Multiple transistors in a single package—physical location of the pins is shown in package outline on schematic.

Identification of logic families as shown (in this case, ECL).

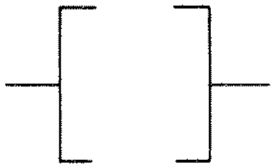


Indicates an opto-isolator of a LED and a photoresistor packaged together. The resistance of the photoresistor is a function of the current flowing through the LED.

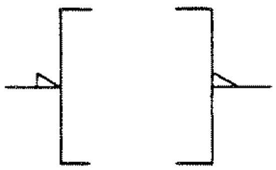
Table 8-1. Schematic Diagram Notes (4 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

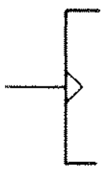
Input and Output Indicators



Implied Indicator—Absence of polarity indicator (see below) implies that the active state is a relative high voltage level. Absence of negation indicator (see below) implies that the active state is a relative high voltage level at the input or output.

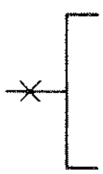


Polarity Indicator—The active state is a relatively low voltage level.



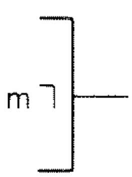
Dynamic Indicator—The active state is a transition from a relative low to a relative high voltage level.

Inhibit Input—Input that, when active, inhibits (blocks) the active state outputs of a digital device.

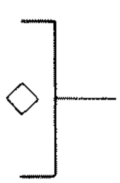


Analog Input—Input that is a continuous signal function (e.g., a sine wave).

Polarity Indicator used with Inhibit Indicator—Indicates that the relatively low level signal inhibits (blocks) the active state outputs of a digital device.



Output Delay—Binary output changes state only after the referenced input (m) returns to its inactive state (m should be replaced by appropriate dependency or function symbols).



Open Collector Output—Output that must form part of a distributed connection.

Table 8-1. Schematic Diagram Notes (5 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators (Cont'd)

3-STATE	Three-state Output—Indicates outputs that can have a high impedance (disconnect) state in addition to the normal binary logic states.

Combinational Logic Symbols and Functions

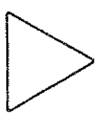
&	AND—All inputs must be active for the output to be active.
≥1	OR—One or more inputs being active will cause the output to be active.
≥m	Logic Threshold—m or more inputs being active will cause the output to be active (replace m with a number).
=1	EXCLUSIVE OR—Output will be active when one (and only one) input is active.
=m	m and only m—Output will be active when m (and only m) inputs are active (replace m with a number).
=	Logic Identity—Output will be active only when all or none of the inputs are active (i.e., when all inputs are identical, output will be active).
	Amplifier—The output will be active only when the input is active (can be used with polarity or logic indicator at input or output to signify inversion).
X/Y	Signal Level Converter—Input level(s) are different than output level(s).
◄──►	Bilateral Switch—Binary controlled switch which acts as an on/off switch to analog or binary signals flowing in both directions. Dependency notation should be used to indicate affecting/affected inputs and outputs. Note: amplifier symbol (with dependency notation) should be read to indicate unilateral switching.
X→Y	Coder—Input code (X) is converted to output code (Y) per weighted values or a table.
(Functional Labels)	The following labels are to be used as necessary to ensure rapid identification of device function.
MUX	Multiplexer—The output is dependent only on the selected input.
DEMUX	Demultiplexer—Only the selected output is a function of the input.
CPU	Central Processing Unit
PIO	Peripheral Input/Output
SMI	Static Memory Interface

Table 8-1. Schematic Diagram Notes (6 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions

1 	Monostable—Single shot multivibrator. Output becomes active when the input becomes active. Output remains active (even if the input becomes inactive) for a period of time that is characteristic of the device and/or circuit.
G 	Oscillator—The output is a uniform repetitive signal which alternates between the high and low state values. If an input is shown, then the output will be active if and only if the input is in the active state.
FF	Flip-Flop—Binary element with two stable states, set and reset. When the flip-flop is set, its outputs will be in their active states. When the flip-flop is reset, its outputs will be in their inactive states.
T	Toggle Input—When active, causes the flip-flop to change states.
S	Set Input—When active, causes the flip-flop to set.
R	Reset Input—When active, causes the flip-flop to reset.
J	J Input—Analogous to set input.
K	K Input—Analogous to reset input.
D	Data Input—Always enabled by another input (generally a C input—see Dependency Notation). When the D input is dependency-enabled, a high level at D will set the flip-flop; a low level will reset the flip-flop. Note: strictly speaking, D inputs have no active or inactive states—they are just enabled or disabled.
m	Count-Up Input—When active, increments the contents (count) of a counter by "m" counts (m is replaced with a number).
−m	Count-Down Input—When active, decrements the contents (count) of a counter by "m" counts (m is replaced with a number).
→ m	Shift Right (Down) Input—When active, causes the contents of a shift register to shift to the right or down "m" places (m is replaced with a number).
← m	Shift Left (Up) Input—When active, causes the contents of a shift register to shift to the left or up "m" places (m is replaced with a number).

NOTE

For the four functions shown above, if m is one, it is omitted.

(Functional Labels)	The following functional labels are to be used as necessary in symbol build-ups to ensure rapid identification of device function.

Table 8-1. Schematic Diagram Notes (7 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions (Cont'd)

mCNTR	Counter—Array of flip-flops connected to form a counter with modulus m (m is replaced with a number that indicates the number of states: 5 CNTR, 10 CNTR, etc.).
REG	Register—Array of unconnected flip-flops that form a simple register or latch.
SREG	Shift Register—Array of flip-flops that form a register with internal connections that permit shifting the contents from flip-flop to flip-flop.
ROM	Read Only Memory—Addressable memory with read-out capability only.
RAM	Random Access Memory—Addressable memory with read-in and read-out capability.

Dependency Notation

mAm	Address Dependency—Binary affecting inputs of affected outputs. The m prefix is replaced with a number that differentiates between several address inputs, indicates dependency, or indicates demultiplexing and multiplexing of address inputs and outputs. The m suffix indicates the number of cells that can be addressed.
Gm	Gate (AND) Dependency—Binary affecting input with an AND relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or letter (the identifier).
Cm	Control Dependency—Binary affecting input used where more than a simple AND relationship exists between the C input and the affected inputs and outputs (used only with D-type flip-flops).
Vm	OR Dependency—Binary affecting input with an OR relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or the letter (the identifier).
Fm	Free Dependency—Binary affecting input acting as a connect switch when active and a disconnect when inactive. Used to control the 3-state behavior of a 3-state device.

NOTE

The identifier (m) is omitted if it is one—that is, when there is only one dependency relationship of that kind in a particular device. When this is done, the dependency indicator itself (G, C, F, or V) is used to prefix or suffix the affected (dependent) input or output.

Table 8-1. Schematic Diagram Notes (8 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Miscellaneous

Schmitt Trigger—Input characterized by hysterisis; one threshold for positive going signals and a second threshold for negative going signals.

Active

Active State—A binary physical or logical state that corresponds to the true state of an input, an output, or a function. The opposite of the inactive state.

Enable

Enabled Condition—A logical state that occurs when dependency conditions are satisfied. Although not explicitly stated in the definitions listed above, functions are assumed to be enabled when their behavior is described. A convenient way to think of it is as follows:

A function becomes active when:

- it is enabled (dependency conditions—if any—are satisfied)
- and its external stimulus (e.g., voltage level) enters the active state.

Service Sheet BD1 Overall Block Diagram

Principles of Operation

General

The power meter is a microprocessor controlled dual channel power meter with a built in 1 mW 50 MHz power reference. Figure 8-1 shows a simplified overall diagram of the power meter. For purposes of explanation and troubleshooting the power meter is divided into the following three functional sections:

1. The Controller Section.
2. The Amplifier Section.
3. The Power Supply Section.

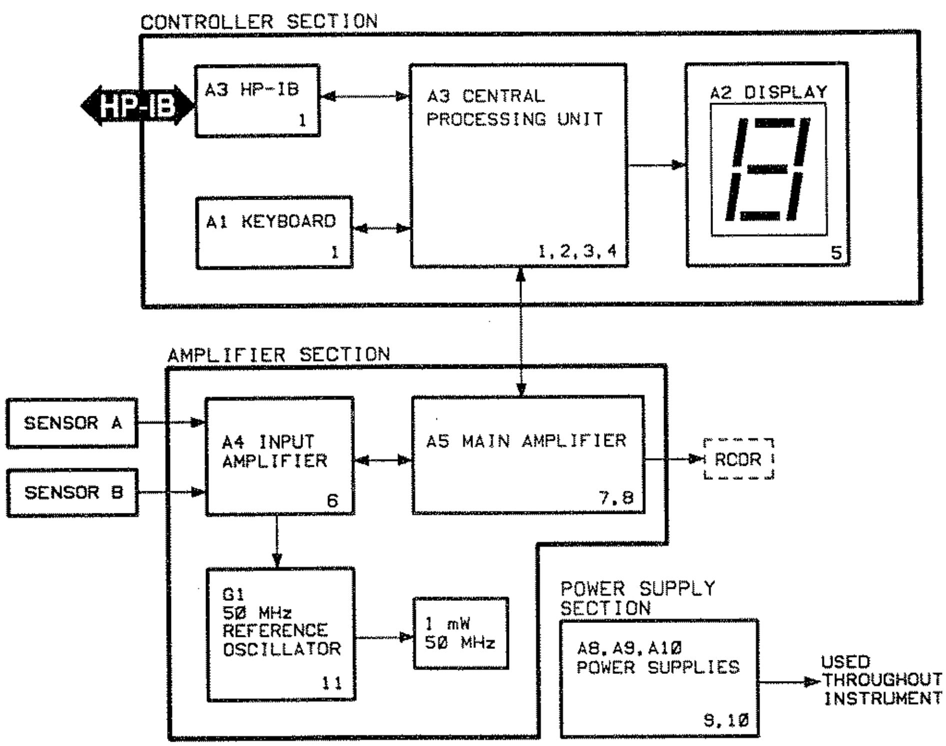


Figure 8-1. Power Meter Simplified Overall Diagram

The Controller Section enables the functions that the user requests by pressing front panel keys (local operation) or by HP-IB program codes (remote operation). The overall power range and frequency response of the power meter is determined by the power sensors that are connected to channel A and channel B.

Under microprocessor control, the analog power inputs from the power sensors are measured and digitized by the Amplifier Section. The Controller Section calculates and displays the measurement result in the requested units.

The following discussion explains Figure 8-9 Overall Block Diagram.

Controller Section ⟨✓ 2⟩

The microprocessor based Controller Section consists of the following assemblies:

1. A1 Keyboard Assembly.
2. A2 Display Assembly.
3. A3 Central Processing Unit (CPU).
4. A11 HP-IB Assembly.

The CPU provides the timing, calculation, and control for the instrument. The microprocessor executes instructions stored in the read only memory (ROM). Data is exchanged between the microprocessor and the other blocks of the CPU over the data bus (DO–D7). The elements of the CPU are enabled to respond to the data on the data bus by control signals. These signals are derived from the address bus (A0–A15) by the address and control decoders. Data values that must be stored are placed in the random access memory (RAM).

The CPU sends and receives data to and from other assemblies through the keyboard interface, HP-IB interface, and the analog input/output (I/0) interface. It also sends data to the display through the display interface. The display indicates the current status of the power meter. This status information can consist of the current measurement configuration and results, or one of the error messages contained in Table 3-8.

A simplified flowchart of the interrupt control routine for the power meter is shown in Figure 8-2.

Note There are no asynchronous interrupts.

The key to understanding the operation of the firmware is to understand that it resides in ROM and is interrupted at 1 ms intervals by a hardware generated interrupt. During these 1 ms intervals the firmware accomplishes the required configuration changes, calculations, and updates to perform all of the power meter's defined functions.

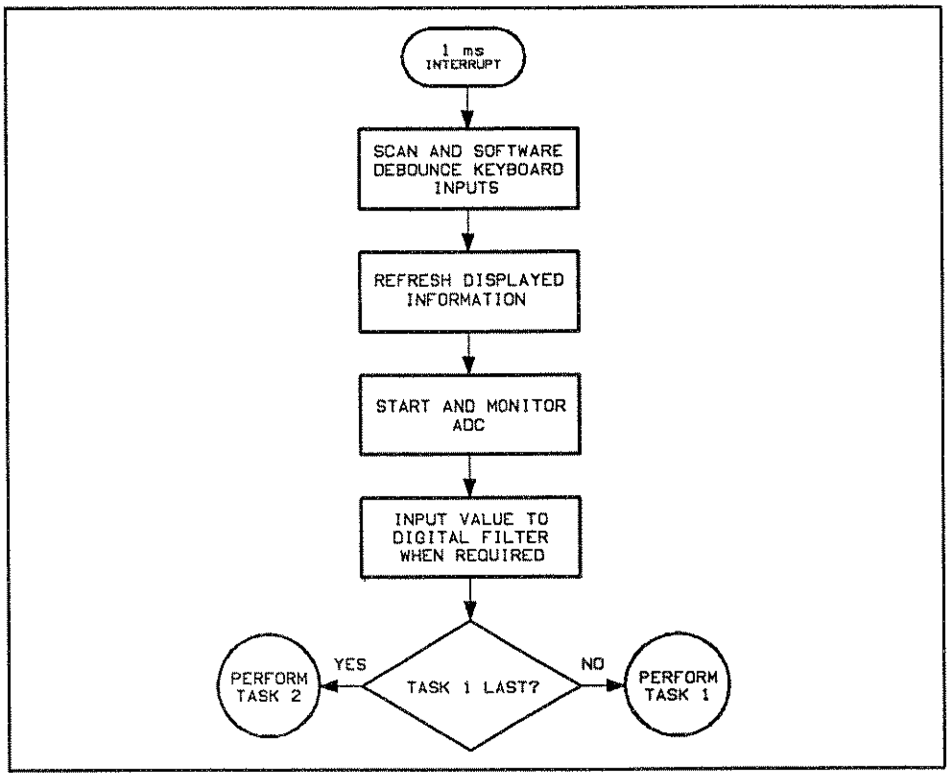


Figure 8-2. Interrupt Control Routine Flowchart

The firmware has the following three main routines:

1. The interrupt routine provides synchronous control of all power meter functions.
2. The task 1 routine primarily handles user commands (both front panel and HP-IB). A flowchart of the Task 1 routine is shown in Figure 8-3.
3. The task 2 routine primarily handles the mathematical calculations for the required measurement results and sets error flags when required. A flowchart of the Task 2 routine is shown in Figure 8-4.

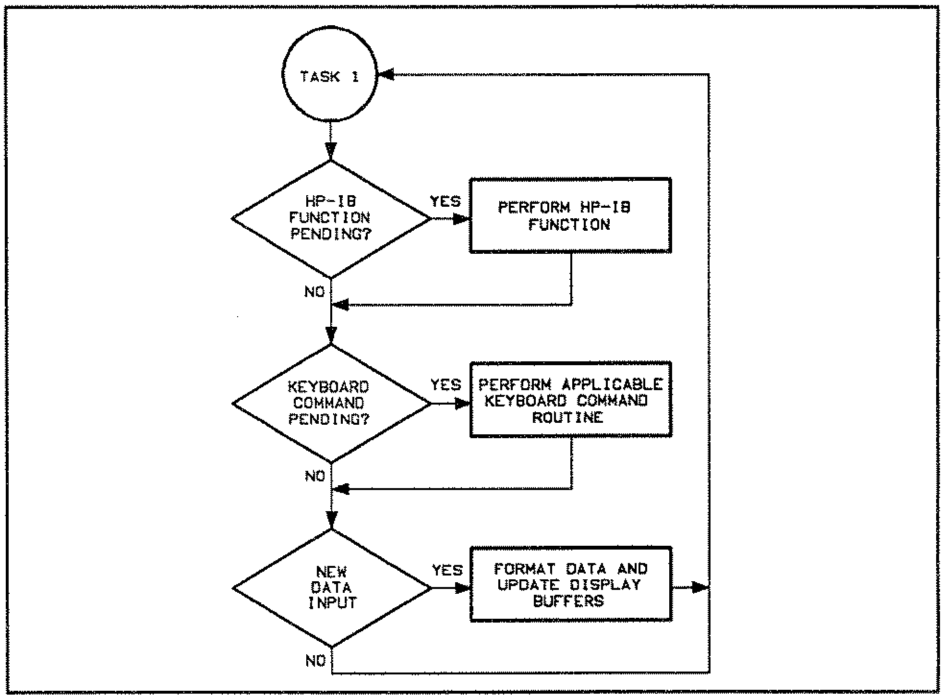


Figure 8-3. Task 1 Flowchart

When the instrument powers up, the status byte is set to 0 and a GT2 (trigger with delay response to group execute trigger) command is executed (refer to section 3 for an explanation of the status byte). After power up, hardware generated interrupts occur every 1 ms. Each interrupt causes the interrupt routine to perform the following functions:

1. Scan the keyboard inputs to determine if a key has been pressed. This subroutine also debounces the keyboard input by verifying that after approximately 10 ms the same key pressed indication is still present.
2. Refresh the front panel display information. This sequence does not change any information, it only allows the display to be refreshed at a rate that provides flicker free operation.
3. Start and monitor the analog to digital conversion (ADC). Once the ADC is started its operation is independent of the software.
4. Input the power measurement value to the digital filter when required. The digital filter is updated every 50 ms (every 50 interrupts). This update rate is maintained regardless of the state of the instrument, HP-IB activity, or front panel activity.

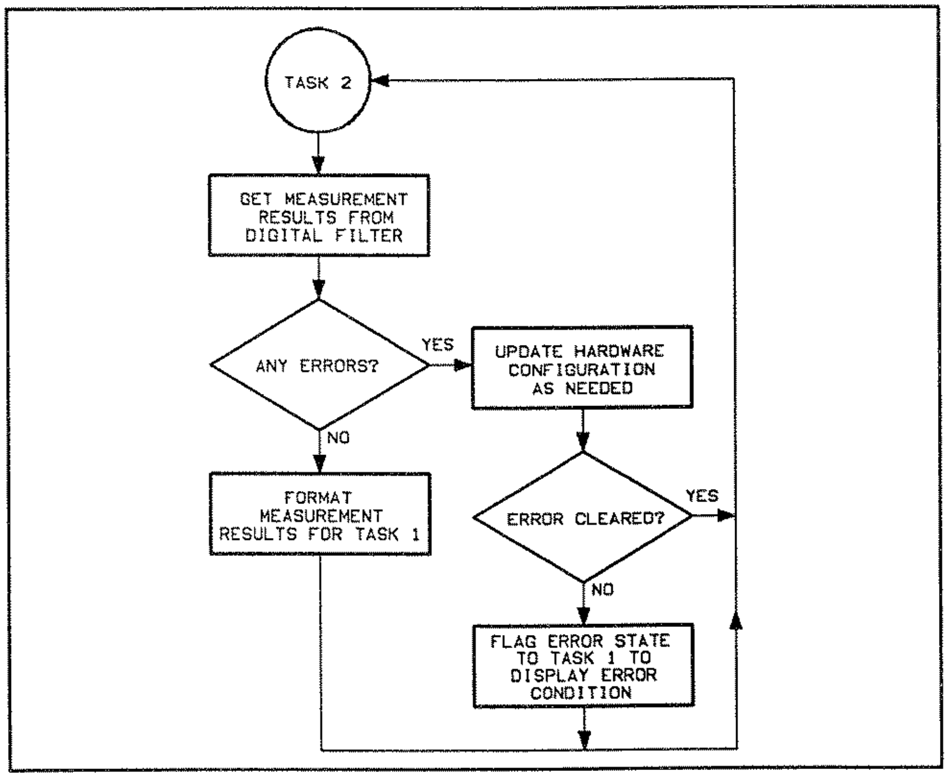


Figure 8-4. Task 2 Flowchart

When the interrupt routine is finished, it returns to either task 1 or 2. The software logic requires that the returns alternate between task 1 and task 2 and that it pass control to the task that was not interrupted. This allows both tasks to have an equal amount of execution time independent of what each is working on. This method of sharing execution time ensures that a high level of HP-IB activity does not slow down mathematical calculations nor does mathematical activity slow down the HP-IB response time.

When task 1 is executing, it performs the following functions:

1. Determine if any HP-IB function is pending and, if it is, perform it. These functions can consist of sending or receiving data over HP- IB or executing HP-IB commands.
2. Determine if any keyboard command is pending and, if it is, perform it. All key functions have individual routines that are performed each time the key is pressed.
3. Determine if there is new data available. This data can be an updated measurement result, new power meter configuration or an error message. If there is new data, the display data buffers are updated and the new information is displayed when the display is refreshed during the interrupt routine.

When task 2 is executing, it performs the following functions:

1. Gets the last measurement result from the software digital filter. This output is the average output of the digital filter at that time. A detailed explanation of the digital filter is contained in Service Sheet BD3.
2. Checks to determine if any error conditions exist. Some error conditions can be cleared by updating the hardware configuration. For example, the power meter can autorange to a different range as required. If the error is cleared, task 2 loops back and begins again. If the error can not be cleared, an error flag is set and the appropriate error message is passed to task 1.
3. If no error condition exists, the measurement result is formatted and passed to task 1.

Note Either task 1 or 2 continues to run until the next 1 ms interrupt. The interrupt routine is then executed and the sequence repeated for the other task.

When the power meter is in local operation the keyboard can be used to select the required measurement configuration. The instrument remembers the last measurement configuration entered prior to turning off power and returns to that configuration when power is turned on. The last measurement configuration that is saved in RAM is battery protected by disabling the write to RAM capability.

When the power meter is in remote operation, with local lockout set, all front panel keys except the LINE ON/OFF are disabled. The measurement configuration is selected by programmed inputs applied through the HP-IB. Remote operation can only be enabled via HP-IB.

Amplifier Section ⟨✓ 3⟩

The Amplifier Section consists of the following assemblies:

1. A4 Input Amplifier.
2. AS Main Amplifier.
3. G1 50 MHz Reference Oscillator.

In addition, Option 002 adds two rear panel sensor input ports in parallel with front panel inputs and a second 50 MHz Reference Oscillator (G2) with its output on the rear panel.

All of the operating functions of the Amplifier Section are enabled and sequenced by the control signals from the CPU. As required, the correct sensor input is applied through channel A or B of the A4 Input Amplifier Assembly to the A5 Main Amplifier Assembly. The primary function of the main amplifier is to selectively attenuate, amplify, filter, and digitize the input signal under the direction of the CPU. This allows the CPU to obtain the necessary data to compute and display the measurement results.

In addition to the primary signal flow, other signals, such as the power sensor resistor signal, can be applied through the multiplexer and digitized. The CPU uses the results of these measurements to determine if any changes or corrections are required.

The 50 MHz Reference Oscillator (G1) is enabled by the CPU when either the (OSC) or entry mode (CAL ADJ) (calibration) key is pressed. The oscillator is turned off manually if the (OSC) key is pressed again or automatically at the end of the calibration cycle. If the optional rear panel reference oscillator is installed, both oscillators are turned on and off at the same time. Each oscillator provides an independent 1 mW 50 MHz output that can be used for calibration or as a signal source when troubleshooting.

Power Supply Section ⟨√ 1⟩

The following five power supplies are isolated to reduce the unwanted interaction in the power meter:

1. The +5 V digital power supply.
2. The pulsed +5 V display power supply. This power supply is enabled by the CPU timer circuit.
3. The +15 V analog power supply.
4. The −15 V analog power supply.
5. The +10.4 V power supply for the fan.

Because of the high precision requirements, the power meter uses separate grounding points for each type of digital and analog signal. Grounding is very important. B-GND is the chassis or earth ground point that is connected to the protective earth terminal of the power receptacle. B-GND is defined as a point at the rear panel RCDR BNC connector. See Figure 8-5 for a simplified diagram of the distribution of the grounds used on the different boards. The grounds are defined as follows:

1. The main instrument ground at the RCDR BNC connector.
2. The A-GND is defined as the ground at the sensor bulkhead that is supplied to the input being measured. The A-GND is not a true ground, but a reference for the signal being amplified through the bandpass amplifiers. The A-GND is created on the A5 Main Amplifier Assembly and applied to the A4 Input Amplifier Assembly. A detailed explanation of the creation of the A-GND is provided on Service Sheet 8.
3. The B-GND is the low current analog ground. It is applied directly to the main amplifier from the main instrument ground. It is used on the main amplifier filters and the analog to digital conversion (ADC).
4. The C-GND is the high current main analog ground. The C-GND is tied to the main instrument ground on the A9 Regulator Assembly and is used on the input amplifier and main amplifier assemblies.

5. The D-GND is the main digital ground. The D-GND is tied to the main instrument ground on the A10 Interconnect Assembly and is applied to the A3 Central Processing Unit Assembly (CPU). From the CPU it is applied to the main amplifier.

6. The display ground is the ground for the display drivers. The display ground is tied to the main instrument ground on the A10 Interconnect Assembly. It is applied to the CPU display driver circuits and used only by the +5 V pulsed power supply.

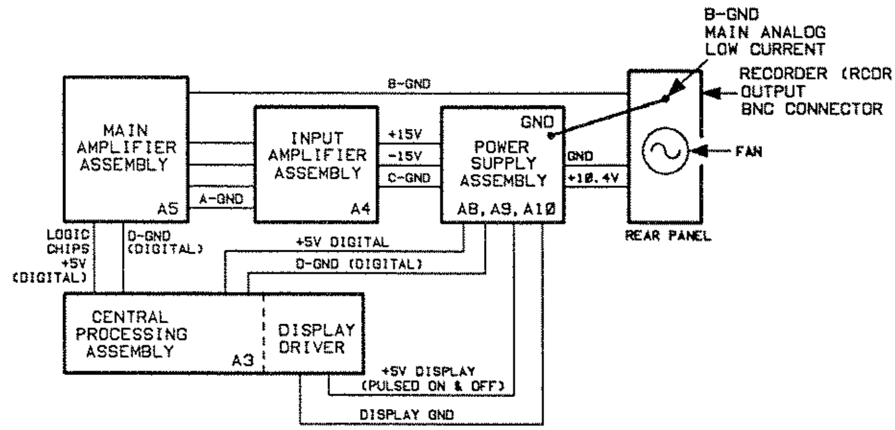


Figure 8-5. Simplified Power Supply Grounding

Troubleshooting Hints

To begin this troubleshooting it is assumed that section 2 Installation, Line Voltage and Fuse Selection checks are completed.

The troubleshooting checks on this service sheet are used to isolate a malfunction to one of the three major sections; Controller Section, Amplifier Section, or Power Supply Section. A symbol with a check mark and a number is used to show the order of the checks. This symbol is shown on the block diagram to locate the section that the trouble shooting relates to. The checks start with the Power Supply Section, move on to the Controller Section and then to the Amplifier Section. The checks are easy to perform and provide key information. In most instances the checks isolate a failure to a major assembly. The comments associated with each procedure summarize the known information as a result of passing or failing the check.

Test Equipment

Oscilloscope HP1740A
Power Sensor (1 or 2) .... HP 8480 series
Sensor Cable .... HP 11730A
Range Calibrator .... HP 11683A
Digital Voltmeter (DVM) .... HP 3456A

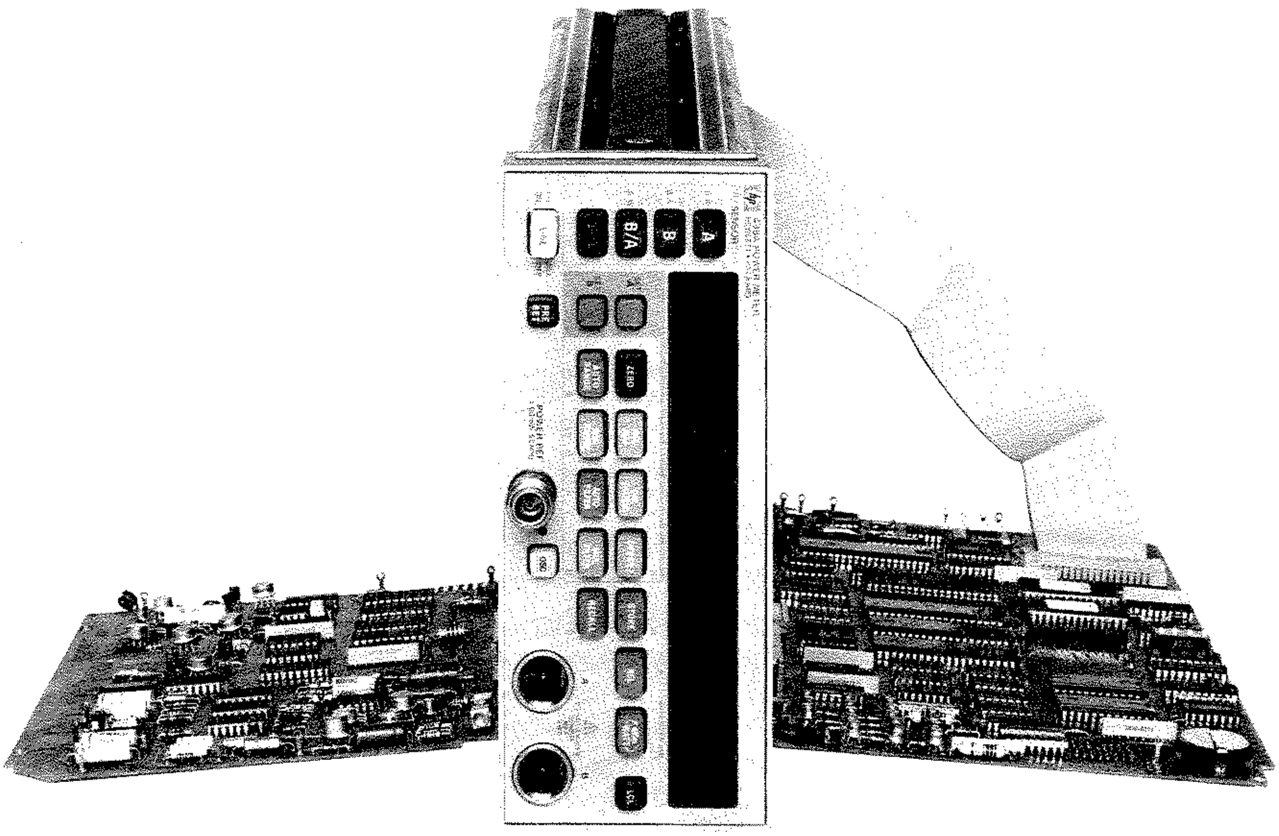


Figure 8-6. Power Meter Service Position

Power Supply Section ⟨√ 1⟩

Procedure. To perform the line check remove the power meters' top and bottom covers. Unscrew the three captive screws holding the A3 CPU Assembly and the two captive screws holding the A5 Main Amplifier Assembly. Swing the hinged printed circuit boards out to the service position. See Figure 8-6 showing this position. After the covers are removed and the assemblies are in the service position connect the line power cable. Press the LINE key to the ON position. The normal indications are:

1. The fan runs indicating line voltage or Mains (ac) power is present at the transformer, that it is being rectified, and regulated giving the voltage necessary for the motor control module to drive the dc fan.
2. The four red LEDs (light emitting diodes) on the A9 Regulator Assembly are lighted indicating that the regulated supplies are operating. This does not mean that the supplies are within the required tolerances.

Abnormal Indications. If an abnormal indication occurs:

1. Check rear panel line fuse.
2. Measure the individual regulated supplies. Test points and levels are shown on this block diagram. The +15 Vdc and −15 Vdc supplies should be equal but of opposite polarity and within 0.05 Vdc of each other. Measure +15 Vdc (14.25 Vdc to 15.75 Vdc) at A9TP8. Measure the −15 Vdc at A9TP7 and adjust it if necessary to match the +15 Vdc supply. Measure the +5 Vdc at A9TP4 and adjust it if necessary to 5.00 ±0.05 Vdc. If the supplies are found to be in error and cannot be adjusted refer to Service Sheets 9 and 10 for more details.

Controller Section ⟨√ 2⟩

If the Turn-on and Operator's Checks were completed in section 3 the Controller Section ⟨√ 2⟩ can be skipped. In that case proceed to Amplifier Check ⟨√ 3⟩

Procedure. To verify the controller power up routine press the LINE key to cycle from the power OFF to power ON condition. This will initiate a diagnostic routine stored in ROM. This routine is a check of ROM, RAM, and the displays. Observe the front panel seven segment displays and annunciators. The normal indications are:

1. All front panel indicators are lighted to provide a visual inspection of each front panel display segment and annunciator.
2. All the display segments (large and small) will display the number eight. The center three columns and the two right-hand columns of annunciators will be lighted.
3. When the power up routine is completed and after a short flash of all dashes the display will show some message defining the next step to be taken. This message will be self explanatory.

Abnormal Indication. If an abnormal indication occurs:

1. If all displays fail to light, check the +5V display enable CLK (clock) at A9TP1 with the oscilloscope. The waveform should be as shown in Figure 8-7.
2. When only one of the display segments or annunciators fails to light, check respective components and display drive circuits. Refer to Controller Section Troubleshooting BD2.

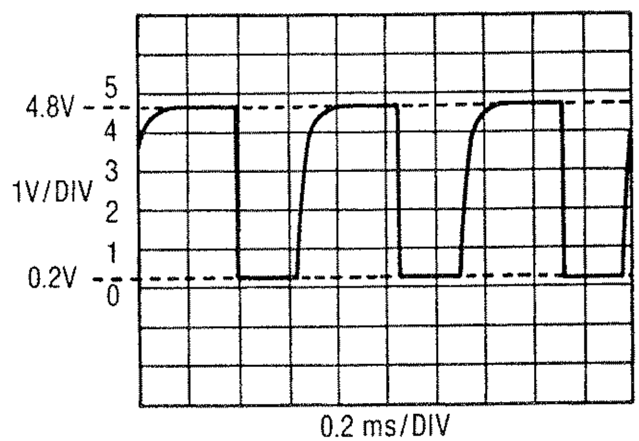


Figure 8-7. Display Enable Waveform

Amplifier Section ⟨✓ 3⟩

As a check of the Amplifier Section, two approches can be taken depending on the test equipment available. If only a power is available it can be used with the 1 mW POWER REF to set up some known conditions for troubleshooting. If the HP 11683A Range Calibrator is available it can used as a variable source for checking the ranges.

Procedure one. Connect a power sensor to channel A and to the POWER REF (1.00 mW 50 MHz). Press (PRESET). Press (ZERO) and wait for routine to finish. Press (CAL ADJ) and enter ref cal factor, wait for routine to finish. Press the POWER REF (OSC) (oscillator) key to turn on the 50 MHz signal. Press (CAL FACTOR) and enter ref cal factor value. The normal indication is:

1. The display should indicate as shown in Table 8-3 and channel A.

Table 8-3. Power Displayed for 1 mW Power Reference

Power Sensor	Displayed Power
HP 8481B (attenuator disconnected)	1.000 Watt
HP 8582B (attenuator disconnected)	1.000 Watt
HP 8481H	100.0 −3 Watt (mW)
HP 8482H	100.0 −3 Watt (mW)
HP 8485A	1.000 −3 Watt (mW)
HP 8481A	1.000 −3 Watt (mW)
HP 8482A	1.000 −3 Watt (mW)
HP 8483A (75Ω)	1.000 −3 Watt (mW)
HP 8484A (with HP 11708A 50 MHz Reference Attenuator)	1.0000 −6 (μ/W)

Abnormal Indication. If an abnormal indication occurs:

1. An error message indicating a faulty sensor. Try a second sensor.
2. Display shows no REF (no power reference). Check the plus and minus 15 Vdc power supplies, connected to the reference oscillator. Refer to A4 Input Amplifier Assembly on Service Sheet 6.
3. The COMP OUT (comparator out) or RAMP END signal at test point A5TP4 is not as shown in Figure 8-8. Refer to Amplifier Section Troubleshooting BD3.
4. The RCDR (rear panel recorder) BNC output is not 1 Vdc. Refer to troubleshooting BD3.

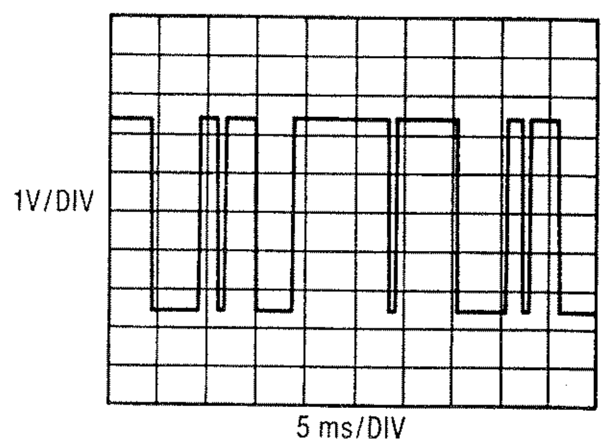


Figure 8-8. Ramp End Waveform

Procedure two. Connect the range calibrator to the power meter using the HP 11730A power sensor cable. Set up the controls to use the range calibrator as a controlled source.

FUNCTION ....STANDBY
POLARITY ....NORMAL
RANGE 1mW
LINE ....ON

1. Set the power meter control.

   Press ....ZERO

   The normal indications are:

2. The display should indicate 0.00 ± −6 WATT (micro/W)

3. Change the range calibrator control setting.

   FUNCTION ....CALIBRATE

4. Set the power meter controls.

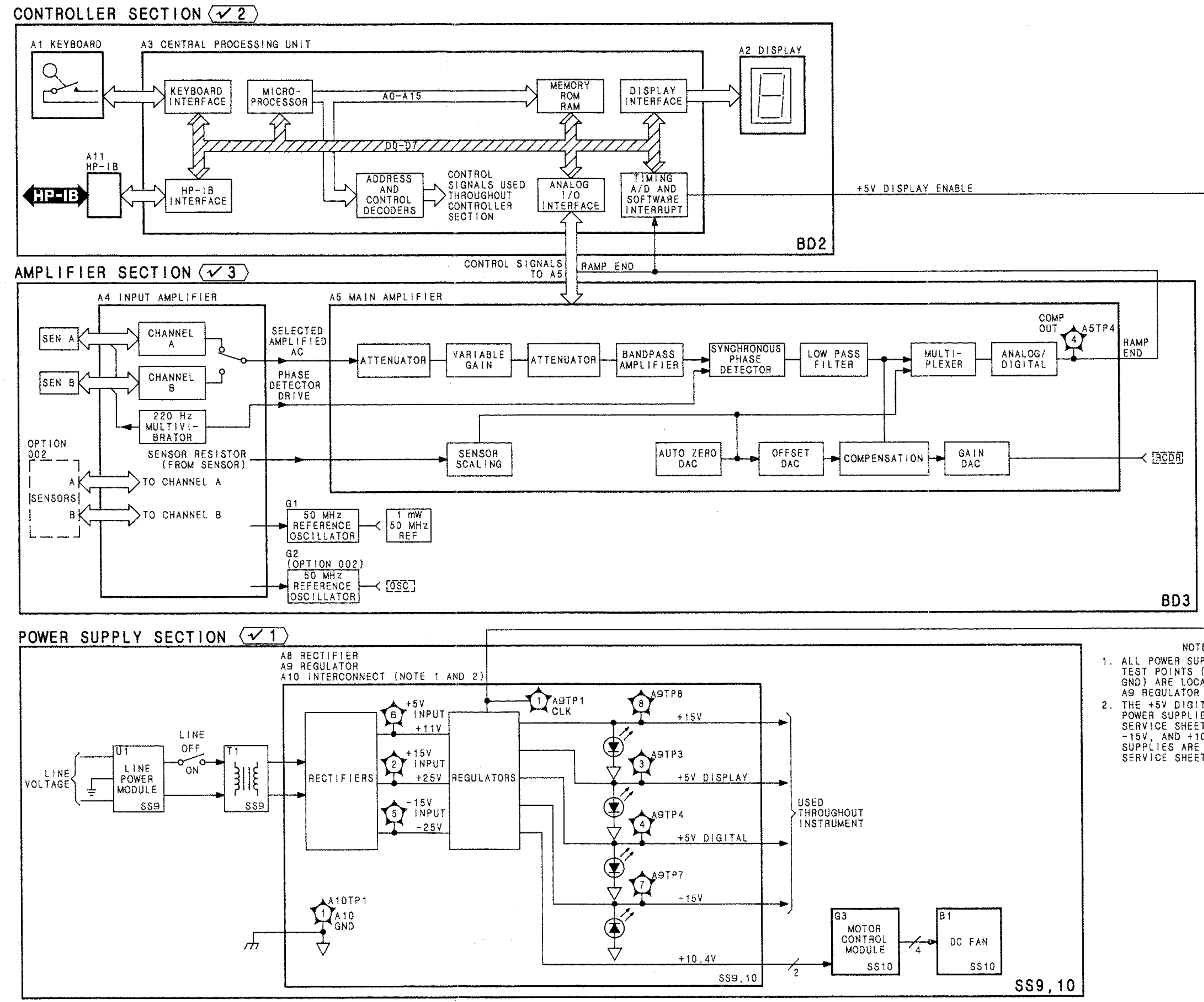
   Press [CAL ADJ], [−] [SET A], [100], and [ENTER]. (The minus sign is needed when an external power reference source is used.)

The display should read 1.000 −3 WATT (mW) and follow the range calibrator as the range is changed.

Abnormal Indication. If an abnormal indication occurs.

1. Channel A or channel B problems can be narrowed down by connecting the power sensor to the opposite channel and observing the results.

2. The connecting cable from the front panel A or B connector to channel A or B on the amplifier can also be switched at the point where it connects to the A4 Input Amplifier Assembly. This indicates a problem with a cable or with the input amplifier analog circuitry. Refer to troubleshoot BD3.



NOTES

1. ALL POWER SUPPLY LEDS AND TEST POINTS (EXCEPT A10TP1, GND) ARE LOCATED ON THE A9 REGULATOR ASSEMBLY.
2. THE +5V DIGITAL AND DISPLAY POWER SUPPLIES ARE SHOWN ON SERVICE SHEET 9. THE +15V, -15V, AND +10.4V POWER SUPPLIES ARE SHOWN ON SERVICE SHEET 10.

BD1

Figure 8-9. Overall Block Diagram
8-27/8-28

Service Sheet BD2 Controller Section

Principles of Operation

General

As shown on the block diagram, the A3 Central Processing Unit (CPU) is the major physical component of the controller. The controller can be divided into the following five functional sections:

1. The data input/output circuits (Service Sheet 1). These circuits consist of the A1 Keyboard Assembly, the A11 HP-IB Interface Assembly, and part of the A3 CPU Assembly.
2. The microprocessor and memory circuits (Service Sheet 2). These circuits are all contained on the A3 CPU.
3. The timer and peripheral interface adapter (PIA) circuits (Service Sheet 3). These circuits are all contained on the A3 CPU.
4. The display drivers (Service Sheet 4). These circuits are all contained on the A3 CPU.
5. The front panel display circuits (Service Sheet 5). These circuits are all contained in the A2 Display Assembly.

The CPU controls the rest of the instrument by using the following three buses to enable, address, and transfer data to the other sections of the instrument:

1. The control bus is derived from part of the address bus and hardware generated signals such as power fail or free run. These signals are used to enable specific digital circuits when they are required to perform their designated functions.
2. The address bus controls access to the ROM and RAM. It also supplies inputs to the control decode circuits.
3. The data bus transfers information throughout the controller. Note that the data bus is buffered at the data inputs to the microprocessor, at the ROM and RAM outputs, at the HP-IB circuits and at the I/O interface. These buffers provide the required signal strength to drive the associated circuits. They also help to isolate problems and aid in locating a malfunction when one occurs.

Data Input/Output Section

The A1 Keyboard Assembly is used during local operation to select the measurement configuration of the power meter. When a key is pressed, the keyboard priority encoder in the CPU encodes and stores this information in the cathode data display and keyboard scan PIA (Peripheral Interface Adapter). When the PIA is enabled, this information is transferred to the microprocessor and the appropriate changes to the instrument are initiated.

The A11 HP-IB Assembly is used during remote operation to interface the HP-IB to the HP-IB interface management and transceiver circuits on the CPU. These circuits manage the exchange of the bi-directional information between the CPU and the HP-IB.

The HP-IB assembly also contains the manual HP-IB address switch. The output from this switch is applied to the HP-IB address buffer on the CPU. Note that the preset HP-IB address that is selected on the switch is only read by the CPU if the current HP-IB address set from the front panel and stored in RAM is lost.

Microprocessor and Memory Circuits

The microprocessor and memory circuits with their associated busses form the kernel of the CPU. The microprocessor reads the permanently stored programs in the ROM and uses these instructions to control the operation of the power meter. During troubleshooting this kernel can be isolated and exercised by grounding A3TP4 FREE RUN prior to applying power. The clock and timer interrupt circuits provide the synchronization required for correct operation of the CPU.

The address and control decode circuits derive the digital control signals from part of the address bus and hardware monitoring inputs. This process is described in detail on Service Sheet 2. These control signals are used to enable different digital circuits when required by the microprocessor.

The RAM is used for temporary data storage while the power meter is operating. However, combined with the reset power fail, RAM chip enable, and the battery circuits, part of the RAM is used to store data when the power meter if turned off. The following information is retained when power is turned off:

1. The current front panel setup.
2. Any other front panel setup that has been saved using the (STORE) key, or the HP-IB program code ST.
3. The current zeroing and calibration data. Additional information on the zeroing and calibration software routines is contained in Service Sheet 3.

When power is applied to the instrument it goes through its pretest routine and the reset power fail resets the CPU to a predetermined hardware configuration. The CPU then retrieves the last front panel setup stored in RAM and establishes the required measurement configuration. This controlled restart ensures that the power meter always starts operation from a known configuration.

When power is turned off (or lost), the combined action of the reset power fail and RAM chip enable circuits protect the data stored in the RAM. This is accomplished by immediately disabling the input/output functions of the RAM and applying the battery voltage to the Vcc input of the portion of RAM used for data storage when power is off. The input/output functions are disabled to prevent any false data from being stored while the power level is dropping. The required restart data is always present in RAM.

The service function switch and buffer can select and initiate diagnostic programs that are used when troubleshooting the power meter. A list of the available diagnostic programs and instructions on how to run them are contained in the troubleshooting section of this service sheet.

Timer A/D, PIA, and Latch Circuits

The two main purposes of the timer A/D or ADC (analog to digital converter) circuit are to time the A/D conversion in the A5 Main Amplifier Assembly and supply the 1 ms software interrupt to the timer interrupt latch. The 4 MHz input clocks the timer A/D circuit. The start ramp signal starts the internal counter at the same time as the ramp generator in the main amplifier is started. When the measured input signal and the ramp generator output are equal, the ramp end signal from the main amplifier stops the counter. The counter output is read to the microprocessor under software control. The microprocessor uses this data to perform the required computations and displays the results on the front panel A2 Display Assembly.

The analog I/O PIA (input/output peripheral interface adapter) applies the required measurement configuration control signals to the main amplifier.

The cathode data display and keyboard scan PIA controls the addressable data display latch circuit and the inputs and outputs to the A1 Keyboard Assembly. The addressable data display latch circuit controls the cathode data display drivers.

The LED data latch is enabled by the anode data display and LED address decode circuit and controlled directly by the microprocessor. The LED lighting patterns are used to obtain circuit information when troubleshooting the instrument. Additional information on how to use the LED information is contained in the troubleshooting section of this service sheet.

The anode data display and LED address decode circuit also selectively enables one of the anode data display latches.

Display Drivers

The anode and cathode display drivers are used to refresh the front panel display. The sequence of the drivers is controlled by the CPU through the anode data display latches and addressable data display latch and drivers (Service Sheet 3).

Display Assembly

The A2 Display Assembly displays the current instrument configuration and the appropriate measurement result or error message.

Troubleshooting Hints

The troubleshooting checks on this service sheet are used to narrow down a malfunction to one of the following assemblies; A1 Keyboard Assembly, A11 HP-IB Assembly, A3 Central Processing Unit (CPU) Assembly, or the A2 Display Assembly. The A3 CPU is the major block. Its schematic diagrams are on Service Sheets one through four (SS1, SS2, SS3, SS4) as shown in the lower right-hand corner of the solid line boxes.

The checks will cover changing switch positions of the service function switch (A3S1) on the A3 CPU, exercising the front panel keys, monitoring the front panel displays, and checking some signatures. When these checks pass, it can be assumed that a major portion of the circuitry is functioning.

Test Equipment

Signature Multimeter .... HP 5005B

Service Function Switch

The service function switch A3S1 contains four single pole double throw toggle switches that are provided to control data bus bits (D0 through D7) going to the microprocessor. With the power meter in the service position these switches can be set to several positions corresponding to some diagnostic routines. The routines can either be for manual or automatic tests of the digital circuitry.

A3S1 can be loaded on the printed circuit board in either of the two positions shown in Figure 8-10.

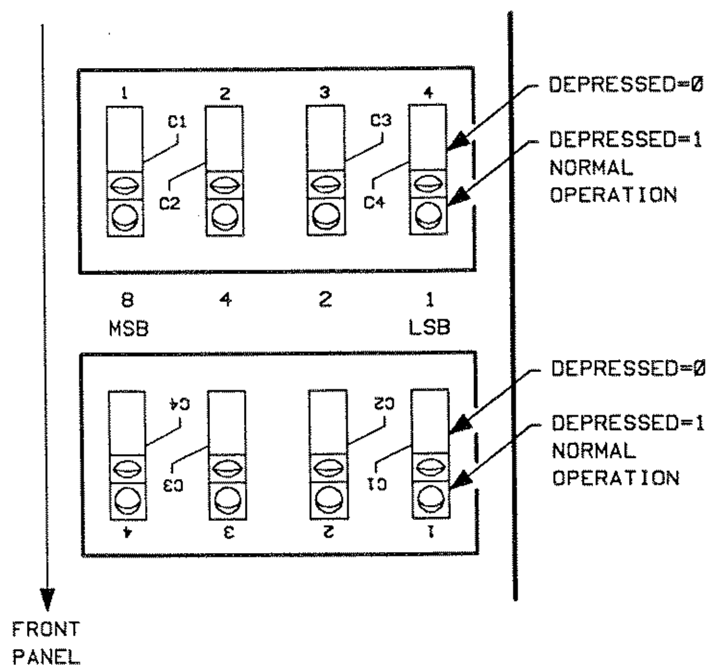


Figure 8-10. Service Function Switch

Table 8-4. Test Switch Pattern

MSB 8	4	2	LSB 1	Decimal Equivalent	Tests
1	1	1	1	15	Normal Operation
1	1	1	0	14	Extended Test Mode
0	1	0	1	5	Manual Display Check
0	1	0	0	4	Automatic Display Check
0	0	1	1	3	Keyboard Manual Check
0	0	1	0	2	Memory Check (RAM)
0	0	0	1	1	Signature Analysis
0	0	0	0	0	A to D Adjustment

Service Function Switch Checks

In normal operation with the switch in the all ones, or normal operating position, the power up routine can be executed. This diagnostic performs a check of ROM, RAM, and displays as was mentioned earlier. However, by changing the least significant bit (LSB) from a zero to a one on the switch an extended test mode can be accessed.

Extended Test Mode Check

Set the switch to decimal 14. This enables an extended test mode for the calibration and zeroing errors reporting routine. This position also allows for HP-IB control of the DACS (digital to analog converters) as well as a check of the variable gain amplifier. The checking of the DACS and the variable gain amplifier will be performed at the service sheet level of troubleshooting. The normal indication is:

This display will show no CH A if a power sensor is not connected and PLEASE 0 if a power sensor is connected but has not been zeroed.

If a problem is detected in the extended test mode an error number will be displayed. The explanation of these errors and their relationship to the zeroing and calibration routines will be given on Service Sheet 1.

Manual Display Check

Set switch to decimal 5. This will enable a manual test of the front panel displays. Repeated pressing of the (A) key will light each LED segment and annunciators. The normal indication is:

> All segments of the large LED's, all of the smaller number eights, and all of the annunciators will light, one at a time as the (A) key is pressed. Continue to press until the sequence starts to repeat.
>
> If any of the displays fail to light refer to Service Sheets 4 and 5.

Automatic Display Check

Set switch to decimal 4. This check is similar to the manual display check except the displays are lighted and sequenced through automatically. The normal indication is:

At turn on all displays will be lit. This will be followed by a walking through turn on of each LED segment large and small. Then the annunciators will be turned on in two groups.

If any of the displays fail to light refer to Service Sheets 1, 3, 4, and 5.

Keyboard Manual Check

Set the switch to decimal 3.

Each front panel key can be pressed and a corresponding number will be displayed (01 through 21) starting with key (A). Refer to the following list:

A = 01
B = 02
B/A = 03
SHIFT = 04
SET A = 05
SET B = 06
PRE SET = 07
ZERO = 08
AUTO RANGE = 09
CAL ADJ = 10
MNL RANGE = 11
CAL FACTOR = 12
AUTO FILTER = 13
OFFSET = 14
MNL FILTER = 15
OSC = 16
STORE = 17
RECALL = 18
REL = 19
dBm WATT = 20
LCL = 21

The normal indication is:

The display shows 00 at turn on. This increments to 01 when the (A) key is pressed and so on through the keyboard as each key is pressed up to 21 for the (LCL) key.

When a key is pressed and the number doesn't change to the number corresponding to that key then either the key or associated circuitry could be the problem. Refer to Service Sheets 1, 3, 4, and 5.

Memory (RAM) Check

Set the switch to decimal 2.

The front panel display is blank during this check. To verify the check is being run observe the anode data bus bits AD0 through AD7 LED's on the A3 CPU Assembly near A3S1. At the next power up there will be a momentary rcl (recall) Fail error message since information in memory was written over during this test routine. The normal indications are:

The data bus bit pattern changes as shown in Table 8-5.

Table 8-5. Data Bus Test Pattern

	Bits	Bit Pattern						
		Start	Test 1 Start	Test 1	Test 1 Complete	Test 2 Complete	Tests Complete	Restart
RAM 1 A3U12	D0	0	1	0	1	0	0	1
	D1	0	1	0	1	0	0	1
RAM 2 A3U13	D2	0	0	1	0	1	1	0
	D3	0	0	1	0	1	1	0
How many times the test was executed and passed?	D4	0	0	0	1	0	1	0
	D5	0	0	0	0	1	1	0
	D6	0	0	0	0	0	1	0
	D7	0	0	0	0	0	1	0

If a RAM failure occurs the test will flash LED's for bits D0, D1 indicating a problem with A3U12, or flash LED's for bits D2, D3 when A3U13 has a problem.

Signature Analysis Check

Set the switch to decimal 1.

This is a check that uses programmed signatures as a method of troubleshooting. Correct signatures at the peripheral interface adapter (PIA) for the analog input/output give a high confidence factor that a major portion of the digital circuitry is working.

Signature Multimeter Control Settings

FUNCTION	SIGNATURE NORM
THRESHOLD	TTL
POLARITY	CLOCK \
	START /
	STOP \

Signature Multimeter Pod Connections

Connect:

START/ST/SP green to	A3TP9 STRT 2 STOP 2
STOP/QUAL red to	A3TP9 STRT 2 STOP 2
CLOCK yellow to	A3TP6 CLK SA
black to	A3TP7 GND

The normal indication is to have valid signatures at the analog I/O (input/output) peripheral interface adapter A3U21.

Valid signatures at A3U21 the analog I/O (input/output) peripheral interface adapter.

Note

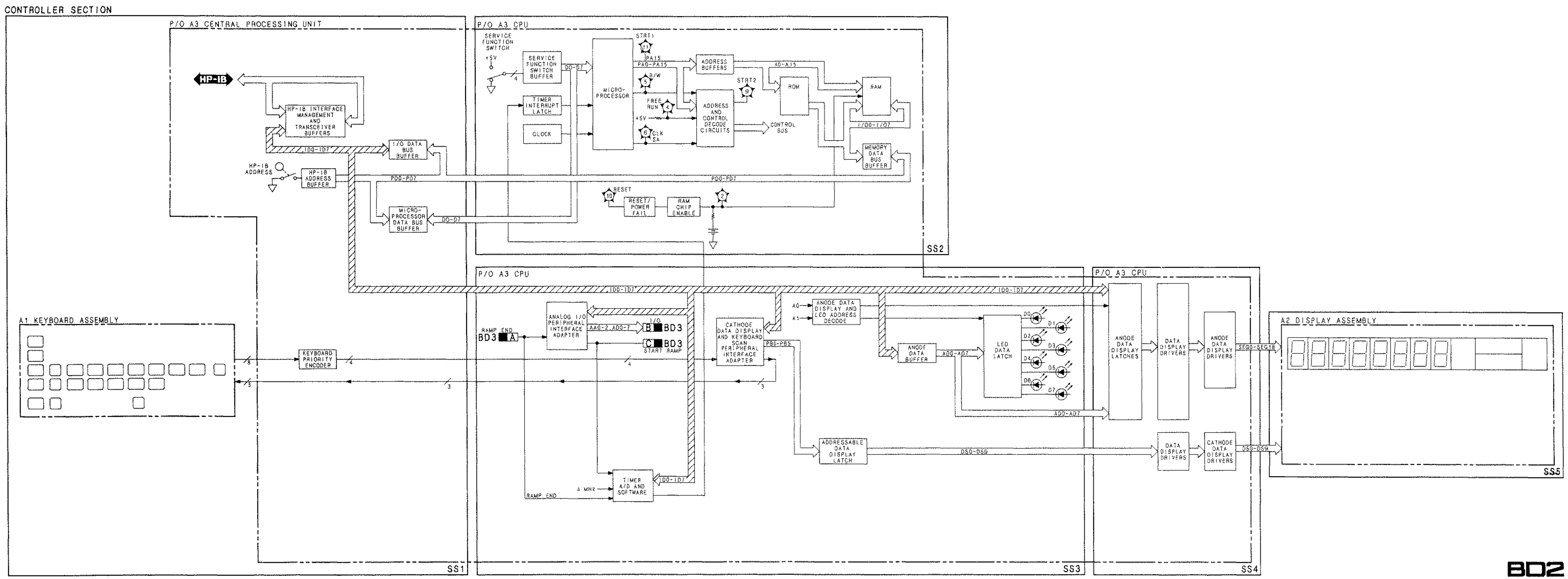
Version 5.0 is used on 00438-60103 boards which require a single EPROM (00438-80036). Version 2.0 is used on 00438-60003 boards which require 2 EPROM's (00438-80037 and 00438-80038).

In order to use the following signatures to repair your A3 board, you must have one of the preceeding versions of EPROM.

Pin Number	Signature	
	5.0	2.0
U21-1	0000	0000
2	3FP5	AC65
3	1F0F	5554
4	6P0P	4P01
9	9UCF	9UCF
10	A1P0	A1P0
11	1PHD	1PHD
12	6414	6414
13	F016	F016
14	66PF	66PF
15	52AA	52AA
18	9UCF	9UCF
19	3176	F229
20	9UCF	9UCF
21	6H64	AH64
22	9UCF	9UCF

Pin Number	Signature	
	5.0	2.0
23	7137	7137
24	9UCF	9UCF
26	HF47	P5A4
27	C421	A878
28	9010	P5CC
29	A7F7	8P88
30	1364	6377
31	75CF	U647
32	1306	48A6
33	1A5H	AHA7
34	9UCF	9UCF
35	9CF2	9CF2
36	445H	445H
39	9UCF	9UCF
40	0001	0001

If any of the signatures are different from those given, troubleshoot the bad signal line by referring to Service Sheet 3.



BD2

Figure 8-11. Controller Section Block Diagram

Service Sheet BD3 Amplifier Section

Principles of Operation

General

As shown on the block diagram the A4 Input Amplifier Assembly and the A5 Main Amplifier Assembly are the major physical components. The Amplifier Section can be divided into the following five functional sections:

1. The connected power sensor. (Not shown on the block diagram refer to the Power Sensor Operating and Service Manual.)
2. The input amplifier circuits (Service Sheet 6). These circuits are on the A4 Input Amplifier Assembly.
3. The digital I/O and DAC circuits (Service Sheet 7). These circuits are all contained on the A5 Main Amplifier Assembly.
4. The amplifier, detector, and comparator circuits (Service Sheet 8). These circuits are all contained on the A5 Main Amplifier Assembly.
5. The 1 mW 50 MHz Power Reference circuits (Service Sheet 11)

Connected Power Sensor and Input Amplifier Circuits

The connected power sensors determine the frequency range, dynamic range, and measurement accuracy of the combined power sensor and power meter. A simplified block diagram of the interconnection between the power sensors, the two channels of the input amplifier, and the monitoring circuits in the main amplifier is shown in Figure 8-12. The basic operation of these circuits is described in the following paragraphs.

The power sensor dissipates the RF input power into a 50 or 75 ohm impedance and generates a dc voltage proportional to the RF input power level.

The 220 Hz multivibrator provides the 220 Hz drive signals to the power sensors which are modulated by the dc voltage. The resulting sensor output is a 220 Hz signal that is proportional in amplitude to the RF input power level and is in phase with the 220 Hz reference signal that is applied to the synchronous phase detector in the power meter's main amplifier.

The shaping feedback circuit serves to reduce the gain of the input amplifier at higher power levels. This reduction in gain is required to offset the improved efficiency of the power sensing elements at the higher power levels.

The sensor resistor input to the sensor resistor circuit in the main amplifier is used by the controller to determine which model power sensor is connected to an input channel. Note that any two HP 848X series power sensors can be connected to the power meter. The controller is able to adjust the individual channel input to the connected power sensor and provide the correct measurement result for each channel. If the Option 002 rear panel input ports are present, the controller can determine if more than one power sensor is connected to the same channel input. For example, if power sensors are connected to both the front panel and real panel A inputs, error message 33, 2inPutS is displayed.

The output from the auto zero DAC on the main amplifier is set by the controller and in conjunction with stored values in the software is used to remove any dc offset voltage associated with the individual power sensors.

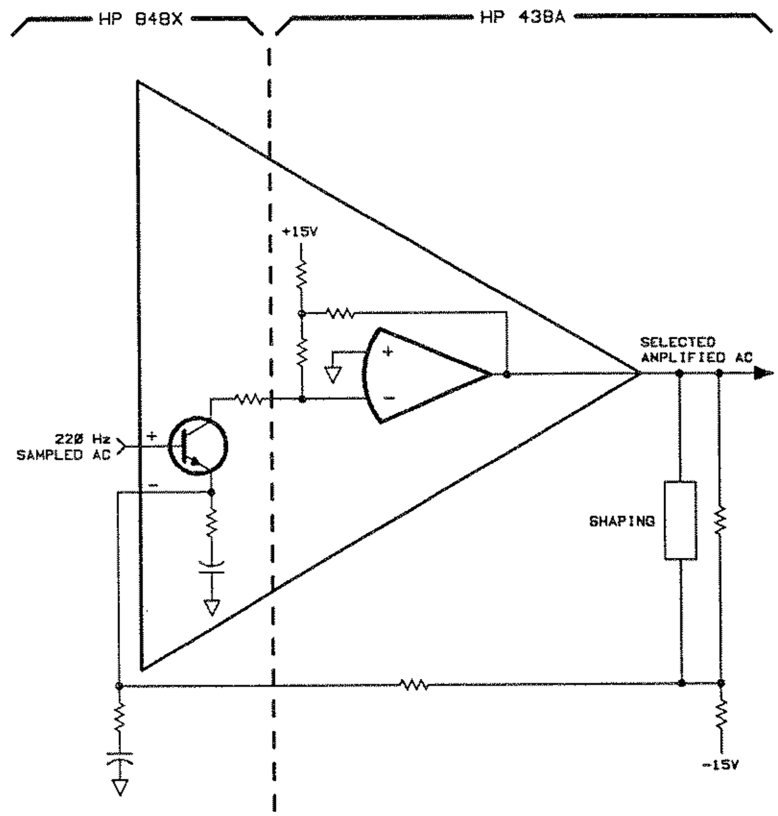


Figure 8-12. Simplified Power Sensor and Input Amplifier Diagram

The controller sets the miscellaneous buffer on the main amplifier to connect the following signal paths for the selected input channel:

1. The amplified ac output.
2. The sensor resistor input.
3. The sensor ground reference to the A-GND circuit on the main amplifier.

The power sensor and the A4 Input Amplifier Assembly function together to amplify the modulated 220 Hz signal by a factor of approximately 600.

Digital I/O and DAC Circuits

The digital I/O circuits interpret the control signals from the CPU (central processing unit) controller and set the input amplifier and the main amplifier to the correct configuration to perform the required measurement. The outputs from the digital I/O circuits are stored in the flip-flop registers of the miscellaneous buffer, the zero DAC (Digital to Analog Converter) buffer, and the gain/attenuator buffer.

Figure 8-13 is a simplified block diagram of the zeroing loop. When the (ZERO) key is pressed, or the HP-IB program code ZE is given, the software zeroing routine is initiated. The auto zeroing DAC output is used to zero the input from the power sensor with no RF signal applied. The DAC output is applied to the power sensor, is chopped in the sensor then the output from the sensor goes through the entire power meter amplifier chain.

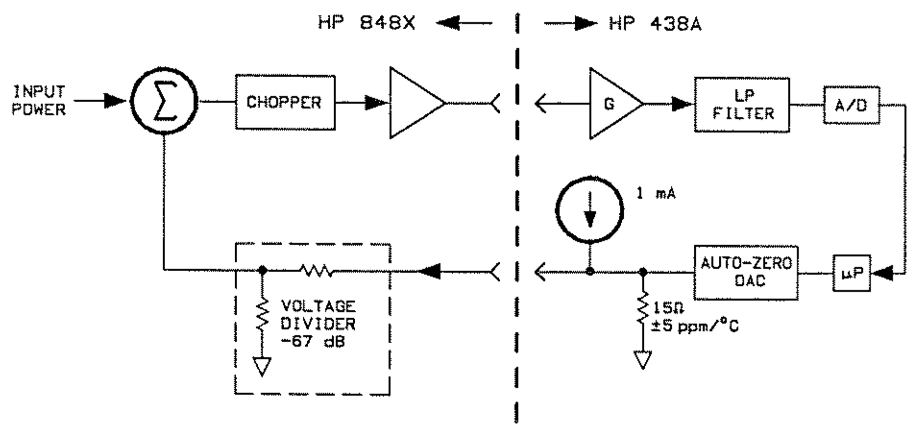


Figure 8-13. Simplified Zeroing Block Diagram

The CPU sets the output of the auto zeroing DAC to get the output from the low pass filter (Service Sheet 8) as close to zero as possible. The remaining offset is computed and stored as a series of 10 values for all combinations of the slow and fast filters and the 5 ranges. These values in conjunction with the computed DAC setting are used to determine the zero level for all input signals until the meter is zeroed again.

The stable current source supplies reference current for the zeroing DAC and the offset removal DAC.

The offset removal DAC is controlled by the CPU and subtracts the offsets introduced by the amplifier chain to produce the analog recorder output. The output of the DAC is summed with the output from the amplifier chain. The resulting signal is buffered and supplies the reference current for the gain DAC. This circuit is the hardware equivalent of the 10 computed values used by the CPU to determine the correct zeroing adjustments for the measurement that is being made.

The gain DAC is controlled by the CPU and multiplies the reference signal by some gain such that the recorder output equals one volt for full scale. The setting of the gain DAC is determined at the time of calibration. The output of the DAC is buffered and applied to the rear panel RCDR (recorder) output through a 1 kΩ resistor.

Amplifier, Detector, Filter, and Comparator Circuits

The settings of the two range attenuators and the variable gain amplifier are controlled by the CPU through the gain/attenuator buffer. The range attenuators are set to match the front panel selected range if in MNL RANGE mode or the CPU selected range if in AUTO RANGE mode. The variable gain amplifier is set to provide an output from the low pass filter between 3.02 and 3.63 Vdc. The setting required is determined during calibration (CAL ADJ). Calibration is described later.

The bandpass amplifiers consist of several active stages and RC networks. The bandpass response peaks at approximately 230 Hz with 0 degrees of phase shift.

The synchronous phase detector rectifies the output from the bandpass amplifier by multiplying the input by + or −1. Thus, the output of the detector is a signal whose filtered dc value is proportional to the true amplitude of the 220 Hz input signal.

The low pass filter consists of a slow filter and a fast filter. The input from the detector is applied to both. These filters are related to the digital filter number. If the digital filter number is 0, 1, or 2 the fast filter is active. If the number is 3 through 9 the slow filter is active. The CPU selects the output of the required filter. The low pass filter output that is selected is determined by the digital filter that is selected. It is important to understand that the digital filter is not a circuit. It is an averaging function that is performed by the software and controlled by the front panel (AUTO FILTER) and (MNL FILTER) keys. The selection of the slow and fast filters is determined as follows:

1. If the digital filter number is 0, 1, or 2, the fast low pass filter (45 ms) is selected.
2. If the digital filter number is 3 through 9, the slow low pass filter (800 ms) is selected.

A detailed description of digital filtering is provided later in this service sheet. The output of the low pass filter is buffered and applied to the following two circuits:

1. The summing point of the offset removal DAC (Service Sheet 7). The use of this output was described previously.
2. The Analog/Digital Input Multiplexer.

The Analog/Digital Multiplexer can select any one of the following signals as the ADC (analog to digital converter) input to the comparator:

1. The low pass filter output.
2. The front and or rear sensor resistors for sensors connected to channels A or B.
3. The B-GND (0V).
4. The auto zero DAC output (this signal is only selected for testing).
5. The offset removal DAC output (this signal is selected during the zeroing routine).
6. The gain DAC output (this signal is only selected during the calibration routine).

The Analog-to-Digital Converter (ADC) in the power meter consists of the following three parts:

1. The ramp generator and comparator circuits in the main amplifier.
2. The timer A/D and software interrupt circuit in the CPU.
3. The software routine that controls these circuits.

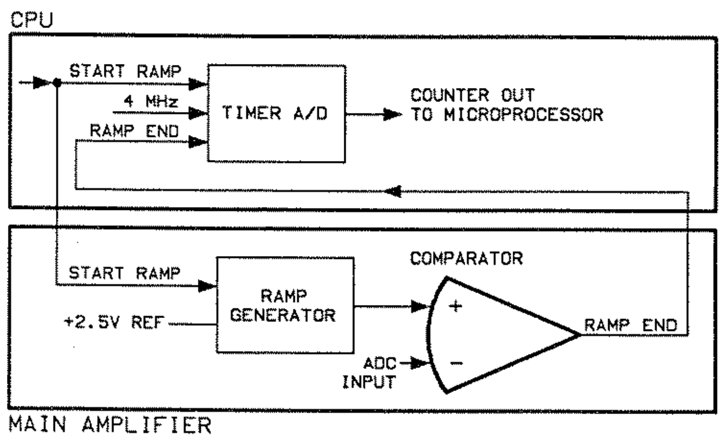


Figure 8-14. Simplified Analog to Digital (A/D) Converter Block Diagram

Figure 8-14 Simplified A/D Converter Block Diagram shows the relationship between the CPU and the main amplifier circuits. The method of digitizing the input signal is identical for all input signals. The sequence is as follows:

1. The selected signal from the analog/digital input multiplexer is applied to the ADC input of the comparator.
2. The CPU generates the start ramp signal. This signal is applied simultaneously to the timer A/D in the CPU and the ramp generator in the main amplifier.
3. The timer A/D starts counting at a 4 MHz rate.
4. Using the 2.5 V reference input, the ramp generator produces a positive linear ramp.

5. When the ramp voltage equals the ADC input voltage, the comparator sends the ramp end signal to the timer A/D circuit in the CPU. The counter is stopped at the count that represents the value of the ADC input signal. This information is used by the microprocessor to compute the measurement value. This value can then be used in any other computations required to obtain the final displayed information.

1 mW 50 MHz Power Reference Circuit

The G1 50 MHz Reference Oscillator provides a 50.0 ±0.5 MHz output at 1.0 mW ± 0.7%. This output is used during operation to calibrate the individual power sensors used with the power meter. It can also be used during the Operator's Check and troubleshooting procedures as a signal source.

As explained previously, the zeroing software routine determines the setting for the auto zero DAC, calculates and stores 10 offset values for the 10 combinations of the two low pass filters and the five available ranges. For correct calibration, the connected power sensor and the power meter must be zeroed prior to calibration.

The main functions of the power sensor calibration software routine are as follows:

1. Verify an appropriate power source and a power sensor are connected to the power meter. In some cases, the power source is the power meter's 1 mW 50 MHz Reference output.
2. Set the range attenuators and the low pass and digital filters to the correct settings for the connected power sensor.
3. Set the variable gain amplifier so that the ADC output indicates between 3.02 and 3.63 Vdc.
4. Calculate and scale the 10 zeroing offset values to provide more accurate power measurements.
5. Calculate the offset DAC settings to match these new values.
6. Find the gain DAC settings required to provide a full scale 1 Vdc output at the rear panel RCDR (recorder) connector.

After the power sensor and power meter are correctly zeroed and calibrated, they can be used to make power measurements within the specified parameters of the combined instruments.

Digital Filter Software Routine (Digital Filter)

The most important point to understand about the digital filter is that it is a software routine and not a hardware component. It does, however, have a direct bearing on the selection of the slow or fast low pass filter. The selected combination of these two filters determine the speed, resolution, and stability (jitter) of the final measurement result.

The digital filter is an averaging filter. The value returned by the digital filter is the average of the last N power readings, where N is the filter length. The filter length is determined by two being raised to some power where that power is the filter range number zero through nine. The filter number can be manually selected using the front panel (MNL FILTER) key or automatically selected by the software if the (AUTO FILTER) key is active. The relationship between the selected filter number and the filter length is as follows:

Filter Number	Filter Length (Number of Readings)
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

Troubleshooting Hints

The troubleshooting checks on this service sheet are used to narrow down a malfunction to one of the following assemblies; A4 Input Amplifier Assembly, A5 Main Amplifier Assembly, and G1 50 MHz Reference Oscillator. The major part of this service sheet is the A5 Main Amplifier Assembly and its schematic diagrams are on Service Sheets 7 and 8. The A4 Input Amplifier Assembly schematic diagram is on Service Sheet 6 and G1 50 MHz Reference Oscillator schematic diagram is on Service Sheet 11.

The checks will cover selected inputs and outputs of these major assemblies. The checks attempt to verify a good interface between the power sensor and the input amplifier so that the zeroing loop is completed and that analog to digital conversion (ADC) is being accomplished by the CPU and main amplifier connections.

Test Equipment

Oscilloscope .... HP 1740A
Power Sensor .... HP 8480 series
Sensor Cable .... HP 11730A
Digital Voltmeter (DVM) .... HP 3456A

Power Sensor to First Amplifier Interface Check

Assuming at this point that BD1 Amplifier ✓3 has been completed and the comparator output RAMP END signal was incorrect or that the RCDR (rear panel recorder) BNC output is not 1 Vdc.

Connect power sensor to channel A or channel B and the 1 mW POWER REF. The normal indication is:

The display should read 1.000 −3 WATT (mW) and channel A or B depending on the active channel.

If any abnormal indication occurs:

1. The selected amplified ac is not as shown in Figure 8-15 at test point A4TP3 or A4TP4 depending on which channel is active. Refer to A4 Input Amplifier Assembly on Service Sheet 6.

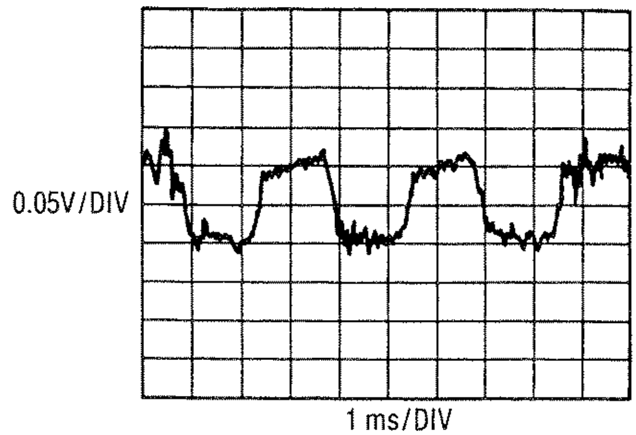


Figure 8-15. Selected Amplified AC

2. The phase detector drive is not as shown in Figure 8-16 at test point A4TP5 or A4TP6. Refer to A4 Input Amplifier Assembly on Service Sheet 6.

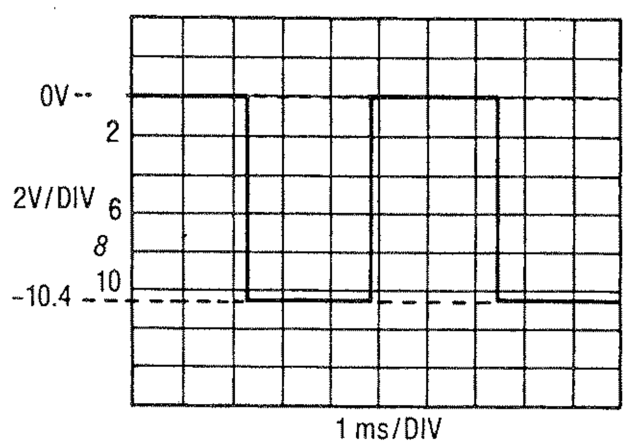
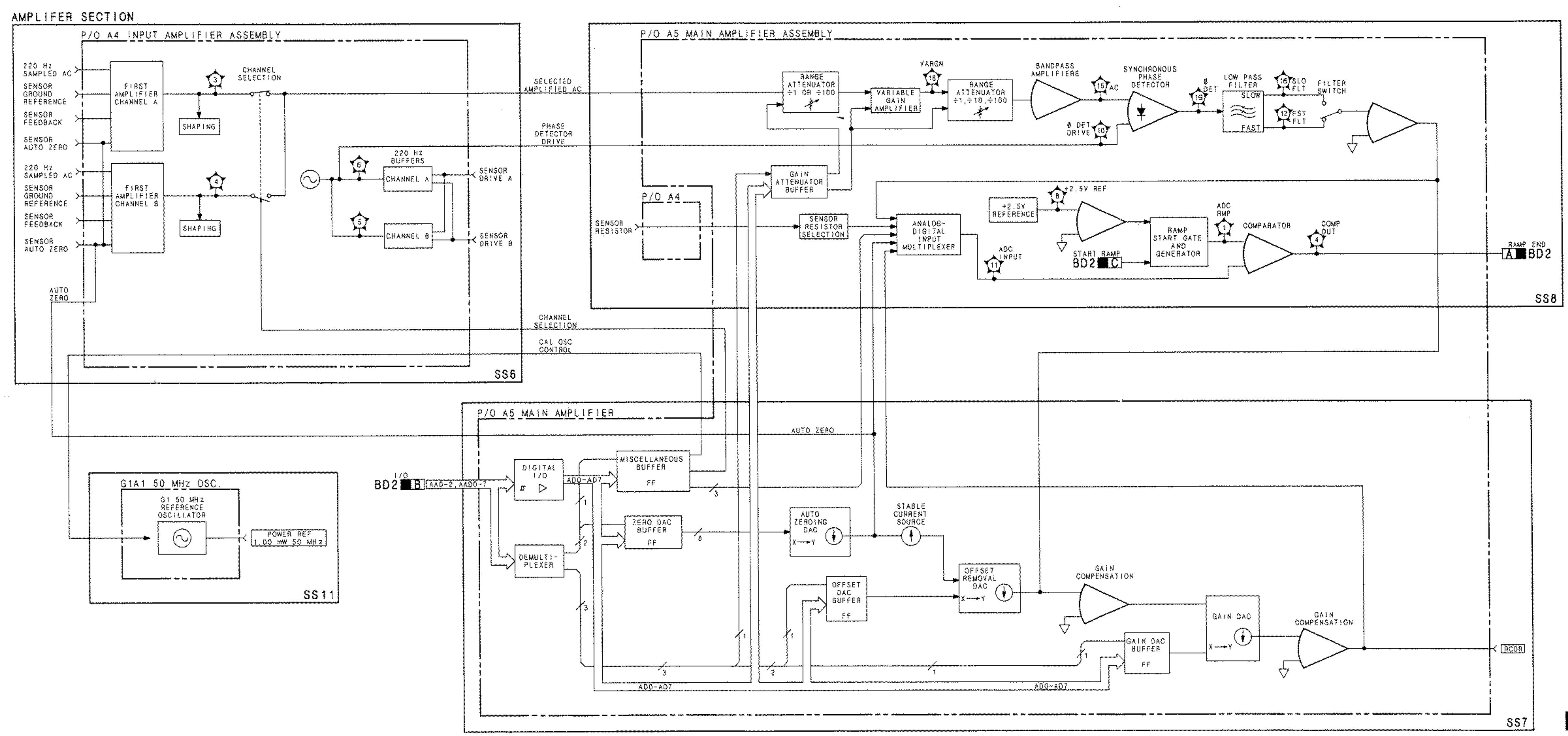


Figure 8-16. Phase Detector Drive

If the RAMP END signal is wrong and steps 1 and 2 are correct, go to Service Sheet 8.

If the RCDR signal is wrong and steps 1 and 2 are correct, go to Service Sheet 7.



BD3

Figure 8-17. Amplifier Section Block Diagram

Service Sheets 1—4 Central Processing Unit Troubleshooting

General

The following troubleshooting is for Service Sheets 1 through 4. Extended Test Mode allows the power meter to report calibration and zeroing errors. Signature Analysis, in most cases, will isolate a problem to the component level.

Extended Test Mode

Turn off the power meter. To put the power meter into extended test mode set A3S1 to decimal 14 as shown in Figure 8-18. Turn on the power meter.

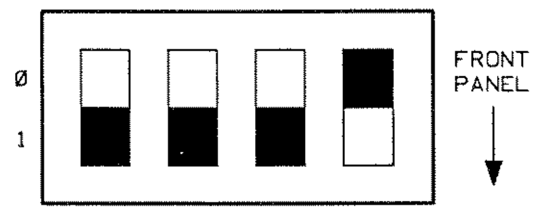


Figure 8-18. A3S1 Decimal 14 Setting

Extended test mode allows for HP-IB control of the DAC's and Variable Gain Amplifier. When the power meter is in extended test mode, the following calibration and zeroing error messages may be displayed on the microprocessor board LED's (A3DS1).

Table 8-6. Extended Test Mode Error Messages

LED Display D3 D2 D1 D0	Description
0 0 0 1	The power meter thinks that there is no sensor connected. If a sensor is connected, the problem could be caused by a bad sensor, sensor cable, or Sensor Resistor Selection circuit (see Service Sheet 8).
0 0 1 0	The Zero DAC was set to its maximum value (255) but a valid zero could not be achieved. This would indicate that the voltage at the A/D converter was too high (>140mV) for the Zero DAC to correct. This could happen if power is applied to the sensor during ZEROing or if there was a failure in the Amplifier Section (see BD3).
0 0 1 1	The Zero DAC was set to its minimum value (0) but a valid zero could not be achieved. This would indicate that the voltage at the A/D converter was too low (<−140 mV) for the Zero DAC to correct. This could happen if there was a failure in the Amplifier Section (see BD3).
0 1 0 0	After the Zero DAC was set, the digitally filtered voltage on RANGE 1 was not between −140 and +140 mV.
0 1 0 1	After the Zero DAC was set, the digitally filtered voltage on RANGE 2 was not between −140 to +140 mV.
0 1 1 0	After the Zero DAC was set, the digitally filtered voltage on RANGE 5 was not between −140 to +140 mV.
0 1 1 1	With Offset DAC set to 64, the offset voltage is not between 0 and 750 mV or with the Offset DAC set to 192, the offset voltage is not less than 0 V. This problem is most likely caused by the Offset DAC Buffer or Offset Removal DAC circuits on Service Sheet 7.
1 0 0 0	Offset DAC setting for one or more of the 10 calculated offset voltages would be less than zero or greater than 255.
1 0 0 1	While trying to execute the CAL ADJ procedure, a variable gain amplifier setting which would result in a valid CAL voltage (3.18 to 3.85 V at the A/D converter) could not be achieved.
1 0 1 0	A/D converter overflowed during the CAL ADJ procedure. This could be caused by a failure in the Amplifier Section (BD3) or applying too much power to the sensor (that is, connecting the HP 8484A without the HP 11708A Attenuator).
1 0 1 1	The A/D converter returned a count (proportional to voltage) for BGND that was out of range. This could be an A/D converter problem or a BGND problem.
1 1 0 0	1 V at the recorder output (RCDR) could not be achieved with a normal setting of the Gain DAC. The most likely cause of this problem would be one of the Gain Compensation amplifiers, the Gain DAC Buffer, or the Gain DAC. However, an incorrect voltage from the filter output of Service Sheet 8 could also cause the problem.
1 1 0 1	When the power meter turned its internal Power Reference Oscillator on and off to make sure that there was a sensor connected, the A/D converter detected that there was always power applied to the sensor. Possibly the sensor was connected to an external reference or the power meter may have been unable to turn off its internal Power Reference Oscillator. A failure in the power sensor, power sensor cable, or Amplifier Section could also cause the problem.

HP-IB Commands in Extended Test Mode

The Extended Test Mode also allows the Zero DAC, Gain DAC, Offset DAC, and the Variable Gain Amplifier to be set over HP-IB for testing purposes only. The Extended Test Mode commands are as indicated in Table 8-7 below.

Table 8-7. HP-IB Commands in Extended Test Mode

Command	Description
ZDA	Cause the system to accept the next number sent and use it as the zero DAC setting for channel A. Valid range of numbers are 0–255.
ZDB	Cause the system to accept the next number sent and use it as the zero DAC setting for channel B. Valid range of numbers are 0–255.
GDA	Cause the system to accept the next number sent and use it as the gain DAC setting for channel A. Valid range of numbers are 0–255.
GDB	Cause the system to accept the next number sent and use it as the gain DAC setting for channel B. Valid range of numbers are 0–255.
ODA	Cause the system to accept the next number sent and use it as the offset DAC setting for channel A. Valid range of numbers are 0–255.
ODB	Cause the system to accept the next number sent and use it as the offset DAC setting for channel B. Valid range of numbers are 0–255.
VGA	Cause the system to accept the next number sent and use it as the variable gain amp setting for channel A. Valid range of numbers are 0–15.
VGB	Cause the system to accept the next number sent and use it as the variable gain amp setting for channel B. Valid range of numbers are 0–15.

Notes

1. To set the Zero DAC to the value 152 using BASIC, type:

   ```
   OUTPUT 713;"ZDA152EN"
   ```

   Do not include any spaces in the command string.

2. Version 5.0 is used on 00438-60103 boards which require a single EPROM (00438-80036). Version 2.0 is used on 00438-60003 boards which require 2 EPROM's (00438-80037 and 00438-80038).

   In order to use the following signatures to repair your A3 board, you must have one of the preceeding versions of EPROM.

Signature Analysis Mode Checks

In most cases, the Signature Analysis procedures will isolate a problem to the component level.

Next to each check, in parentheses, is the component being checked and the Service Sheet where the component is located.

The procedures must be done in the order shown. All checks up to and including Miscellaneous Checks must be done.

Test Equipment

Signature Analyzer .... HP 5005B
Oscilloscope .... HP 1725A

Free Run Signature Analysis

General. Free Run Signature Analysis is to be used to verify operation of the following:

- Data Bus
- Address Decoding
- Address Bus
- The contents and operation of ROM.

The signatures represent firmware for ROM's with HP part number 00438-80036 (A3U9), version 5.0 or with part numbers 00435-80037 and 00438-80038 (A3U9–U10), version 2.0. (To find your firmware version use the HP-IB command, ?ID .)

Memory Data Bus Signatures.

Note If the Data Bus signatures are normal, then the Address Bus does not need to be checked.

1. Connect the signature analyzer as shown below:

Signature Analyzer Pod	A3 Assembly
Start	A3TP11
Stop	A3TP11
Clock	A3TP6
Ground	A3TP7

2. Set the controls on the signature analyzer as shown below:

   FUNCTION .... NORM
   Clock .... \ falling edge
   Start .... / rising edge
   Stop .... \ falling edge

3. With the power meter off, connect a jumper from A3TP4 to ground.

4. Ensure that switch A3S1 is set to the NORMAL position (1111). The least significant bit is the switch that is closest to the edge of the printed circuit board. When the switches are set towards the front panel of the instrument, they are set to one.

5. Turn the power meter on and use the following signatures to verify that the signature analyzer has been set up properly.

   +5V ....(0001)
   GND ....(0000)

Note If the microprocessor will not go into Free Run, perform the Free Run Mode Troubleshooting near the end of Free Run Signature Analysis.

6. Verify the signatures in Table 8-8.

   If all signatures are correct, continue with the Chip Select signatures.

Table 8-8. Memory Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U8-11	PD3	F7CH	19C7
12	PD2	P177	0320
13	PD4	P09U	7526
14	PD1	0C90	7F7P
15	PD5	409D	7517
16	PD0	9839	PUH7
17	PD6	H793	18F2
18	PD7	U73C	1FC8

If any signature is incorrect, verify the signatures in Table 8-9

Table 8-9. Memory Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U8-2	I/07	U73C	1FC8
3	I/06	H793	18F2
4	I/00	9839	PUH7
5	I/05	409P	7517
6	I/01	0C90	7F7P
7	I/04	P09V	7526
8	I/02	P177	0320
9	I/03	F7CH	19C7

If all signatures are correct, replace U8. If any signature is incorrect, verify the Chip Select signatures.

Chip Select Signatures.

1. Set the controls on the signature analyser as follows:

   Start .... / (rising edge)
   Stop .... / (rising edge)
   Clock .... \ (falling edge)

2. Verify the signatures in Table 8-10.

Table 8-10. Chip Select Signatures

Pin Number		Signal Name	Signature	
5.0	2.0		5.0	2.0
U28-16	U28-12	NRAME	4P08	4P08
17	13	STAT2/STOP2	F2A4	F2A4
18	14	NSWE	0000	0000
19	15	NROM1E	0001	0001
20	16	NMEME	4P0A	4P0A
21	17	NIRT	0003	0003
22	18	NIOE	12U1	12U1
23	19	NADS	6H4C	6H4C

If all signatures are correct and you have version 2.0, continue with step 3. If you have version 5.0, proceed to step 4. If any signature is incorrect, verify the signatures in Table 8-11.

Table 8-11. Chip Select Signatures

Pin Number		Signal Name	Signature	
5.0	2.0		5.0	2.0
U28-1	U28-1	R/NW	0003	0003
2	2	NFREERUN	0000	0000
3	3	BS	0000	0000
4	4	BA	0000	0000
5	5	PA12	4FCA	4FCA
6	6	PA15	0002	0002
8	8	PA14	9UP1	9UP1
9	9	PA13	4868	4868
10	10	NPWR FAIL	0003	0003
11		PA11	6U28	
13		PA10	37C5	

If the signature for pin 2 is incorrect, verify that A3TP4 is grounded or look for an open trace.

If the signature for pin 10 is incorrect, perform the troubleshooting for the Reset/Power Fail circuit.

If any other signature is incorrect, replace U19.

If all signatures are correct, replace U28.

3. (Applies to version 2.0 only.) Verify the signatures in the table below.

Chip Select Signatures

Pin	Signature
U7-4	3838
5	7633
10	PACH
12	PACU

If all signatures are correct, continue with step 4.

If any of the signatures are incorrect, verify the signature in the following table.

Chip Select Signatures

Pin	Signature	
U7-13	A14	9UP1

If the signature is correct, replace U7. If the signature is incorrect, replace U19.

4. Verify the signatures in Table 8-12.

Table 8-12. Chip Select Signatures

Pin Number		Signal Name	Signature	
5.0	2.0		5.0	2.0
U15-3	U15-3	NRESET	0003	0003
5	5	A0	UUUU	UUUU
7	7	A1	FFFF	FFFF
9	9	A2	8484	8484
12	12	R/NW2	0003	0003
14	14	NWR	0003	0003
U13-22	U13-20	NRD	*	*
U9-22	U9-22	NOE	*	*

* The probe should blink indicating signal activity.

If all the signatures are correct, perform the Signature Analysis Mode Checks.

If any of the signatures are incorrect, verify the signatures in Table 8-13.

Table 8-13. Chip Select Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U15-2	———	*	*
4	———	*	*
6	———	0003	0003
8	R/NW	0003	0003
11	PA2	8484	8484
13	PA1	FFFF	FFFF
15	PA0	UUUU	UUUU
17	NRESET	0003	0003

* The probe should blink indicating signal activity.

If the signature for pin 2 is incorrect, replace U37 and/or R17.

If the signature for pin 4 is incorrect, replace U36 and/or R20.

If the signature for pin 6 is incorrect, check for a TTL low at U37 pin 8. If pin 8 is a TTL low, replace U36. If pin 8 is not a TTL low, replace U37.

If the signatures for pins 11, 13 and 15 are incorrect, replace U19.

If the signature for pin 17 is incorrect, troubleshoot the Reset/Power Fail circuit.

Note If the Memory Data Bus and Chip Select Signatures are correct, perform the Signature Analysis Mode Checks. If the signatures are incorrect, continue with the Address Bus Signatures.

Address Bus Signatures

1. Set the controls on the signature analyzer as follows:

   Start ..../ (rising edge)
   Stop .... \ (falling edge)
   Clock .... \ (falling edge)

2. Verify the signatures in Table 8-14.

Table 8-14. Address Bus Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U18-3	A7	HC89	HC89
5	A6	52F8	52F8
7	A3	5H21	5H21
9	A1	CCCC	CCCC
12	A0	5555	5555
14	A2	7F7F	7F7F
16	A4	0AFA	0AFA
18	A5	UPFH	UPFH

If all signatures are correct, continue with step 3.

If any signature is incorrect, verify the signatures in Table 8-15.

Table 8-15. Address Bus Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U19-8	PA0	5555	5555
9	PA1	CCCC	CCCC
10	PA2	7F7F	7F7F
11	PA3	5H21	5H21
12	PA4	0AFA	0AFA
13	PA5	UPFH	UPFH
14	PA6	52F8	52F8
15	PA7	HC89	HC89

If any signature is incorrect, continue with step 3. If all signatures for pins 8 through 15 are correct, replace U18.

3. Verify the signatures in Table 8-16.

Table 8-16. Address Bus Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U30-3	A12	3C96	3C96
5	A9	HPP0	HPP0
7	A14	755U	755U
9	A13	3827	3827
12	02	*	*
14	A10	1293	1293
16	A11	HAP7	HAP7
18	A8	2H70	2H70

* The probe should blink indicating signal activity.

If any of the signatures are correct, verify the signatures in Table 8-17.

Table 8-17. Address Bus Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U19-16	PA8	2H70	2H70
17	PA9	HPP0	HPP0
18	PA10	1293	1293
19	PA11	HAP7	HAP7
20	PA12	3C96	3C96
21	PA13	3827	3827
22	PA14	755U	755U

If all of the signatures are correct, replace U30.

If the signatures in Table 8-15 or Table 8-17 are incorrect, perform Free Run Mode Troubleshooting. If Free Run Mode Troubleshooting is normal replace U19.

If the Address Bus signatures are correct, perform the Memory Data Bus Tests.

Reset/Power Fail Test Voltage Checks

1. Ensure the power meter is turned on.
2. Verify that U19 pin 37 is a TTL high. If the measured voltage is correct, go to the Timing Check. If the measured voltage is incorrect, go to step 3.
3. Verify that U35 pin 5 is +2.5 Vdc. If pin 5 is incorrect, check the +5 volt supply, R4 and R5. If pin 5 is correct, go to step 4.
4. Verify that U35 pin 4 is +5 Vdc. If pin 4 is correct, replace U35. If pin 4 is incorrect, go to step 5.
5. Verify that U35 pin 7 is +5 Vdc. If pin 7 is correct, replace C5 or R3. If pin 7 is incorrect, go to step 6.
6. Verify that U35 pin 10 is approximately +2.5 Vdc. If pin 10 is correct, go to step 7. If pin 10 is incorrect, check R10, R11 and C16.
7. Verify that U35 pin 9 is >2.5 Vdc. If the voltage at pin 9 is incorrect, check R12–R14 and C15.

Timing Check

1. Connect the oscilloscope to U19 pin 37. Connect the oscilloscope's External Trigger Input to A3TP8.
2. Set the controls on the oscilloscope as follows:

   Vertical Scale .... 2 volts/division
   Horizontal Scale .... 20 ms/division

Trigger Mode .... Normal, external
Trigger Level .... Slightly positive
Trigger .... Positive Edge

3. At turn on, the oscilloscope should display a waveform that is at 0 volts for >80 ms and then goes to +5 volts.

Note

The following procedure is to be used if Free Run Mode will not operate.

Free Run Mode Troubleshooting

1. Verify that U28 pin 14 is a TTL low. If pin 14 is correct, go to step 2. If pin 14 is incorrect, verify that U28 pin 2 is 0 volts. If pin 2 is incorrect, check for an open trace to TP4 or verify that TP4 is grounded. If pin 2 is 0 volts, replace U28.

2. Verify lines D0–D7 (at U19) are as shown in Table 8-18.

Table 8-18. Data Line Logic Levels

Test Node	Data Line	TTL Logic
U19 Pin 31	D0	1
30	D1	1
29	D2	1
28	D3	1
27	D4	1
26	D5	0
25	D6	1
24	D7	0

If there is activity on the data lines, verify that U1 pin 19 is a TTL high. If pin 19 is correct, replace U1. If pin 19 is incorrect, replace U37.

If there is no activity on the data lines and the logic levels are incorrect, verify that the Service Function Switch (A3S1) is set to the proper position. When set to the proper position, U3 pins 4, 6, 8 and 11 are TTL highs.

If pins 4, 6, 8 and 11 are incorrect, set the switch to all "1s" or replace the switch.

If pins 4, 6, 8 and 11 are correct, replace U3.

3. Verify that U19 pins 2, 4, and 40 are TTL highs. If pins 2, 4, and 40 are not TTL highs, replace R9.

4. Verify there is a 2 MHz clock signal at TP6.

   If TP6 does not have a 2 MHz clock, check for an 8 MHz clock at U19 pin 38. If the 8 MHz clock is present, replace R16 or U19. If the 8 MHz signal is not present, check the Clock circuit.

5. Verify that U19 pin 3 is a TTL high. If pin 3 is not a TTL high or there is a signal present, verify there is a TTL low at U38 pin 13.

   If U38 pin 13 is correct, temporarily ground U38 pin 10 and verify that U38 pin 9 goes to a TTL high. If pin 9 is incorrect, replace U38. If pin 9 is correct, replace U38 or U20.

6. Verify TP5 is a TTL high (>3.5 Vdc). If TP5 is incorrect, replace U19.

7. Verify TP11 is a square wave of approximately 15 Hz and 5 volts peak-to-peak. If TP11 is incorrect, replace U19.

   If no failures were found, the microprocessor should be in Free Run Mode.

Data Bus Tests

1. Connect the signature analyzer as described under Free Run Signature Analysis. Turn the power meter OFF. Remove ROM U9 for version 5.0, or ROMs U9 and U10 for version 2.0.

2. Turn the power meter ON. Verify that the signature of each data line is either low (0000) or high (0001). If any other signature is seen, then one of the RAMs is probably defective.

   If the signatures with the ROM in the circuit were low (0000) or high (0001), then U8 is most likely defective.

   If the data bus signatures are correct, then the problem is U9 for version 5.0, or ROMs U9 and U10 for version 2.0.

Note Free Run Signature Analysis must be performed before attempting Programmed Signature Analysis.

Microprocessor Data Bus Buffer Check (U1—Service Sheet 1).

1. Connect the signature analyzer to the A3 assembly as follows:

Signature Analyzer Pod	A3 Assembly
Start/Stop	A3TP9
Qual	U1 Pin 19
Clock	A3TP6
Ground	A3TP7

2. Make the following settings on the signature analyzer:

   Function .... QUAL
   Clock .... (falling edge)
   Start .... (rising edge)
   Stop .... (falling edge)
   Qual .... LO

3. Set switch A3S1 to 0001. The least signifiant bit is the switch that is closest to the edge of the printed circuit board. When the switches are set towards the front panel of the instrument, they are set to one. Turn the instrument off then back on again.

4. Verify the signatures for +5 volts and ground are as shown below:

		Rev. 5.0	Rev. 2.0
+5 volts	(A3TP8)	(9UCF)	(7PU0)
Ground		(0000)	(0000)

Note If Signature Analysis Mode will not run, perform the Signature Analysis Mode Troubleshooting under "Miscellaneous Checks".

5. Verity the signatures in Table 8-19.

Table 8-19. Microprocessor Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U1-2	PD7	PUH1	CU45
3	PD6	AP0P	C839
4	PD0	10U2	43FA
5	PD5	P640	9900
6	PD1	F0FA	0328
7	PD4	UU34	UFF3
8	PD2	2388	8P33
9	PD3	7992	P648

If all signatures are correct, perform the Miscellaneous Tests.

If any signature is incorrect, move the QUAL line to U1 pin 1, set QUAL to "High" and verify the signatures for +5 volts (version 2.0—A988, version 5.0—F039) and ground (0000) are as shown.

Verify the signatures in Table 8-20.

Table 8-20. Microprocessor Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U1-2	PD7	9U27	9U27
3	PD6	P48H	P48H
4	PD0	97C4	97C4
5	PD5	940U	940U
6	PD1	2AAC	2AAC
7	PD4	U7FA	U7FA
8	PD2	8305	8301
9	PD3	HU5P	HU5P

If any signature was incorrect, replace U1.

If all the signatures were correct, set QUAL to "LO" and verify the signatures in Table 8-21.

Table 8-21. Microprocessor Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U1-2	PD7	1390	4P43
3	PD6	4899	2266
4	PD0	F7UA	1UPA
5	PD5	1F95	7256
6	PD1	57A8	5PA2
7	PD4	971P	5F79
8	PD2	5386	4P1A
9	PD3	47H9	1U65

If any signature is incorrect, replace U1.

If all signatures are correct, perform the "Memory Data Bus Buffer Check".

Memory Data Bus Buffer Check (U8—Service Sheet 2).

1. Move the QUAL line to U8 pin 1, set QUAL to "LO" and verify the signatures for +5 volts (version 5.0 — 7610, version 2.0 — H843) and ground (0000) are as shown.
2. Verify the signatures in Table 8-22.

Table 8-22. Meory Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U8-2	I/O7	PC0P	AF38
3	I/O6	H7C2	5PFC
4	I/O0	U5H7	H75U
5	I/O5	PC00	AF38
6	I/O1	9UCA	7PPC
7	I/O4	1U8F	7P30
8	I/O2	H286	4A1A
9	I/O3	1U5L	7H77

If all signatures are correct, perform the "RAM Check".

If any of the signatures are incorrect, replace U8.

RAM Check (Version 2.0, U12 and U13—Service Sheet 2 and Version 5.0, U13—Service Sheet 3).

Note

For the RAM Check to be valid, the Microprocessor Data Bus Buffer and Meory Data Bus Buffer must be operating properly.

1. Set Switch A3S1 to 2 (0010). The least significant bit of A3S1 is closest to the edge of the printed circuit board. When the switches are set towards the front panel of the power eter, they are set to "1".

   The front panel display is blank during this check. To verify the check is being run, observe the anode data bus bits AD0 through AD7 LED's on the A3 Assembly near A3S1. At the next power up there will be a momentary rcl (recall) Fail error message since information in memory was written over during this test routine. The normal indications are:

   The data bus bit pattern changes as shown in Table 8-23.

Table 8-23. Data Bus Test Pattern

	Bits	Bit Pattern						
		Start	Test 1 Start	Test 1	Test 1 Complete	Test 2 Complete	Tests Complete	Restart
RAM 1 A3U12	D0	0	1	0	1	0	0	1
	D1	0	1	0	1	0	0	1
RAM 2 A3U13	D2	0	0	1	0	1	1	0
	D3	0	0	1	0	1	1	0
How many times the	D4	0	0	0	1	0	1	0
test was executed	D5	0	0	0	0	1	1	0
and passed?	D6	0	0	0	0	0	1	0
	D7	0	0	0	0	0	1	0

Note

D4—D7 count in binary. For version 5.0, ignore RAM 1 A3U12—not used.

   If a RAM failure occurs the test will flash LED's for bits D0, D1 indicating a proble with A3U12, or flash LED's for bits D2, D3 when A3U13 has a problem.

2. Reset A3S1 to 1 (0001). If RAM is operating properly, perform "I/O Data Bus Buffer Check".

I/O Data Bus Buffer Check (U39—Service Sheet 1).

1. Move the QUAL line to U39 pin 19, set QUAL to "LO" and verify the signatures for +5 volts (versions 5.0 and 2.0, 2881) and ground (0000) are as shown.
2. Verify the signatures in Table 8-24.

Table 8-24. I/O Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U39-2	ID7	F3U9	F3U9
3	ID6	U603	U603
4	ID0	44F9	44F9
5	ID5	2832	2832
6	ID1	A0UH	A0UH
7	ID4	011A	011A
8	ID2	P133	P133
9	ID3	7208	7208

If all the signatures are correct, perform the "Miscellaneous Checks".

If any of the signatures are incorrect, go to step 3.

3. Move the QUAL line to U39 pin 1, set QUAL to "LO" and verify the signatures for +5 volts (version 5.0 — 7610, version 2.0 — H843) and ground (0000) are as shown.
4. Verify the signatures in Table 8-25.

Table 8-25. I/O Data Bus Buffer Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U39-2	ID7	228F	8A32
3	ID6	U960	P583
4	ID0	9HHP	7778
5	ID5	5FC3	72FH
6	ID1	6U3U	CFUP
7	ID4	0CHF	2U70
8	ID2	89HP	277A
9	ID3	F315	0F56

If any signature is incorrect, replace U39.

If all signatures are correct, connect the signature analyzer as follows:

Start A3TP9
Stop............ A3TP9
Clock........... A3TP6

5. Make the following settings on the signature analyzer:

Function ....NORM
Clock ....falling edge
Start ....rising edge
Stop ....falling edge

6. Verify the signatures for +5 volts (version 5.0 and 2.0, 9UCF) and ground (0000) are as shown.
7. Verify the signatures in Table 8-26.

Table 8-26. I/O and Display Address Decode Signatures

Test Node	Signal Name	Signatures
A3U27 Pin 11	NCS4	7137
12	NCS3	7A5C
13	NCS2	12H3
14	NCS1	9HP7
15	NCS0	PFP0
A3U33 Pin 9	NY3	10H0
10	NY2	7H33
11	NY1	FP4P
12	NY0	A1U6

If all signatures are correct, perform the "Analog I/O PIA Check".

If any signature is incorrect, replace the integrated circuit associated with the bad signature.

Analog I/O PIA Check (U21—Service Sheet 3).

1. Connect the QUAL line to U21 pin 23.

   Verify that the controls on the signature analyzer are set as follows:

   Function .... QUAL
   Clock .... falling edge
   Start .... rising edge
   Stop .... falling edge
   Qual .... LO edge

2. Verify the signatures for +5 volts (versions 5.0 and 2.0, 494F) and ground (0000) are as shown.
3. Verify the signatures in Table 8-27.

Table 8-27. Analog I/O PIA Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U21-26	ID7	14CH	14CH
27	ID6	7U68	7U68
28	ID5	1284	1284
29	ID4	2P7A	2P7A
30	ID3	0C88	0C88
31	ID2	AC97	AC97
32	ID1	P9P8	P9P8
33	ID0	UP62	UP62
2	AA0	HP66	HP66
3	AA1	F102	F102
4	AA2	3H66	3H66
10	AAD0	U6FH	U6FH
11	AAD1	045U	045U
12	AAD2	62A3	62A3
13	AAD3	05F4	05F4
14	AAD4	973H	973H
15	AAD5	8942	8942
16	AAD6	3UC4	3UC4
17	AAD7	8A5P	8A5P

If any signature is incorrect, replace U21.

If all signatures are correct, perform the "Cathode Data Display and Keyboard Scan PIA Check".

Cathode Data Display and Keyboard Scan PIA Check (U22—Service Sheet 3).

1. Move the QUAL line to U22 pin 23, set QUAL to "LO" and verify that the signatures for +5 volts (versions 5.0 and 2.0, A2OU) and ground (0000) are as shown.
2. Verify the signatures in Table 8-28.

Table 8-28.
Cathode Data Display and Keyboard Scan PIA Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U22-26	ID7	0000	0000
27	ID6	0000	0000
28	ID5	0000	0000
29	ID4	104F	104F
30	ID3	029F	029F
31	ID2	2C3C	2C3C
32	ID1	H733	H733
33	ID0	8HA3	8HA3
2	PA0	3C8U	3C8U
3	PA1	A7HU	A7HU
4	KPE0	A20U	A20U
5	KPE1	A20U	A20U
6	KPE2	A20U	A20U
9	KPE	0000	0000
10	PB0	5775	5775
11	PB1	666H	666H
12	PB2	3UC6	3UC6
13	PB3	014P	014P
14	PB4	8HA7	8HA7
15	PB5	0000	0000
19	CB2	*	*

* The probe should blink indicating signal activity.

If all signatures are correct, perform the "Timer A/D and Software Check".

If the signatures for pins 4, 5, 6 or 9 were incorrect, perform the "Miscellaneous Checks". If the signatures for any other pins were incorrect, replace U22.

Timer A/D and Software Check (U20—Service Sheet 3).

1. Move the QUAL line to U20 pin 10, set QUAL to "LO" and verify the signatures for +5 volts (versions 5.0 and 2.0, HFC3) and ground (0000) are as shown.
2. Verify the signatures in Table 8-29.

Table 8-29. Timer A/D and Software Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U20-12	ID0	UC82	UC82
13	ID1	UC82	UC82
14	ID2	CU0P	CU0P
15	ID3	0000	0000
16	ID4	FCUF	FCUF
17	ID5	6AUA	6AUA
18	ID6	H5U4	H5U4
19	ID7	U2F5	U2F5

Verify the signal at U20 pin 2 is 2 kHz and U20 pin 3 is 1 kHz.

If the signatures and frequencies are correct, perform the "HP-IB Interface Check".

If any signature or frequency is incorrect, verify that 4 MHz is at U20 pin 6. If there isn't a signal, replace R28 or R27. If there is a signal, replace U20.

HP-IB Interface Check (U29—Service Sheet 1).

1. Move the QUAL line to U29 pin 8, set QUAL to "LO" and verify the signatures for +5 volts (versions 5.0 and 2.0, P95U) and ground (0000) are as shown.
2. Verify the signatures in Table 8-30.

Table 8-30. Analog I/O PIA Signatures

Pin Number	Signal Name	Signature	
		5.0	2.0
U29-1	T(1)/NR(1)	0000	0000
2	T(2)/NR(2)	0000	0000
12	ID0	A5FH	A5FH
13	ID1	4FA8	4FA8
14	ID2	PA5F	PA5F
15	ID3	UA97	UA97
16	ID4	3PA5	3PA5
17	ID5	0UA9	0UA9
18	ID6	82C3	82C3
19	ID7	10UA	10UA

If any of the signatures are incorrect, replace U29, U17 or U16.

If all of the signatures are correct, perform the "Miscellaneous Checks."

Miscellaneous Checks

The "Miscellaneous Checks" provide troubleshooting for the following areas:

- Keyboard Priority Encoder (U43 — Service Sheet 1)
- Addressable Data Display Latch (U31 and U32 — Service Sheet 3)
- Signature Analysis Mode Troubleshooting (Service Sheets 1 – 4)

Note The display circuits must be operating properly to perform the Keyboard Priority Encoder test.

Keyboard Priority Encoder. Perform the Manual Keyboard Check on Block Diagram 2. If the power meter doesn't display OO at power ON, perform "Free Run Signature Analysis" and the "Signature Analysis Mode Checks".

If the indication for one key is incorrect, the problem is either the switch, for that key, U43 or U22.

To determine where the problem is, set the oscilloscope to $\geq$0.5 ms/division and 1 V/division; look at the column line (NKC0–NKC7) corresponding to the suspected switch. For example, monitor NKC7 (U43 pin 4) for the (LCL) key. When the key is not pressed, the line should be a TTL high. When the key is pressed, a TTL signal should be on the line. If the TTL signal does not appear, replace the switch. If the signal does appear, replace U43 or U22.

Addressable Display Latch. Verify that there is a signal on U31 pins 4 through 7 and 9 through 12 and on U32 pins 4 and 5.

If all signals are incorrect, ensure that there is a signal on U33 pin 1. If there isn't a signal on pin 1, perform Free Run Signature Analysis following this procedure. If the signal is on pin 1, check for a signal on U33 pins 4 and 5. If signals are present on pins 4 and 5, check the logic level on U32 pin 15. If the level is a TTL low, perform the Signature Analysis Mode Checks at the beginning of this procedure. If the level is a TTL high, check the signatures for PB1–PB3 using the "Signature Analysis Mode Checks" (Cathode Data Display and Keyboard Scan PIA Check).

If outputs for U31 are bad, check U31 pin 14 for a TTL signal and U31 pin 15 for a logical high. If the clock signal is absent, replace U33. If the reset is held low, check the Reset/Power Fail circuit on Service Sheet 2. If the Reset/Power Fail circuit is operating properly, replace U15. If the conditions on pins 14 and 15 are correct, replace U31.

If the outputs for U32 are bad, check U32 pin 14 for a clock signal and U32 pin 15 for a logical high. If the clock signal is absent, replace U33. If the reset is held low, check the Reset/Power Fail circuit on Service Sheet 2. If the Reset/Power Fail circuit is operating properly, replace U15. If the conditions on pins 14 and 15 are correct, replace U32.

Verify that there is a signal on U25 pin 6. If there isn't any signal, check for a signal on U25 pin 5. If there isn't any signal on pin 5, perform the Signature Analysis Mode Check for U20 (Timer A/D and Software Check). If the signatures for U20 are normal, perform "Free Run Signature Analysis" and the "Signature Analysis Mode Checks". If there is a signal on U25 pin 5, replace U25.

Note The following troubleshooting should only be used if there seems to be a problem running the Signature Analysis Mode Checks.

Signature Analysis Mode Troubleshooting. Verify that the following three areas are operating properly.

- ☐ Service Function Switch and Service Function Switch Buffer—Set the microprocessor to Free Run Mode (ground A3TP4). Set A3S1 to 0001(LSB). The least significant bit (LSB) is closest to the edge of the printed circuit board. When the switches are set towards the front panel of the power meter, they are set to one. Verify that the four bits on A3U3 pins 4, 6, 8 and 11 are seen on the output (A3U3 pins 16, 14, 12 and 9) of the buffer.
- ☐ Verify the operation of the Reset/Power Fail circuit (refer to procedure following Free Run Signature Analysis).
- ☐ If Free Run Signature Analysis has been performed and all tests are normal, A3U1 or A3U19 should be replaced.

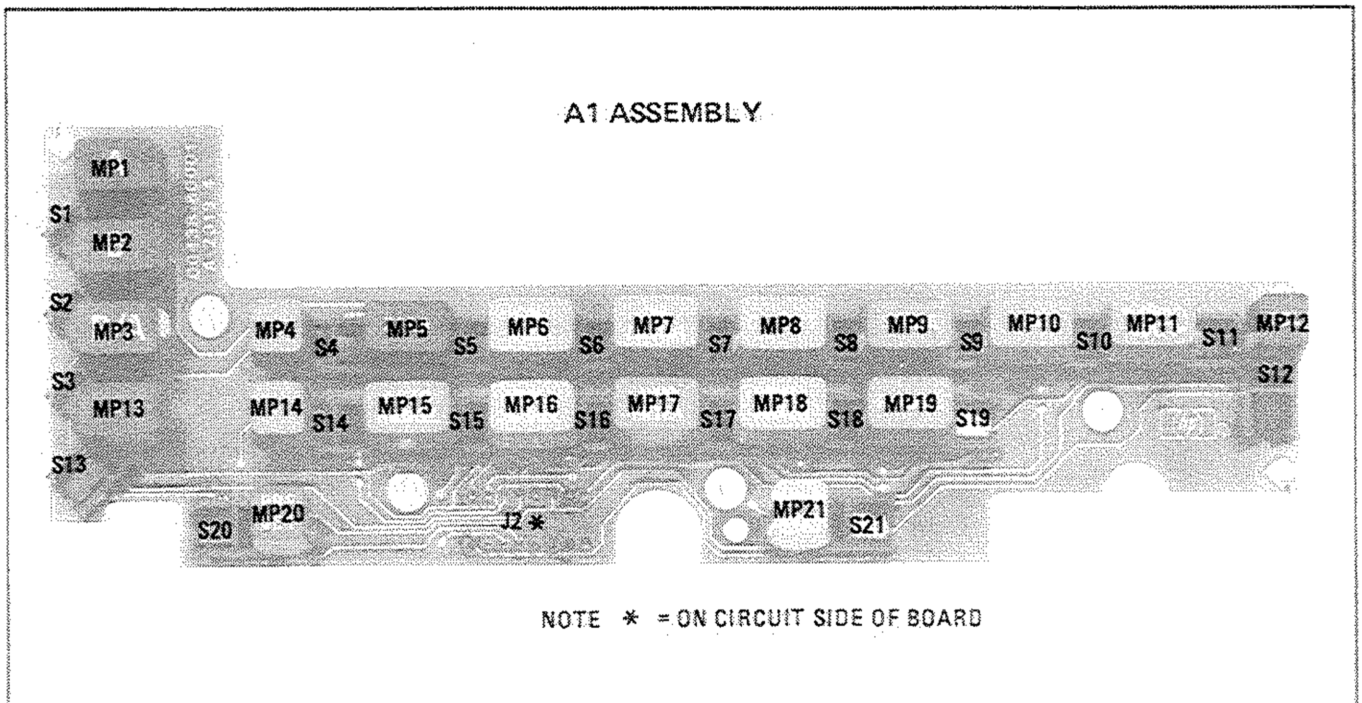
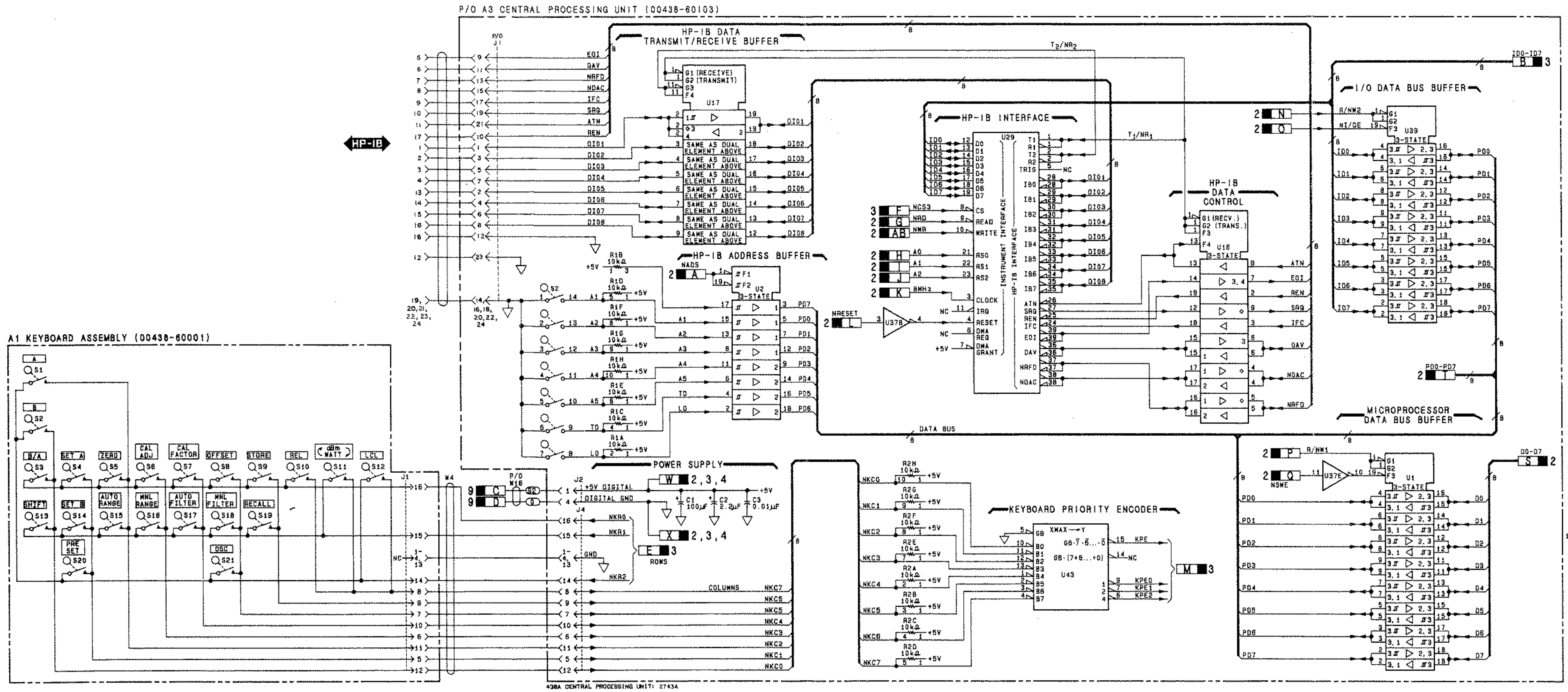


Figure 8-19. Keyboard Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

† BACKDATING INFORMATION IN SECTION 7.

REFERENCE DESIGNATIONS

NO PREFIX	A3
W4, 7, 16	C1-3 J1, 2, 4 R1, 2 U1, 2, 16, 17, 29, 37, 39, 43
A1	**A11**
J1 S1-21	J1, 2 S1

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

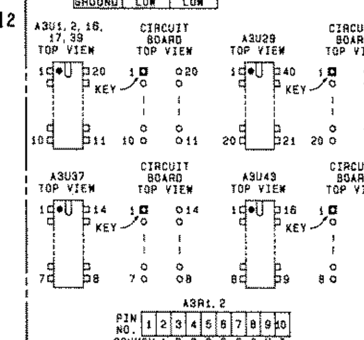
REFERENCE DESIGNATION	PART NUMBER
U1, 39	1820-2075
U2	1820-2024
U16	1820-3513
U17	1820-3431
U29	1820-2549
U37	1820-1199
U43	1820-1851

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U1, 2, 17, 39	+5V - 20 ▽ - 10
U16	+5V - 11, 20 ▽ - 10
U29	+5V - 40 ▽ - 20
U37	+5V - 14 ▽ - 7
U43	+5V - 16 ▽ - 8

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW



1

A1, A11, P/O A3

Figure 8-21. Data Input/Output Circuits Schematic Diagram
8-73/8-74

A3 ASSEMBLY

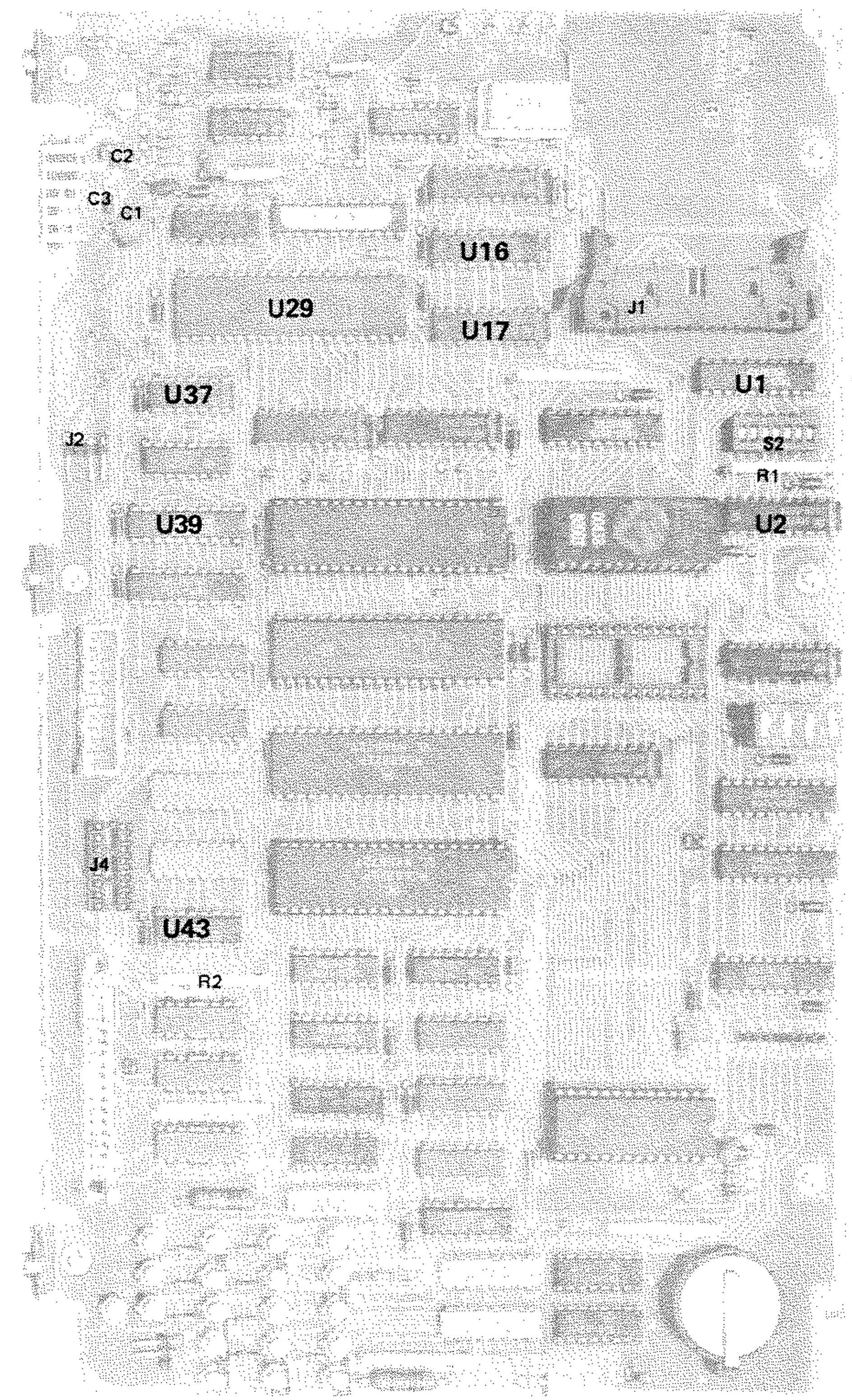
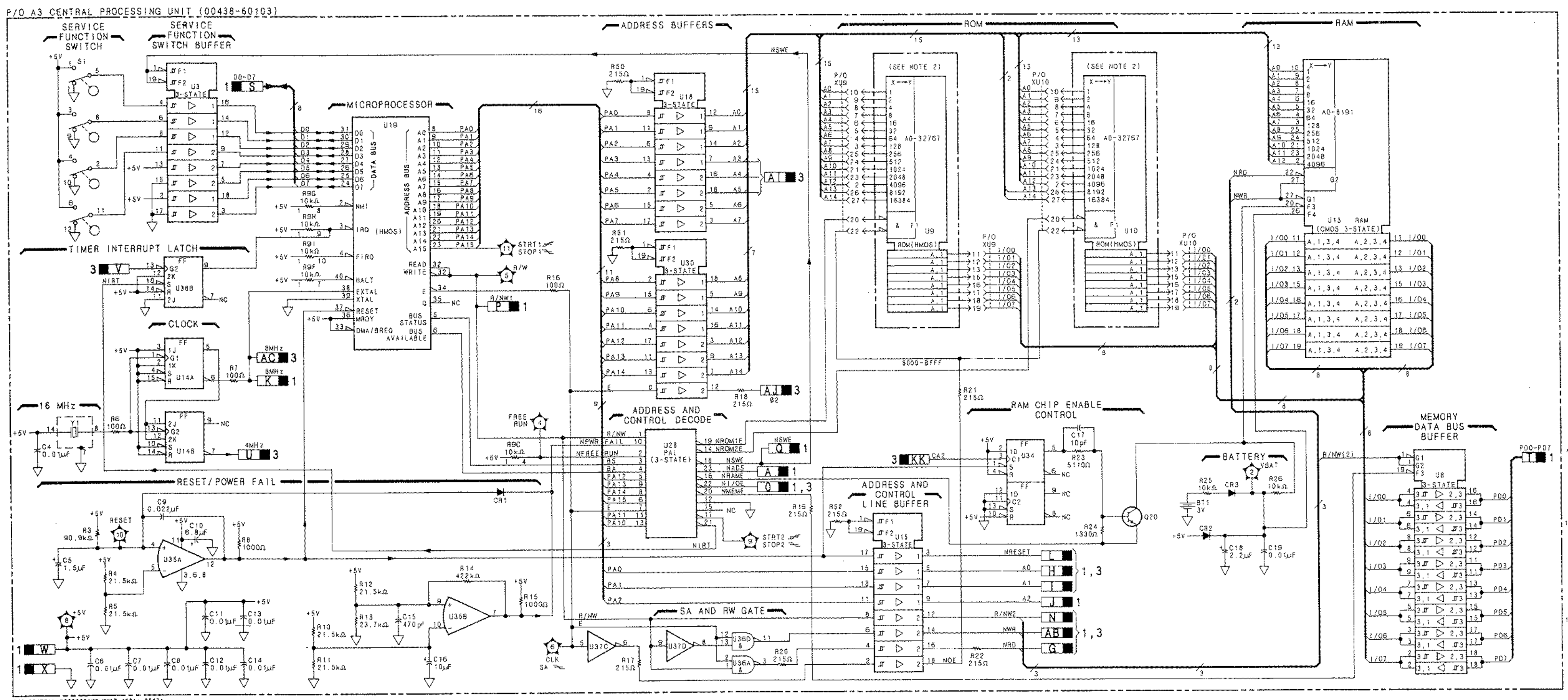


Figure 8-20. Central Processing Unit Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. U9 AND U10 ARE NOT PART OF THE A3 ASSEMBLY.

REFERENCE DESIGNATIONS

A3	A3 CONT.
BT1 C4-19 CR1-3 Q20 R3-26,50-52 S1	TP2,4-6,8-11 U3,8-10,14-15,18,28,30,34-38 Y1

LOGIC LEVELS

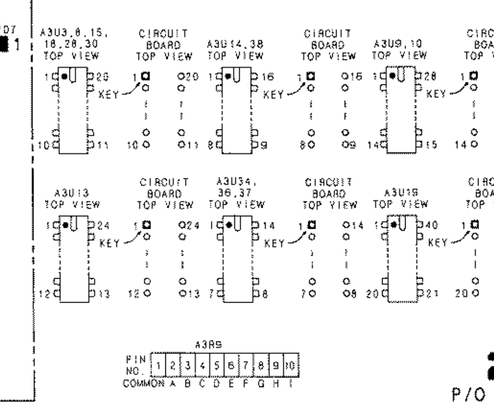
	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q20	1854-0477
U3,15,18,30	1820-2024
U8	1820-2075
U9	00438-80014
U10	00438-80015
U13	1818-3183
U14,38	1820-1212
U19	1820-2824
U28	00438-80013
U34	1820-1753
U35	1826-0175
U36	1820-1197
U37	1820-1199

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U3,8,15,18,28,30	+5V - 20 GND - 10
U14,38	+5V - 16 GND - 8
U9,10	+5V - 1,28 GND - 14
U13	+5V(F1)-28 GND - 14 NC - 1
U19	+5V - 7 GND - 1
U34,35,37	+5V - 14 GND - 7



2
P/O A3

Figure 8-23. Microprocessor and Memory Circuits Schematic Diagram
8-75/8-76

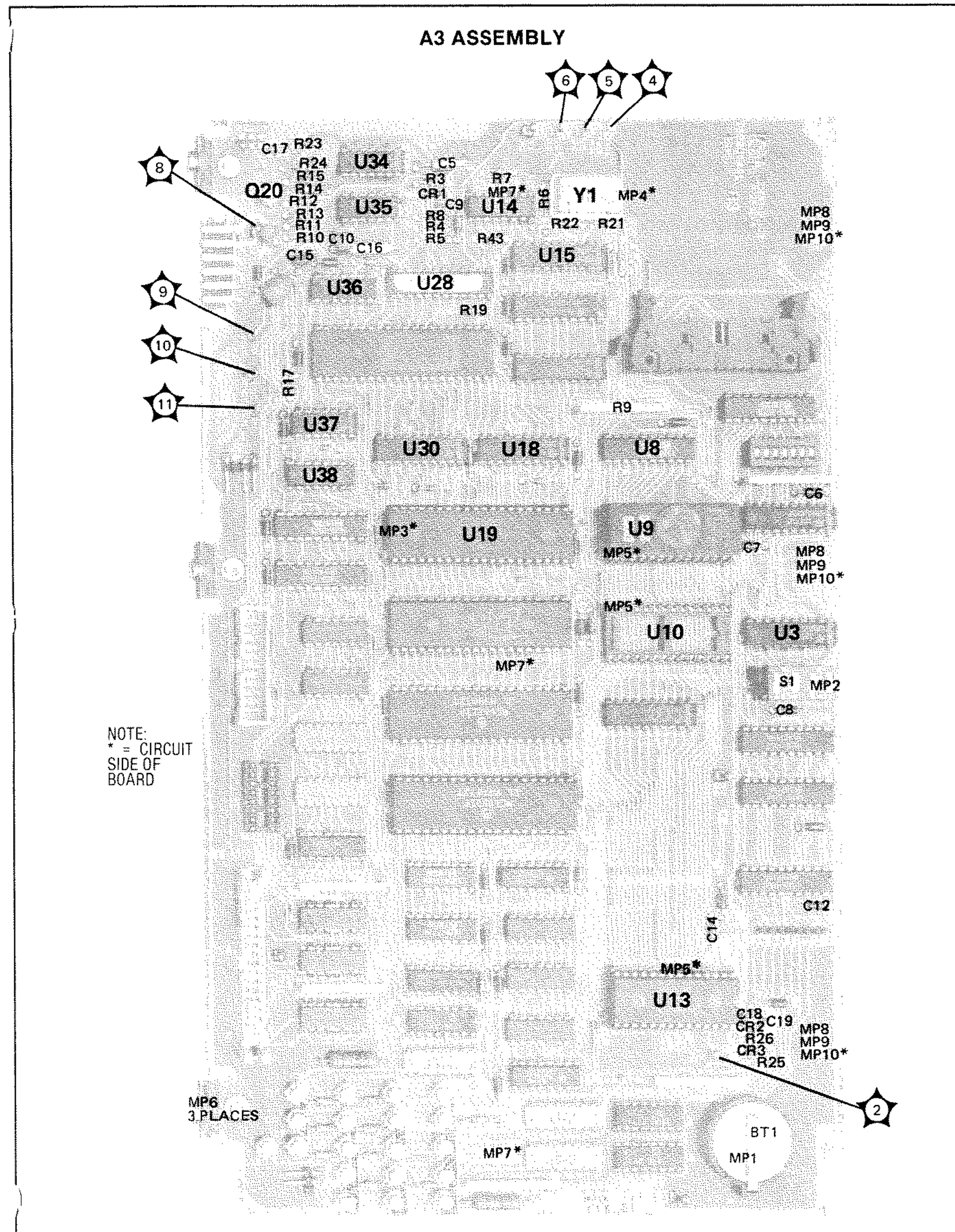
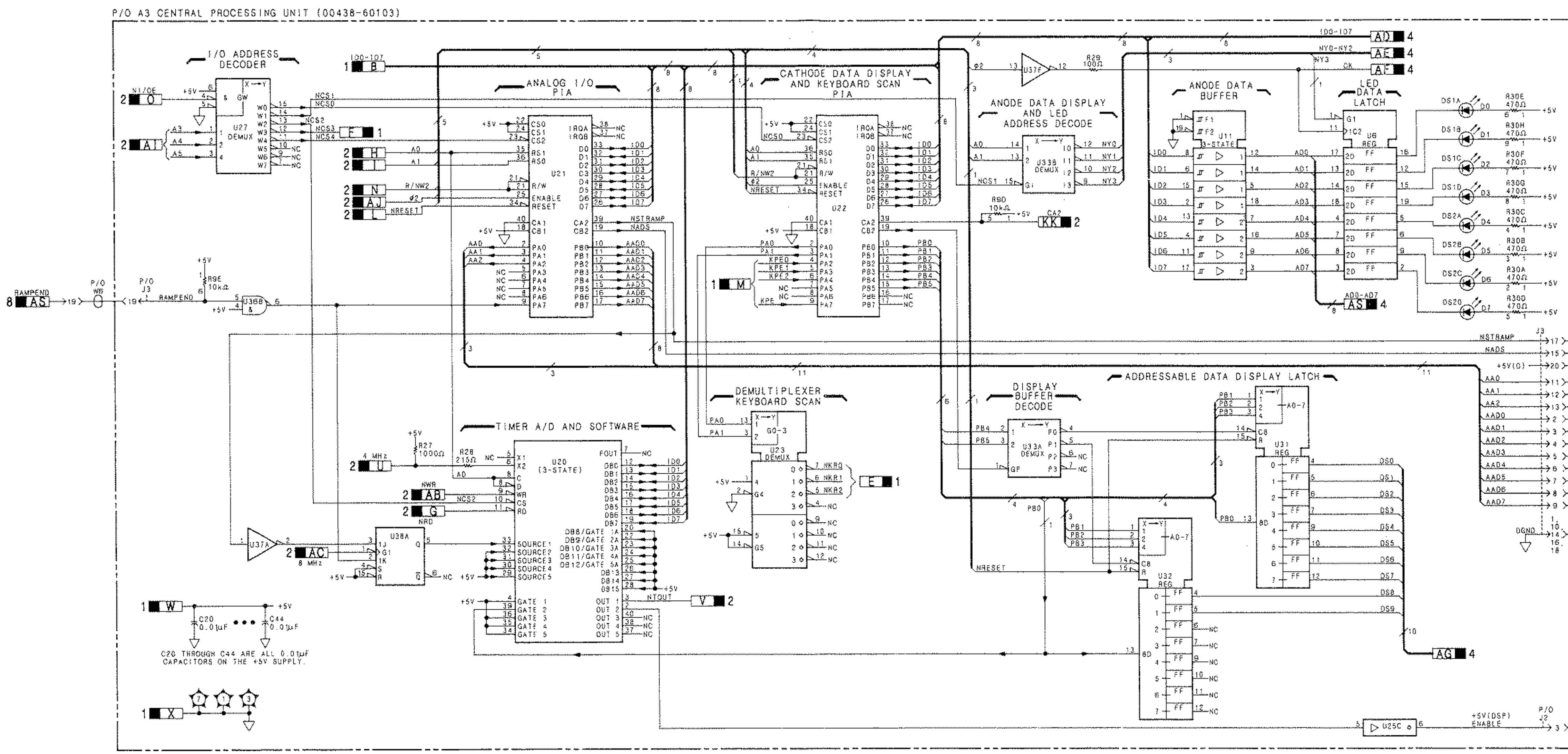


Figure 8-22. P/O Central Processing Unit Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

NO PREFIX	A3
W6,16	C20-44 DS1,2 J2,3 R12,18-20 TP1,3,7 U6,11,20-23,27,31-33,36-38

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
U6	1820-1858
U11	1820-2024
U20	1820-2705
U21,22	1820-2983
U23	1820-1427
U25	1820-0668
U27	1820-1216
U31,32	1820-1729
U33	1820-1281
U35	1820-1197
U37	1820-1199
U38	1820-1212

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U6,U11	+5V - 20 GND - 10
U20	+5V - 1 GND - 21
U21,22	+5V - 20 GND - 1
U23,27,31-33,38	+5V - 16 GND - 8
U25,35,37	+5V - 14 GND - 7

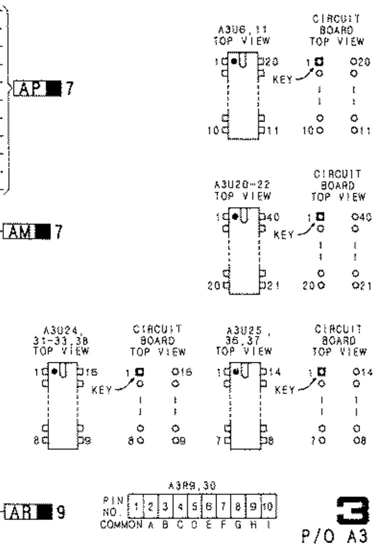


Figure 8-25. Timer and Peripheral Interface (PIA) Circuits Schematic Diagram
8-77/8-78

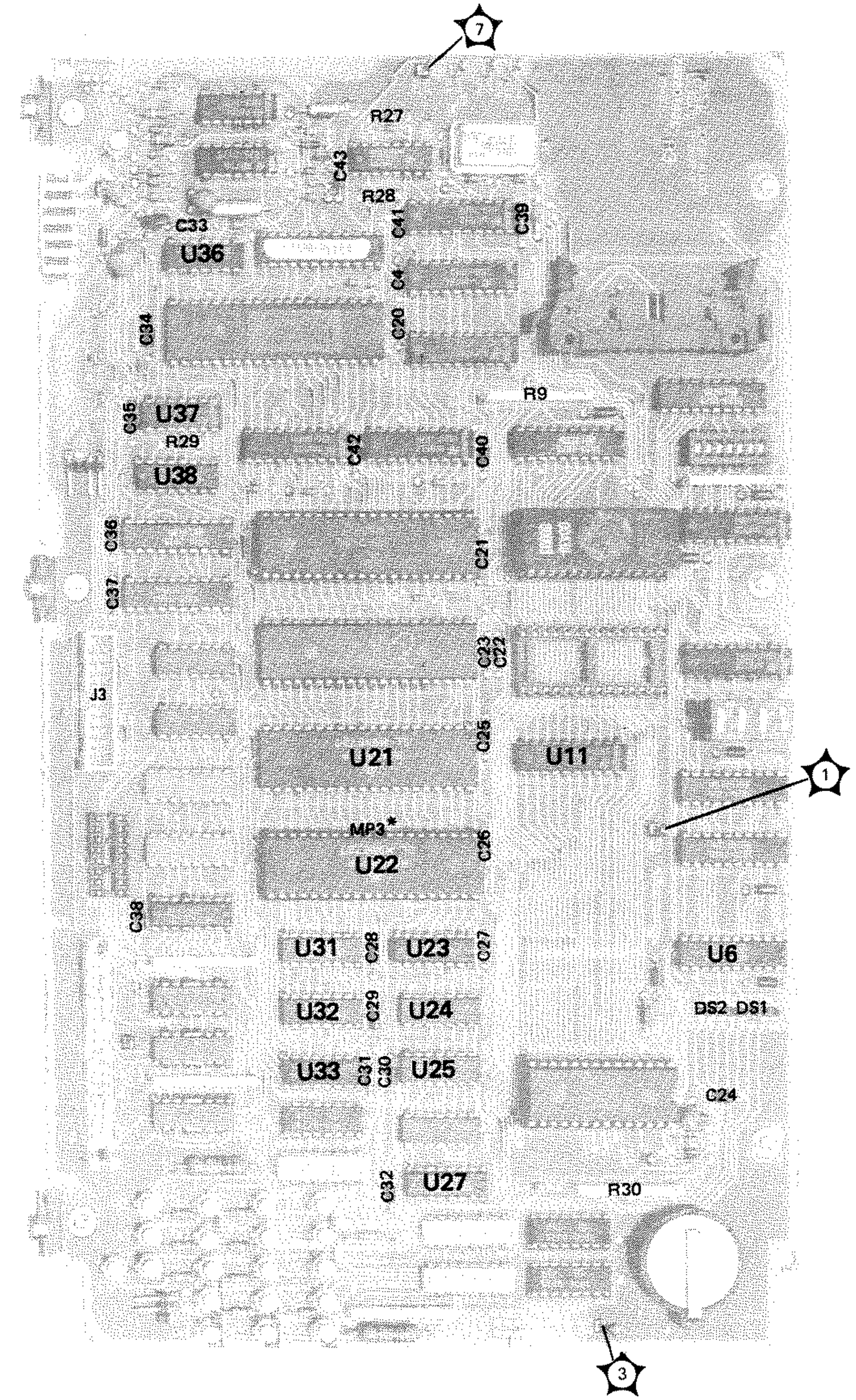
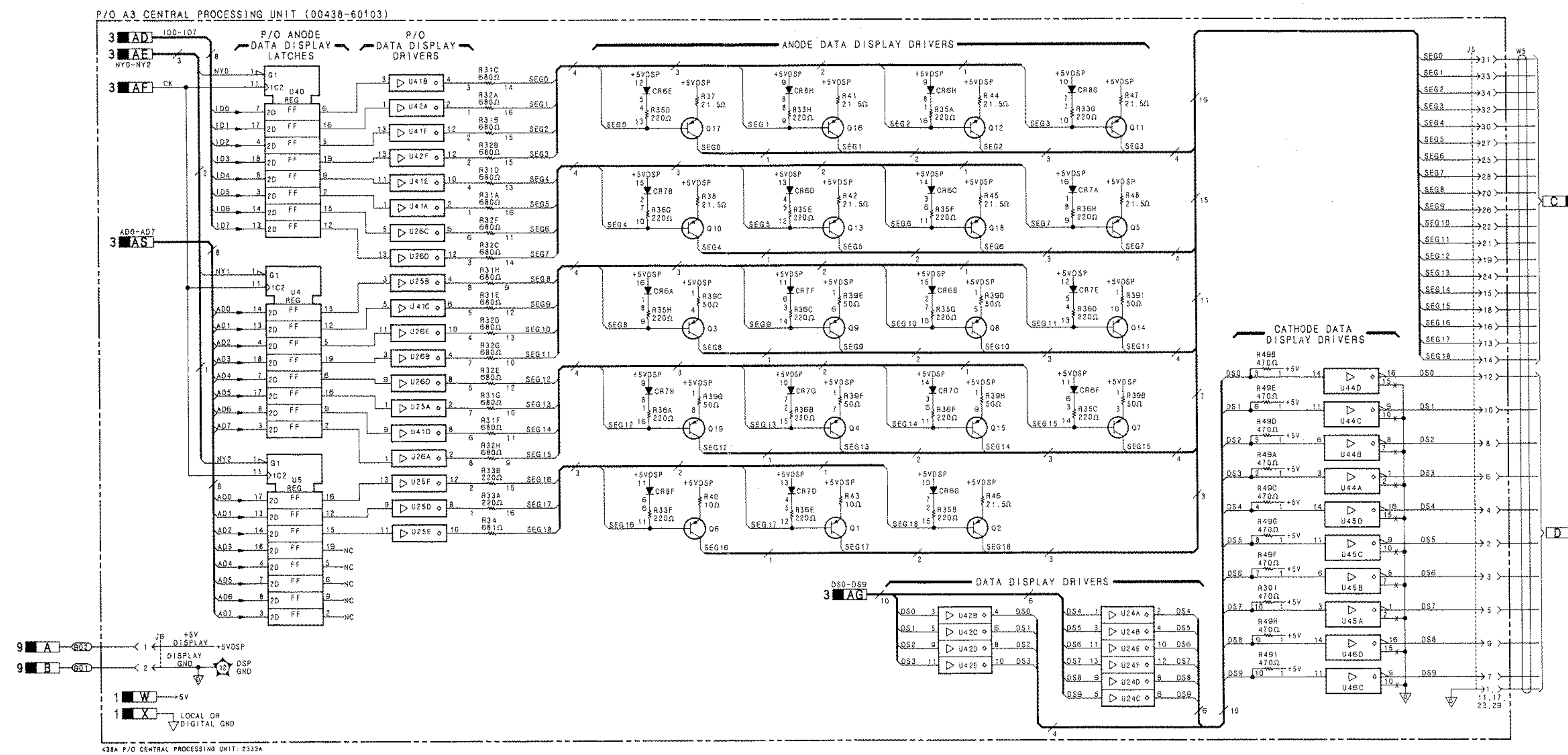


Figure 8-24. P/O Central Processing Unit Assembly Component Locations



NOTES
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

NO PREFIX	A3
W5	CR6-8 J5,6 Q1-19 R31-49 U4,5,24-26, 40-42,44-46

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

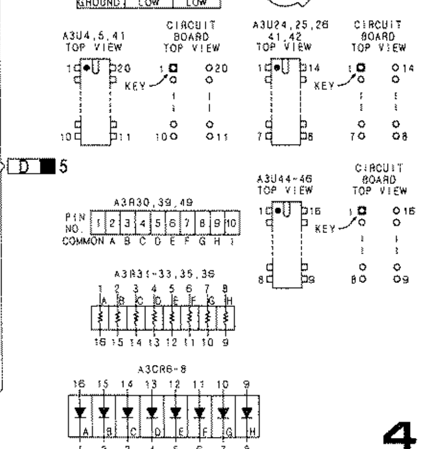
REFERENCE DESIGNATION	PART NUMBER
Q1-19	1853-0281
U4,5,40	1820-1858
U24,25,26, 41,42	1820-0668
U44-46	1820-2130

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U4,5,40	+5V - 20 GND - 10
U24,25,26, 41,42	+5V - 14 GND - 7

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW



4
P/O A3

Figure 8-27. Display Driver Circuits Schematic Diagram
8-79/8-80

A3 ASSEMBLY

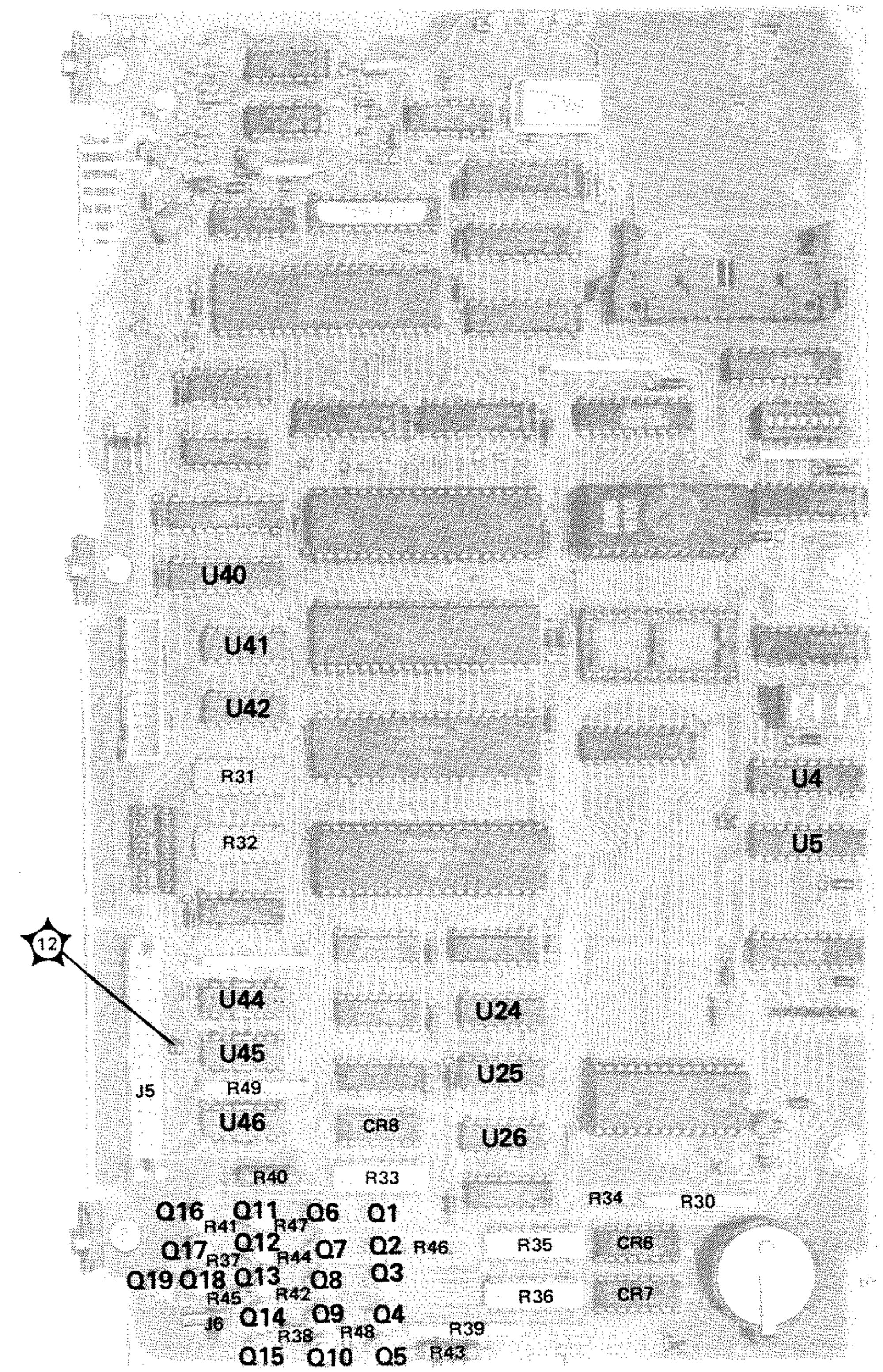


Figure 8-26. P/O Central Processing Unit Assembly Component Locations

Service Sheet 5 Display Assembly Troubleshooting

General

These procedures will isolate a problem to one of the following areas:

- Display LEDs
- Anode Data Display Drivers
- Cathode Data Display Drivers
- Data Display Drivers

Test Equipment

Oscilloscope .... HP 1725A

Fault Isolation Procedure

1. Turn the power meter OFF.
2. Set switch A3S1, on the A3 assembly, to 0101(LSB). The switch closest to the edge of the printed circuit board is the least significant bit (LSB). When the switches are set towards the front panel of the instrument, they are set to "1."
3. Turn the power meter ON.
4. A manual test of the front panel displays is now enabled. All front panel displays will be illuminated. Repeated pressing of the (A) key will light each LED segment and annunciator. Below is the normal indication as the (A) key is pressed:

   The front panel will be blank, then all segments of the large LEDs, all of the smaller number eights and all of the annunciators will light one at a time as the (A) key is pressed. Continue to press the (A) key until the sequence starts to repeat.

Note

If only one segment of a single seven-segment display is defective or only one LED of one LED bar display is defective, replace the appropriate display.

5. Once the defective segment, LED or display has been identified, trace the lines for the component in question back to Service Sheet 4.
6. Use the voltage levels in Table 8-31 and the procedure in step 7 to determine if the problem is with the Cathode Data Display Drivers or the Anode Data Display Drivers.

Note

The voltage levels for A3U25, A3U26, A3U41 and A3U42 are a TTL low (<0.8V) when the display is illuminated and >4.5 volts when the display is off.

Note (cont'd)

The voltage levels in Table 8-31 are valid only when the entire front panel is illuminated. When switch A3S1 is set to 1101 and the power meter is turned on, the entire front panel will be illuminated.

Table 8-31. Anode Data Display Drivers Voltage Levels

Integrated Circuit	Voltage Level (Vdc)
A3U25—2	<0.5
4	<0.5
8	<0.5
10	<0.5
12	<0.5
A3U26—2	<0.5
4	<0.5
6	<0.5
8	<0.5
10	<0.5
12	<0.5
A3U41—2	<0.5
4	<0.5
6	<0.5
8	<0.5
10	<0.5
12	<0.5
A3U42—2	<0.5
12	<0.5

If the voltage levels are correct, go to step 7.

If any of the levels are incorrect, check the input of the integrated circuit with the incorrect level.

If the inputs are correct, replace the appropriate integrated circuit.

If any of the inputs for lines SEG0 through SEG18 are incorrect, perform signature analysis troubleshooting on Service Sheet 1. If signature analysis does not reveal the problem, continue as follows:

- If the problem is with the inputs for lines SEG0 through SEG7, replace A3U40.
- If the problem is with the inputs for lines SEG8 through SEG18, replace A3U4, A3U5 or A3U11.

- Verify that a pulsed TTL signal can be seen at the following points:

A3U24—2 (DS0)	A3U42—4 (DS6)
4 (DS1)	6 (DS7)
6 (DS2)	8 (DS8)
8 (DS3)	10 (DS9)
10 (DS4)	
12 (DS5)	

  If any pin doesn't have a pulsed TTL signal, check the inputs for a pulsed TTL signal.

  If there is a pulsed signal on the input, replace the appropriate integrated circuit.

  If there isn't any pulsed signal, perform signature analysis troubleshooting on Service Sheet 1.

- After a problem has been isolated to the Cathode Data Display Drivers or the Anode Data Display Drivers, use the following examples as a guide to eliminating the Cathode Data Display Drivers or the Anode Data Display Drivers as the cause of a front panel display problem.

Example 1:

While observing the front panel it is discovered that display A2DS6 is not illuminated, but all the other displays are illuminated. This fact rules out the possibility that the segment lines are not operating properly.

Also, it is observed that line DS5 activates display A2DS6, the first seven-segment display in A2DS13 and the B/A and REL annunciators. Since the first seven-segment display in A2DS13 and the B/A and REL annunciators are illuminated, display A2DS6 must be defective.

Example 2:

While observing the front panel it is discovered that the "g" segment in all five seven-segment displays of A2DS12 and A2DS13 are not illuminated.

The "g" segment corresponds to the SEG15 line. Since the "g" segment in all of the displays is not illuminated, the problem must be with the Data Display Drivers (A3U26) or the Anode Data Display Drivers (A3Q7).

If the voltage at A3U26 pin 2 is low (<0.5V), replace A3Q7 or the associated components.

If the voltage at A3U26 pin 2 is high (>4.5V), check A3U26 pin 1 for a TTL low (<0.8V). If pin 1 is low, replace A3U26. If pin 1 is not low, go to Service Sheet 1 and begin troubleshooting using signature analysis. If signature analysis does not locate the problem, replace A3U4, A3U5 or A3U11.

Example 3:

While performing the Fault Isolation Procedure, it is observed that segments"d" and "e" of displays A2DS1 through A2DS8 come on at the same time. This would indicate that the SEG4 and SEG5 lines are shorted together.

Check the connections and traces for the SEG4 and SEG5 lines. If a short is not found, check the logic levels at A3U40 pins 2 and 9. If pins 2 and 9 are at different logic levels, replace A3U41. If pins 2 and 9 seem to be shorted (they are at the same logic level), go to Service Sheet 1 and perform signature analysis troubleshooting. If signature analysis is normal, replace A3U40.

When troubleshooting is complete, reset switch A3S1 to all ones.

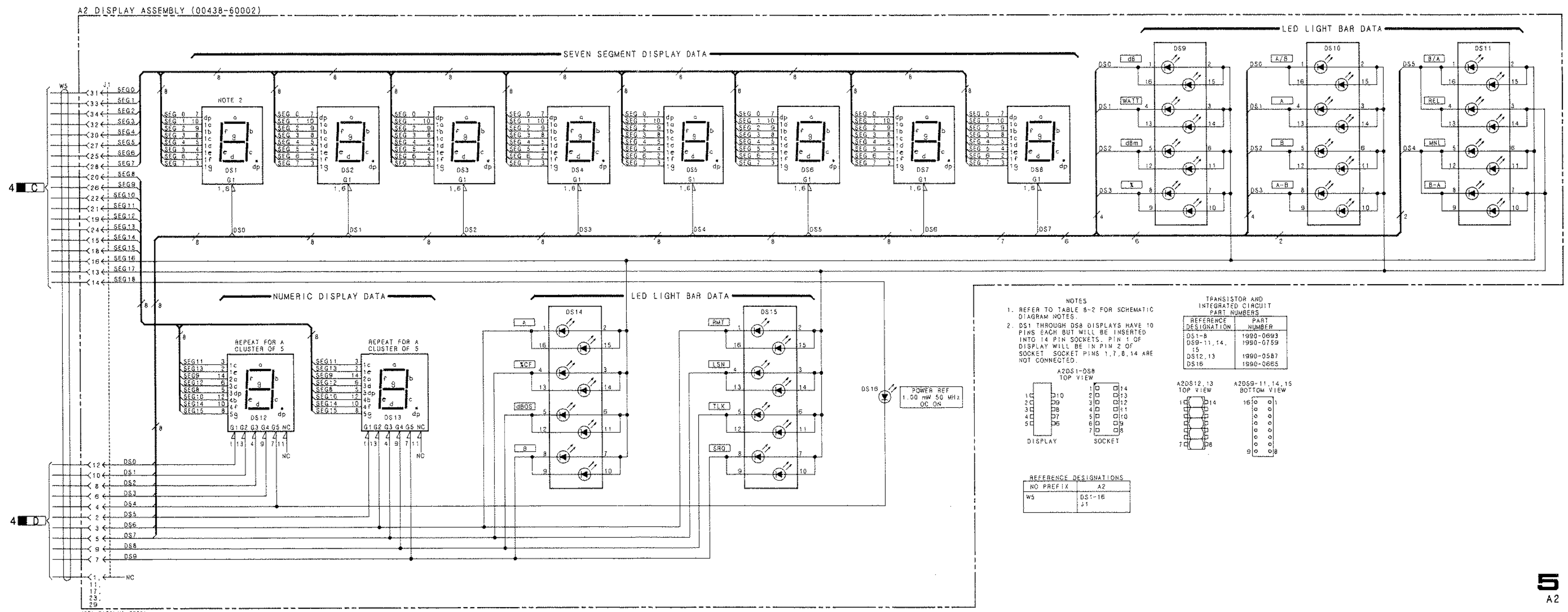
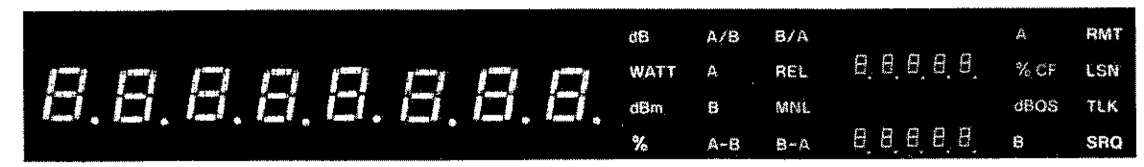
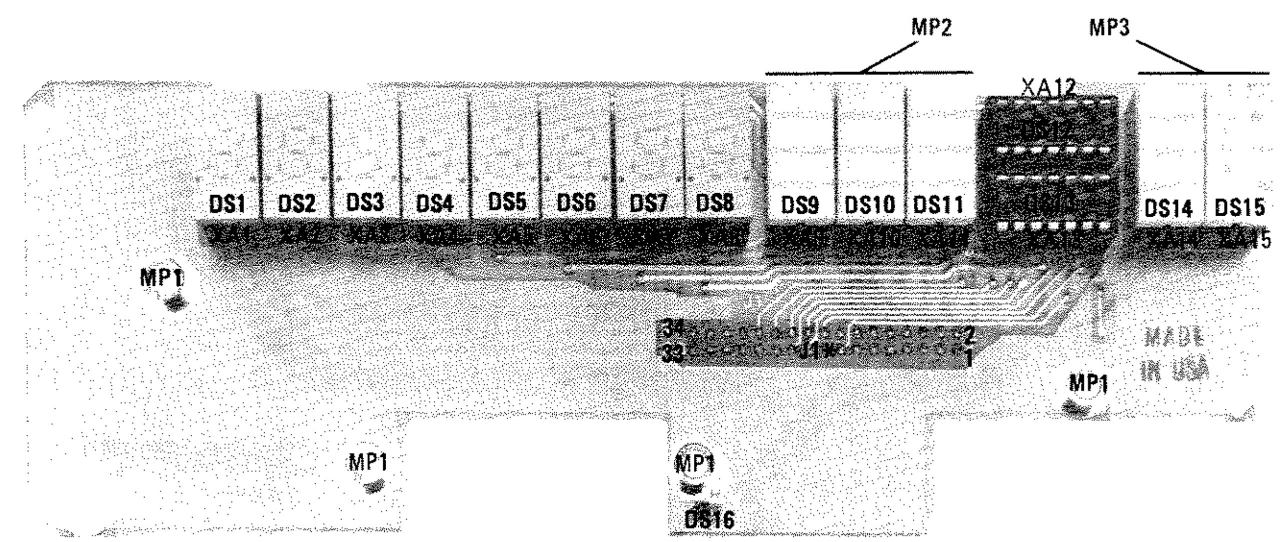


Figure 8-29. Front Panel Display Circuits Schematic Diagram



A2 ASSEMBLY



NOTE ∗ = ON CIRCUIT SIDE

Figure 8-28. Display Assembly Component Locations

Service Sheet 6 Input Amplifier Circuits Troubleshooting

General

The procedures for checking the Input Amplifier Circuits are given below. The Fault Isolation Procedure should be used if the problem has not been isolated to a particular circuit. If the problem is known to be in a particular circuit, go directly to the troubleshooting for that circuit. Whether performing the Fault Isolation Procedure or the troubleshooting for a particular circuit, always do the Power Supply Checks first.

Test Equipment

Oscilloscope ....HP 1725A
Voltmeter ....HP 3456A
Range Calibrator ....HP 11683A

Fault Isolation Procedure

Power Supply Checks.

1. Verify the voltages at the following test points.

   A4TP8 ....+15 Vdc ±0.75 Vdc
   A4TP10 ....−15 Vdc±0.75 Vdc

Note The +15 volt and −15 volt supplies should be within ±0.05 volts of each other but of opposite polarity.

If the measured voltages are not as shown, troubleshoot the circuits shown on Service Sheet 10.

Channel A and B Verification.

2. Connect the oscilloscope to A4U2 pin 10 and set the instruments as follows:

Power Meter	PRESET
Calibrator	Range — 100 mW Polarity — Normal Function — Calibrate
Oscilloscope	5 volts/div. 1 ms/div.

Connect the calibrator to channel A and compare the waveform on the oscilloscope with the one in Figure 8-30. Set the power meter to channel B; connect the calibrator to channel B and compare the waveform on the oscilloscope with waveform in Figure 8-30.

If both signals are good, the A4 assembly is operating properly.

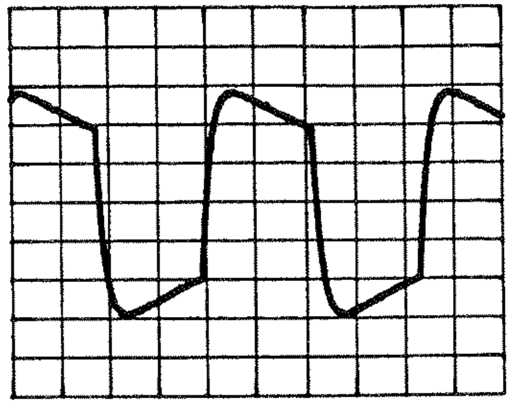


Figure 8-30. Selected Amplifier AC Signal

Note

If the power meter did not pass the Instrument Accuracy Performance Test and the Ranges 4 and 5 Shaper Adjustment for Channels A and B did not help to bring the instrument into tolerance, the components listed below could be causing the problem.

Channel A; Range 4	A4CR1, A4CR3, A4R24, A4R26
Channel A; Range 5	A4VR1, A4VR2, A4R28, A4R34
Channel B; Range 4	A4CR2, A4CR4, A4R25, A4R27
Channel B; Range 5	A4VR3, A4VR4, A4R29, A4R35

If only one channel is bad, perform the following tests in the order given:

a. Amplifier Test
b. Channel Selection Circuitry Test
c. 220 Hz Multivibrator Test

If both channels are bad, perform the following tests in the order given:

a. Decoupled Power Supply Test
b. 220 Hz Multivibrator Test
c. Channel Selection Circuitry Test
d. Amplifier Test

Amplifier Test

Note This test assumes channel A is bad. Use the test points shown in parentheses when troubleshooting channel B.

1. Verify the voltage at A4TP4 (A4TP2) is 0 volts. If the voltage is not 0 volts, replace A4U1 (A4U3).
2. Verify the following conditions are found at A4TP3 (A4TP1):

   AC ....12 Vp-p ±0.2 volts
   DC ....−0.9 Vdc ±0.2 volts
   Frequency ....220 Hz ±20 Hz

   If the signals are correct, continue with the Channel Selection Circuitry Test.

   If the signals are incorrect, check the following list of possible problems and causes:

   a. Voltage at A4TP3 (A4TP1) is approximately −12 Vdc.
      - Open cable between A4J5 (A4J7) and J2 (J3)
      - A4U1 (A4U3) is defective
      - Open in main feedback path — A4R20, A4R21 (A4R22, A4R23)
      - DC bias network bad — A4R8, A4R12, A4R14 (A4R9, A4R13, A4R15)
   b. Voltage at A4TP3 (A4TP1) is −0.9 Vdc, no AC:
      - Open cable between A4J8 (A4J9) and J2 (J3) (Power meter should indicate Error 31 (32).)
      - 220 Hz Oscillator or Buffers are defective. Perform 220 Hz Buffer Test
   c. The dc voltage at A4TP3 (A4TP1) is too high:
      - Shorted or leaky A4C9 (A4C10)
      - DC bias network defective — A4R8, A4R12, A4R14 (A4R9, A4R13, A4R15)
      - A4U1 (A4U3) is defective
   d. The dc voltage at A4TP3 (A4TP1) is too low:
      - Shorted or leaky A4C13 (A4C14)
      - DC bias network defective — A4R8, A4R12, A4R14 (A4R9, A4R13, A4R15)
      - A4U1 (A4U3) is defective.

220 Hz Buffer Test

Check for a signal (220 Hz, 10 Vp-p) at A4J8 pins 1, 3 and A4J9 pins 1, 3. If only one signal is bad, replace A4U5 and/or the associated resistors (A4R53–A4R56).

If more than one signal is bad, check for a signal (220 Hz, 10 Vp-p) at A4TP5 and A4TP6.

If either signal is bad, continue with the 220 Hz Multivibrator Test.

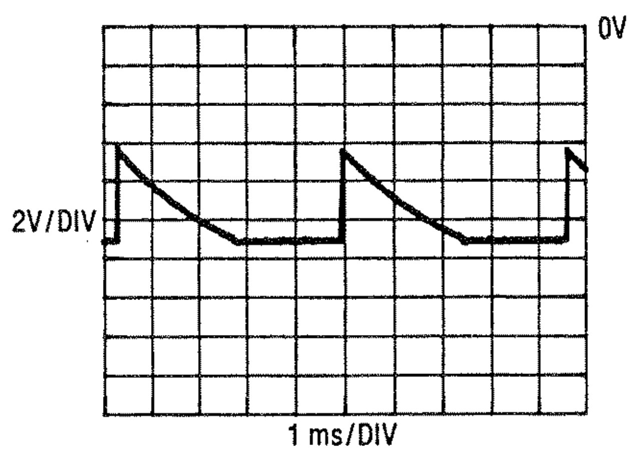
If the signals are both good, replace A4U5 and/or the associated resistor(s) (A4R53–A4R56).

220 Hz Multivibrator Test

Check A4TP5 and A4TP6 for a square wave of 220 Hz ±20 Hz and 10 Vp-p. If the signals are good, the Multivibrator is working normally.

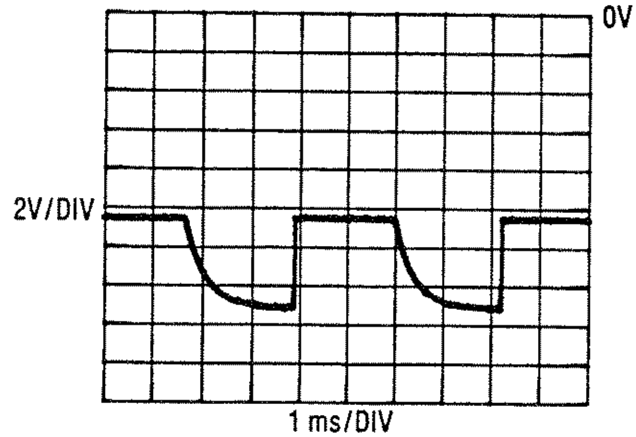
If only one of the signals is bad, then the problem is A4Q2 (if A4TP5 was bad) or A4Q3 (if A4TP6 was bad).

If both signals are bad, the problem is one of the transistors (A4Q1–A4Q5). Figure 8-31 shows signals and voltages which are present when the multivibrator is operating normally.

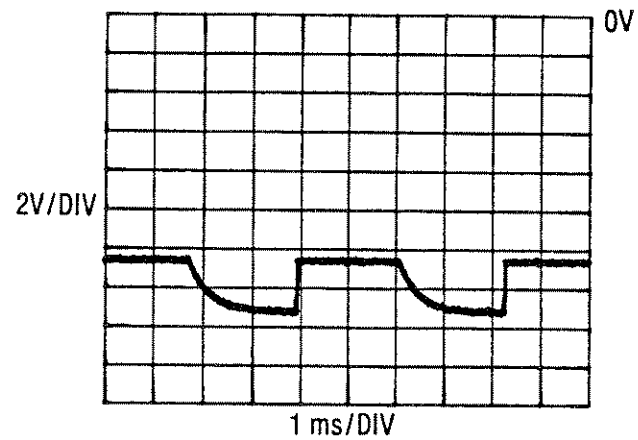


A4Q4 and A4Q5 Base Waveform

Figure 8-31. Multivibrator Waveforms



A4Q4 and A4Q5 Collector Waveform



A4Q2 and A4Q3 Base Waveform

Figure 8-31. Multivibrator Waveforms (continued)

Channel Selection Circuitry Test

Select channel A and verify the following:

A4U2	Pin 1 = Logical high (>2.0 volts)
	Pin 16 = Logical low (<0.8 volts)
A4U4	Pin 1 = Logical low (<0.8 volts)
	Pin 16 = Logical high (>2.0 volts)

Select channel B and verify the following:

A4U2	Pin 1 = Logical low (<0.8 volts)
	Pin 16 = Logical high (>2.0 volts)
A4U4	Pin 1 = Logical high (>2.0 volts)
	Pin 16 = Logical low (<0.8 volts)

If any level is incorrect, troubleshoot the Miscellaneous Buffer (A5U14) on Service Sheet 7.

If only one channel is bad, set the power meter to that channel. This procedure will assume that channel A is bad, but all of the steps will be applicable to channel B. Be sure to use the test points and values shown in parentheses when troubleshooting channel B.

With an oscilloscope, check to see that the signal at A4U2 (A4U4) pin 14 is equal to the signal at A4U2 (A4U4) pin 10 (±0.1 volts) and that the voltage at A4U2 (A4U4) pin 6 is equal to the voltage at A4U2 (A4U4) pin 7 (±0.1 volts).

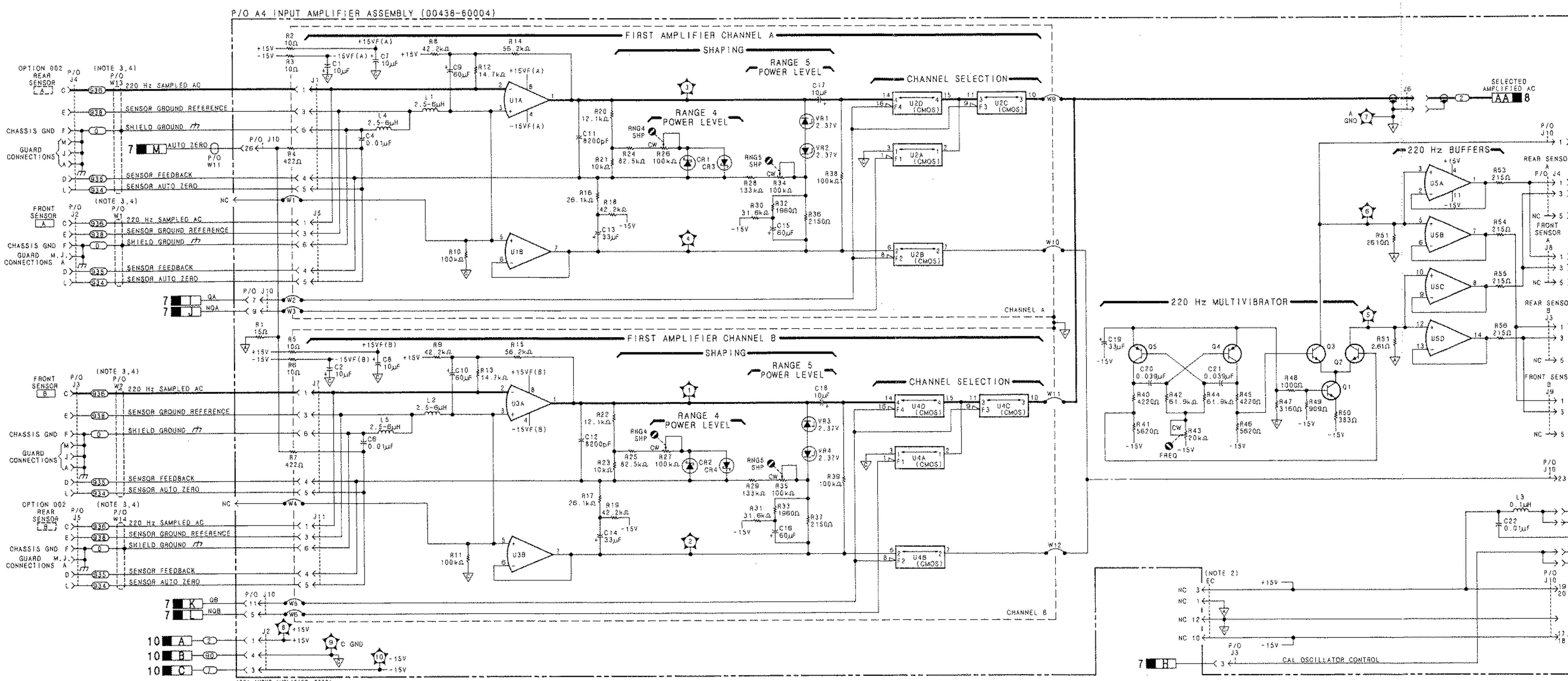
If either case is not true, replace A4U2 (A4U4).

If A4U2 (A4U4) pin 6 equals A4U2 (A4U4) pin 7 (±0.1 volts), but the voltage does not equal 0 volts (±0.05 volts), replace A4U1 (A4U3).

Decoupled Power Supply Test

Check for the proper voltages at the following points:

A4U1	Pin 8 > +14 Vdc — If the voltage is not correct, check A4R2, A4C7, A4U1 and A4U2. Pin 4 < −14 Vdc — If the voltage is not correct, check A4R3, A4C1, A4U1 and A4U2.
A4U3	Pin 8 > +14 Vdc — If the voltage is not correct, check A4R5, A4C8, A4U3 and A4U4. Pin 4 < −14 Vdc — If the voltage is not correct, check A4R6, A4C2, A4U3 and A4U4.



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. E.C. REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.
3. THE FOUR SENSOR RESISTOR LINES THAT ARE PART OF CABLES W1, W2, W13, AND W14 ARE SHOWN ON SERVICE SHEET 8.
4. CABLES W1 AND W14 HAVE A YELLOW COVERING. CABLES W2 AND W13 HAVE AN ORANGE COVERING.

REFERENCE DESIGNATIONS

NO PREFIX	A4 CONT.
J2-5 W1,2,11,13,14	L1-5 Q1-5 R1-56 TP1-10 U1-5 VR1-4 W1-6,9-12
A4	
C1-22 CR1-4 J1-11 W7,8 NOT ASSIGNED	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

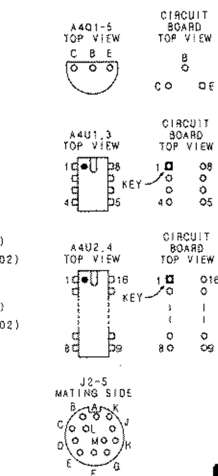
REFERENCE DESIGNATION	PART NUMBER
Q1-3	1854-0810
Q4,5	1853-0459
U1,3	1826-0547
U2,4	1826-1019
U5	1826-0600

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U2	+15VF(A) - 13 -15VF(A) - 4 C - 5
U4	+15VF(B) - 13 -15VF(B) - 4 C - 5

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW



6
P/O A4

Figure 8-33. Input Amplifier Circuits Schematic Diagram
8-93/8-94

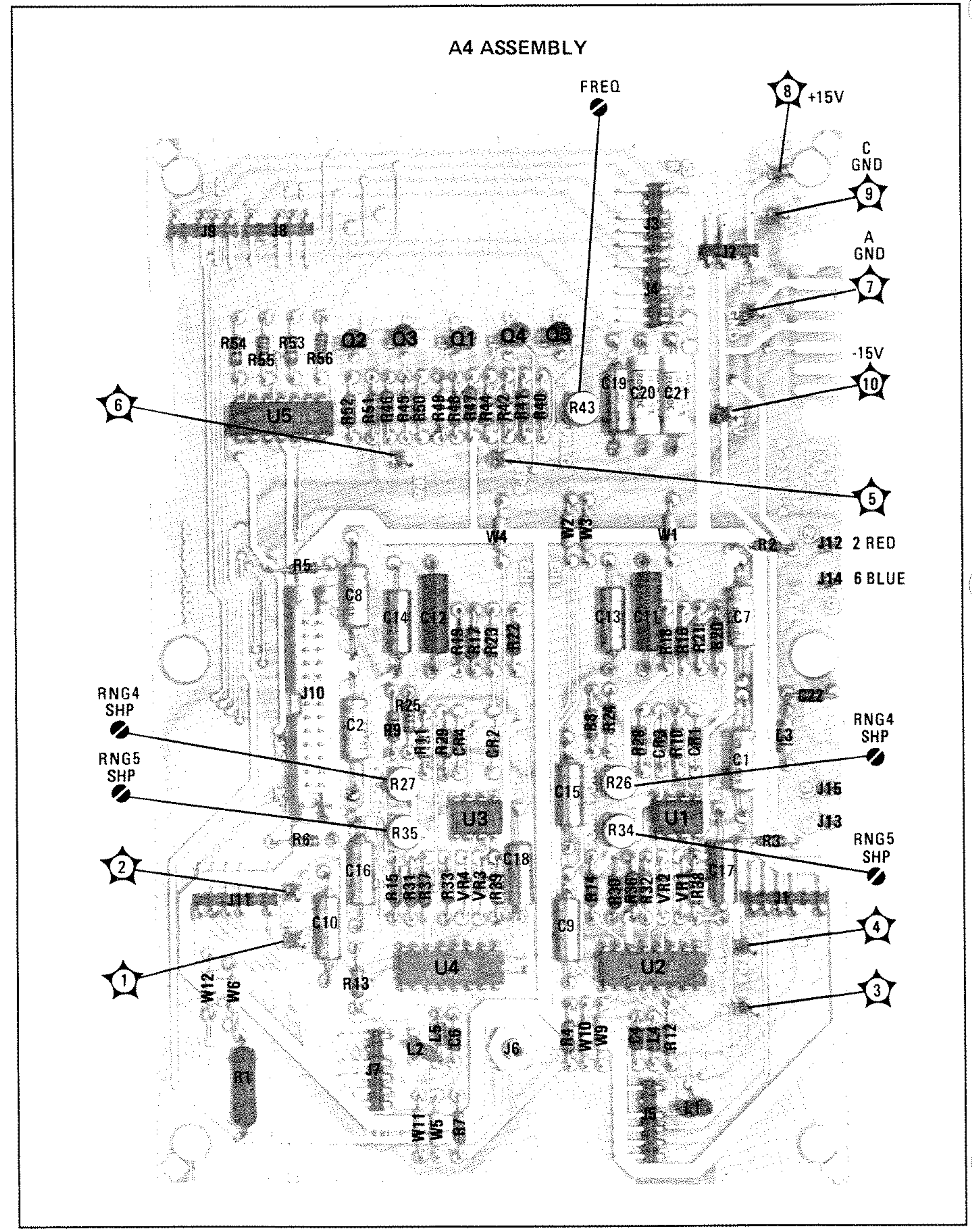


Figure 8-32. Input Amplifier Assembly Component Locations

Service Sheet 7 P/O Main Amplifier Assembly Troubleshooting

General

The following procedures will help to isolate a problem to one of the following circuits:

- Digital I/O
- Miscellaneous Buffer
- Cal Oscillator Control
- Auto Zero DAC and Buffer
- Stable Current Source
- Offset Removal DAC Buffer and Gain Compensation (A5U9)
- Gain DAC, Buffer and Gain Compensation (A5U2)

The Fault Isolation Procedure should be used if the problem has not been isolated to a particular circuit. If the problem is know to be in a particular circuit, go directly to the troubleshooting for that circuit. Whether performing the Fault Isolation Procedure or the troubleshooting for a particular circuit, always perform the Power Supply Checks and the Digital I/O Test first.

Test Equipment

Oscilloscope .... HP 1725A
Signature Analyzer .... HP 5005B
Range .... HP 11683A

Fault Isolation Procedure

Power Supply Checks.

1. Verify the following voltages are at the points indicated.

   A5TP6 .... +15 ±0.75 Vdc
   A5TP5 .... −15 ±0.75 Vdc
   A5TP3 .... +5 ±0.05 Vdc

Note

The +15 volt and −15 volt supplies should be within ±0.05 volts of each other but of opposite polarity.

If the measured voltages are not as shown above, troubleshoot the power supply circuits on Service Sheet 9 (+5 Vdc) or 10 (+15 Vdc and −15 Vdc).

Problem Isolation Using Signature Analysis.

1. Turn the power meter OFF.

2. On the A3 assembly, set A3S1 to signature analysis mode. A3S1 is the red switch assembly. When the switches are set towards the front panel of the power meter, they are set to "1". The switch closest to the edge of the printed circuit board is the least significant bit (LSB). To set signature analysis mode, set the switches as follows:

   0001(LSB)

3. Connect the signature analyzer pod to the A3 assembly as follows:

Signature Analyzer Pod	A3 Assembly
CLK	A3TP6
START/STOP	A3TP9
QUAL	A3U6 Pin 9
GND	A3TP7

4. Set the controls on the signature analyzer as follows:

   Clock .... \ (falling edge)
   Start ..../ (rising edge)
   Stop .... \ (falling edge)

5. Turn the power meter ON.

6. Verify the signatures for +5 volts and ground are as shown below:

		Rev. 5.0	Rev. 2.0
+5 volts	(A3TP8)	(9UCF)	(94CF)
Ground		(0000)	(0000)

   If the signatures are incorrect, go to Service Sheet 1 and begin troubleshooting using signature analysis.

7. Perform the following tests, in the sequence given, to determine the problem circuit.

   - Digital I/O Test
   - Auto Zero DAC and Buffer Test
   - Offset Removal DAC, Buffer and Gain Compensation Test
   - Gain DAC, Buffer and Gain Compensation Test
   - Miscellaneous Buffer Test
   - Cal Oscillator Control Test

8. Disconnect the signature analyzer and reset switch A3S1 to all ones.

Digital I/O Test

1. Perform steps 1 through 6 of the Fault Isolation Procedure.

2. Verify the signatures in Table 8-32.

Table 8-32. Digital I/O Signatures

Pin	Signal Name	Signatures			
		A5U18		A5U15	
		5.0	2.0	5.0	2.0
3	AD7	85PP	85PP		
5	AD6	H16U	H16U		
7	AD5	52AA	52AA		
9	AD4	66PF	66PF	UPP9	UPP9
10	—			C7A9	C7A9
11	—			1H76	1H76
12	—			1F44	1F44
12	AD3	F016	F016		
13	—			8A5C	8A5C
14	AD2	6414	6414		
16	AD1	1PHP	1PHP		
18	AD0	A1PQ	A1PQ		

If all signatures are correct, the Digital I/O circuits are operating properly. If the Fault Isolation Procedure is being performed and the Digital I/O circuits are operating properly, go to the Auto Zero DAC and Buffer Test.

If any signature is incorrect, verify the signatures in Table 8-33.

Table 8-33. Digital I/O Signatures

Pin	Signal Name	Signatures			
		A5U18		A5U15 Digital I/O	
		5.0	2.0	5.0	2.0
1	AA0			AC65	AC65
2	AA1			5554	5554
2	AAD0	A1P0	A1P0		
3	AA2			4P01	4P01
4	NADS			F229	F229
4	AAD1	1PHP	1PHP		
6	AAD2	6414	6414		
8	AAD3	F016	F016		
11	AAD4	66PF	66PF		
13	AAD5	52AA	52AA		
15	AAD6	H16U	H16U		
17	AAD7	85PP	85PP		

If all signatures are correct, replace the integrated circuit (A5U15 or A5U18) that was associated with the incorrect signatures from Table 8-32.

If any of the signatures are incorrect, continue with the troubleshooting for Service Sheet 3.

3. If troubleshooting is complete, disconnect the signature analyzer and reset switch A3S1 to all ones.

Auto Zero DAC and Buffer Test

1. Using the oscilloscope, compare the waveform at A5U10 pin 4 to the waveform shown in Figure 8-34.

   If the displayed waveform is the same as Figure 8-34, the circuit is operating properly. If the Fault Isolation Procedure is being performed and the circuit is operating properly, go to the Offset Removal DAC, Buffer and Gain Compensation Test.

   If the displayed waveform is not the same as Figure 8-34, measure the voltage at the collector of A5Q1. The measured voltage should be +6.2 ±0.4 Vdc. If the measured voltage is not as stated, continue with the Stable Current Source Test. If the measured voltage is correct, go to step 2.

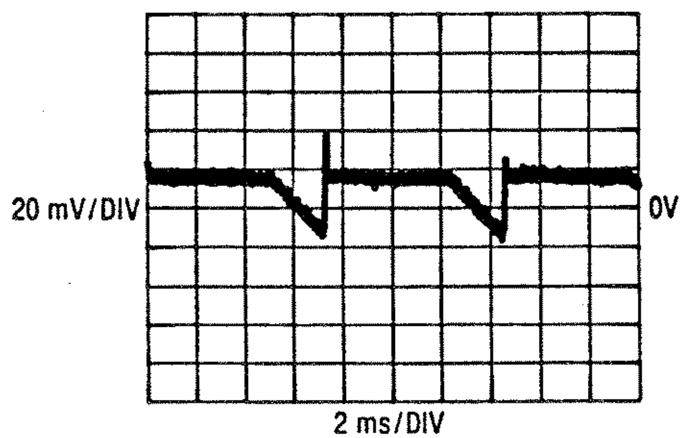


Figure 8-34. Auto Zero DAC Test Signal

2. Performs steps 1 through 6 of the Fault Isolation Procedure.
3. Verify the signatures in Table 8-34.

Table 8-34. Zero BAC Buffer Signatures

Pin	A5U11 Signatures	
	5.0	2.0
2	8879	8879
5	AP47	AP47
6	P982	P982
9	4621	4621
12	U9U2	U9U2
15	2UPU	2UPU
16	1633	1633
19	7HCC	7HCC

If any signature is incorrect, replace A5U11. If all signatures are correct, replace A5U10.

4. If troubleshooting is complete, disconnect the signature analyzer and reset A3S1 to all ones.

Offset removal DAC, Buffer and Gain Compensation Test

1. Connect the oscilloscope to A5U3 pin 15.
2. Compare the oscilloscope display with Figure 8-35.

Note

The dc voltage of the waveform is set by the voltage at the SUMMING POINT between A5R15 and A5R71. This waveform was taken with 3.4 Vdc at the SUMMING POINT. A voltage other than 3.6 ±0.6 Vdc may indicate a problem on Service Sheet 8.

If the displayed waveform is the same as Figure 8-35, the circuit is operating properly. If the Fault Isolation Procedure is being performed and the circuit is operating properly, go to the Gain DAC, Buffer and Gain Compensation Test.

If the displayed waveform is not the same as Figure 8-35, compare the waveform at A5U5 pin 4 with the waveform in Figure 8-36.

If the waveform at A5U5 pin 4 is correct, replace A5U9 and/or A5R15, A5R71, A5R17 and A5R16.

If the waveform at A5U5 pin 4 is incorrect, go to step 3.

3. Perform steps 1 through 6 of the Fault Isolation Procedure.
4. Verify the signatures in Table 8-35.

Table 8-35. Offset DAC Buffer Signatures

Pin	A5U6 Signatures	
	5.0	2.0
2	84H9	84H9
5	CCA6	CCA6
6	CC0F	CC0F
9	H024	H024
12	F3AP	F3AP
15	A101	A101
16	54F7	54F7
19	1A93	1A93

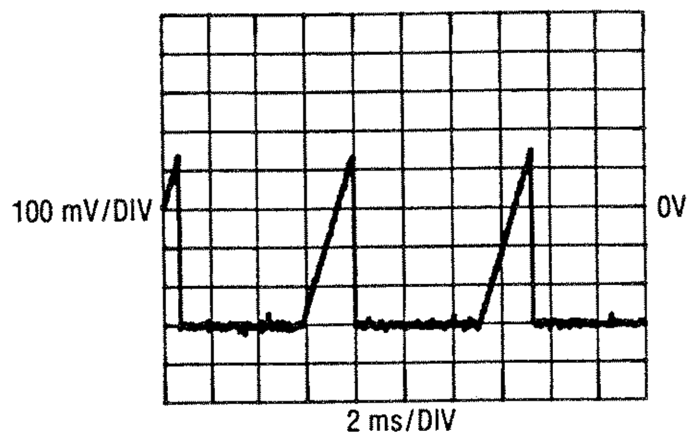


Figure 8-35.
Offset Removal DAC Test Signal (After Gain Compensation)

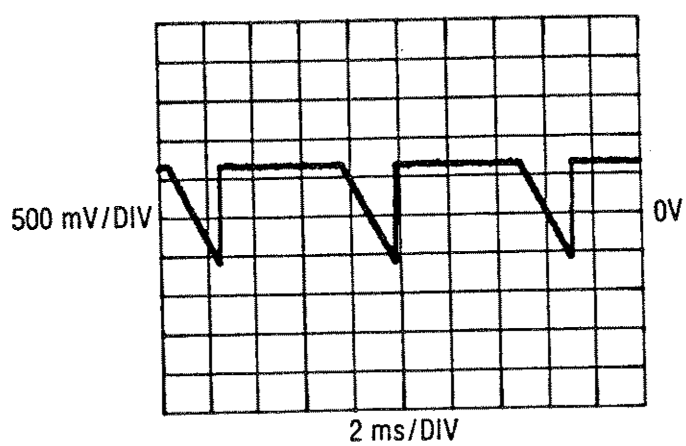


Figure 8-36.
Offset Removal DAC Test Signal (Before Gain Compensation)

If any signature is incorrect, replace A5U6. If all signatures are correct, measure the voltage on the collector of A5Q1. If the measured voltage is +6.2 ±0.4 Vdc, replace A5U5. If the measured voltage is not +6.2 ±0.4 Vdc, perform the Stable Current Source Test.

5. If troubleshooting is complete, disconnect the signature analyzer and reset switch A3S1 to all ones.

Gain DAC, Buffer and Gain Compensation Test

1. Connect an oscilloscope to the RECORDER OUTPUT on the rear panel of the power meter.
2. Compare the waveform on the oscilloscope with the waveform in Figure 8-37.
3. If the displayed waveform is the same as Figure 8-37, the Gain DAC, Buffer and Gain Compensation circuits are operating properly. If the Fault Isolation Procedure is being performed and the circuits are operating properly, go to the Miscellaneous Buffer Test.
4. If the displayed waveform is not the same as Figure 8-37, connect the oscilloscope to A5U3 pin 15 and compare and display to Figure 8-35.

   If the displayed waveform is not the same as Figure 8-35, perform the Offset Removal DAC, Buffer and Gain Compensation Test.

   If the displayed waveform is the same as Figure 8-35, go to step 5.

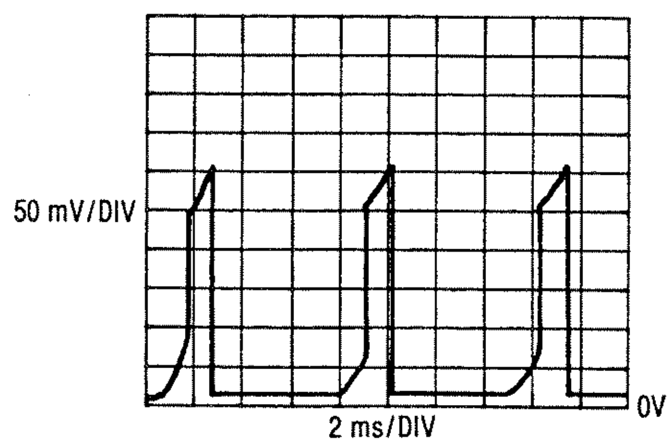


Figure 8-37. Recorder Output Test Signal

5. Perform steps 1 through 6 of the Fault Isolation Procedure.
6. Verify the signatures in Table 8-36.

Table 8-36. Gain DAC Buffer Signatures

Pin	A5U4 Signatures	
	5.0	2.0
2	C14F	C14F
5	PHA5	PHA5
6	FF41	FF41
9	P02C	P02C
12	9H98	9H98
15	PF57	PF57
16	18U2	18U2
19	6152	6152

If any signatures are incorrect, replace A5U4. If all the signatures and the waveform at A5U3 pin 15 are correct, replace A5U3 and A5U2.

7. If troubleshooting is complete, disconnect the signature analyzer and reset switch A3S1 to all ones.

Miscellaneous Buffer Test

1. Perform steps 1 through 6 of the Fault Isolation Procedure.
2. Connect the QUAL line from the Signature Analyzer Timing Pod to A3U6 Pin 2 and verify the signatures in Table 8-37.

   If all signatures are correct, the circuit is operating properly. If the Fault Isolation Procedure is being performed and the circuit is operating properly, go to the Cal Oscillator Control Test.

   If any of the signatures are incorrect, replace the integrated circuit associated with the bad signature(s).

Stable Current Source

Verify that the voltage, at the base of A5Q1, is 3.6 ±0.4 Vdc less than the +15 volt supply. If the measured voltage is not as stated, replace A5VR2 or A5R6.

Verify that the voltage, at the collector of A5Q1, is 6.2 ±0.4 Vdc. If the measured voltage is not as stated, replace A5Q1 and A5VR3. If the measured voltage is as stated, A5Q1 is operating properly.

Verify that the voltage, at the collector of A5Q2, is 6.2 ±0.4 Vdc. If the measured voltage is not as stated, replace A5Q2 and A5VR1. If the measured voltage is as stated, A5Q2 is operating properly.

Cal Oscillator Control Test

Monitor the voltage at the collector of A5Q5. With the oscillator turned on, the voltage should be within 0.2 volts of the −15 volt supply. With the oscillator off, the voltage should be >0 volts. If either voltage is incorrect, replace A5Q4 or A5Q5.

Table 8-37. Miscellaneous Buffer Signatures

Pin	Signatures			
	A5U14		A5U13	
	5.0	2.0	5.0	2.0
2	CU76	CU76	—	—
5	H87F	H87F	—	—
6	U263	U263	20FA	20FA
9	8F8P	8F8P	—	—
10	—	—	A7F0	A7F0
12	3874	3874	—	—
15	U5PU	U5PU	—	—
16	CP0U	CP0U	—	—
19	3H1U	3H1U	—	—

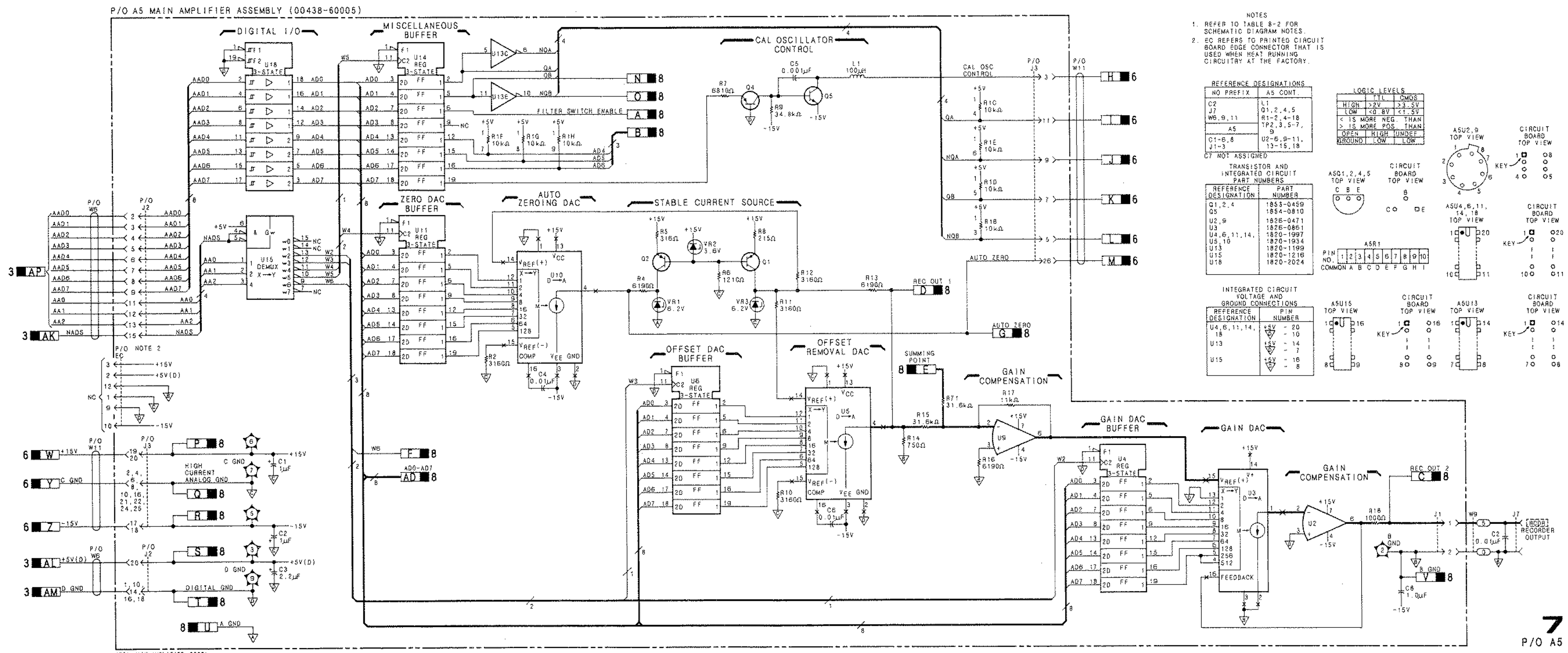


Figure 8-39. P/O Main Amplifier Circuits Schematic Diagram
8-105/8-106

A5 ASSEMBLY

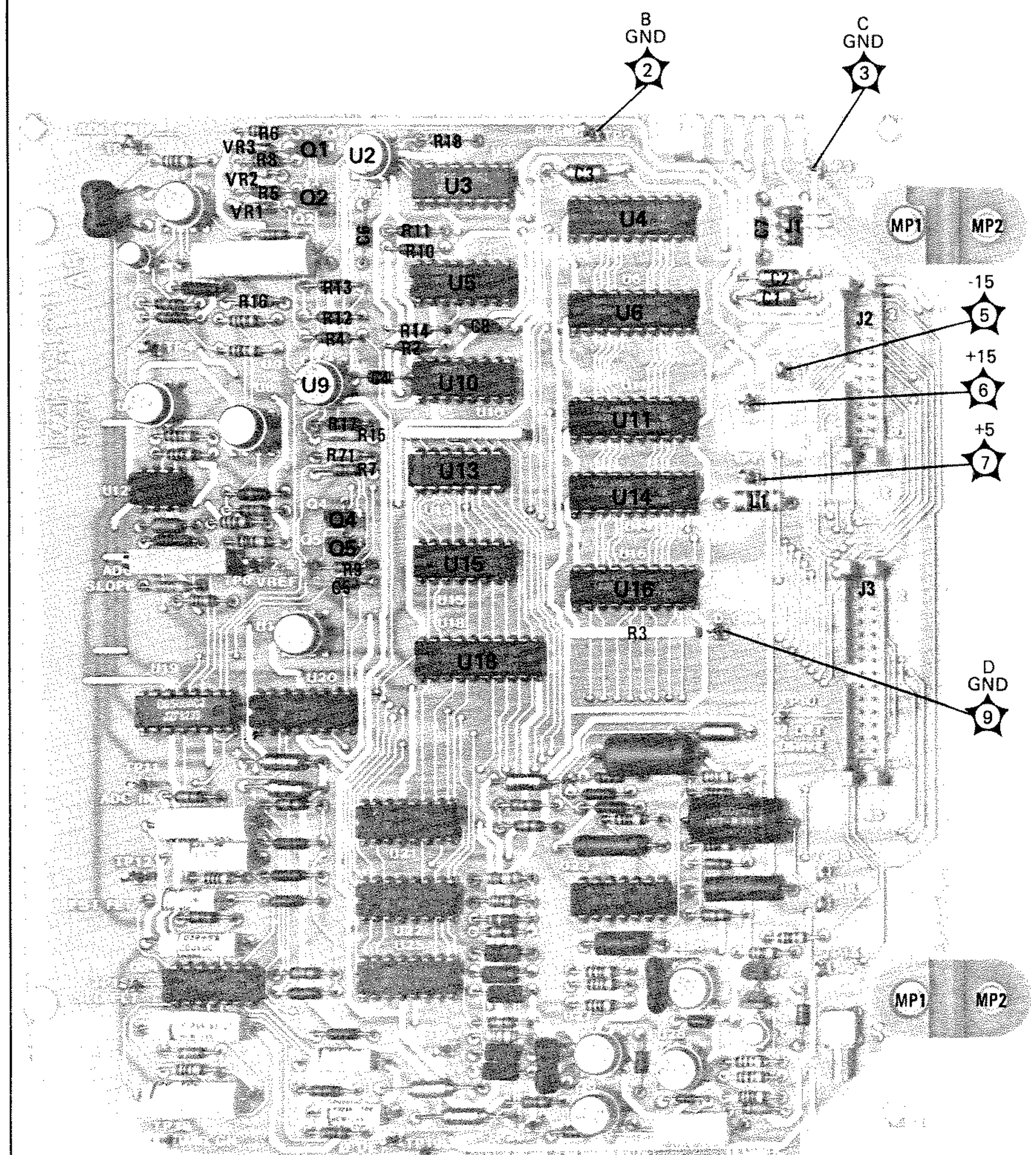


Figure 8-38. P/O Main Amplifier Assembly Component Locations

Service Sheet 8 P/O Main Amplifier Assembly Troubleshooting

General

The following procedures will help to isolate a a problem to one of the following circuits:

- Range Attenuators
- Variable Gain Amplifier
- Gain/Attenuator Buffer
- AC Gain Stage
- Synchronous Phase Detector
- Low Pass Filter
- Sensor Resistor Selection
- Analog/Digital Input Multiplexer
- Reference
- Ramp Start Gate
- Ramp Generator
- Comparator

Test Equipment

Oscilloscope	HP 1725A
Digital Voltmeter	HP 3456A
Signature Analyzer	HP 5005B
Range Calibrator	HP 11683A

Fault Isolation Procedure

1. Set up the equipment as follows:

Power Meter	PRESET
Calibrator	Range —1 mW Function — Calibrate Polarity — Normal

2. Connect the calibrator to channel A. Select MNL Filter 2. If A5U13 pin 3 is not a TTL high (>2.0V), continue troubleshooting on Service Sheet 7. Verify that A5U13 pin 4 is the complement of A5U13 pin 3. If pin 4 is not the complement of pin 3, replace A5U13.
3. Select MNL Filter 3. If A5U13 pin 3 is not a TTL Low (<0.8V), continue troubleshooting on Service Sheet 7. Press (AUTO FILTER).
4. Connect an oscilloscope to A5TP4 (Comp out) and compare the displayed waveform with Figure 8-40.

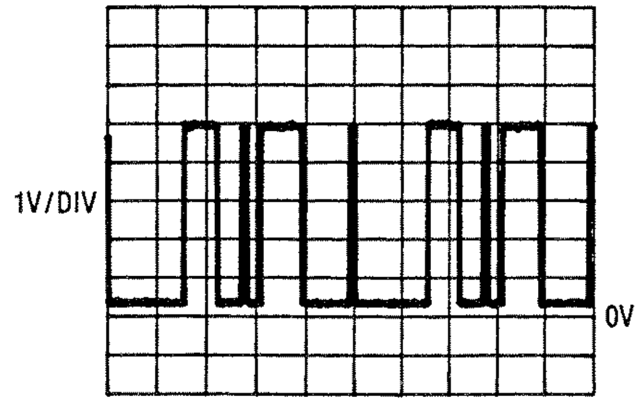


Figure 8-40. Ramp End Waveform

If the waveform is correct, the circuits on Service Sheet 8 are operating normally. If Performance Test 4-9 (Instrument Accuracy Test) indicates that there is a range to range accuracy problem, perform the Range Attenuator Tests. If the signal at A5TP4 is not correct, perform the following tests in the order given:

1. Compare the waveform at A5TP1 with Figure 8-41. If it is incorrect, perform the Reference, Ramp Start Gate and Ramp Generator Tests. If the waveform is normal, continue with step 2.

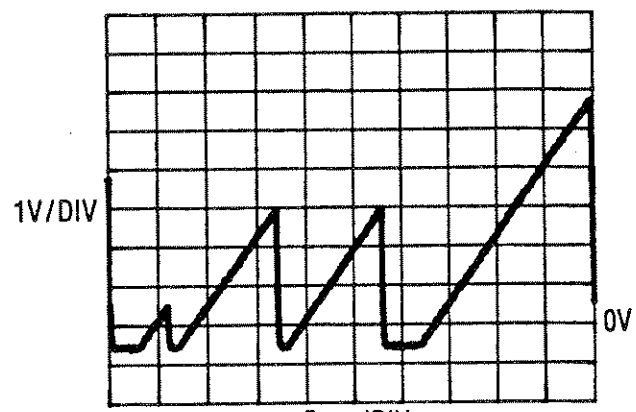


Figure 8-41. Analog to Digital Converter Ramp Waveform

2. Compare the waveform at A5TP18 with Figure 8-42. If the waveform is incorrect, perform the Range Attenuator (÷1, ÷100) and Variable Gain Amplifier Tests. If the waveform is normal, continue with step 3.

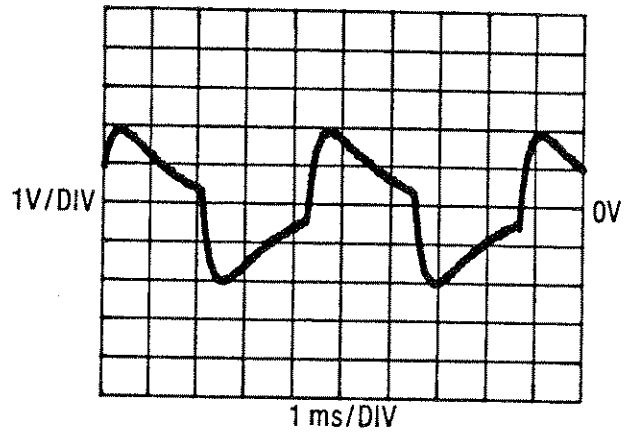


Figure 8-42. Variable Gain Amplifier Waveform

3. Compare the waveform at A5TP15 with Figure 8-43. If the waveform is incorrect, perform the Range Attenuator (÷1, ÷10, ÷100) and AC Gain Stage Tests. If the waveform is normal, continue with step 4.

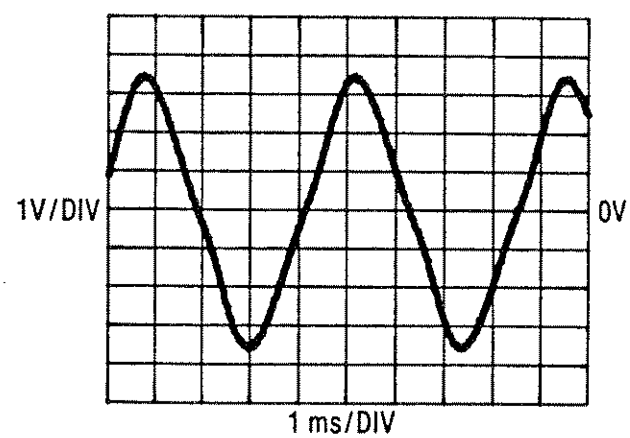


Figure 8-43. AC Gain Stage Waveform

4. If A5U24 pin 14 is not 3.4 ±0.4 Vdc, perform the Synchronous Phase Detector and Low Pass Filter Tests. If the voltage is normal, continue with step 5.
5. Compare the waveform at A5TP11 with Figure 8-44. If the waveform is incorrect, perform the Analog/Digital Input Multiplexer and Sensor Resistor Selection Test. If the waveform is normal, replace A5U7, A5R80, A5R81 or A5R82.

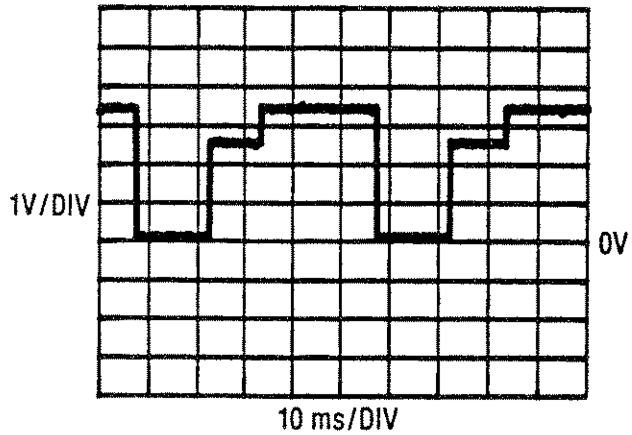


Figure 8-44. Analog to Digital Converter Input Waveform

Gain/Attenuator Buffer

1. Connect the Signature Analyzer as shown below:

Signature Analyzer Pod	**A3 Assembly**
Start/Stop	A3TP9
Clock	A3TP6

2. Set the controls on the signature analyzer as shown below:

   FUNCTION .... NORM
   Clock .... \ (falling edge)
   Start .... / (rising edge)
   Stop .... \ (falling edge)

3. Set switch A3S1 to 0001(LSB). The least significant bit (LSB) is the switch closest to the edge of the printed circuit board. When the switches are set towards the front panel of the instrument, they are set to one.

4. Use the following signatures to verify that the signature analyzer is set up properly.

		Rev. 5.0	**Rev. 2.0**
+5 volts	(A3TP8)	(9UCF)	(9UCF)
Ground		(0000)	(0000)

5. Verify the signatures in Table 8-38.

   If all of the signals are correct, continue with step 6.

Table 8-38. Gain/Attenuator Buffer Signatures

Pin Number	Signal Name	Signatures	
		5.0	2.0
5U16-2	AD0	H26A	H26A
5	AD1	A857	A857
6	AD2	5PA6	5PA6
9	AD3	9AAC	9AAC
12	AD4	AFFU	AFFU
15	AD5	3P63	3P63
16	AD6	8FCP	8FCP
19	AD7	U992	U992

If any signatures are incorrect, check the Digital I/O circuits on Service Sheet7. If the Digital I/O signatures are correct, replace A5U16.

6. Verify the signatures in Table 8-39.

Table 8-39. A/D Input Multiplexer Signatures

Pin Number	Signal Name	Signatures	
		5.0	2.0
A5U19-1	AD4	387H	387H
15	AD6	CP0U	CP0U
16	AD5	U5PU	U5PU

If all of the signatures are correct, the circuit is operating normally. If any of the signatures are incorrect, continue troubleshooting on Service Sheet 7.

Reference, Ramp Start Gate and Ramp Generator Test

1. Check A5U8 pin 2 for a 5 Vp-p digital waveform. If there isn't any signal, perform signature analysis troubleshooting on Service Sheet 1.
2. If the voltage at A5TP8 is not equal to 2.5 ±0.05 Vdc, replace A5U12.
3. If the voltage on A5U17 pin 6 is not between −6 and −8 Vdc, replace A5U17, A5R59, A5R61, A5R62 or A5R64.
4. If the voltage on A5U8 pin 3 is not equal to 1.8 ±0.1 Vdc, replace A5R66 or R67.
5. Compare the waveform at A5U8 pin 7 with Figure 8-45.

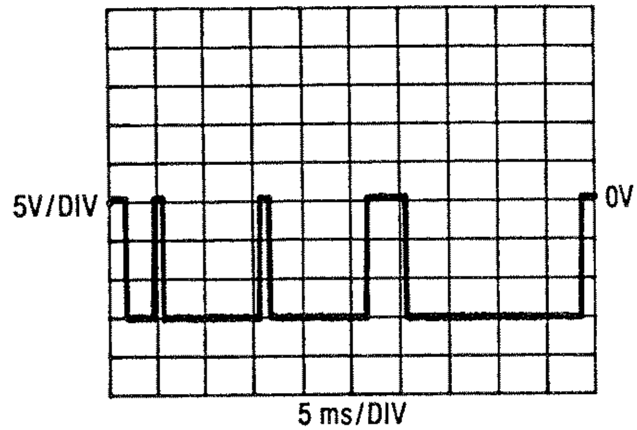


Figure 8-45. Ramp Start Gate Waveform

If the waveform is not present at A5U8 pin 7, replace A5U8. If the signal is more than 0.7 volts positive, replace A5Q3 or A5U1. (If the voltage on ATU1 pin 2 is 0 ±0.01 volts, replace A5Q3).

6. Compare the waveform at A5TP1 with Figure 8-46.

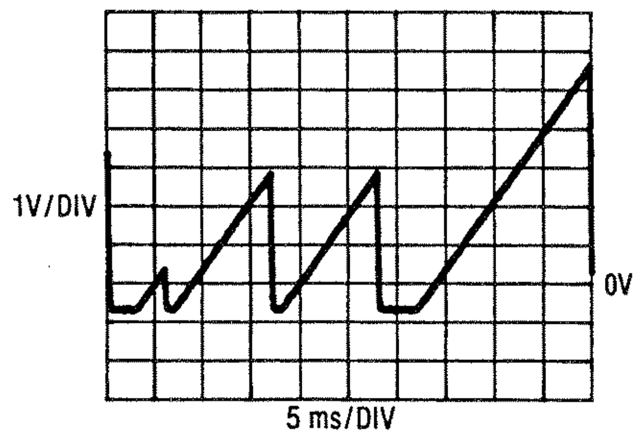


Figure 8-46. Analog to Digital Converter Ramp Waveform

If the signal is correct, the circuit is operating properly.

If the signal is incorrect, replace A5Q3, A5U1, A5R77, A5R79 or A5C35.

Range Attenuator (÷1, ÷100)

1. Measure the +5 volt supply at A5TP7 using A5TP20 as ground.
2. Connect a jumper from A5TP7 to A5U25 pin 3.
3. Select MNL Range 3 and measure the voltage at A5U25 pin 2. If the voltage is not equal to the voltage at A5TP7 (±0.01 volts), check A5U25 pin 1. If A5U25 pin 1 is high (>2.0V), perform the Gain/ Attenuator Buffer Test. If A5U25 pin 1 is low (<0.8V), check A5U25

pin 8. If A5U25 pin 8 is high (>2.0V), replace A5U25. If pin 8 is not high, replace A5U13.

4. Select MNL Range 4. If A5U25 pin 2 is not equal to the voltage at A5TP7 divided by 100 plus or minus 0.001 Vdc, replace A5U25, A5R23, or A5R24.

Variable Gain Amplifier

1. Measure the AC voltage at A5TP18 and divide it by the AC voltage at A5U27 pin 3. If the calculated value is between 21 and 65, the circuit is operating properly. If the gain is not between 21 and 65, perform the Gain/ Attenuator Buffer Test. If that test is normal, replace A5U27, A5U22 or A5R46–A5R49.

Range Attenuator (÷1, ÷10, ÷100)

1. Perform the Gain/Attenuator Buffer Test, if it has not already been performed.
2. Measure the voltage at A5TP7 (+5V) using A5TP20 as ground.
3. Connect A5TP7 to A5U25 pin 11.
4. Select MNL Range 1. If the voltage on A5U25 pin 10 is not equal to the voltage at A5TP7 ±0.01 volts, replace A5U25.
5. Select MNL range 4. If the voltage on A5U25 pin 10 is not equal to the voltage at A5TP7 divided by 10 plus or minus 0.01 volts, replace A5U25, A5R53, A5R54 or A5R55.
6. Select MNL Range 5. If the voltage on A5U25 pin 10 is not equal to the voltage at A5TP7 divided by 100 plus or minus 0.001 Vdc, replace A5U25, A5R53–A5R55.

AC Gain Stage Test

1. Measure the gain of the AC Gain Stage. The gain is equal to the voltage at A5TP15 divided by the voltage at A5U23 pin 3. The gain should be about 240.

   If there is no signal at A5TP15, replace A5U23.

   If the gain is significantly off, ±20, check the gains of A5U23A and A5U23B and replace the associated components, if necessary. The gain of A5U23A should be 27 ±5, and is equal to the voltage at A5U23 pin 1 divided by the voltage at A5U23 pin 3. The gain of A5U23B is 10 ±4 and is equal to the voltage at A5TP15 divided by the voltage at A5TP14.

Synchronous Phase Detector Test

1. Set up the equipment as described in the Fault Isolation procedure.
2. Compare the waveform at A5TP19 to Figure 8-47.

Note

The amplitude of the waveform should be equal to the peak amplitude of the signal at A5TP15. If the amplitude of the waveform does not equal the peak amplitude of the signal at A5TP15, check A5R26, A5R27 and A5T38.

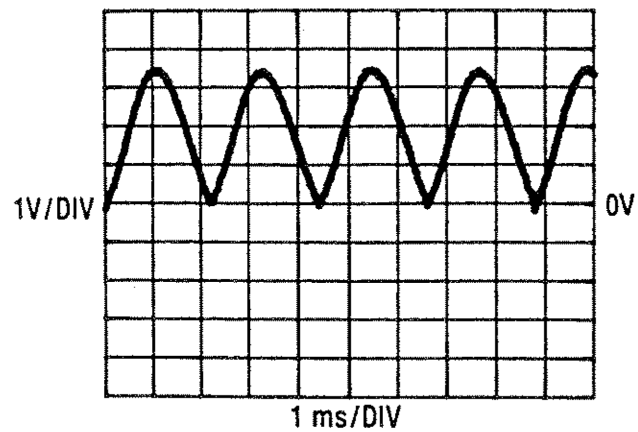


Figure 8-47. Synchronous Phase Detector Output Waveform

If the signal is correct, the circuit is operating properly. If the signal is incorrect, go to step 3.

3. If the signal appears to be only half-wave rectified, check for an open A5R26.
4. If the signal at A5TP19 is equal to the signal at A5TP15, compare the waveform at A5TP10 with Figure 8-48.

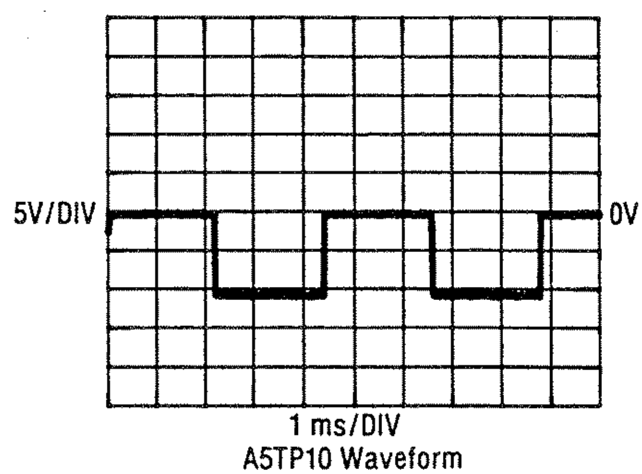
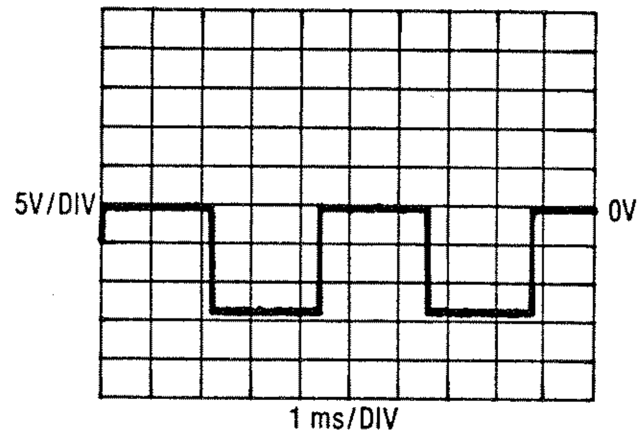
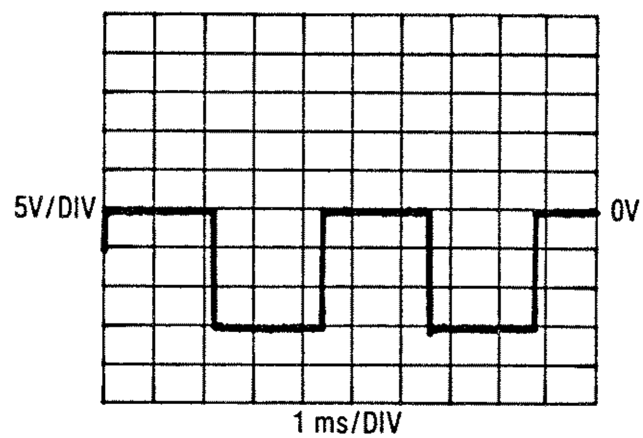


Figure 8-48. Phase Detector Drive Waveforms



Collector of A5Q6



Collector of A5Q7

Figure 8-48. Phase Detector Drive Waveforms (continued)

If the signal is incorrect, continue troubleshooting on Service Sheet 6.

5. Compare the signal at A5U26 pin 3 with Figure 8-49.

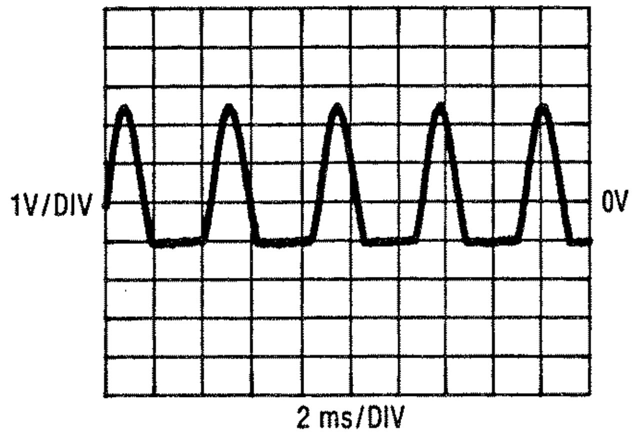


Figure 8-49. Phase Detector Control Waveform

If the signal is correct, check for an open A5R27. If the signal is incorrect, compare the signals at the collectors of A5Q6 and A5Q7 with the waveforms in Figure 8-48.

If the signal at the collector of A5Q6 is incorrect, replace A5Q6, A5R19, or A5R20.

If the signal at the collector of A5Q7 is incorrect, replace A5Q7, A5R21, or A5R22.

6. If the signal at A5TP19 is not as shown in Figure 8-47, replace A5U26 or A5R38.

Low Pass Filters

1. Set up the equipment as described in the Fault Isolation procedure.
2. Select MNL Filter 0.
3. If A5U21 pin 8 is a logical low (<0.8V), continue troubleshooting on Service Sheet 7.
4. Verify that A5U21 pin 9 is the complement of A5U21 pin 8. If pin 9 is not the complement of pin 8, replace A5U13.
5. Select MNL Filter 9.
6. If A5U21 pin 8 is high (>2.0V), continue troubleshooting on Service Sheet 7.
7. Again, verify that A5U21 pin 9 is the complement of A5U21 pin 8. If pin 9 is not the complement of pin 8, replace A5U13.

Note

At this point the control lines that control the Filter Switch have been verified. The following steps will verify that the switch will pass and block a signal.

8. Connect a jumper from the +5 volt supply (A5TP7) to A5TP16 and measure A5U24 pin 14. The voltage at A5U24 pin 14 should be 8.4 ±0.4 Vdc.

9. If the voltage at A5U24 pin 14 is incorrect, check the voltage at A5U24 pin 12. If the voltage at A5U24 pin 12 is equal to the +5 volt supply, replace A5U24, A5R83 or A5R84. If the voltage is incorrect, replace A5U21.
10. If A5U24 pin 14 is correct, select MNL Filter 0 and verify that removing the jumper from A5TP16 makes no difference in the reading at A5U24 pin 14. If moving the jumper does make a difference, replace A5U21.
11. Connect a jumper from the +5 volt supply (A5TP7) to A5TP12 and measure the voltage at A5U24 pin 12.
12. If the voltage at A5U24 pin 12 is equal to the +5 volt supply, select MNL Filter 9 and verify that removing the jumper from A5TP12 makes no difference in the voltage at A5U24 pin 12. If moving the jumper does make a difference or if A5U24 pin 12 was not equal to the +5 volt supply, replace A5U21.

Note

At this point, the Filter Switch has been fully verified. The following steps will check the Slow and Fast Filters.

13. Verify that the voltages at A5TP12 and A5TP16 are approximately equal to 0.6 times the peak voltage at A5TP19 plus or minus 0.3 volts.

    If the voltages at A5TP12 and A5TP16 are incorrect, replace A5U24.

    If the voltage at A5TP12 or A5TP16 is incorrect, the problem is more likely to be with the resistors and capacitors associated with the defective filter.

Analog/Digital Input Multiplexer Test

1. Compare the waveform at A5TP11 with Figure 8-50.

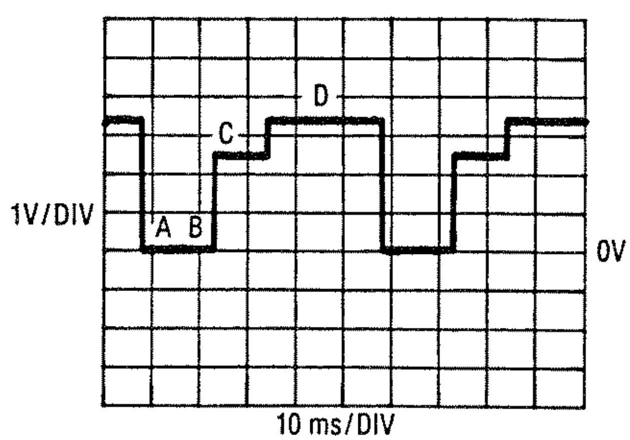


Figure 8-50. Analog to Digital Converter Input

2. The voltage levels at points A, B, C and D, on Figure 8-50, should be as indicated below:

   Point A should be the same as A5U19 pin 6.
   Point B should be the same as A5U19 pin 12.
   Point C should be the same as A5U19 pin 5.
   Point D should be the same as A5U19 pin 4.

3. If the voltage levels at A, B, C and D are not as indicated in step 2, perform step 5 of the Gain/Attenuator Buffer Test. If the test is normal, replace A5U19.

   If the voltage levels at points A, B, C and D are not as shown in Figure 8-50, go to step 4.

   If the voltage levels are correct, perform the "A" Ground Circuit Test.

4. Verify the following voltages:

   A5U19 pin 5=2.5 volts ±0.2 volts
   pin 12=0.0 volts ±0.2 volts

   If either voltage is incorrect, perform the Sensor Resistor Selection Test. If the voltage at A5U19 pin 4 is not 3.5 ±0.5 Vdc, perform the Fault Isolation procedure to isolate the problem.

Sensor Resistor Selection Test

1. With no sensor connected, verify the following voltages:

   A5U20 pin 3=2.5 ±0.2 volts
   pin 6=2.5 ±0.2 volts
   pin 11=2.5 ±0.2 volts
   pin 14=2.5 ±0.2 volts.

   If any of the voltages are incorrect, replace the appropriate components.

2. Verify that A5U20 pins 2 and 7 are equal to 2.5 ±0.1 volts.

   If the voltages are correct, continue with step 4.

3. If the voltage at pins 2 and 7 do not equal 2.5 ±0.1 volts, verify that A5U20 pin 1 is low (<0.8V) and that A5U20 pin 16 is high (>2.0V).

   If the voltages are correct, replace A5U20.

   If the voltages are incorrect, make sure that sensor A is selected. If it is, continue troubleshooting on Service Sheet 7.

4. Connect the calibrator to the sensor A input of the power meter. If the voltage on A5U20 pin 3 is not equal to 0 ±0.1 volts, check for a bad connection at A5J3, an open cable or an open A5R32.

5. If the voltage on A5U20 pin 2 is not equal to 0 ±0.1 volts, by the voltage on A5U20 pin 3 is equal to 0 ±0.1 volts, replace A5U20.

6. If the voltage on A5U20 pin 7 is not equal to 2.5 ±0.2 volts, replace A5U20.

"A" Ground Circuit Test

If the voltage from A5TP20 to A4TP4 is 0 ±0.01 volts, the "A" Ground Circuit is operating properly. If the voltage is not 0 ±0.1 volts, check A5U28, A5Q9 and associated circuitry. Under normal conditions, the voltage at A5U28 pin 6 is −0.7 ±0.1 Vdc. Figure 8-51 shows the feedback path for the "A" Ground Circuit.

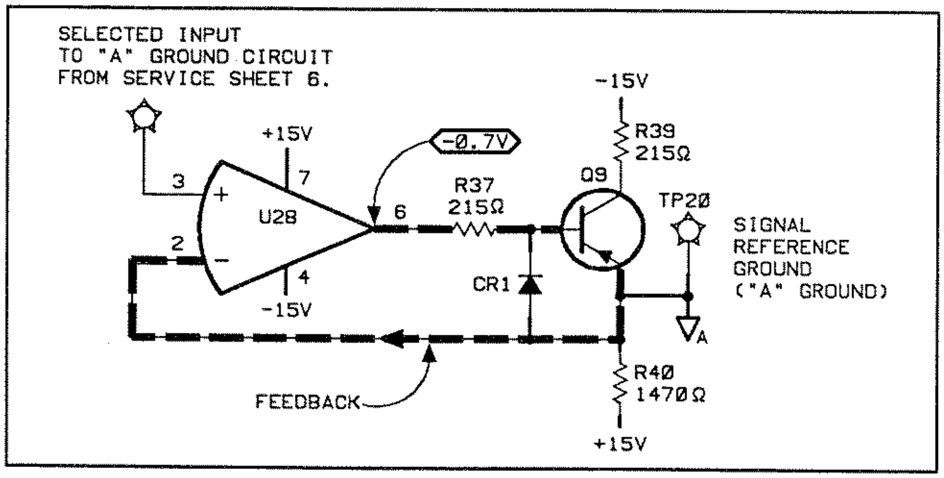
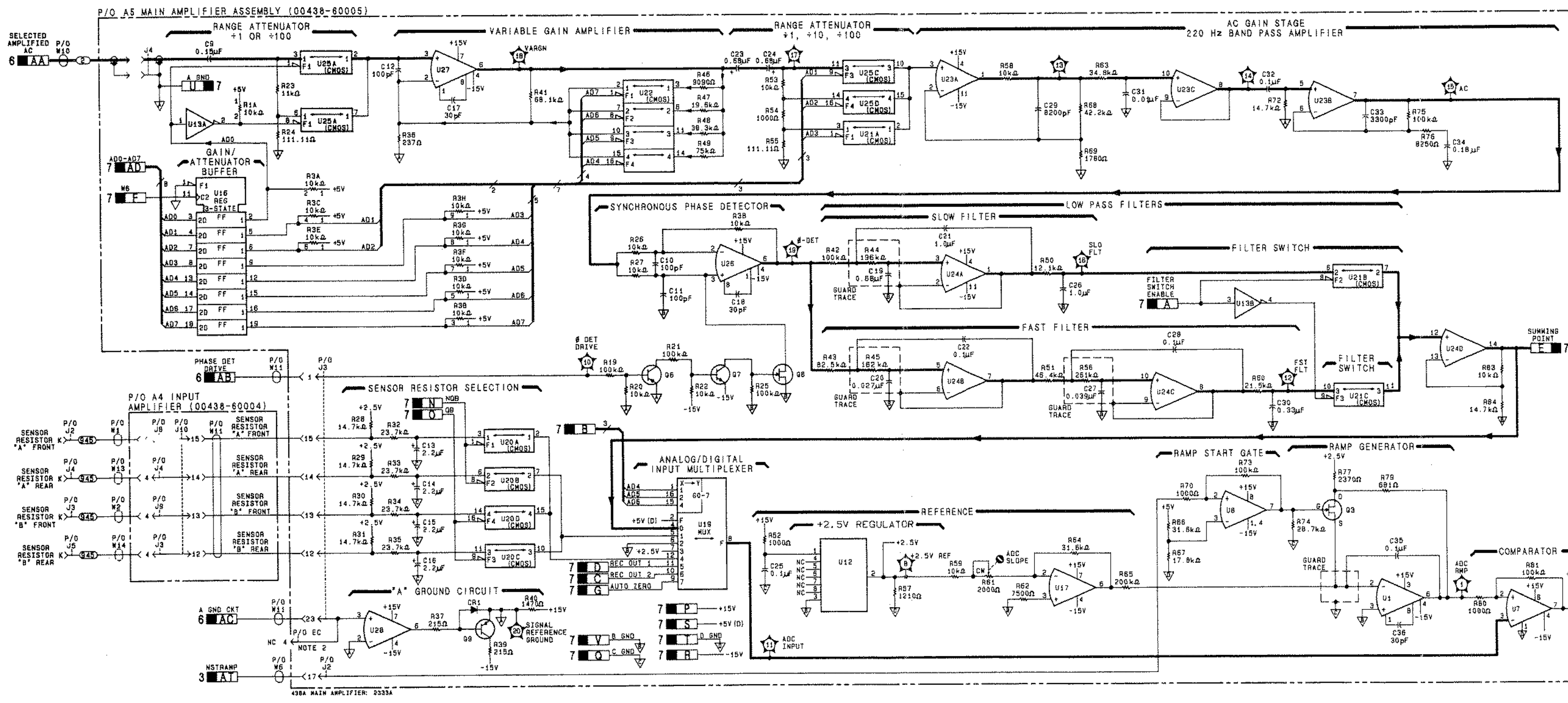


Figure 8-51. "A" Ground Circuit Showing Feedback Path



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. EC REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.

REFERENCE DESIGNATIONS

NO PREFIX	A5
J3-5 W1, 2, 6, 10, 11, 13, 14	C9-36 CR1 J2-4 Q3, 6-9 R1, 19-84 TP1, 4, 8, 10-20 U1, 7, 8, 12, 13, 16, 17, 19-28
A4	
J3, 4, 8-10 W11	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

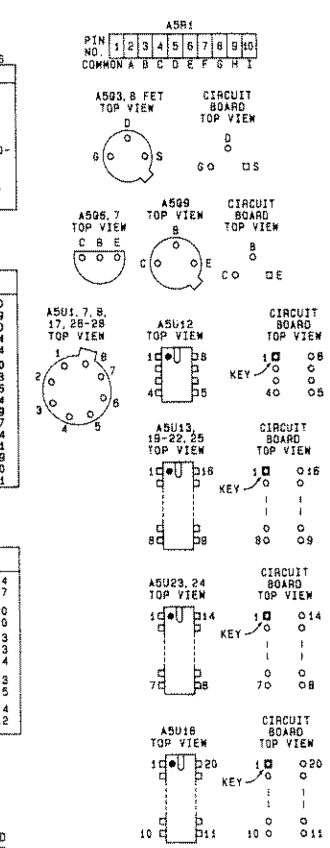
REFERENCE DESIGNATION	PART NUMBER
Q3	1855-0420
Q6	1853-0459
Q7	1854-0810
Q8	1855-0414
Q9	1853-0314
U1, 26, 27	1826-1460
U7	1826-0098
U8	1826-0026
U12	1826-0544
U13	1820-1199
U16	1820-1997
U17	1826-0574
U19	1826-1021
U20-22, 25	1826-1019
U23, 24	1826-0600
U28	1826-0471

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U13	+5V - 14 ⏚ - 7
U16	+5V - 20 ⏚ - 10
U19	+15V - 13 -15V - 3 ⏚ - 14
U20-22, 25	+15V - 13 ⏚ - 5 -15V - 4 NC - 12

LOGIC LEVELS

	TTL	CMOS
HIGH	>2V	>3.5V
LOW	<0.8V	<1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDEF.
GROUND	LOW	LOW



P/O A4, P/O A5

Figure 8-53. P/O Main Amplifier Circuits Schematic Diagram

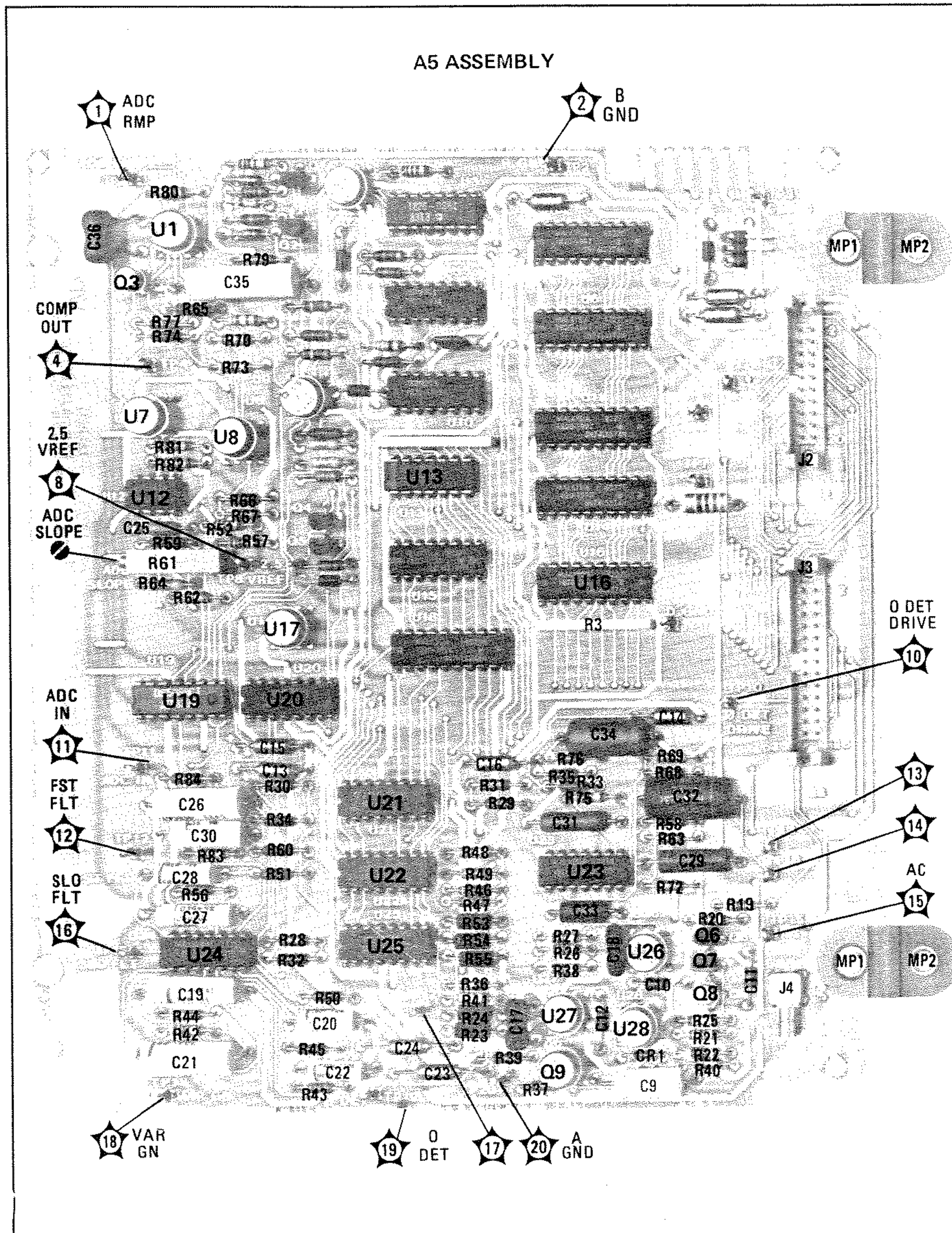


Figure 8-52. P/O A5 Main Amplifier Assembly Component Locations

Service Sheet 9 P/O Power Supply Circuits Troubleshooting

General

The following procedures will help to isolate a a problem to one of the following circuits:

- +5 Volt Digital Supply
- +5 volt Display Supply
- Transformer (T1)
- Line Power Assembly (U1)

Test Equipment

Oscilloscope ....HP 1725A
Digital Voltmeter ....HP 3456A

Fault Isolation Procedure

1. Verify that the following voltages are at the points indicated.

   A9TP4 (+5V Digital) ....+5 ±0.05 Vdc
   A9TP3 (+5V Display) ....See Figure 8-55

   If both both supplies are incorrect, check to see if both the plus and minus 15 volt supply indicators are illuminated. If they are not illuminated, perform the Total Power Failure Test.

   If there is a problem with the +5 Volt Digital Supply, perform the +5 Volt Digital Supply Test.

   If there is a problem with the +5 Volt Display Supply, perform the +5 Volt Display Supply Test.

+5 Volt Digital Supply Test

1. Connect the oscilloscope or voltmeter to A9TP4 (+5V). Leave the power meter turned off.
2. Adjust A9R3 (+5V ADJ) fully counterclockwise, disconnect A10J1 and turn the power meter on.
3. If A9TP6 is ≥10 Vdc, continue with step 4. If the voltage is incorrect, the problem is probably the +5 Volt Bridge circuit, the transformer secondary, the filter capacitors or the crowbar circuit.
4. Try to adjust A9R3 until A9TP4 reaches +5V. If this cannot be accomplished, replace A8U2. Otherwise, reconnect A10J1 and make sure the voltage at A9TP4 is +5 volts. If the voltage is incorrect, the problem is located on the A3 or A5 assemblies. Continue with step 5.

5. To isolate the problem to a particular board, disconnect the following cables one at a time until the voltage at A9TP4 returns to normal:

Cable	Problem Location	Related Service Sheets
A3J2	A3	Service Sheets 1–4
A3J6	A3	Service Sheet 4
A5J2	A5	Service Sheets 7 and 8

When the problem has been isolated to a particular board, refer to the related service sheets and try to identify the defective component(s).

+5 Volt Display Supply Test

1. Connect an oscilloscope to A9TP3. Compare the waveform in Figure 8-54 with the waveform on the oscilloscope.

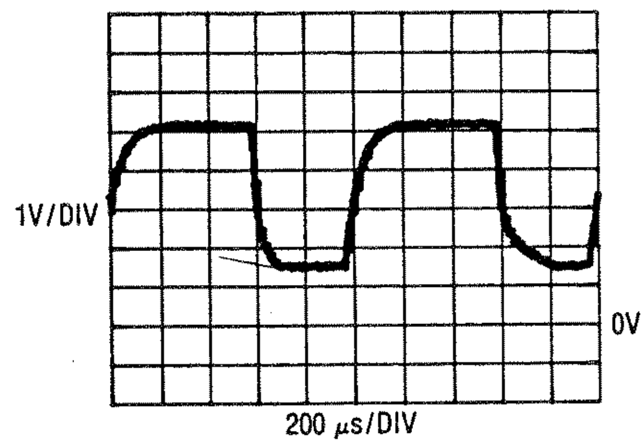


Figure 8-54. +5 Volt Display Supply Waveform

If the signal is incorrect, disconnect A3J6. If the signal is now correct, there is a short somewhere on the A3 assembly. Service Sheet 4 shows the related circuits. If disconnecting A3J6 does not relieve the problem, continue with step 2.

2. If the +5V Digital Supply (A9TP4) is not +5 ±0.05 Vdc, continue troubleshooting with the +5V Digital Supply test.
3. Compare the signal at A9TP1 (CLK) with Figure 8-55. If the signal is incorrect, continue troubleshooting on Service Sheet 3. If the signal is correct, replace A8U1.

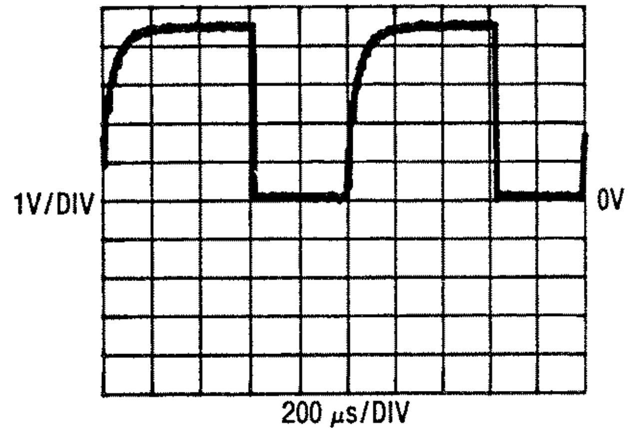


Figure 8-55. +5 Volt Display Clock

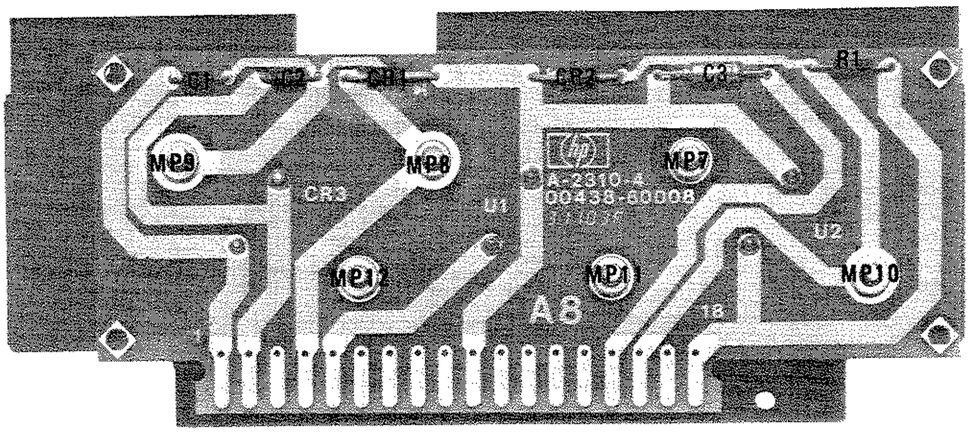
Total Power Failure Test

1. Unplug the instrument from the line (Mains).
2. Remove fuse F1 and check it with an ohmmeter. If it doesn't measure zero ohms, replace it.
3. Verify that the line voltage selection card is in the correct position.
4. If everything seems to be correct, the problem is in the transformer or line switch assembly.

Note If the line fuse blows repeatedly, there may be a problem with the Crowbar circuit on Service Sheet 10.

A8 ASSEMBLY

COMPONENT SIDE



1
(19)

18
(36)

CIRCUIT SIDE

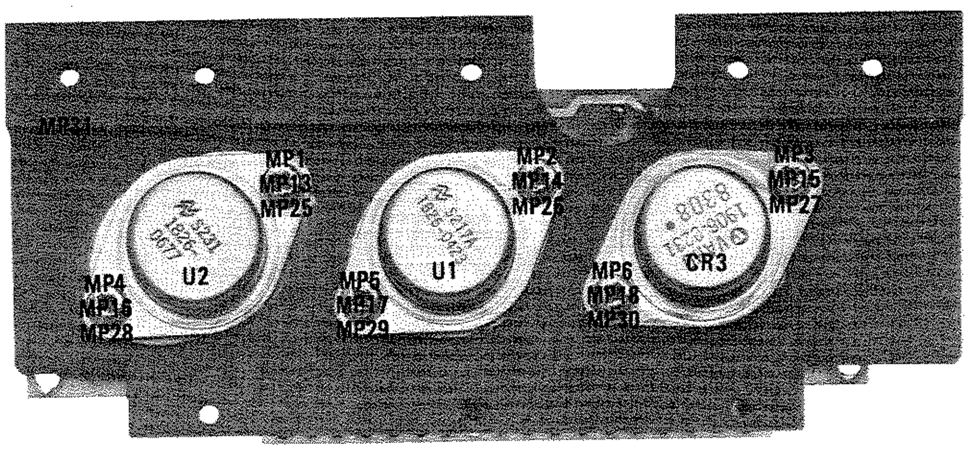


Figure 8-56. Rectifier Assembly Component Locations

A10 ASSEMBLY

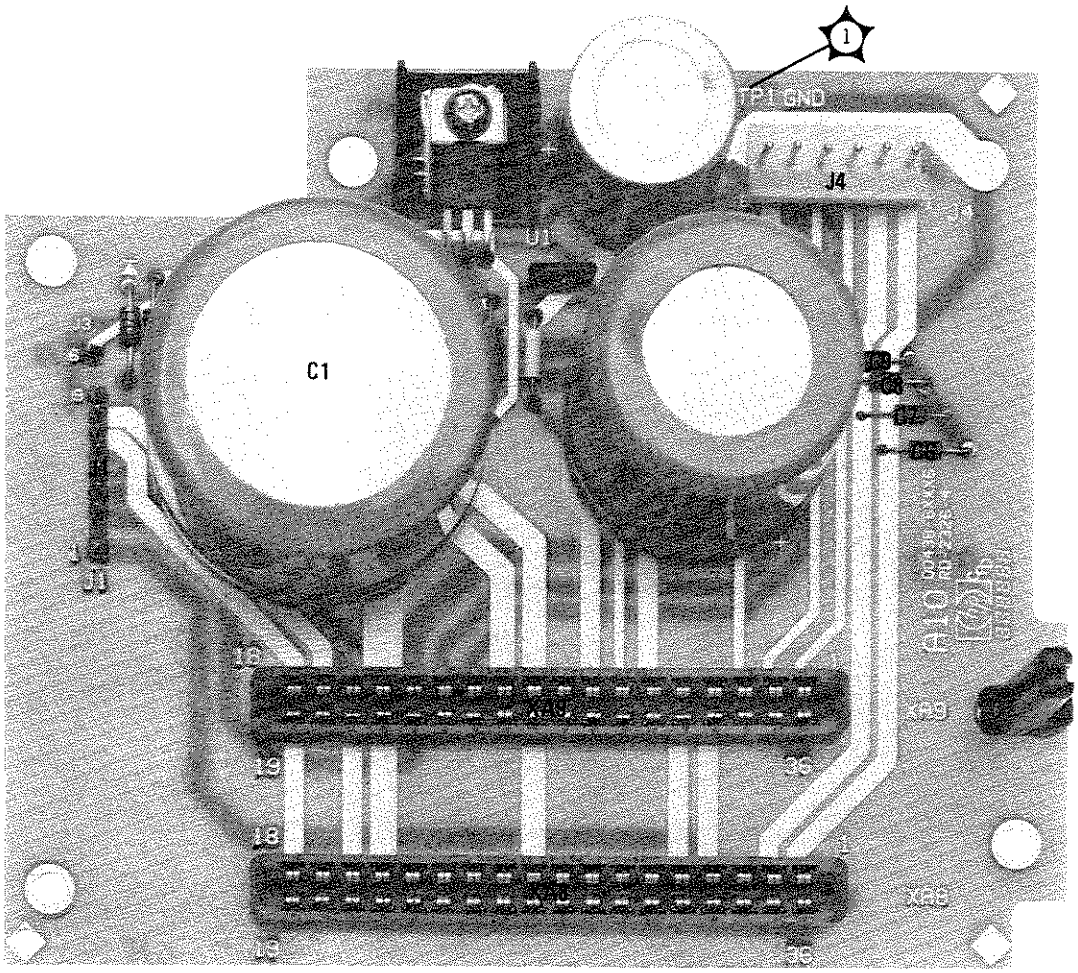
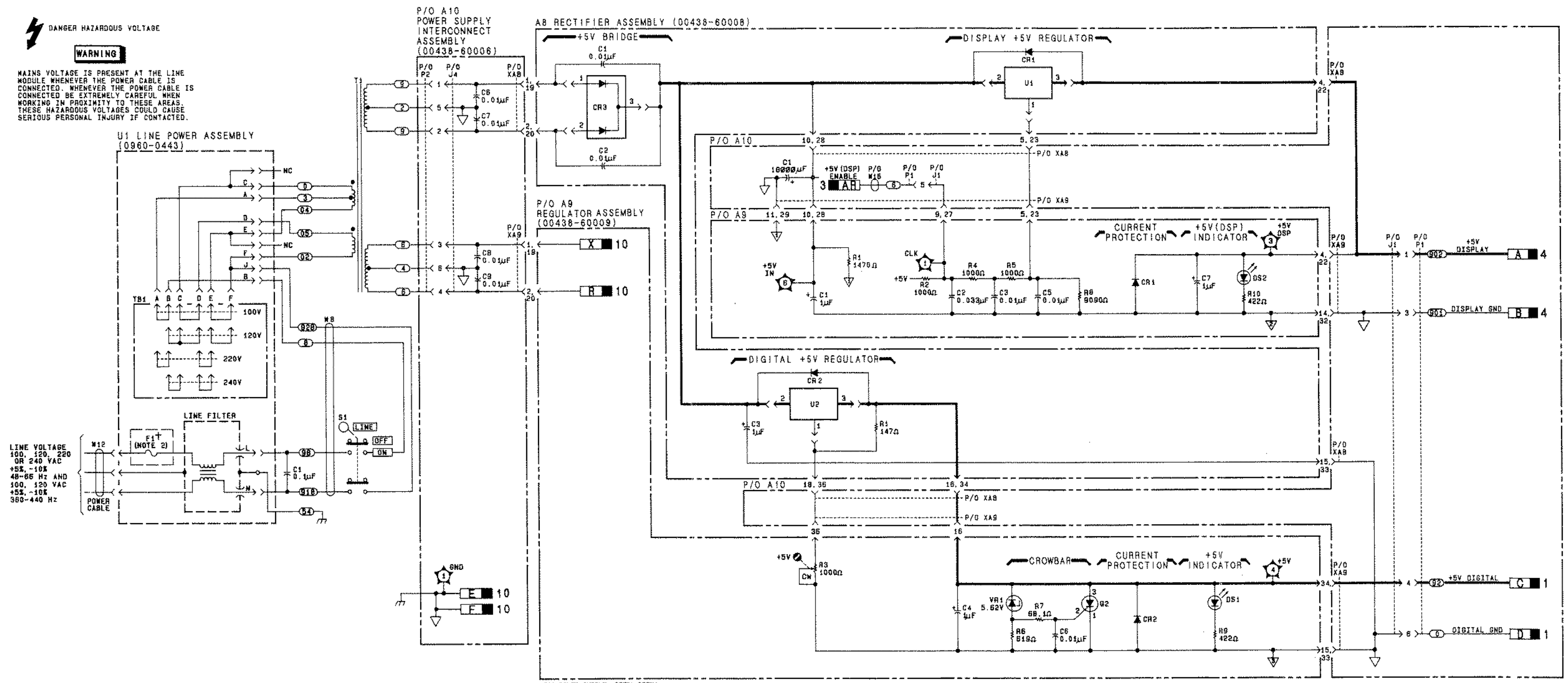


Figure 8-57. P/O Interconnect Assembly Component Locations



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. VALUE OF F1 IS:
   1.0A FOR A LINE VOLTAGE OF 100-120 VAC.
   375 mA 250V FOR A LINE VOLTAGE OF 200-240 VAC.

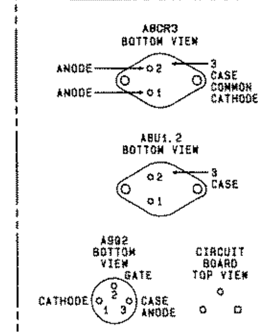
† BACKDATING INFORMATION IN SECTION 7.

REFERENCE DESIGNATIONS

NO PREFIX	A9
C1 S1 T1 U1 W8, 12	C1-7 CR1, 2 DS1, 2 Q2 R1-10 TP1, 3, 4, 6 VR1
A8	**A10**
C1-3 CR1-3 R1 U1, 2	C1, 6-9 J1, 4 TP1 XA8, XA9

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A8	
U1	1826-0423
U2	1826-0677
A9Q2	1884-0244



9
A8, P/O A9, P/O A10

Figure 8-59. P/O Power Supply Circuits Schematic Diagram

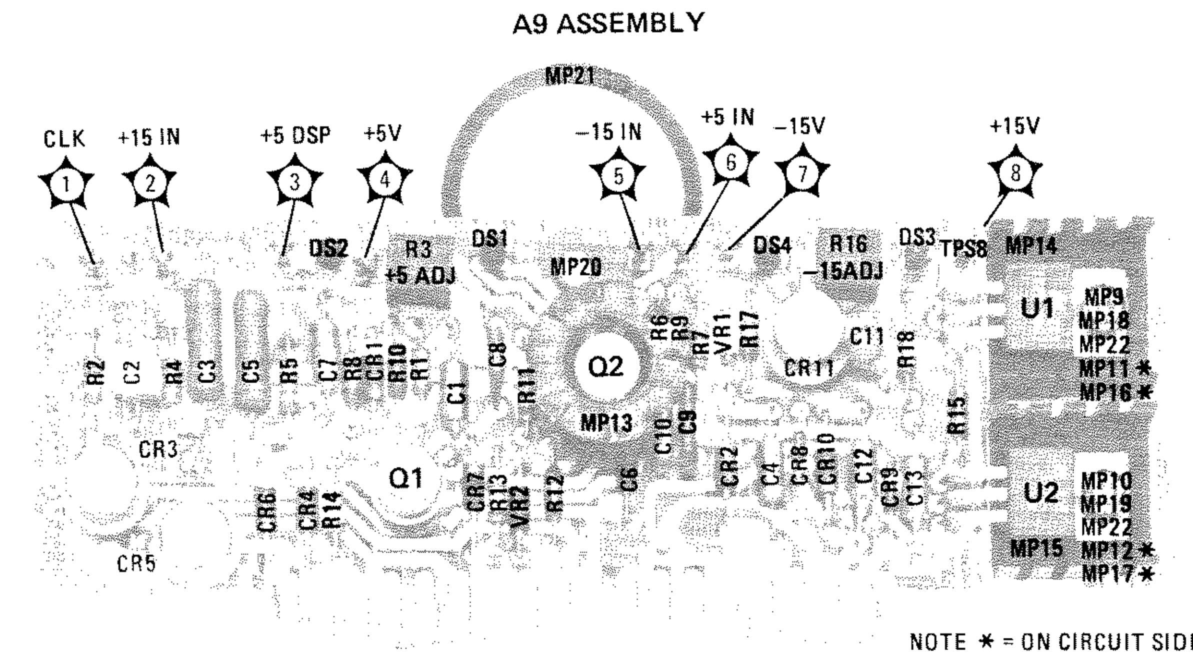


Figure 8-58. Regulator Assembly Component Locations

Service Sheet 10 P/O Power Supply Circuits Troubleshooting

General

The following procedures will help to isolate a problem to one of the following circuits:

- +15 Volt Supply
- −15 Volt Supply
- +12 Volt Fan Supply

Test Equipment

Oscilloscope .... HP 1725A
Digital Voltmeter .... HP 3456A

Fault Isolation Procedure

1. Verify that the following voltages are at the points indicated.

   A9TP8 (+15V) .... +15 ±0.75 Vdc
   A9TP7 (−15V) .... −15 ±0.75 Vdc

Note

The magnitude of the −15V supply should be within ±0.05 volt of the +15V supply.

If both supplies are incorrect, check to see if both the +5V Digital and Display indicators are illuminated. If they are not illuminated, continue troubleshooting on Service Sheet 9.

If there is a problem with the +15 Volt Supply, perform the +15 Volt Supply Test.

If there is a problem with the −15 Volt Supply, perform the −15 Volt Supply Test.

+15 Volt Supply Test

1. Connect the oscilloscope or voltmeter to A9TP8 (+15V). If the voltage is not +15 ±0.75 Vdc, continue with step 2. If the voltage is +15 ±0.75 Vdc, the supply is operating normally.
2. Disconnect A10J1 and the red lead for the Fan Motor Control Module (the lead is on A10). If the voltage is still incorrect, continue with step 3. If the voltage returns to normal, reconnect A10J1. If the voltage is still normal, the problem is with the Fan or the Fan Motor Control Module. If the problem remains, disconnect the following cables, one at time, until the voltage returns to normal:

Note Remove the cables in the order given.

Cable	Problem Location	Related Service Sheets
A5J3	A5	Service Sheet 7
A4J2	A4	Service Sheet 6

3. Check A9TP2 (+15V IN). If A9TP2 is ≥20 Vdc, replace A9U1. If the voltage is incorrect, the problem is in one of the following circuits:

   +12V Fan Regulator
   +15V Regulator
   Filter capacitors
   ±15V Bridge circuit
   Crowbar circuit
   Transformer secondary

−15 Volt Supply Test

1. Connect an oscilloscope to A9TP7. If the voltage is −15 ±0.75 Vdc, the supply is operating normally. If the voltage is incorrect, continue with step 2.

Note Adjust the magnitude of the −15 volt supply to within ±0.05 volts of the +15 volt supply.

2. Disconnect A10J1 and the red lead for the Fan Motor Control Module (the lead is on A10). If the voltage is still incorrect, continue with step 3. If the voltage returns to normal, reconnect A10J1. If the voltage is still normal, the problem is with the Fan or the Fan Motor Control Module. If the problem remains, disconnect the following cables, one at a time, until the voltage returns to normal:

Note Remove the cables in the order given.

Cable	Problem Location	Related Service Sheets
A5J3	A5	Service Sheet 7
A4J2	A4	Service Sheet 6

3. Check A9TP5 (−15V IN). If A9TP5 is ≤−20 Vdc, replace A9U2. If the voltage is incorrect, the problem is in one of the following circuits:

   +12V Fan Regulator
   +15V Regulator
   Filter capacitors
   ±15V Bridge circuit
   Crowbar circuit
   Transformer secondary

A10 ASSEMBLY

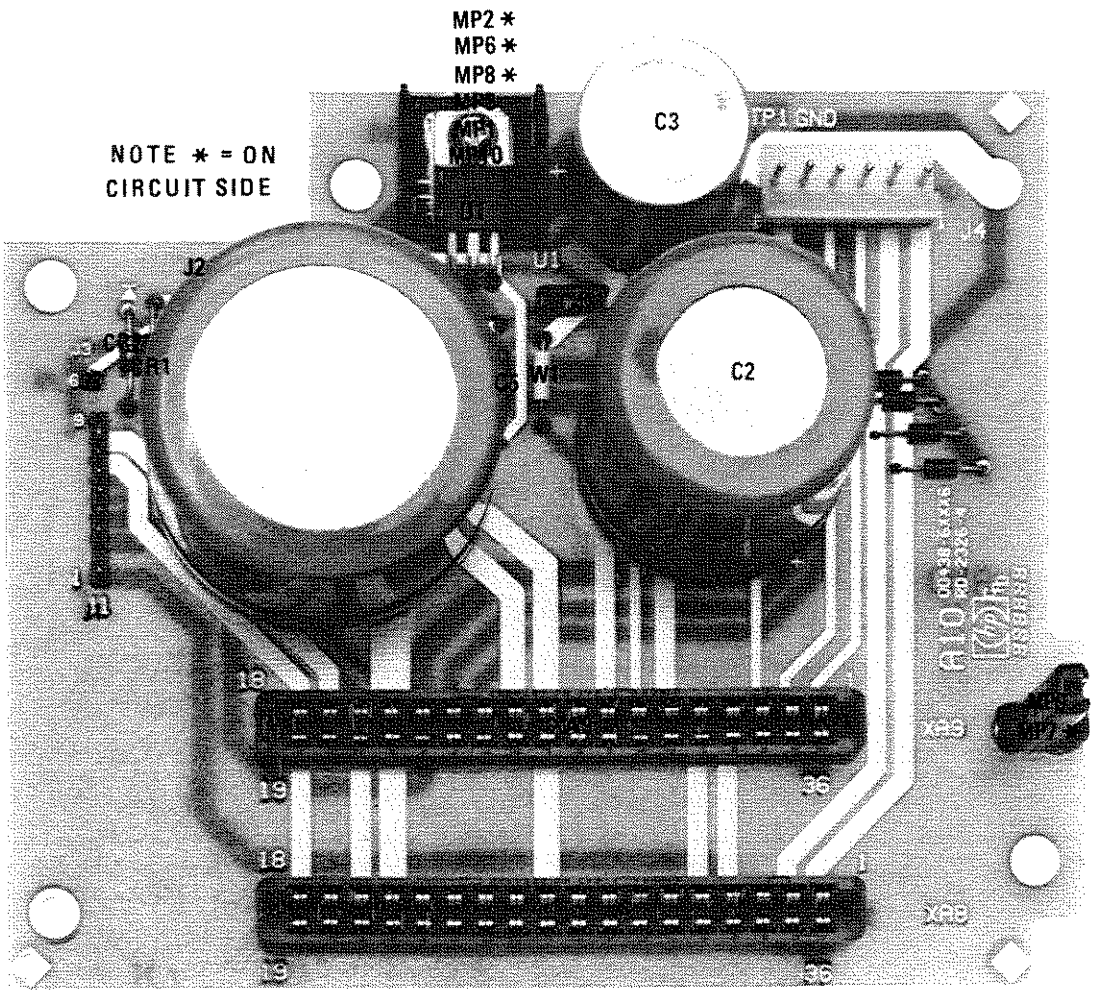
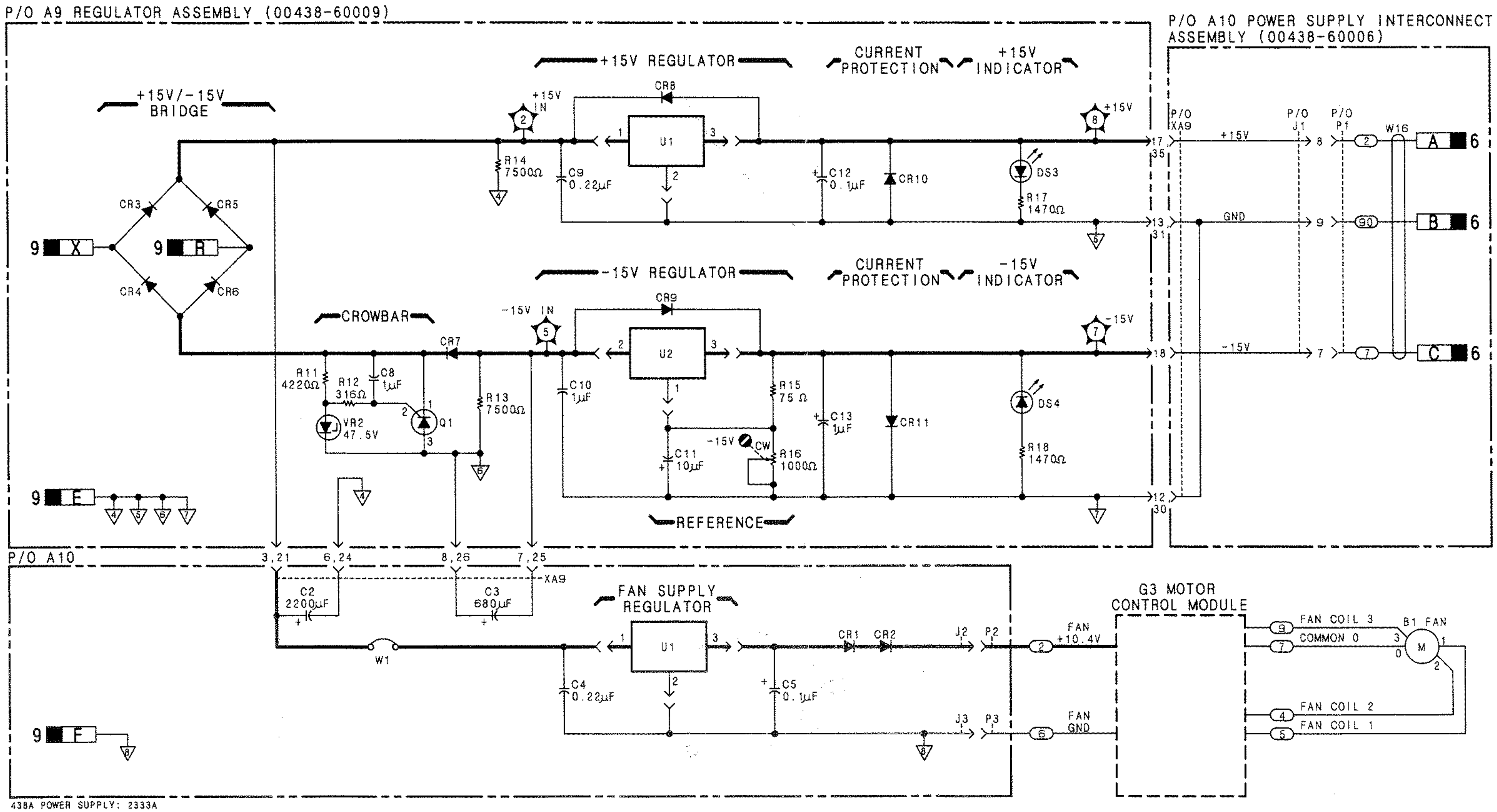


Figure 8-60. P/O Interconnect Assembly Component Locations



NOTES

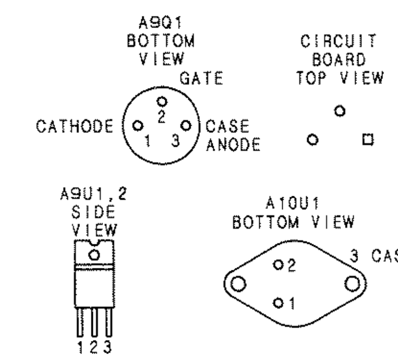
1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS

NO PREFIX	A10
B1 G3	C2-5 CR1,2 J1-4 U1 W1,16 XA9
A9	
C8-13 CR3-11 DS3,4 Q1 R11-18 TP2,5,7,8 U1,2 VR2	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A9	
Q1	1884-0244
U1	1826-0607
U2	1826-0527
A10	
U1	1826-0147



10

P/O A9, P/O A10, G3

Figure 8-62. P/O Power Supply Circuits Schematic Diagram

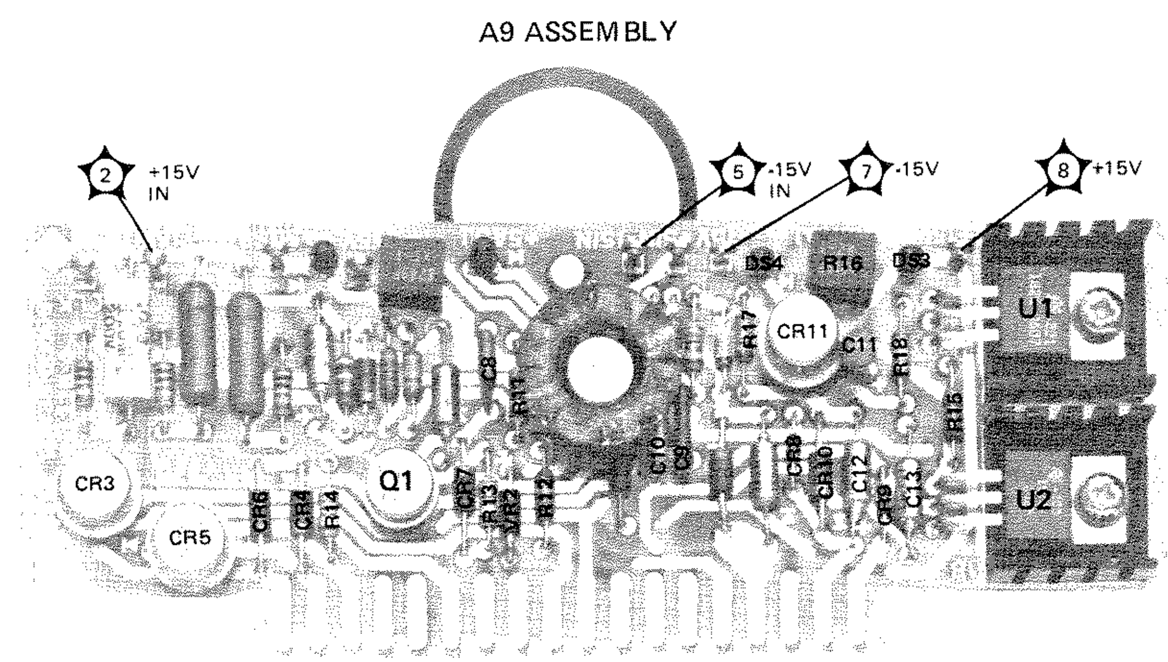


Figure 8-61. Regulator Assembly Component Locations

Service Sheet 11 Power Reference Oscillator Circuits Troubleshooting

General

Before trying to troubleshoot the G1A1 Assembly, verify the presence of +15 Vdc and −15 Vdc on the circuit board. If the −15 volt supply is not correct, troubleshoot the Cal Oscillator Control and Miscellaneous Buffer on Service Sheet 7.

If a defect in the G1A1 Assembly is isolated and repaired, the correct output level (1 mW ±0.7%) must be set by a very accurate power measurement system. Hewlett-Packard employs a special system, accurate to ±0.5% and traceable to the National Institute of Standards and Technology (NIST). When setting the power level, a transfer error of ±0.2% is introduced making the total error ±0.7%. If a system this accurate is available it may be used to set the proper output level. Otherwise, Hewlett-Packard recommends returning the power meter so it can be reset at the factory. Contact your nearest Hewlett-Packard office for more information.

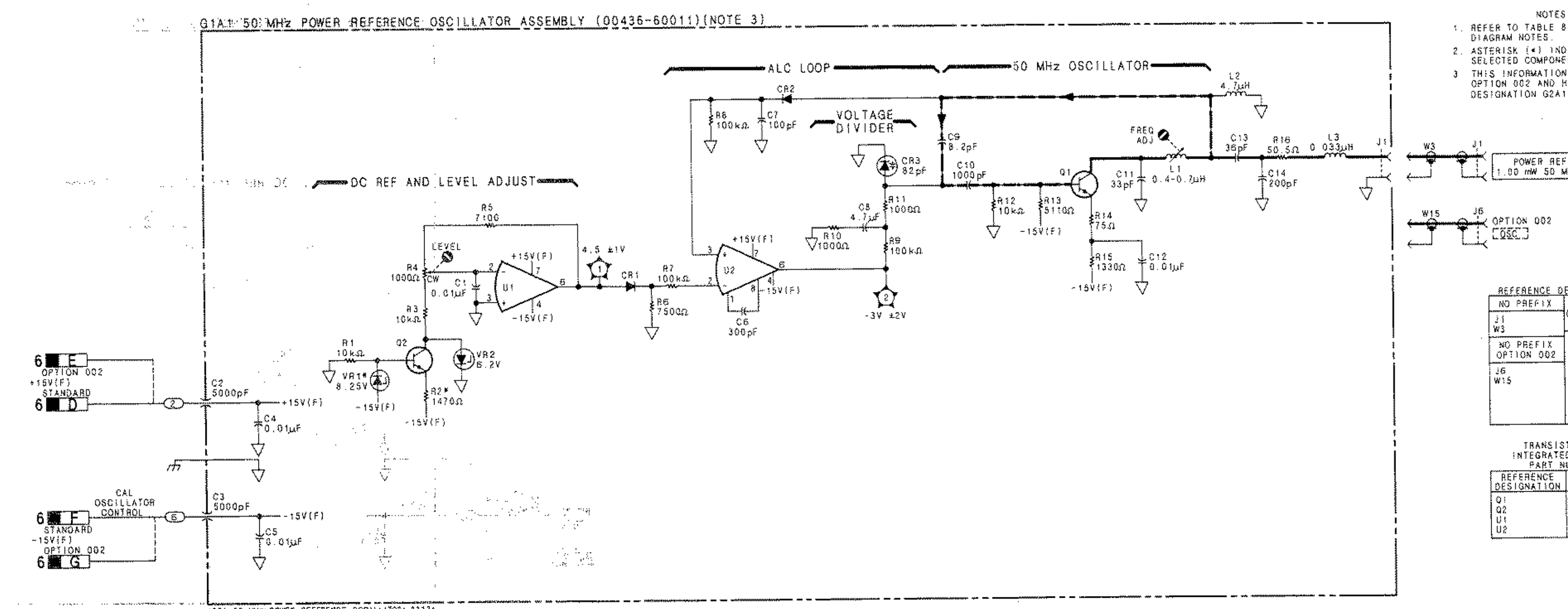
50 MHz Oscillator

Malfunctions of the oscillator circuit will occur as a wrong output frequency or as an abnormal output level. The voltage at G1A1TP2 will indicate if the ALC loop is trying to compensate for an incorrect output level.

Modulation of the 50 MHz signal or spurious signals, which are part of the output, may be caused by defects in G1A1R9, G1A1R10, G1A1R11, or G1A1C8 in the ALC loop.

ALC Loop and Power Supply

Isolating problems in the ALC Loop and Power Supply circuits may be quickly isolated by measuring dc voltages at the inputs and outputs of the integrated circuits.



NOTES

1. REFER TO TABLE 8-2 FOR SCHEMATIC DIAGRAM NOTES.
2. ASTERISK (*) INDICATES FACTORY SELECTED COMPONENT.
3. THIS INFORMATION IS REPEATED FOR OPTION 002 AND HAS REFERENCE DESIGNATION G2A1.

REFERENCE DESIGNATIONS

NO PREFIX	G1A1 (G2A1 OPTION 002)
J1 W3	C1-14 CR1-3 J1 L1-3 Q1,2 R1-16 TP1,2 U1,2 VR1
NO PREFIX OPTION 002	
J6 W15	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q1	1854-0247
Q2	1854-0071
U1	1826-0013
U2	1820-0223

11

G1A1 (G2A1 OPTION 002)

Figure 8-64. Power Reference Oscillator Circuits Schematic Diagram

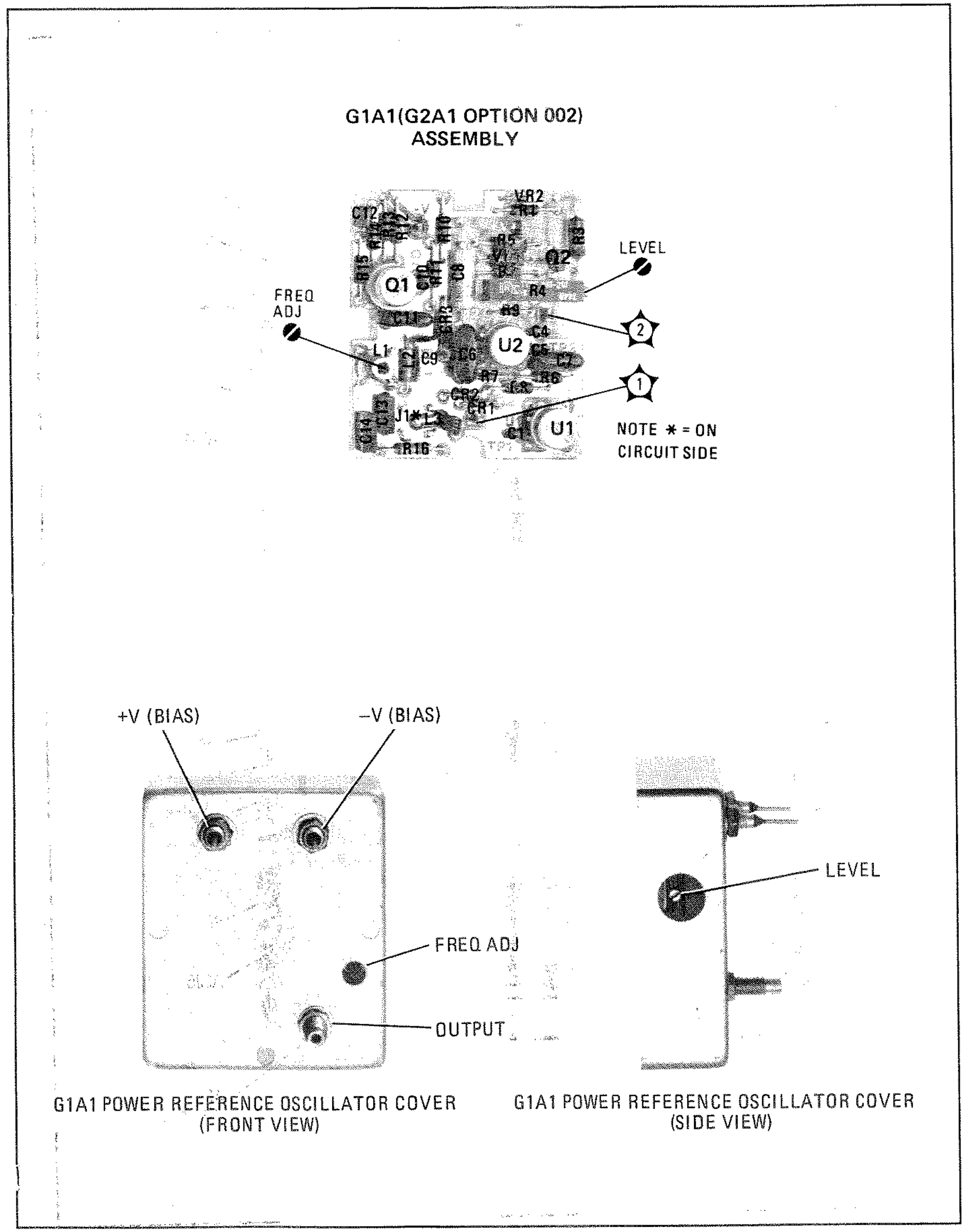


Figure 8-63. Power Reference Oscillator Assembly Component, Test Points and, Adjustment Locations

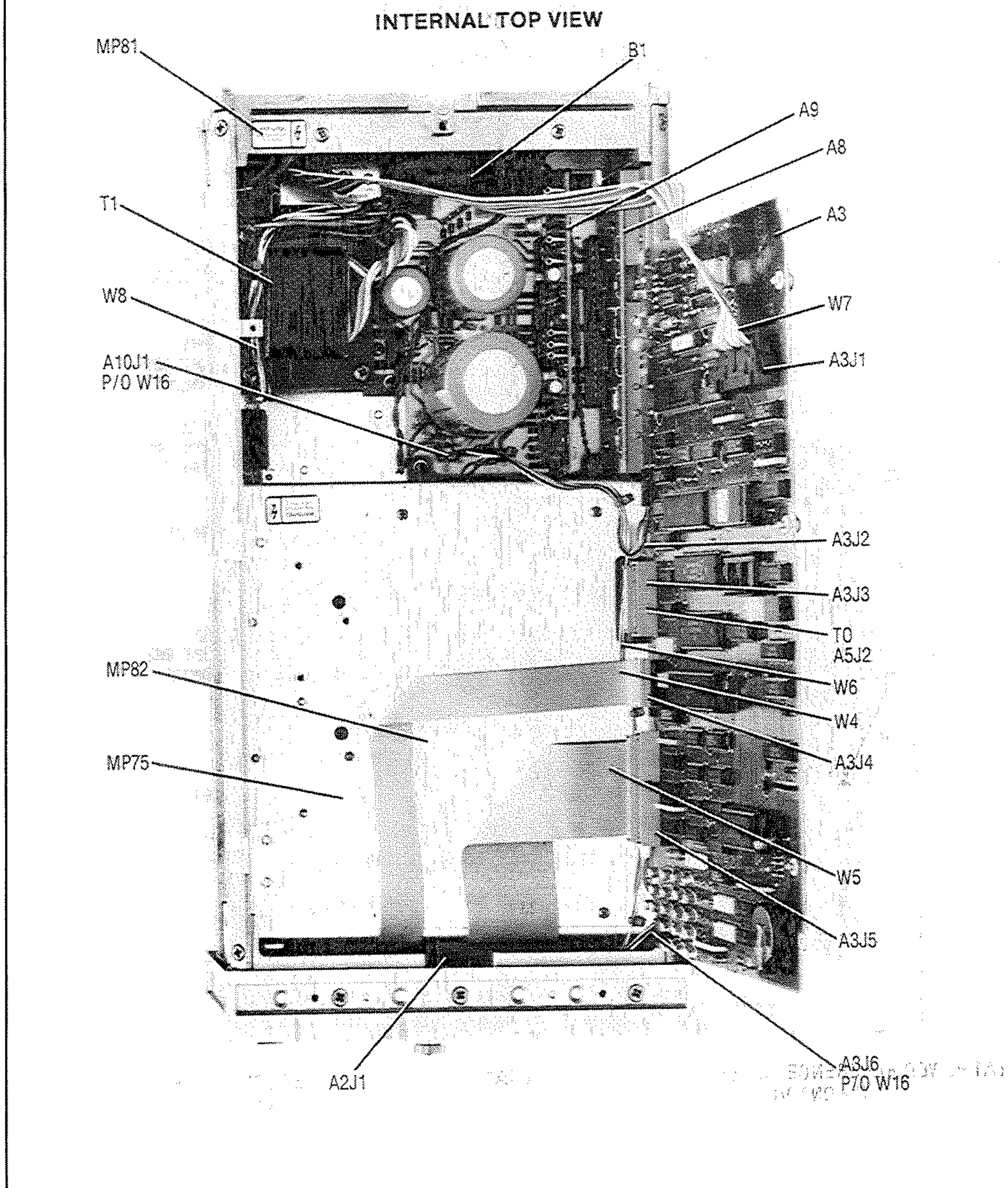


Figure 8-65. Internal Top View

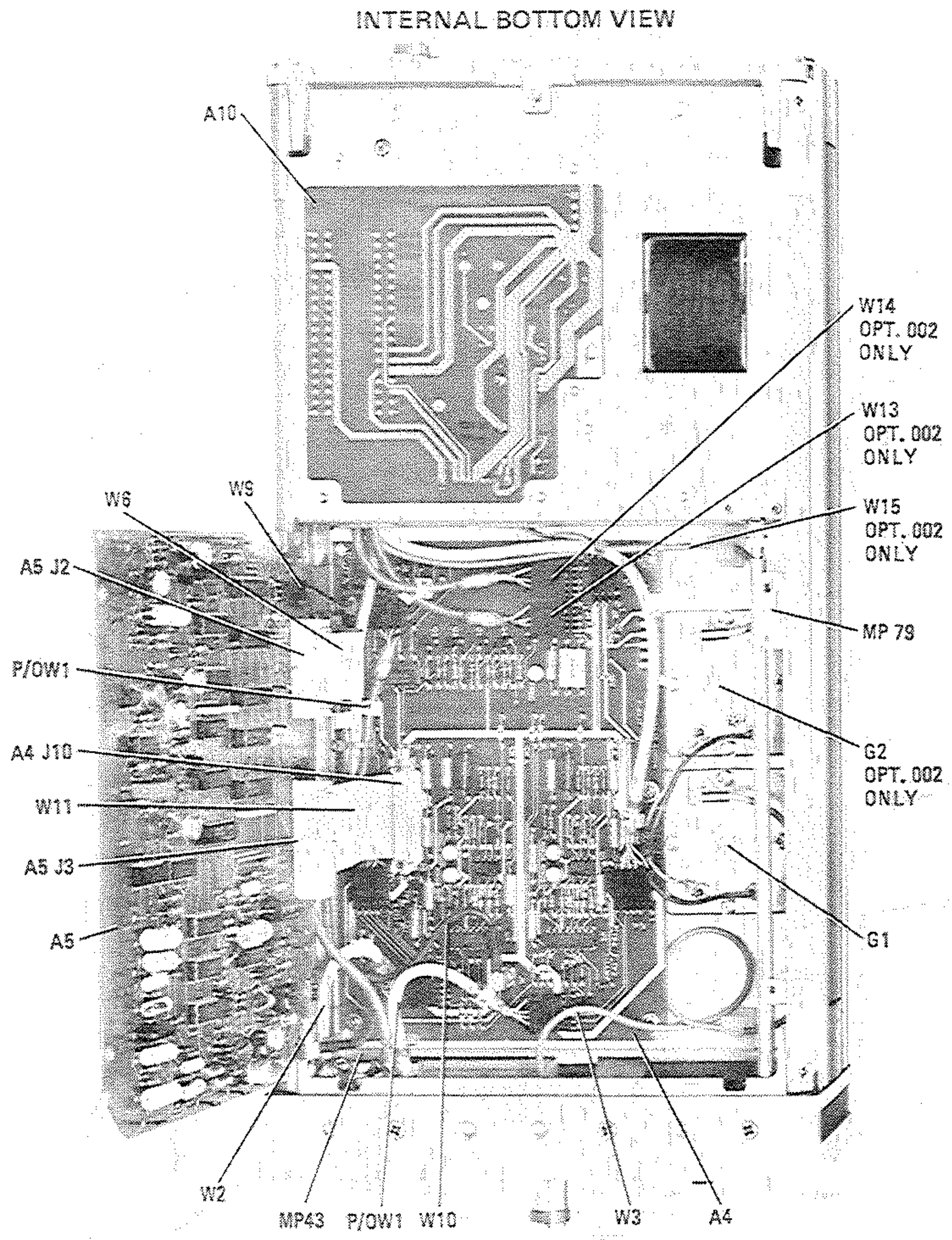


Figure 8-66. Internal Bottom View