

Errata

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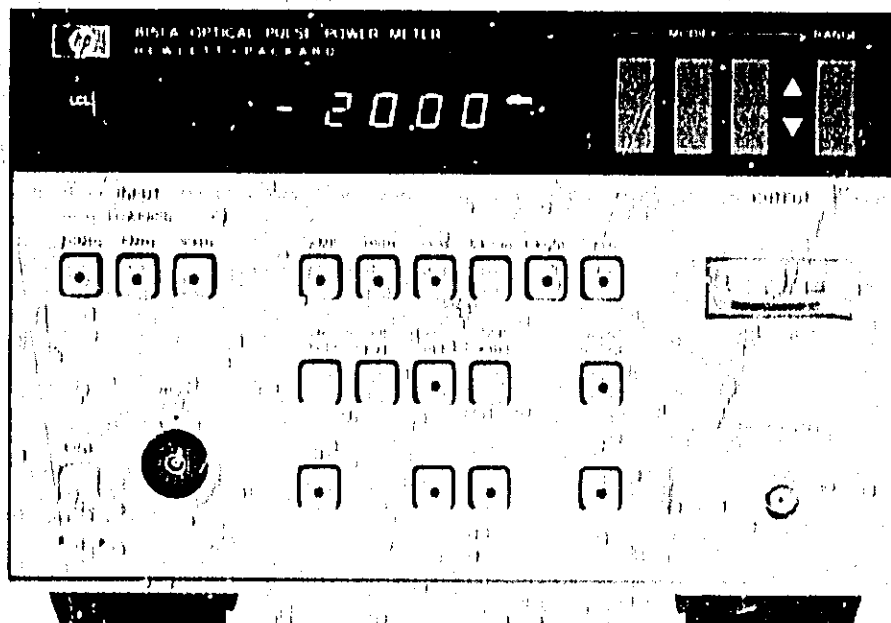
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Agilent Technologies

OPERATING AND PROGRAMMING INSTRUCTIONS

8151A OPTICAL PULSE POWER METER

**HEWLETT
PACKARD**



CERTIFICATION

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

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OPERATING AND PROGRAMMING INSTRUCTIONS

8151A OPTICAL PULSE
POWER METER

This manual applies directly to all instruments

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HERRENBERGER STR. 110, D-7030 BOBLINGEN
FEDERAL REPUBLIC OF GERMANY

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GENERAL — This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

OPERATION — BEFORE APPLYING POWER comply with the installation section. Additionally, the following shall be observed:

Do not remove instrument covers when operating.

Before the instrument is switched on, all protective earth terminals, extension cords, auto-transformers and devices connected to it should be connected to a protective earth via a ground socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in serious personal injury. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

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

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.

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present. Do not replace components with power cable connected.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

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

SAFETY SYMBOLS



The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.



Indicates dangerous voltages.



Earth 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 injury or loss of life. 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 equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.



Dangerous voltages, capable of causing serious personal injury, are present in this instrument. Use extreme caution when handling, testing, and adjusting.



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8151A

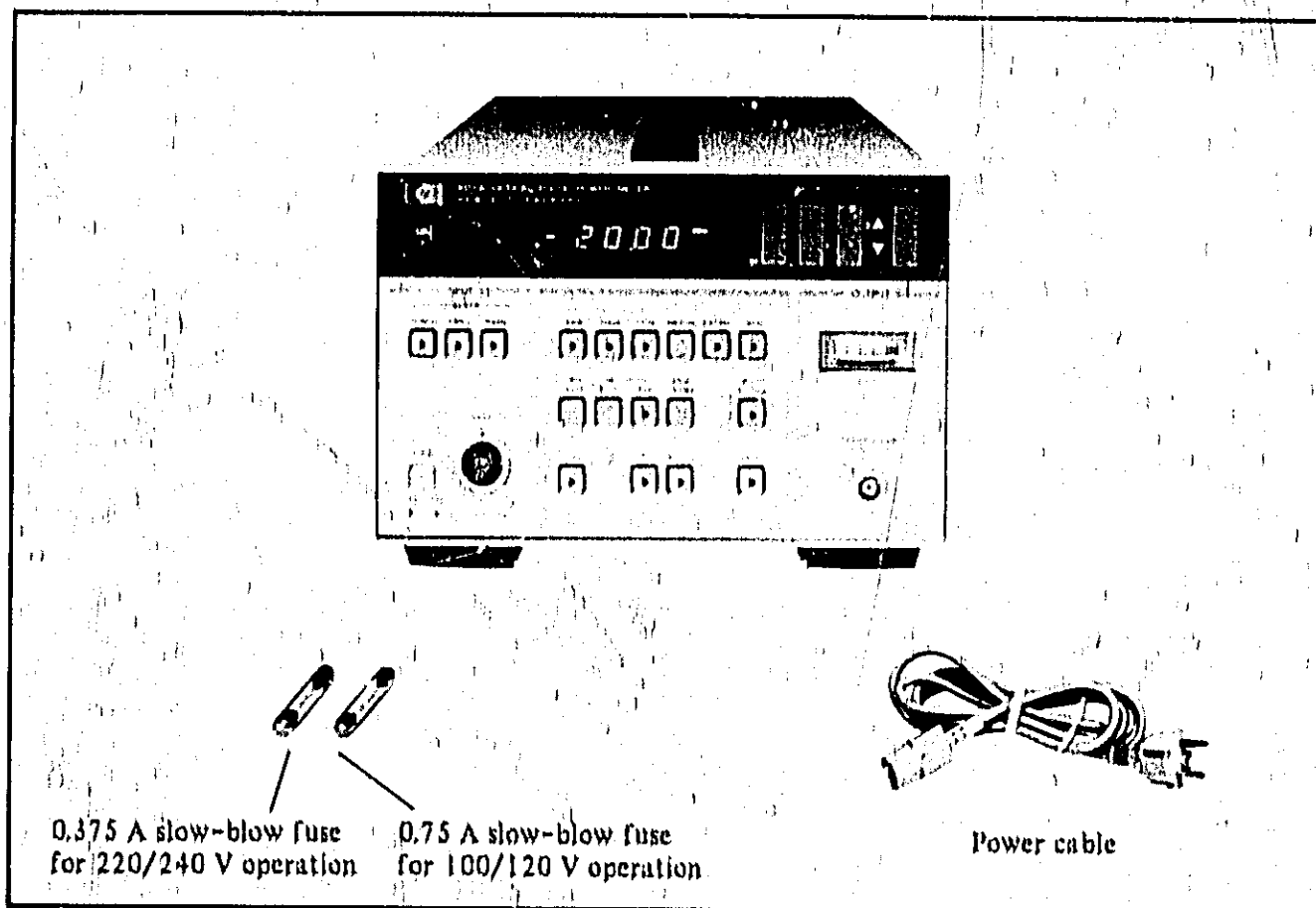


Figure 1-1. 8151A and supplied accessories

1-1 Introduction

1-2 This manual contains all the information required to install, test and operate the Hewlett-Packard Model 8151A Optical Pulse Power Meter. This section deals with instrument description, specifications and accessories.

1-3 Specifications

1-4 Specifications for this instrument are to be found in Table 1-2. These specifications are the performance standards against which the instrument is tested with an Optical Head connected.

1-5 Safety considerations

1-6 The 8151A is a Safety Class 1 instrument (it has an exposed metal chassis which is connected directly to earth via the power cable). Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be adhered to in order to ensure safe operation, and the maintenance of the instrument in a safe condition.

CAUTION

Do not make contact with the pins inside the frontpanel HEAD connector. A potential of up to 250 V may be present.

1-7 Description

1-8 The 8151A is capable of measuring both peak and average values of an optical signal, when aided by an Optical Head. It has a measurement range of +30 to -70 dBm within its 250 MHz bandwidth, and a resolution of 30 dB of full-scale in each range. In addition, a transducer output is provided to give an analog equivalent of the optical input signal.

1-9 Accessories supplied

1-10 The 8151A is supplied complete with the following items:

ITEM	HP PART NUMBER
0.75 A slow-blow fuse for 100/120 V operation or, 0.375 A slow-blow fuse for 220/240 V operation.	2110-0360
Power cable	2110-0427
	see Figure 2-2

1-11 Accessories available

ITEM	HP PART NUMBER
Front handle kit	5061-0089
Rack adapter kit (incl. filler panel)	5061-0057

1-12 Recommended test equipment

1-13 Equipment required to maintain the 8151A is listed in Table 1-1. Alternative equipment may be substituted, provided that it meets or exceeds the critical specifications listed.

TABLE 1-1, RECOMMENDED TEST EQUIPMENT

Instrument	Recommended model	Required characteristics
High-speed System Voltmeter	HP3437A	dc, > 400 readings/sec, delay
Digital Voltmeter	HP3456A	AC (rms), dc, HP-IB
Digital Multimeter	HP3465A	0.1 mA - 10 mA, dc
Oscilloscope	HP1740A	100 MHz bandwidth
Sampling scope	TEK 7603 + 7T11/ 7S11, S-3A	1 GHz bandwidth, one channel
Function Generator	HP3325A	20 MHz, THD < 1%, HP-IB
VHF Generator	HP8656A or 8654A	
Spectrum Analyzer	HP8558B	100 kHz - 1.5 GHz
Distortion Measurement Set	HP339A	
Power Meter	HP436A (opt.001)	HP-IB
Power Sensor	HP8482A	100 kHz
Pte-amplifier	HP8447A (opt.001)	2 x 20 dB
Optical Signal Source	HP8150A	1 nW - 2 mW, dc - 170 MHz, 850 nm
Optical/Electrical Transducer	ET18580A	calibrated standard 1 V/mW, 1 V/10 uW, 1 V/100 nW
Fast Optical Source	ET18857	Transition time < 1 ns, 2 mW
Optical Attenuator	NEC OD 8550	20 dB
Optical Attenuator	NEC OD 8550	10 dB
Computer	HP85F	HP-IB, BASIC
Signature Analyzer	HP5005A	
Logic Probe	HP545A	TTL/CMOS
Logic Probe	HP10525E	ECL
Connector Adapter	HP81510A	Diamond GFS1

TABLE 1-2, 8151A SPECIFICATIONS

All specifications are given for the 8151A operating with Optical Head HP81511A

Instrument accuracy excludes the Reference Standard Accuracy of $\pm 3.0\%$. Ranges are specified relative to the 10 uW point.

Optical Characteristics (81511A)

Wavelength Range	550 nm to 950 nm, actual wavelength is user-selectable. Calibrated for 850 nm.
Numerical Aperture	0.4 max.
Radiating Spot Diameter	400 um max.
Power Density	6 W/mm ² max. (+10 dBm range). 600 mW/mm ² max. (other ranges)
Connector Uncertainty	< 0.05 dB for Diamond GFS1, GFS3, NEC OD 9470, Amphenol 906 and HP SMA

Optical Power Measurements

Parameter displayed in Watts, dBm, and dB relative to a selectable power level.

Display 4 1/2 digits; shows decimal point, polarity, units (dB, dBm, mW, uW, nW and pW), overflow, underflow, HP-IB address, error conditions. Refresh rate is 1 Hz.

Following parameters can be measured:

High Power Level (HPL) Upper level of optical input power.
Low Power Level (LPL) Lower level of optical input power.
Mean Power Level (MPL) $1/2 (HPL - LPL)$
Extinction Ratio (EXR) HPL / LPL
Amplitude (AMP) $HPL - LPL$

Average Power (AVG) Sum of constant power and modulation power, averaged by 8 Hz lowpass. Average power range is related to high level peak power. Therefore, to prevent peak power overload, correct range must be selected if AUTORANGE function not active.

Measurement Ranges +10 dBm (10 mW) to -60 dBm (1 nW) in 8 ranges, 10% overload of full-scale.

Resolution 3 digits (Watts), 1 pW min.
 4 digits (dB), 0.01 dB min.

Measurement Accuracy

Peak power measurement specifications apply to 200 Hz squarewave in the ranges +10, 00 and -10 dBm; 30 Hz squarewave in all other ranges. ZERO function activated prior to measurement. 10 dBm range specified at 3 dBm optical input power.

Accuracy

Range (dBm)	High/Low Peak Power				Average
	+/- (of read + counts)	Flatness	typ. min Pulse top or base	min. Rep. Rate	Average Power +/- (of read + counts) dc < f < 50 Hz.
+10	0.3 dBopt +5	200 Hz-9.99 MHz +/- .3 dBopt of AMP	4 ns	200 Hz	0.1 dBopt +5
+00	0.15 dBopt +10	10 MHz-99.9 MHz +/- .5 dBopt of AMP	4 ns	200 Hz	0.1 dBopt +5
+10*	0.35 dBopt +50		4 ns	200 Hz	0.1 dBopt +5
Bandwidth					
-20	0.2 dBopt +10	10 kHz	110 us	5 Hz	0.1 dBopt +5
-30	0.2 dBopt +10	6 kHz	200 us	5 Hz	0.1 dBopt +5
-40	0.2 dBopt +10	4 kHz	300 us	5 Hz	0.1 dBopt +5
-50	0.2 dBopt +20	4 kHz	300 us	5 Hz	0.15 dBopt +10
-60	0.3 dBopt +80	4 kHz	300 us	5 Hz	0.2 dBopt +50

* For Flatness add ± 0.1 dBopt of amplitude

Amplitude, Measial Power Level and Extinction Ratio derived by mathematical conversion from Peak Power measurements.

Transducer (opto-electric)

Optical input signal is converted to its electrical equivalent; actual waveform depends on measurement range. Output calibrated for 850 nm, independent of calibration factor. Conversion factor and bandwidth follow measurement range selected.

Accuracy is specified for output voltages between 0.1 V and 1.1 V, with the ZERO function activated prior to conversion; applies to 30 Hz squarewave.

Range (dBm)	Conversion Factor dc	Accuracy of Conversion	Bandwidth w/o Lowpass	rms Noise (dBm)
+10	1 V/10 mW	± 0.3 dBopt ± 10 mV	dc - 250 MHz	-20
+00	1 V/1 mW	± 0.3 dBopt ± 10 mV	dc - 250 MHz	-30
-10	1 V/100 uW	± 0.35 dBopt ± 20 mV	dc - 250 MHz	-30
-20	1 V/10 uW	± 0.3 dBopt ± 20 mV	dc - 10 kHz	-50
-30	1 V/1 uW	± 0.3 dBopt ± 20 mV	dc - 6 kHz	-60
-40	1 V/100 nW	± 0.3 dBopt ± 20 mV	dc - 4 kHz	-70
-50	1 V/10 nW	± 0.3 dBopt ± 20 mV	dc - 4 kHz	-70
-60	1 V/1 nW	± 0.3 dBopt ± 50 mV	dc - 4 kHz	-70

Flatness of Conversion cumulative with Accuracy of Conversion (Ranges +10, +00, -10 dBm*)

30 Hz to 9.99 MHz	± 0.3 dBopt of amplitude
10 MHz to 99.9 MHz	± 0.5 dBopt of amplitude
100 MHz to 150 MHz	± 1.0 dBopt of amplitude
250 MHz	-3.0 dBopt of amplitude
	* add ± 0.1 dBopt of amplitude

Response (1 ns pulse transition of optical input)

Transition Time tr	≤ 1.8 ns full bandwidth
	≤ 10 ns 50 MHz lowpass
	≤ 100 ns 6 MHz lowpass

Overshoot, Ringing	$\leq 10\%$ of amplitude
Output Impedance	5 Ohm $\pm 2\%$
Mux. ext. voltage	± 2 Volts

Supplementary Performance Characteristics

Lowpass	50 MHz, 6 MHz, 10 kHz lowpass filters selectable for reduction of noise and perturbations of optical signals.
---------	---

Display Modes	
Watt	Linear readings.
dBm	Logarithmic readings.
dB(rel)	Readings as difference relative to selectable reference level setting.
REF	For entry of reference level setting.

REF→DISP

Defines momentary display readings as reference power level and sets dB(rel) to dBm.

AUTOrange

Automatically selects correct measurement range.

ZERO

Automatic compensation for amplifier offsets and peak noise. Accuracy specifications valid within 60 min. after ZERO activated.

CAL

For entry of calibration factors. Adjusts display so that gains and losses in measurement path are automatically included in displayed value. Watt range up to 1999 mW max., 0.1 pW min. dB range +/-99.99 dB. Transducer output is independent of calibration factor.

 λ

Display and selection of wavelength in nm increments.

 λ -CAL

Entry of correction factor as indicated on calibration grid on top of optical head.

Propagation Delay (Optical input to Transducer input)

Range

Delay (typ.)

+10 dB

20 ns

+00 dB

20 ns

-10 dB

20 ns

-20 dB

17 ns

-30 dB

25 ns

-40 dB

60 ns

-50 dB

60 ns

-60 dB

60 ns

Bit Error Rate

For BER $< 10^{-9}$ input power must be 10 dB greater than noise.

General

Recalibration Period

1 year

Warm-up Time

30 min. to meet accurate specifications

HP-IB Capability. All modes and parameters can be programmed.

Programming Times: Listen (time for 8151A to receive and verify a message)

Lcwpass, Unit change

< 6 ms

DISP→REF

< 8 ms

AUTOrange

< 6 ms

AMP, HPL, LPL, MPL, EXR,

< 4 ms

AVG

REF

< 11 ms

CAL

< 6 ms

WVL

< 18 ms

ZERO

< 25 sec

Selftest Routine (EST)

< 2.5 s

Talk (time for 8151A to transmit message)

Learn Mode

< 1 ms/character

Error Recognition

< 1 ms/character

Measurement Value

< 1 ms/character

Status

< 15 ms

Environmental**Storage Temperature**

-40 degC to +70 degC

Operating Temperature

0 degC to +55 degC

Humidity Range

95% R.H. > 0 degC to +40 degC

Power

100/120/220/240 Vrms +5% - 10%

48 - 66 Hz, 100 VA max.

Power-off Storage

After eight hours of operation, the battery is fully charged and maintains all current mode and parameter information for up to 2 weeks with instrument switched off.

Dimensions

140H x 220W x 530D millimeters

5.7" x 9" x 21.6"

Weight

net 8.0 kg (17.5 lbs), shipping 10 kg (22 lbs)

SECTION II

INSTALLATION

2-1 Introduction

2-2 This section provides installation instructions for the instrument and its accessories. It also includes information about initial inspection and damage claims, preparation for use and packaging, storage and shipment.

2-3 Initial inspection

2-4 Inspect the shipping container for damage. If the container or cushioning material has been damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1, plus any accessories which were ordered with the instrument. Procedures for checking the performance of the instrument are given in Section IV. If the contents are incomplete, mechanical damage or defect is apparent, or if the instrument does not pass the Operator's checks, contact the nearest Hewlett-Packard Office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting for settlement.

2-5 Preparation for use

WARNING

2-6 To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any part of the outer enclosure (covers, panels, connectors etc).

2-7 Power requirements

2-8 The 8151A requires a power source of 100/120/220 or 240 V rms (+5%, -10%) at a frequency of 48 to 66 Hz single phase. The maximum power consumption is 100 VA.

2-9 Line voltage selection

CAUTION



2-10 Before applying power to the instrument, ensure that it has been set for operation at the local line voltage. The line voltage selector is situated inside the line voltage connector on the rear panel.

Figure 2-1 details the switch assembly. Open the assembly by inserting a flat-bladed screwdriver into the recess at the top, and twisting it. The cover will open, revealing the selector. Remove the selector from the connector assembly and then replace it so that the local line voltage value is displayed at the front. In addition, ensure that the fuse is of the correct rating. Close the cover and ensure that the line voltage value shown is correct for local operation.

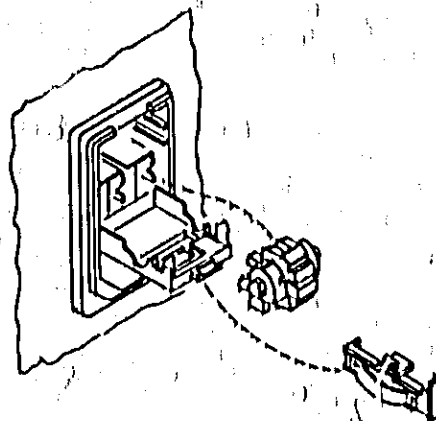


Figure 2-1. Line Voltage Selector

2-11 Power cable

WARNING

2-12 To avoid the possibility of injury or death, the following precautions must be noted before the instrument is switched on:

- If the instrument is to be energized via an autotransformer for voltage reduction, make sure that the Common terminal is connected to the grounded pole of the power source.
- The power cable plug shall only be inserted into a socket outlet provided with a protective ground contact. The protective action must not be negated by the use of an extension cord without a protective conductor.

- c) Before switching on the instrument, the protective ground terminal of the instrument must be connected to the protective conductor of the power cable. This can be verified by checking that the resistance between the instrument chassis, the frontpanel and the ground pin of the power cable is zero Ohms.

2-13 In accordance with International Safety Standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate a.c. power receptacle, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends upon the country of destination. Figure 2-2 gives details of the power cords available.

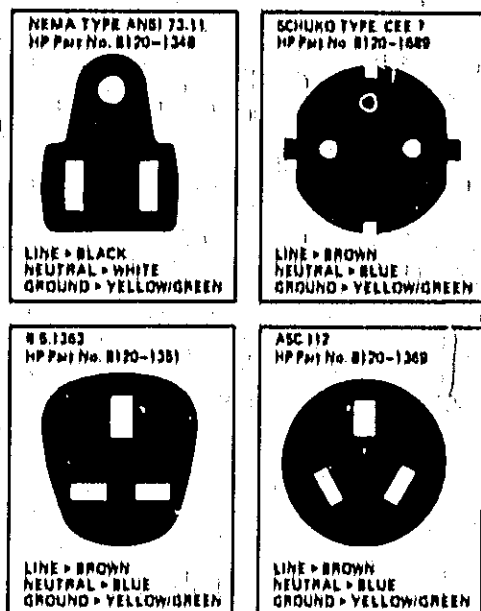


Figure 2-2. Power cords available

2-14 The following work should be performed by a qualified electrician only - all local electrical codes being strictly observed.

If the plug on the cable does not fit the power outlet, or the cable is to be connected to a terminal block, cut the cable at the plug and re-wire it. The color coding used in the cable will depend on the cable supplied (see Figure 2-2). If a new plug is to be connected, it must meet local safety requirements and include the following features:

- Adequate load-carrying capacity
- Ground connection
- Cable clamp

2-15 HP-IB connector

2-16 The rear panel HP-IB connector, shown in Figure 2-3, is compatible with the connector on cable assemblies 10833A, B, C and D. If a cable is to be manufactured locally, use connector male, HP part number 1251-0293.

2-17 HP-IB logic levels

2-18 The HP-IB lines use standard TTL logic, the levels being as follows:

True = low = digital ground or 0V dc to 0.4V dc
False = high = open or 2.5V dc to 5V dc

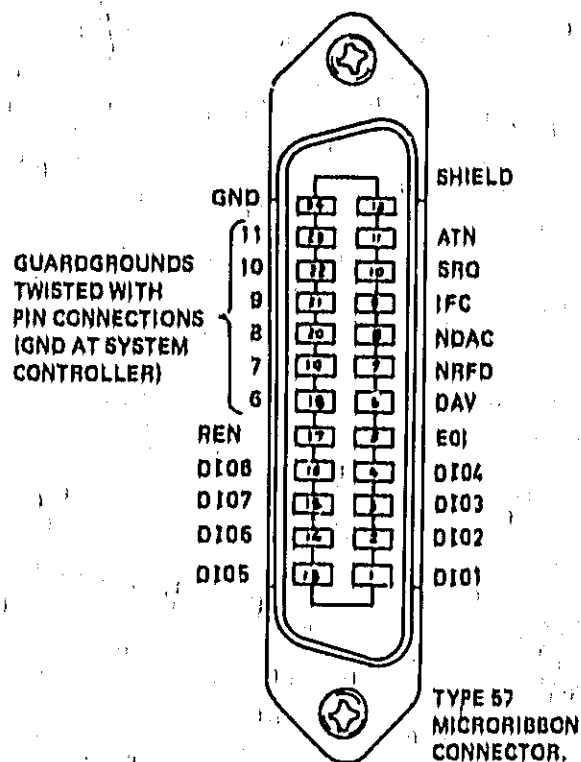


Figure 2-3. HP-IB connector

2-19 All HP-IB lines have low assertion states. High states are held at 3.0 V dc by pull-ups inside the instrument. When a line functions as an input, approximately 3.2 mA is required to pull it low through a closure to digital ground. When a line functions as an output, it will sink up to 48 mA in the low state and 0.6 mA in the high state.

ISOLATION: The HP-IB line screens are not isolated from ground.

2-20 Claims for damage

2-21 If physical damage is evident or if the instrument does not meet its specifications when received, notify the carrier and the nearest Hewlett-Packard Sales/Service office. The office will arrange for repair or replacement of the instrument without waiting for settlement of the claim against the carrier.

2-22 Storage and shipment

2-23 The instrument can be stored or shipped at temperatures between -40°C and $+70^{\circ}\text{C}$. The instrument should be protected from temperature extremes which may cause condensation within it.

2-24 If the instrument is to be shipped to an Hewlett-Packard Sales/Service office, attach a tag showing owner, return address, model number and full serial number and the type of service required. The original shipping carton and packing material should be used wherever possible, but the HP Office will provide recommendations on materials to be used if the original packing is no longer available or reusable. General instructions for repacking are as follows:

1. Wrap the instrument in heavy paper or plastic.
2. Use a strong shipping container. A double-wall carton made from 350-pound test material is adequate.
3. Use enough shock-absorbing material (3 to 4 inch layer) around the sides of the instrument to provide a firm cushion and prevent movement inside the container. Protect the control panel with cardboard.
4. Seal the shipping container securely.
5. Mark the shipping container FRAGILE to encourage careful handling.
6. In any correspondence, refer to instrument by model number and serial number.

OPERATION

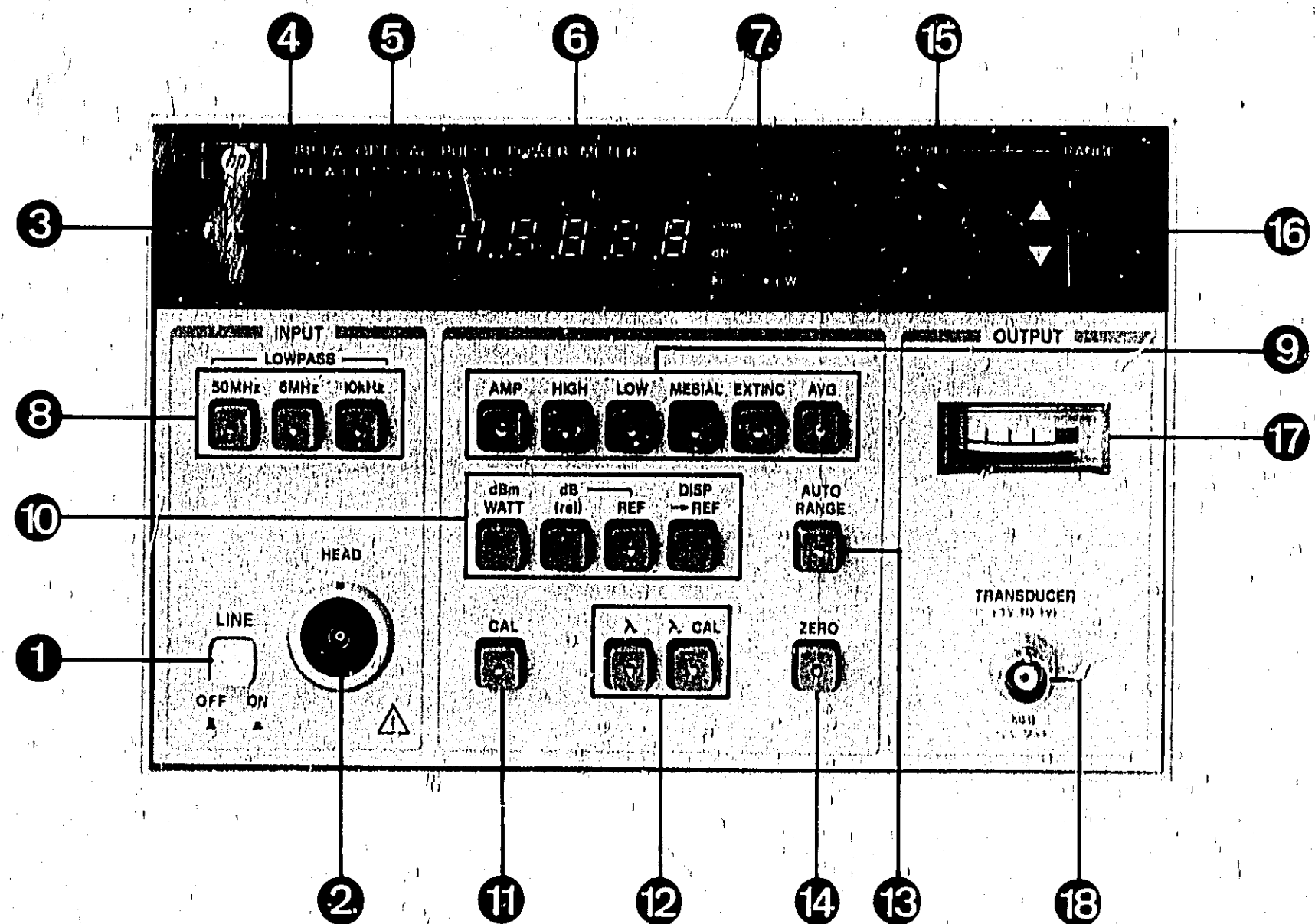


FIGURE 3-1. FRONTPANEL CONTROLS AND INDICATORS

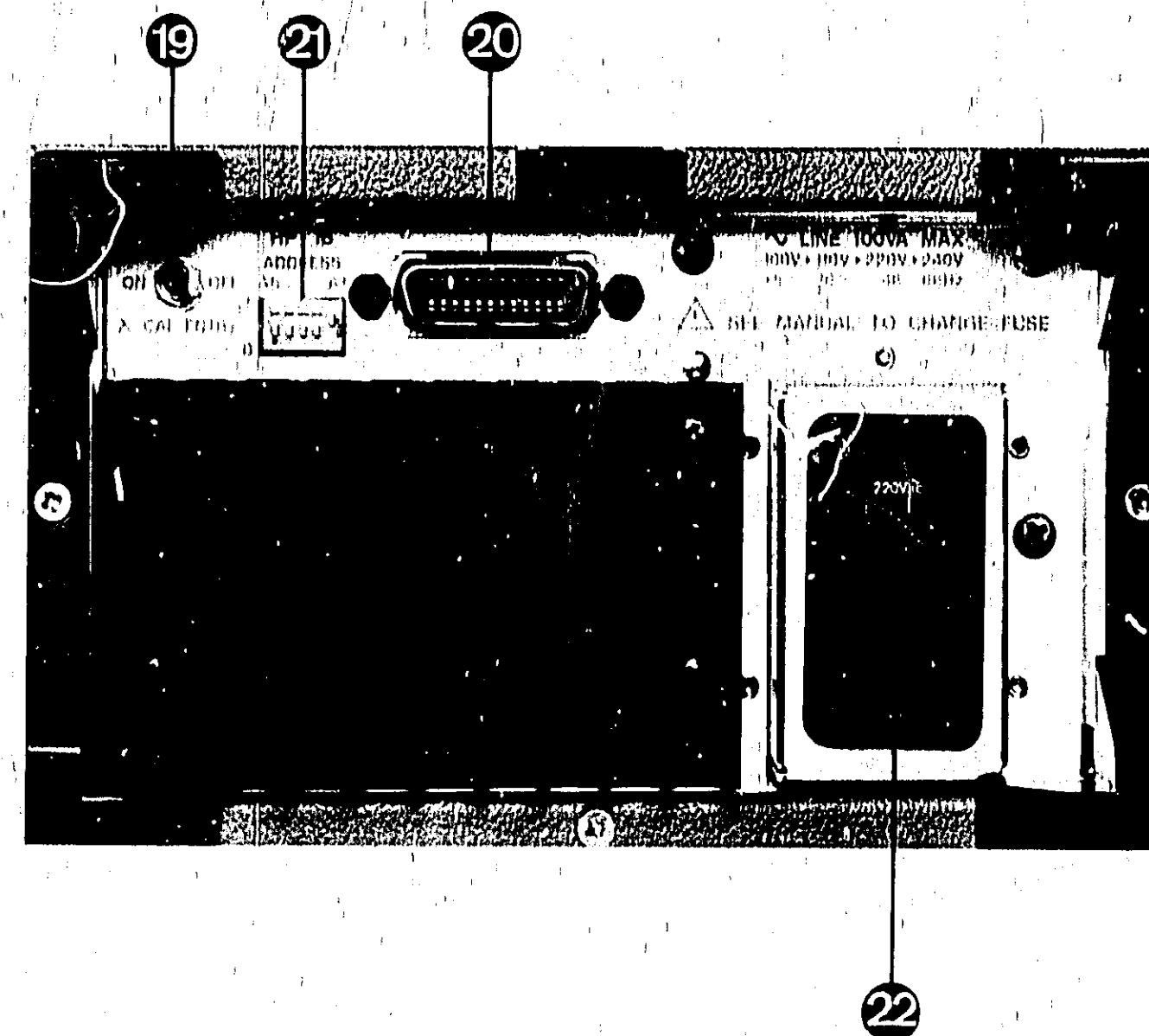


FIGURE 3-2. REARPANEL CONTROLS AND CONNECTORS

SECTION III OPERATING AND PROGRAMMING

3-1 Introduction

3-2 The following operating information explains the control and indicator functions of the Model 8151A Optical Pulse Power Meter. Front and rear panel controls, indicators and connectors are briefly described in Figures 3-1 and 3-2, which should be read before continuing with the following, more detailed descriptions. Programming information is to be found at the end of this section.

3-3 Special operating considerations

3-4 The following points should be noted before applying power to this instrument:

1. Ensure that the Safety Summary at the beginning of the manual has been carefully read and fully understood.
2. Ensure that the line voltage selector switch has been set to the local line voltage and the fuse is correctly rated.

3-5 Operator's checks

3-6 The 8151A performs a selftest routine at power switch-on. Before switching the instrument on, ensure that the Optical Head is connected. During the test sequence, all frontpanel led's shall be momentarily lit. In the event of a fault being detected, an error code will be presented in the digital display. The error codes are as follows:

☐ - Keyboard test failed.

E01 - Microprocessor RAM test failed

E02 - Wavelength calibration files destroyed.*

- * The wavelength calibration files may become corrupted or destroyed as a result of RAM back-up battery charge deterioration. This can be expected when the 8151A has not been connected to the mains supply for two weeks or more. In the event of this error code being displayed, the user will have to re-input the calibration factors for the Optical Head being used.

E03 - Service purposes only: Switches on measurement board not returned to their correct positions.

E04 - Timer test failed.

E10 - ADC, multiplexer, decoder or reference circuit failure.

E11 - Range DAC test failed.

E12 - Ramp DAC test failed.

E20 - AVERAGE measurement signal path test failed.

E21 - High Frequency measurement signal path test failed.

E22 - Low Frequency measurement signal path test failed.

E30 - High Frequency detector flip-flop failure.

E31 - Low Frequency high peak level detector test failed.

E32 - Low Frequency low peak level detector test failed.

E33 - High Frequency peak detector level test failed.

E80 - Informs the user that the zero calibration routine must be activated. If the routine is unsuccessful, a zero error (E51 or E52) appears. The 8151A is therefore defective.

3-7 The following tests are performed every time the ZERO function is activated:

E50 - Displayed if the ZERO function is selected when no Optical Head is connected.

E51 - Offset cannot be compensated for. Execute selftest routine to establish whether the fault lies with the optical head or the 8151A. If no selftest failure occurs, the optical head signal path is faulty.

E52 - Zero calibration test failed. Ensure that the optical input is closed. If so, refer to E51. If not, close the optical input and initiate the zeroing routine again.

3-8 The following test is performed continuously:

E90 - Head interface test failed.

FRONTPANEL CONTROLS AND INDICATORS

1. LINE

- Instrument power ON/OFF switch.

2. HEAD

- connector for signal from Optical Head.

3. LCL

- selection of this key when the 8151A is under remote (HP-IB) control returns the instrument to LOCAL (frontpanel) control, provided that the Local Lockout command has not been sent by the controller. When the instrument is under frontpanel control, selection of this key causes the 8151A's current HP-IB address to be displayed.

4. HP-IB status indicators

RMT

- when lit, indicates that the 8151A is under REMOTE HP-IB control. All frontpanel keys are inoperative except LCL.

ADS

- when illuminated, indicates that the 8151A is currently being ADDRESSED under program control. The frontpanel keys may be operative, depending upon the status of the RMT indicator.

SRQ

- indicates that a SERVICE REQUEST has been sent by the 8151A to the controller (see Programming).

5. Measurement status indicators

OVERLOAD

- indicates that the value of the parameter to be measured is outside the specified range. In AUTO RANGE mode, this indicator will only be illuminated when the absolute range limits are reached (see Figure 3-4 and specifications).

CAL ≠ 0

- displayed to remind the user that a cal. factor other than 0 dB has been selected.

HEAD

- illuminated when the Optical Head is not connected. Frontpanel keys continue to function and the middle segment of each digital display is illuminated to indicate that no measurement will be attempted by the instrument.

OVERRANGE

- the measured signal is outside the selected range. The digital display provides the indicators for overranging. Refer to Figure 3-4 for details.

6. Digital Display

- functions in two modes: When the instrument is displaying an input parameter or reference in Watts, the display occupies 3 1/2 digits. All other measurements and selections are performed with a 4 1/2 digit display.

7. Units Led's

- work in conjunction with the digital display to indicate the base units of the currently displayed data.

8. Filters

- The performance of all filters is dependent upon the position of the input signal on Sensitivity/Bandwidth curve.

FULL BANDWIDTH

- When no filter has been selected (or the active filter has been de-selected), the 8151A moves into FULL BANDWIDTH mode.

LOWP 50 MHz

- a lowpass filter with a 50 MHz cut-off frequency.

LOWP 6 MHz

- a lowpass filter with a cut-off frequency of 6 MHz.

LOWP 10 kHz

- a lowpass filter with a cut-off frequency of 10 kHz.

9. Parameter measurement group**AMP**

- when selected, the 8151A calculates the peak-to-peak AMPLITUDE power of the input signal. The calculation is based on the difference in HIGH and LOW peak power levels (HIGH - LOW). The result is displayed digitally.

HIGH

- when selected, causes the peak HIGH power level of the input signal to be displayed.

LOW

- when selected, causes the peak LOW power level of the input signal to be displayed.

MESIAL

- when selected, causes the 8151A to calculate the peak MESIAL (mean) power level of the input signal. The calculation is based upon the sum of peak HIGH and LOW power levels divided by two [$1/2 (HIGH + LOW)$].

EXTINC

- when selected, causes the 8151A to calculate the EXTINCTION RATIO of the input signal. The calculation is based upon the division of the peak HIGH power level by the peak LOW power level (HIGH/LOW).

AVG

- when selected, causes the 8151A to measure the AVERAGE power level of the input signal.

10. Parameter Units and Reference keys**dBm/WATT**

- toggles between units of dBm and WATTS, and causes the current parameter measurement to be displayed in the units selected. Note that when WATT is selected, the display reverts to 3 1/2 digits.

dB (rel)

- used to display the currently active parameter measurement in dB's RELATIVE to the previously selected REF value. The dB (rel) key is also used in conjunction with the REF key, and the reference always displayed in dBm.

REF

- used in conjunction with the DISP → REF, MODIFY and RANGE rocker keys to select a value to which all measurements are referenced. The units of reference are dBm or Watt.

DISP → REF

- when selected, this key enables the user to update the previously-selected REF value with the measurement value currently in display. The displayed value is then automatically stored as the new REF value. Only dBm and Watt values may be taken as references. Note that EXR values cannot be used as references.

11. CAL. (cal. factor)

- the cal. factor is always input in dB's and has a range of ± 99.99 dB. The value of the displayed parameter is representative of any cal. factor selected for the input signal. If the cal. factor is greater or less than zero, the CAL $\neq 0$ display will be illuminated.

12. Wavelength (λ) and Wavelength cal. factor (λ CAL).

- These keys are used in conjunction with the λ CAL ENTRY key on the instrument's rear panel. They are used together to input the cal. factor values shown on the Optical Head in steps of 50 nm, so that the 8151A can interpolate the change in sensitivity of the Optical Head for the wavelength of the signal input to it. The interpolation is performed in steps of 1 nm. When active, all other keys except MODIFY and RANGE rocker keys are disabled, in addition to those displays not associated with this task.

 λ (Wavelength)

- used in conjunction with the MODIFY and RANGE rocker keys to select a wavelength value to which a λ CAL factor is to be assigned. Also used to select the wavelength at which the instrument is currently operating.

 λ CAL (Wavelength cal. factor)

- when selected after a wavelength value has been input, enables the user to enter a λ CAL factor value via the MODIFY and RANGE rocker keys. This key is also used to call the interpolated λ CAL factor for the wavelength at which the 8151A is working into display. When the key is released, the display returns to its previous status.

13. AUTO RANGE

- when selected, the 8151A automatically selects the optimum range for the measurement of the currently active parameter to be performed in.

14. ZERO

- functions only when the Optical Head is connected to the instrument. When selected, the display and all other keys become momentarily inoperative. The 8151A is then automatically recalibrated to a zero reference.

15. MODIFY keys

- used in conjunction with REF, CAL, λ and λ CAL keys to MODIFY the three most-significant digits of the displayed value.

16. RANGE

- used for the ranging of all parameter measurements and ranging for base units of Watts. Also used in conjunction with REF, CAL, λ and λ CAL keys to control the least-significant digit of the display.

17. TREND METER

- indicates the average value of the input signal in the selected range. Can also be used in conjunction with the AVG and AUTO RANGE keys to determine the most effective connection between an optical cable and the Optical Head.

18. TRANSDUCER output

- outputs an electrical signal, centered at 850 nm, representative of the optical input signal to the Optical Head. The strength of the signal appearing at this port depends upon the range selected for the measured parameter.

NOTE: If the 8151A has been set up to operate at a wavelength other than 850 nm, which has been assigned a λ CAL factor other than 0, the displayed measurement value and the transducer output will not be the same.

REAR PANEL CONTROLS AND CONNECTORS**19. λ CAL ENTRY switch**

- used in conjunction with the λ and λ CAL keys. The switch is activated before values are input, and de-activated to fix the last (Stop) wavelength value in the memory.

20. HP-IB connector.
21. HP-IB Address switch.
22. Line voltage input and selector assembly.

3-9 Peak level measurements

3-10 In all peak modes (AMP, HIGH, LOW, MESIAL and EXR), the instrument measures the high and low signal parameters only. For AMP, MESIAL and EXR results, the 8151A calculates values as follows:

$$\begin{aligned}\text{AMP} &= \text{HIGH} - \text{LOW} \\ \text{MESIAL} &= 1/2(\text{HIGH} + \text{LOW}) \\ \text{EXR} &= \text{HIGH}/\text{LOW}\end{aligned}$$

Note that as EXR is a ratio, no units led's are illuminated.

3-11 Average power level measurements

3-12 As illustrated in Figure 3-3, the AVG power level measurement is a function of both signal width (or duty cycle) and frequency. The displayed value for any measurement is that of the average power level between signal events.

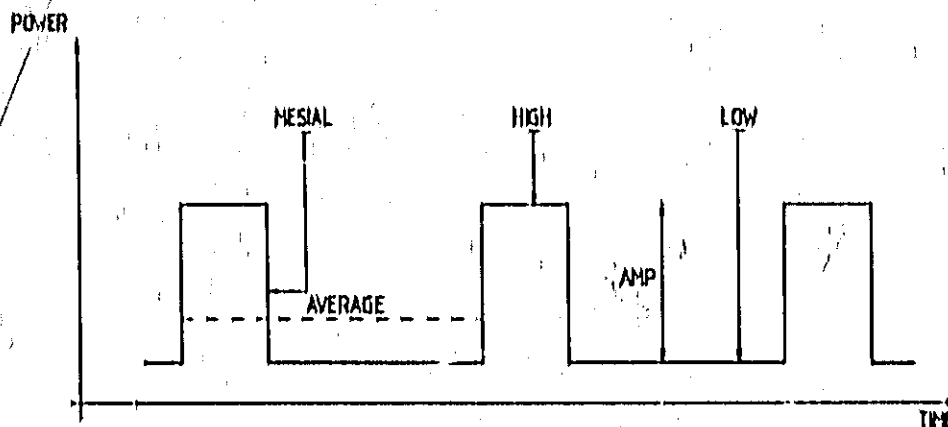


Figure 3-3. Measurement parameters

3-13 Calibration factor

3-14 For some applications, the user will require that the value of the displayed measurement should take into account gains and attenuations through repeaters and lengths of fiber cables etc. If an optical system has, for example, two elements with a total gain of 6.5 dB, and a cable with losses of 8.7 dB, entering a cal. factor of -2.2 dB will result in the displayed measurement value being equal to the signal input to the system.

3-15 Displayed measurement values

3-16 As stated in the description for Figure 3-1, measurement values can be displayed in Watts, dBm or dB's - relative to a given reference. The methods of calculating the the relationship between base units are as follows:

display

$$\text{dBm: input (dBm) - cal (dB)}$$

$$\text{dB: input (dBm) - cal (dB) - REF (dBm)}$$

$$\text{mW: exp}\{0.1 [\text{input (dBm) - cal (dB)}]\}$$

$$\text{input dBm: } 10 \log [\text{input (mW)}]$$

Table 3-1 shows various display values for a series of inputs to the instrument. The REF and CAL. values have been carefully selected, in order to provide the variety of values shown.

Table 3-1. Displayed measurement values

Input		CAL. dBm	REF dBm	Display		
dBm	Watts			Watts	dBm	dB
+30	1000mW	0	-10	1000mW	+30	+40
+20	100mW	+10	-10	10mW	+10	+20
+10	10mW	+30	+20	10uW	-20	-40
0	1mW	-20	+10	100mW	+20	+10
-10	100uW	+10	+10	10uW	-20	-30
-20	10uW	-30	-50	10mW	+10	+60
-30	1uW	-30	-10	1mW	0	+10
-40	100nW	-30	+30	100uW	-10	-40
-50	10nW	-30	0	10uW	-20	-20
-60	1nW	-30	+20	1uW	-30	-50
-70	100pW	-30	-10	100nW	-40	-30

3-17 Ranging

3-18 The 8151A performs peak and average measurements throughout eleven specified ranges (+30 dBm to -70 dBm). The number of ranges actually used, however, depends upon the type of optical head connected. For example, the 8151A optical head utilizes ranges +10 dBm through -60 dBm. Figure 3-4 illustrates the 8151A measurement ranges. Measurement results can be displayed linearly in Watts, or logarithmically in dBm and dB (rel). Figure 3-4 further shows the absolute range limits imposed at +/-10% of full-scale (linear), and the corresponding equivalents for

logarithmic ranges. In addition, a further 10% at the top end of each range is dedicated to informing the user that an OVERLOAD has occurred. This means that the high power level parameter of the input signal is outside the selected specified range. In this case, the user must either range-up to the next range manually, using the RANGE rocker key, or select the AUTORANGE function to find the best range to perform measurements in. Pressing the AUTORANGE key a second time returns control to the RANGE key. Each range has a measurement resolution of 30 dB below full-scale, e.g. the -20 dBm range (1 uW to 10 uW) will measure parameter values to a resolution of 10 nW.

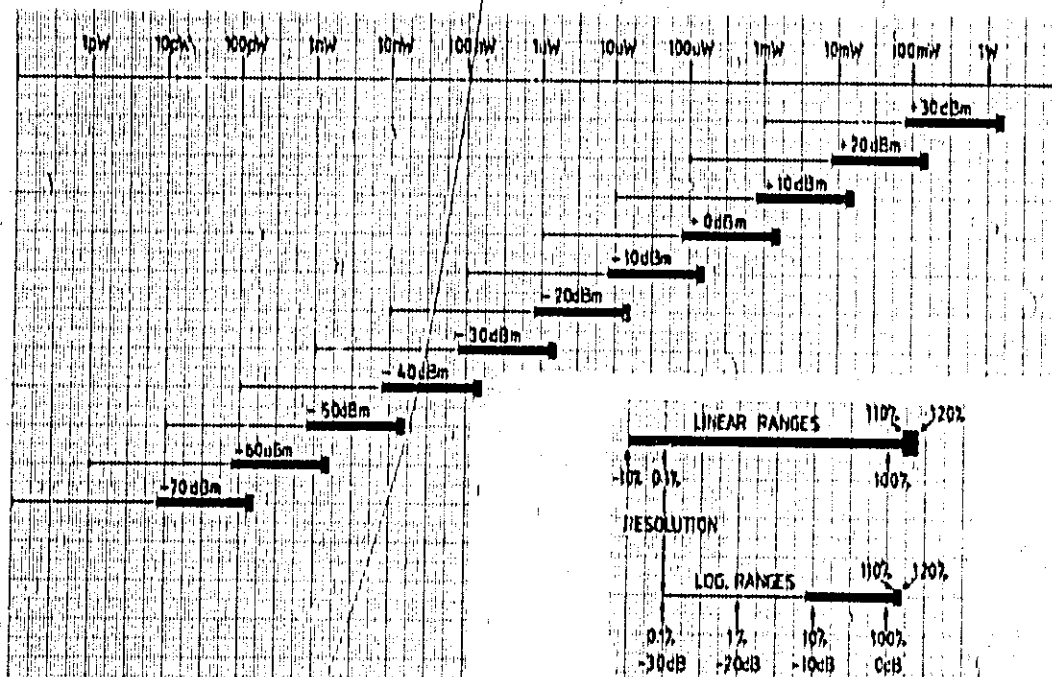


Figure 3-4. 8151A ranges

3-19 If the high power level of the 8151A input signal exceeds the +20% limit at the top end of a range, an **OVERRANGE** condition occurs. When this happens, the instrument will display a message digitally, e.g.

- 30 □ dBm

The numerical value displayed informs the user of the current range selection, and so helps to determine the range which will give the best resolution.

3-20 At any time during a parametric measurement, the user can interrogate the 8151A to determine the currently selected range. This is achieved by pressing the active parameter key (key led illuminated). Range identification will be displayed for as long as the parameter key is pressed. Note that range identification is based upon the full-scale value of that range i.e. -10 dBm range is from 10 uW to 100 uW (linear), and -20.00 dBm to -10.00 dBm (logarithmic). The measurement resolution for all ranges is 30 dB below full-scale.

3-21 When the Meas'd power level of the input signal is below the -10% absolute limit of the selected range, error code E80 will be displayed. It will be necessary at this stage for the user to initiate the **ZERO** function. If the calibration routine is successful, the 8151A returns to its operational status. If the routine is unsuccessful, error codes E51 or E52 will be displayed. See Operator's checks at the beginning of this section.

3-22 Filters

3-23 The filters serve two purposes: Firstly, they help to remove any noise present on the transducer output and the resulting display values, and secondly, they allow the minimum pulse width for peak power measurements to be increased (see specifications).

3-24 The filters have cutoff frequencies of 50 MHz, 6 MHz and 10 kHz respectively. The first two filters are of the 'third order' type, which means that the frequency response curve of the filter falls away at 60 dB/decade below the cutoff frequency. The 10 kHz filter is a 'first order' type, in which the response falls away at 10 dB/decade below the cutoff frequency.

3-25 Entry of λ and λ Cal data in Local mode

3-26 The entry of λ and λ CAL values is necessitated because some wavelengths are attenuated within the bandwidth of the Optical Head, which is more sensitive to variations in optical wavelength than the 8151A. Figure 3-5 illustrates the bandwidth curve for the 8151A Optical Head and serves to illustrate the point. Entering the cal. factors for various wavelengths under the bandwidth curve allows the 8151A to compensate for the reduction in peak amplitude power, thereby giving accurate results for measurements made.

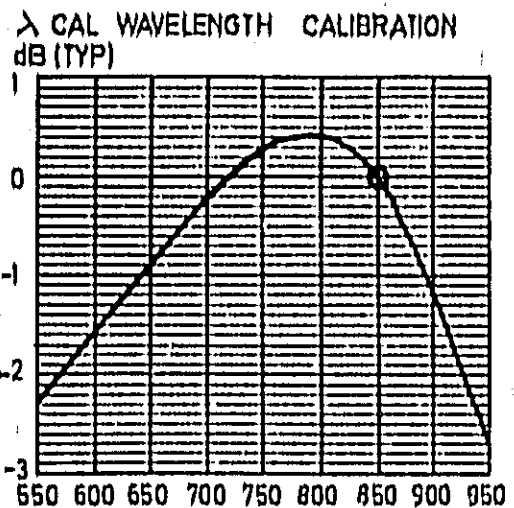


Figure 3-5. Optical Head bandwidth curve

3-27 To begin with, the Optical Head must be connected to the instrument before any data associated with the Head type can be input. Next, activate the λ CAL ENTRY switch on the rear panel. All displays except the digital, nm and dB units led's will be masked. In addition, all front-panel keys other than λ , λ CAL and the MODIFY/RANGE group are inhibited. The method of data entry is as follows:

1. Select the λ key and enter the wavelength value via the MODIFY keys. The displayed value changes in steps of 50 nm.
2. To enter the λ CAL value for a wavelength, press the λ CAL key. Any previous λ CAL value for the wavelength will be displayed. If the displayed value is unacceptable, it can be altered via the MODIFY/RANGE keys.

3. The next wavelength to be assigned a λ CAL value is selected by pressing the λ key. The key led will become illuminated. The last wavelength to have been selected will again be displayed. Increment the display using the MODIFY keys to the value required and press the λ CAL key to enter it into the memory. Select the λ cal. factor via the MODIFY/RANGE group.
4. Continue with step 3 until the last λ CAL value has been assigned. When all wavelengths have been assigned a value, de-activate the λ CAL ENTRY switch on the rear panel. A wavelength value will then be called into display.

NOTES:

- a) Before taking any parametric measurements of the input signal, the 8151A must be informed of the wavelength of the signal in order to measure accurately. The working wavelength is entered by pressing the λ key and incrementing or decrementing the display digits via the MODIFY and RANGE keys to the required value. It will be noted at this point that the display can be altered in units of 1 nm if so desired.
- b) The λ CAL value for the selected wavelength can be called to display by pressing the λ CAL key. When the instrument has been set for operation at a wavelength other than one which had a λ CAL value assigned to it, the 8151A automatically interpolates the λ CAL value, and displays it on demand. After release of the λ CAL key, the 8151A display returns to its previous operational status.
- c) If the instrument has been switched-off for sufficient time to drain the RAM back-up battery, the contents of the RAM's which hold the last set of operational data will have become corrupted or destroyed. In this case, error code E02 will be displayed when the 8151A is switched-on again. The previously-entered λ and λ CAL values will also be lost, and the instrument will, upon interrogation, provide default values of 0.00dB for each value selected.

3-28 Zero function

3-29 The ZERO key is used to initiate a calibration routine, performed under software control, in which the 8151A hardware is referenced to zero (no offset). The calibration routine typically takes between 20 and 30 seconds to complete. If the routine is successfully accomplished, the instrument returns to its former operational status. If however, the routine is unsuccessful, an error code will be presented by the digital display when the 8151A is operating locally. If the instrument is being operated remotely on the HP-IB, a Service Request will be sent to the controller should any problem arise with the zeroing of the instrument.

NOTE: In order to achieve precise results, it is recommended that the zero calibration routine be initiated every five minutes during the prescribed half-hour warm-up time, and every hour thereafter.

3-30 Optical head connector

3-31 In addition to taking the signal from the optical head, the HEAD connector acts as an interface between the two instruments. Information concerning peak and average measurement modes, head shutter position and range selection is sent by the 8151A to the optical head. In return, the optical head passes information concerning its operational status and identification to the 8151A.

WARNING

Do not make contact with any of the pins inside the frontpanel HEAD connector. A potential of up to 250 V may be present.

3-32 Transducer

3-33 The power level of the input signal is converted via a preset conversion factor, as shown in Table 3-2.

Table 3-2. Transducer conversion factors

Range	Conversion factor
+30 dBm	1 V/1000 mW
+20 dBm	1 V/100 mW
+10 dBm	1 V/10 mW
0 dBm	1 V/1 mW
-10 dBm	1 V/100 μ W
-20 dBm	1 V/10 μ W
-30 dBm	1 V/1 μ W
-40 dBm	1 V/100 nW
-50 dBm	1 V/10 nW
-60 dBm	1 V/1 nW
-70 dBm	1 V/100 pW

NOTE: If the 8151A has been set for operation at a wavelength which has a λ CAL factor of, say -2.2 dB, the transducer output will be 2.2 dB down on the displayed value. Furthermore, if the user sets the instrument to operate at, say 950 nm, and inputs an 850 nm wavelength signal, the displayed measurement values will differ by whatever the 950 nm λ CAL value is. Again, the displayed value and the transducer output will not agree.

3-34 PROGRAMMING INSTRUCTIONS

3-35 General

3-36 The 8151A operates on the HP-IB in Listener and Talker modes.

3-37 In Listener mode, the instrument listens to messages from the system controller. In this state, all modes and parameters are fully programmable. In addition, there are special HP-IB-only functions to aid the programmer.

3-38 In Talker mode, the 8151A reports on operational status, measurements taken and provides error messages, when prompted by the controller. This is known as Local Talk Capability.

3-39 Lines on the HP-IB all use negative logic and are assigned as follows:

8-bit data bus - lines DIO0 to DIO7

handshake lines - DAV (data valid), NRFD (not ready for data), NDAC (data not accepted)

control lines - IFC (interface clear), ATN (attention) SRQ (service request), REN (remote enable), EOI (end or identify)

3-40 The 8151A uses all lines on the bus. In this manual bus information is restricted to 8151A specifics (it is assumed that the user has a working knowledge of HP-IB intrinsics). For this reason, handshake lines are not discussed, and control lines are mentioned only with specific 8151A activity in mind.

3-41 Address assignment

3-42 The 8151A's HP-IB address (i.e. the binary number to which the instrument responds on the bus) is held in an internal storage register. This register is initialized at power switch-on by reading address bits A1 thru A5 of the HP-IB address switches on the rear panel. The address to which the instrument responds is determined by the setting of the slider switches to the desired binary number (0 to 30). When the address has been set, enter it into the register by pressing the LCL key on the frontpanel. The new address will be displayed digitally. All examples in this manual assume the address to be 18.

Note: When allocating addresses to instruments on the bus, ensure that no two devices have the same address.

3-43 Talk and Listen addresses are transmitted over the bus lines by the system controller with the ATN line set true. When an instrument recognizes its address, it will respond accordingly, i.e. listen if Listen addressed, or talk if Talk addressed. To address the instrument, set ATN line true and transmit the ASCII character which has been chosen as the address down the bus. To de-address, use UNL or UNT commands, or address a different device.

3-44 Remote operator's checks

3-45 A quick check of the 8151A's Talk/Listen functions is provided in Figure 3-7.

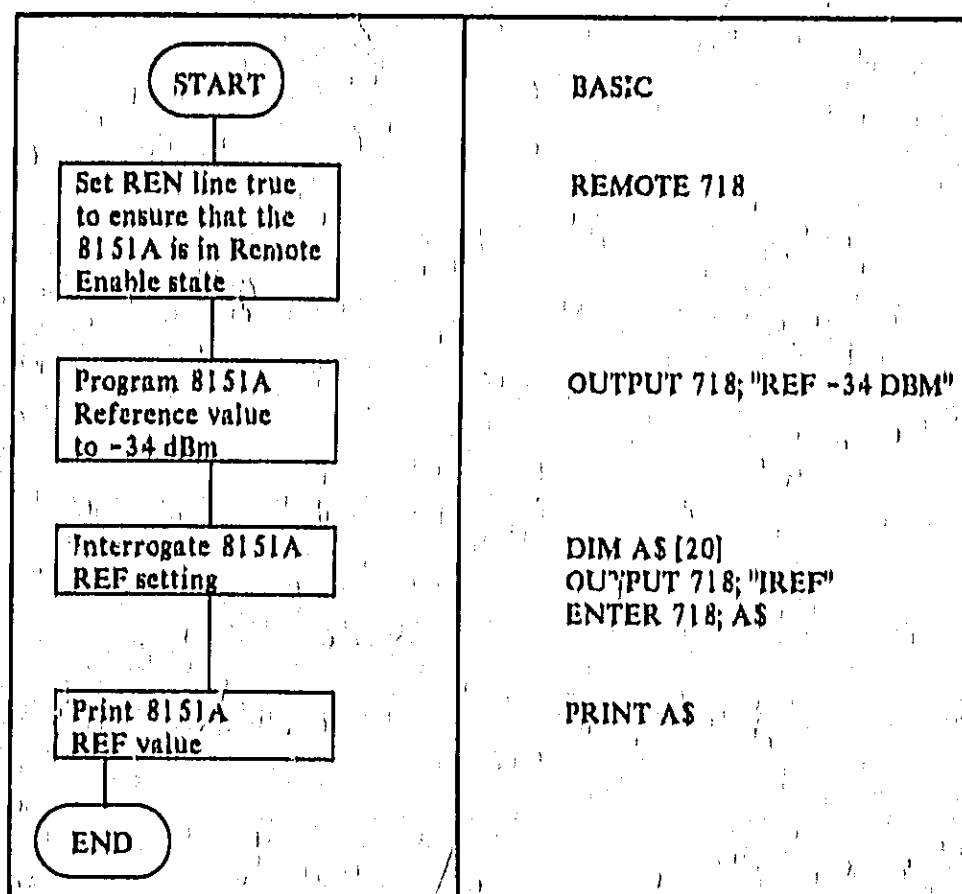


Figure 3-7. Talk/Listen function check

3-46 The 8151A has been provisioned with a hardware selftest routine which is initialized by the HP-IB message "EST". In the event of a fault being detected, bit 7 of the HP-IB Status Byte will be set true (see Error Reporting).

3-47 Mode and parameter settings (Listener function)

3-48 When the 8151A is in the Remote (RMT) mode, and has been Listen addressed, messages which change mode and/or parameter selections are accepted. Each mode and parameter selection comprises either a number of ASCII data bytes transmitted serially over the data lines, or an HP-IB Universal command. The coding of the bytes is given in Table 3-3, which shows all messages re-

quired by the 8151A for bus operation. Table 3-6 is provided in order to reference each ASCII byte a bit pattern on the data bus.

3-49 Mode and parameter settings (Talker function)

3-50 The 8151A can send messages consisting of mode and parameter settings, when addressed to talk. The available modes are as follows:

- Measurement results
- Interrogate parameter
- Learn string
- Status

Table 3-4 lists the ASCII commands associated with each of these modes.

3-51 Measurement results

3-52 These can be accessed via the command "IMR", and are representative of the following current parametric measurements:

AVG if active, or
AMP, HPL, LPL, MPL and EXR if a PEAK
measurement key is active.

Note that the base units of power level parameters can be selected via the commands U0 (dBm), U1 (Watts) and U2 (dBr). See Table 3-3 and Programming examples for details.

3-53 Parameter interrogation

3-54 The Interrogate Parameter commands (see Table 3-4) allow the user to interrogate the specified parameter settings. In addition, complete sets of Optical Head wavelength calibration factors can be accessed. Furthermore, the user can extract data concerning an individual parameter or a selected group of parameters using the following process:

BASIC (HP85)

```
DIM AS [50]
OUTPUT 718; "HPL"
ENTER 718; A3
PRINT AS
END
```

output: HPL -23.66 DBM

3-55 Learn string

3-56 The Learn string message (interrogated by the "CST" command), consists of an ASCII string which represents the current 8151A settings. The order in which data is presented is always the same. The last parameter to appear in the string is that of the active (currently displayed) parameter. Note that measurement values are not present in the Learn string.

3-57 Status Byte

3-58 The Status function sends an 8-bit byte in response to a serial poll, i.e;

BASIC (HP85)**S-SPOLL (718)**

Detailed information concerning the Status Byte is given under 'Error Reporting'.

3-59 In all Talker modes, the 8151A terminates its data message with the ASCII character sequence CR/LF.

3-60 Error reporting

3-61 Generally, whenever a program attempts to put the 8151A into an error condition, the instrument responds by making a Service Request. Under these circumstances, the controller must address the 8151A as Talker by sending a serial poll command. The instrument will then respond by outputting an error message to the data bus. This error message is composed of an 8-bit byte in which bit 6 is set true (logic '1'), and bits 0 to 3 and bit 7 indicate the error type. In all cases, the error can be identified by a logic '1' level on any of these seven bits.

3-62 When interrogated by Serial Poll, the 8151A will send the controller a message which is displayed decimally. This number will be between 1 and 255. The number can be broken down into its binary components (D0=1, D1=2, D2=4, D3=8 etc) to determine which bits of the Status Byte have gone high. The bits can also be interrogated individually by inputting the following commands to the controller:

```
BIT (S,0)
BIT (S,1)
BIT (S,2) etc
```

3-63 As can be seen from Table 3-5, bits 0 to 3 are each allocated an error type, i.e. RANGE, NO HEAD, SYNTAX and ZERO FAILURE. As stated above, a logic '1' on any of these bits indicates an error.

3-64 Should a more detailed description of the error be required, (e.g. Head failure or Selftest failed when System failure is indicated by the Status Byte), the Interrogate Error ("IERR") command may be used. The 8151A will then respond by specifying the error type.

Table 3-3. HP-IB Commands (Listener function)

Parameter/Operation	Mnemonics	Data	Units
Full Bandwidth	F	0	
Lowpass 50 MHz	F	1	
Lowpass 6 MHz	F	2	
Lowpass 10 kHz	F	3	
Power Level Unit			
dBm	U	0	
Watt	U	1	
dB (rel)	U	2	
Auto Ranging			
off	AR	0	
on	AR	1	
Single Trigger			
off	T	0	Default (continuous mode)
on	T	1	
Zero Adjust	ZER		
Disp→Ref	DTR		
Range	RNG	value	DBM
		+30	
		+20	
		0	
		-60	
		-70	
Measurement keys			
Amplitude	AMP		
High Power Level	HPL		
Low Power Level	LPL		
Merital Power level	MPL		
Extinction ratio	EXR		
Average	AVG		
Reference	REF	value	W = Watt MW = milliwatt UW = microwatt NW = nanowatt PW = picowatt DBM
Cal. Factor	CAL	value	DBR
Wavelength (λ)	WVL	value	NM = nanometer
Wavelength Cal. value	WCV	form 1	Input sequence
Execute Selftest	EST		

Table 3-4. HP-IB commands (Talker function)

Learn Mode	CST	current setting without measurement values
Interrogate Parameter		report parameter value to controller
	IREF	interrogate reference value
	ICAL	interrogate cal. factor value
	IWVL	interrogate working wavelength
	IWCP	interrogate sensitivity loss
Range	IRNG	talk actual range
Interrogate λ CAL setting	IWC1	complete setting for head 1
	IWC2	complete setting for head 2
	IWC3	complete setting for head 3
	IWC4	complete setting for head 4
	IWCV	form 2 (output sequence)
Interrogate Measurement Results	IMR	report current value of AVG, if active, or AMP, HPL, LPL, MPL and EXR, if in PEAK mode
Identify Device Firmware	IDF	(8151A Firmware 29 NOV 1983)
Head Identifier	IHD	currently connected optical head 0 = no head, N = head number
Interrogate error	IEPR	

Form 1: WCV head number, λ position, λ CAL. factor
Form 2: IWCV head number, λ position
Head number: 1 to 4 #
 λ position: λ value in nanometers
 λ value: 500 to 2000 in steps of 50
 λ CAL. factor: +4 to -10 dB

HP-IB Universal Commands

Group Execute Trigger	BS	initialize one measurement in Single Trigger mode
Device Clear	DC4	loads Standard Parameter Set
Selected Device Clear	EOT	loads Standard parameter Set

Table 3-5. BISA Status Byte

D7	D6	D5	D4	D3	D2	D1	D0	
0	0	0	0	0	0	0	1	--- Range Error (causes error)
0	0	0	0	0	0	1	0	--- No Optical Head (causes error)
0	0	0	0	0	1	0	0	--- Syntax Error (causes error)
0	0	0	0	1	0	0	0	--- Zero Failed (causes error)
0	0	0	1	0	0	0	0	--- Device or Measurement Ready *
0	0	1	0	0	0	0	0	--- Error (causes SRQ)
0	1	0	0	0	0	0	0	--- Service Request (SRQ)
1	0	0	0	0	0	0	0	--- System Failure (Head Failure, Selftest Failed)

*Device and measurement ready (continuous mode, T0)
Device ready (single trigger mode, T1)

1990

Applies only in Command Mode (ATN true)



These characters cause SRO



'These characters are ignored

HP-IB DATA LINES					7	0	0	0	0	1	1	0	1	1
					6	0	0	1	1	0	0	1	1	1
					5	0	1	0	1	0	1	0	1	1
4	3	2	1	0										
0	0	0	0	0	NUL			SP		0		P		p
0	0	0	1	1	SOH	GTL	LLO			1			a	
0	0	1	0	2	STX			#		2			b	r
0	0	1	1	3	ETX					3			c	s
0	1	0	0	4	EOT	SDC	DCL			4			d	t
0	1	0	1	5	ENO			%		5			e	u
0	1	1	0	6	ACK					6			f	v
0	1	1	1	7	BEL					7			g	w
1	0	0	0	8	BS	GET	SPE			8			h	x
1	0	0	1	9	HT		SPD			9			i	
1	0	1	0	10	LF							Z		z
1	0	1	1	11	VT									
1	1	0	0	12	FF									
1	1	0	1	13	CR									
1	1	1	0	14	SO								m	
1	1	1	1	15	SI								n	
										UNL		UNT	o	

3-66 Standard Parameter Set

3-66 The Standard Parameter Set serves to overcome RAM corruption, should the instrument not have been switched on for some time, and can be accessed by inputting the command "CST" to the system controller. The output values sent back to the controller depend upon; a) whether or not an optical is connected to the 8151A, and b) if a head is connected, the characteristics of the signal applied. See Programming examples for details.

3-67 Programming examples

3-68 The following examples are intended to aid the user when operating the 8151A on the HP-IB. The examples given are based upon the input signal illustrated in Figure 3-6 being input to an HP8151A Optical Head. An HP85 System Controller was used to produce the following data, and all examples given are in BASIC. The 8151A address was set to 18.

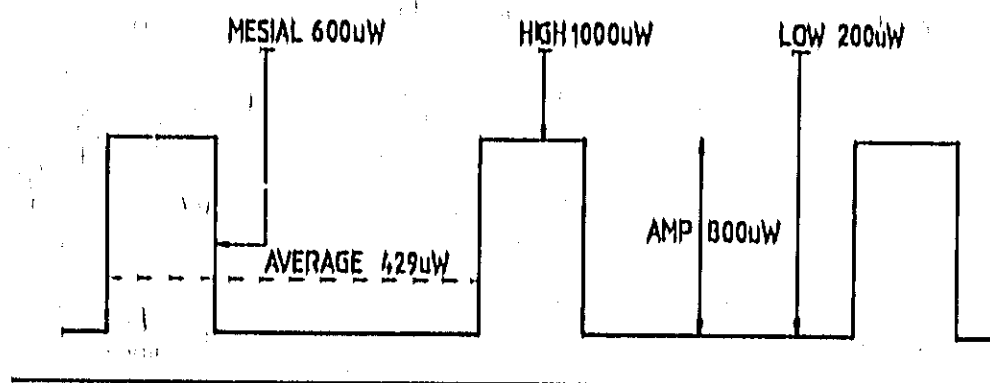


Figure 3-6. Input signal

Program	Controller output
<pre> 10 DIM AS(500) 20 CLEAR 718 30 OUTPUT 718;"U0,IMR" 40 ENTER 718;AS 50 PRINT AS 60 END </pre>	AMP - 0.97 DBM;HPL + 0.00 DBM; LPL - 6.99 DBM;MPL - 2.22 DBM; EXR 5.00#;
<pre> 10 DIM AS(500) 20 OUTPUT 718;"U1,IMR" 30 ENTER 718;AS 40 PRINT AS 50 END </pre>	AMP 800.E-06 W;HPL 1000.E-06 W; LPL 200.E-06 W;MPL 600.E-06 W; EXR 5.00#;
<pre> 10 DIM AS(500) 20 OUTPUT 718;"U2,REF 0DBM,IMR" 30 ENTER 718;AS 40 PRINT AS 50 END </pre>	AMP - 0.97 DBR;HPL - 0.00 DBR; LPL - 6.99 DBR;MPL - 2.22 DBR; EXR 5.00#;
<pre> 10 DIM AS(500) 20 OUTPUT 718;"REF -60DBM,U2, HPL" 30 ENTER 718;AS 40 PRINT AS 50 END </pre>	HPL + 60.00 DBR

```

10 DIM AS [500]                                CAL - 10.00 DBR
20 OUTPUT 718;"U0,CAL -10DBR"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM AS [500]                                MPL + 7.78 DBM
20 OUTPUT 718;"U0,MPL"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM AS [500]                                MPL 6.00E-03 W
20 OUTPUT 718;"U1,MPL"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM AS [500]                                MPL + 67.78 DBR
20 OUTPUT 718;"U2,MPL"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM AS [500]                                AVG 429.E-06 W
20 OUTPUT 718;"CAL 0DBR,AR0,
  T1,U1,AVG"
30 S=SPOLL (718)
40 IF BIT (S,4)=0 THEN GOTO 30
50 TRIGGER (718)
60 ENTER 718;AS
70 PRINT AS
80 END

```

```

10 DIM AS [500]                                (1st output) REF -6.99 DBM
20 OUTPUT 718;"T0,LPL,U2,                (2nd output) LPL -0.00 DBR
  DTR,IREF"
30 ENTER 718;AS
40 PRINT AS
50 ENTER 718;AS
60 PRINT AS
70 END

```

```

10 DIM AS [500]                                RNG +00 DBM
20 OUTPUT 718;"IRNG"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM AS [500]                                LPL 0.20E-03
20 OUTPUT 718;"AR0,U1,RNG
  10DBM,LPL"
30 ENTER 718;AS
40 PRINT AS
50 END

```

```

10 DIM A$(500)
20 OUTPUT 718;"IID"
30 ENTER 718;A$
40 PRINT A$
50 END

```

HD 1#

```

10 DIM A$(500)
20 OUTPUT 718;"REF -60DBM,CAL
  -10DBR,U2,HPL"
30 ENTER 718;A$
40 PRINT A$
50 END

```

HPL + 70.00 DBR

```

10 OUTPUT 718;"WCV1#,550NM,-2.2DBR"
20 OUTPUT 718;"WCV1#,600NM,-1.6DBR"
30 OUTPUT 718;"WCV1#,650NM,-0.9DBR"
40 OUTPUT 718;"WCV1#,700NM,-0.2DBR"
50 OUTPUT 718;"WCV1#,750NM,0.3DBR"
60 OUTPUT 718;"WCV1#,800NM,0.4DBR"
70 OUTPUT 718;"WCV1#,850NM,0DBR"
80 OUTPUT 718;"WCV1#,900NM,-1.2DBR"
90 OUTPUT 718;"WCV1#,950NM,-2.7DBR"
100 END

```

81511A Optical Head λ cal values

```

10 DIM A$(1500)
20 OUTPUT 718;"1WCI"
30 ENTER 718;A$
40 PRINT A$
50 END

```

```

WCV1#,500 NM,+0.00 DBR;
WCV1#,550 NM,-2.20 DBR;
WCV1#,600 NM,-1.60 DBR;
WCV1#,650 NM,-0.90 DBR;
WCV1#,700 NM,-0.20 DBR;
WCV1#,750 NM,+0.30 DBR;
WCV1#,800 NM,+0.40 DBR;
WCV1#,850 NM,+0.00 DBR;
WCV1#,900 NM,-1.20 DBR;
WCV1#,950 NM,-2.70 DBR;
WCV1#,1000 NM,+0.00 DBR;
WCV1#,1050 NM,+0.00 DBR;
WCV1#,1100 NM,+0.00 DBR;
WCV1#,1150 NM,+0.00 DBR;
WCV1#,1250 NM,+0.00 DBR;
WCV1#,1300 NM,+0.00 DBR;
WCV1#,1350 NM,+0.00 DBR;
WCV1#,1400 NM,+0.00 DBR;
WCV1#,1450 NM,+0.00 DBR;
WCV1#,1500 NM,+0.00 DBR;
WCV1#,1550 NM,+0.00 DBR;
WCV1#,1600 NM,+0.00 DBR;
WCV1#,1650 NM,+0.00 DBR;
WCV1#,1700 NM,+0.00 DBR;
WCV1#,1750 NM,+0.00 DBR;
WCV1#,1800 NM,+0.00 DBR;
WCV1#,1850 NM,+0.00 DBR;
WCV1#,1900 NM,+0.00 DBR;
WCV1#,1950 NM,+0.00 DBR;
WCV1#,2000 NM,+0.00 DBR

```

```
10 DIM AS(500)                                WCV1#,875 NM,-0.60 DBR
20 OUTPUT 718;"WCV1#,875NM"
30 ENTER 718;AS
40 PRINT AS
50 END

10 DIM AS(500)                                F0;U0;A0;T0;HD1#;RNG 00 DBM;
20 OUTPUT 718;"CST"                          REF +0.00 DBM;CAL +0.00 DBR;
30 ENTER 718;AS                              WVL 875 NM;WCP -0.60 DBR;
40 PRINT AS                                  HPL +70.00 DBR;
50 END

10 OUTPUT 718;"WVL 850NM"                    WVL 850 NM
20 DIM AS(500)
30 OUTPUT 718;"WVL"
40 ENTER 718;AS
50 PRINT AS
60 END

10 DIM AS(500)                                WCP +0.00 DBR
20 OUTPUT 718;"WCP"
30 ENTER 718;AS
40 PRINT AS
50 END

10 OUTPUT 718;"ZER"
20 S=SPOLL(718)
30 IF BIT(S,4)=0 THEN GOTO 20
40 IF BIT(S,3)=0 THEN PRINT "ZERO
CALIBRATION PASSED" @ END
50 PRINT "ZERO CALIBRATION FAILED"
60 OUTPUT 718;"EST"
70 P=SPOLL(718)
80 IF BIT(P,4)=0 THEN GOTO 70
90 IF BIT(P,7)=0 THEN PRINT "SELF
TEST PASSED***HEAD FAILURE" @ END
100 DIM BS(500)
110 OUTPUT 718;"IERR"
120 ENTER 718;BS
130 PRINT BS
140 END
```

PERFORMANCE CHECK

SECTION IV

PERFORMANCE TESTS

4-1 Introduction

4-2 The procedures in this section test the electrical performance of the instrument, using the specifications of Table 1-2 as performance standards. All tests can be performed without access to the interior of the instrument.

4-3 Equipment Required

4-4 Equipment required for the performance tests is listed in Table 1-1, Recommended Test Equipment. Any equipment which satisfies the critical specifications given in the table may be substituted for recommended models.

4-5 Test Record

4-6 Results of the performance tests may be tabulated on the Test Record provided at the end of the test procedures. The Test Record lists the tested specifications and their acceptable limits. Test results recorded at incoming inspection can be used for comparison in periodic maintenance, troubleshooting, and after repairs or adjustments.

4-7 Performance Tests

4-8 The performance tests given in this section are suitable for incoming inspection, troubleshooting and preventative maintenance. During any performance test all protective covers and connecting hardware must be in place. The tests are designed to verify the published instrument specifications. Perform the tests in the order given and record the results in the Test Record at the end of the procedures.

HIGH PEAK POWER

Specifications:

Peak power measurement specifications apply to a 200 Hz squarewave signal in the ranges +10 dBm, 00 dBm and -10 dBm; 30 Hz squarewave in all other ranges; ZERO function activated prior to measurements being taken. +10 dBm range specified at 3 dBm optical input power.

Range (dBm)	High Peak Power reading/counts
+10	+/- 0.3 dB (opt) +/- 5
+00	+/- 0.25 dB (opt) +/- 10
-10	+/- 0.35 dB (opt) +/- 50
-20	+/- 0.2 dB (opt) +/- 10
-30	+/- 0.2 dB (opt) +/- 10
-40	+/- 0.2 dB (opt) +/- 10
-50	+/- 0.2 dB (opt) +/- 20
-60	+/- 0.3 dB (opt) +/- 80

Equipment:

Optical Signal Source
Optical/Electrical Transducer Standard
DVM, triggerable, triggerable delay
High-Speed System Voltmeter
Optical Cable Assembly (Diamond - Diamond)
2 x Optical Cable Assembly (Diamond - NEC)
Optical Attenuator 20 dB
2 x Cable Assembly BNC

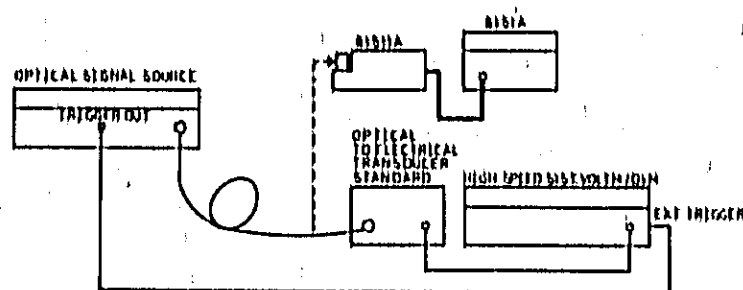


Figure 4-1. Test setup for High Peak Power measurements

Procedure:

- Set the Optical Signal Source as follows:

MODE	NORM
FREQUENCY	200 Hz
WAVEFORM	square
DUTY CYCLE	50%
HIGH POWER LEVEL	as required
LOW POWER LEVEL	as required

2. Set the Optical/Electrical Transducer Standard to 1 V/mW.
3. Set the 8151A to HIGH, +10 dBm range, wavelength 850 nm (λ -CAL. 0 dB).
4. Press the ZERO key.
5. Set the System Voltmeter to its 1.0 V range, external trigger (negative edge), 1 reading per trigger event and a trigger delay of 0.0027 sec.
6. Connect the Optical Signal Source, via the Transducer Standard, to the System Voltmeter, as shown in Figure 4-1.
7. Adjust the HIGH POWER LEVEL of the Optical Signal Source to give a reading of 1.800 V $\pm$ 9 mV on the System Voltmeter.
8. Connect the Optical Signal Source to the 8151A/8151A.
9. Verify that 1.63 mW < 815A reading < 1.98 mW
10. Repeat steps 6 to 8, using the settings listed below. Verify that the 8151A readings are within the given limits.

High Power Level Voltmeter reading	8151A Range	8151A Reading
1.000 V $\pm$ 5 mV	+10 dBm	0.88 mW to 1.12 mW
1.000 V $\pm$ 5 mV	+00 dBm	934 uW to 1069 uW
0.500 V $\pm$ 2.5 mV	+00 dBm	462 uW to 540 uW
0.100 V $\pm$ 0.5 mV*	-10 dBm	87.3 uW to 113.4 uW
0.100 V $\pm$ 0.25 mV*	-10 dBm	41.1 uW to 59.2 uW

*Set the System Voltmeter to its 0.1 V range

11. For the following tests, use the triggerable DVM (with higher resolution) in place of the System Voltmeter.
12. Set the DVM to dc, 10 V range, external trigger (negative edge), trigger delay 5 ms, recording rate > 35/sec and 1 measurement per trigger event.

NOTE: If an HP3456A is being used for this test, the recording rate can be set as follows.

INTEGRATION TIME	1 power line cycle
AUTOZERO	off
AUTORANGE	off
FILTER	off

13. Set the Optical/Electrical Transducer Standard to 1 V/10 uW.
14. Set the Optical Signal Source as follows:

FREQUENCY	30.0 Hz
DUTY CYCLE	90%
HIGH POWER LEVEL	as required
LOW POWER LEVEL	any value

15. Connect the Optical Signal Source, via the Transducer Standard, to the DVM and continue the procedure, as in steps 6 to 8, using the following table. Verify that the 8151A readings are within the given limits.

High Power Level DVM reading	8151A Range	8151A Reading
1,000 V +/-5 mV	-20 dBm	9.45 uW to 10.57 uW
0,500 V +/-2.5 mV	-20 dBm	4.67 uW to 5.34 uW
0,100 V +/-0.5 mV	-30 dBm	945 nW to 1057 nW
0,050 V +/-0.25 mV	-30 dBm	467 nW to 534 nW

16. Set the Optical/Electrical Transducer Standard to 1 V/100 nW

17. Continue the procedure using the settings listed below. Verify that the 8151A readings are within the limits given.

High Power Level DVM reading	8151A Range	8151A Reading
1,000 V +/-5 mV	-40 dBm	94.5 nW to 105.7 nW
0,500 V +/-2.5 mV	-40 dBm	46.7 nW to 53.4 nW
0,100 V +/-0.5 mV	-50 dBm	9.35 nW to 10.67 nW
0,050 V +/-0.25 mV	-50 dBm	4.57 nW to 5.44 nW

18. Connect the Optical Signal Source, via the 20 dB Optical Attenuator, first to the Transducer Standard, to set the High Power level and then to the 81511A/8151A.
19. Set the DVM to its 0.1 V range.
20. Adjust the HIGH POWER LEVEL of the Optical Signal Source to give a reading of 10 mV +/-0.05 mV on the DVM.
21. Set the 8151A to its -60 dBm range.
22. Connect the Optical signal source, via the Optical Attenuator, to the 81511A/8151A.
23. Verify that $853 \text{ pW} < 8151A \text{ reading} < 1152 \text{ pW}$.

LOW PEAK POWER

Specifications:

Pink power measurement specifications apply to a 200 Hz squarewave in the ranges +10, 0 and -10 dBm, and a 30 Hz squarewave in all other ranges - the ZERO function being activated prior to any measurements being taken.

Range (dBm)	Low Peak Power reading/counts
+10	+/- 0.3 dB (opt) +/- 5
+00	+/- 0.25 dB (opt) +/- 10
-10	+/- 0.35 dB (opt) +/- 50
-20	+/- 0.2 dB (opt) +/- 10
-30	+/- 0.2 dB (opt) +/- 10
-40	+/- 0.2 dB (opt) +/- 10
-50	+/- 0.2 dB (opt) +/- 20
-60	+/- 0.3 dB (opt) +/- 80

Equipment:

Optical Signal Source (850 nm)
Optical/Electrical Transducer Standard
DVM, triggerable
System Voltmeter, high-speed
Function Generator
3 x Cable Assembly BNC
Optical Cable Assembly (Diamond - Diamond)
2 x Optical Cable Assembly (Diamond - NEC)
Optical Attenuator 20 dB

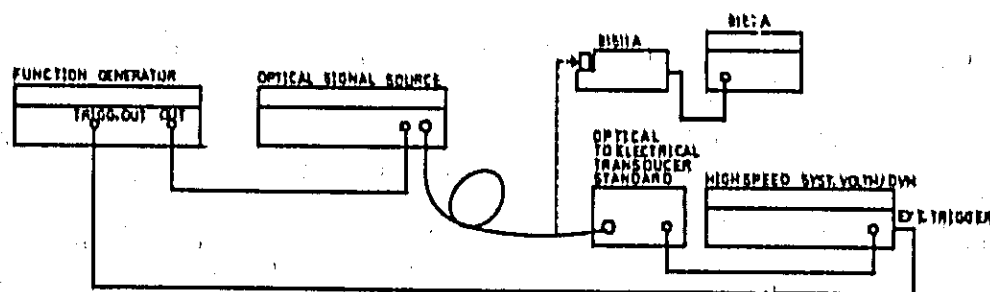


Figure 4-2. Test setup for Low Power Level measurements in +10 dBm range

Procedure:

1. Set the Optical Signal Source as follows:

TRANSDUCER	on
CONVERSION FACTOR	1.8 mW/V
OFFSET COMPENSATION	0.00 V
COMPL	off
DISABLE	off

2. Set the Optical/Electrical Transducer Standard to 1 V/mW.
3. Set the 8151A to LOW, +10 dBm range, 850 nm wavelength (λ -CAL=0 dB) and 10 kHz lowpass filter.
4. Press the ZERO key.
5. Set the System Voltmeter to 1 V range, external trigger (negative edge), 1 reading per trigger event and a trigger delay of 0.001 sec.
6. Connect the Optical Signal Source, via the Transducer Standard, to the System Voltmeter as shown in Figure 4-2.
7. Set the Function Generator as follows:

FREQUENCY	200 Hz
WAVEFORM	square, symmetrical
AMPLITUDE	250 mVpp

and adjust the dc offset to give a 1.500 V $\pm$ 5 mV reading on the System Voltmeter.
8. Connect the Optical Signal Source to the 8151A/8151A.
9. Verify that $1.35 \text{ mW} < 8151\text{A reading} < 1.66 \text{ mW}$.
10. Set the Optical Signal Source as follows:

MODULATOR	on
MODE	NORM
FREQUENCY	200 Hz
WAVEFORM	square
DUTY CYCLE	50%
HIGH POWER LEVEL	as required
LOW POWER LEVEL	as required
11. Set the 8151A to its +00 dBm range.

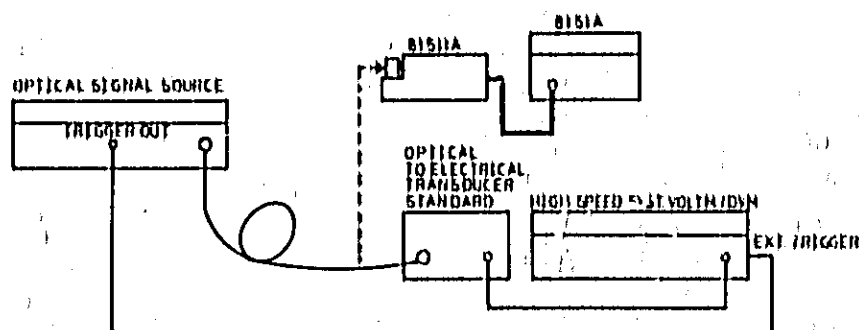


Figure 4-3. Test setup for Low Peak Power measurements for 0 dBm and below

12. Connect the Optical Signal Source to the System Voltmeter as shown in Figure 4-3.
13. Set the Optical Signal Source High Power Level to 800 uW, and adjust the Low Power Level to give a reading of 0.500 V $\pm$ 2 mV on the System Voltmeter.

14. Connect the Optical Signal Source to the 8151A/8151A.
15. Verify that $462 \mu\text{W} < 8151\text{A reading} < 540 \mu\text{W}$.
16. Set the System Voltmeter to its 0.1 V range.
17. Repeat steps 12 to 14 using the settings listed in the following table. Verify that the 8151A readings are within the given limits.

High Power Level	Low Power Level Voltmeter reading	8151A Range	8151A Reading
400 μW 80.0 μW	0.100 V $\pm$ 0.5 mV 0.050 V $\pm$ 0.2 mV	+00 dBm -10 dBm	84 μW to 116 μW 41.1 μW to 59.2 μW

18. Set the Optical Signal Source as follows:
 FREQUENCY 30.0 Hz
 DUTY CYCLE 10%
 HIGH POWER LEVEL as required
 LOW POWER LEVEL as required

19. Set the Optical/Electrical Transducer Standard to 1 V/10 μW .
20. Change the System Voltmeter for a triggerable Voltmeter (reading rate $> 35/\text{sec}$).
21. Set the DVM to dc, 1 V range, external trigger(negative edge) and 1 reading per trigger event.

NOTE: If an HP3456A is being used for this test, set the recording rate as follows:

INTEGRATION TIME 1 power line cycle
 AUTOZERO off
 AUTORANGE off
 FILTER off

22. Connect the Optical Signal Source, via the Transducer Standard, to the DVM, and continue with the procedure using the settings listed below. Verify that the 8151A readings are within the given limits.

High Power Level	Low Power Level DVM reading	8151A Range	8151A Reading
8.0 μW 8.0 μW 800 nW	0.500 V $\pm$ 2.5 mV 0.100 V $\pm$ 0.5 mV 0.050 V $\pm$ 0.25 mV	-20 dBm -20 dBm -30 dBm	4.67 μW to 5.34 μW 0.85 μW to 1.15 μW 467 nW to 534 nW

23. Set the Optical/Electrical Transducer Standard to 1 V/100 nW.

24. Continue the procedure with the following table:

High Power Level	Low Power Level DVM Reading	8151A Range	8151A Reading
200 nW 80.0 nW 80.0 nW	1.000 V $\pm$ 5 mV 0.500 V $\pm$ 2.5 mV 0.100 V $\pm$ 0.5 mV	-30 dBm -40 dBm -40 dBm	85 nW to 115 nW 46.7 nW to 53.4 nW 8.5 nW to 11.5 nW

25. Connect the Optical Signal Source, via the 20 dB Optical Attenuator, first to the Transducer Standard, to set the Low Power Levels shown in the following table, and then to the 8151A/8151A.
26. Set the DVM to its 0.1 V range.
27. Using the table, complete the procedure - verifying that the 8151A readings are within the given limits.

High Power Level	Low Power Level DVM Reading	8151A Range	8151A Reading
800 nW 120 nW	0,050 V +/-0,25 mV 8,00 mV +/-0,08 mV	-50 dBm -60 dBm	4,57 nW to 5,44 nW 667 pW to 937 pW

AVERAGE POWER

Specifications:

Specifications apply for continuous power or modulating frequency greater than 50 Hz. Specified accuracy does not take into account the $\pm 2.5\%$ accuracy of the measuring standard.

Range	Accuracy
+10 dBm	± 0.1 dB ± 5 counts
+00 dBm	± 0.1 dB ± 5 counts
-10 dBm	± 0.1 dB ± 5 counts
-20 dBm	± 0.1 dB ± 5 counts
-30 dBm	± 0.1 dB ± 5 counts
-40 dBm	± 0.1 dB ± 5 counts
-50 dBm	± 0.15 dB ± 10 counts
-60 dBm	± 0.2 dB ± 50 counts

Equipment:

Optical Signal Source (850 nm)
 Optical/Electrical Transducer Standard
 DVM
 Optical Attenuator
 2 x Optical Cable Assembly (Diamond - NEC)
 Optical Cable Assembly (Diamond - NEC)
 Cable Assembly BNC

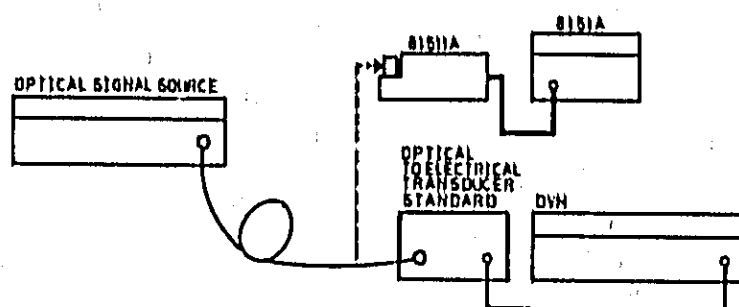


Figure 4-4. Test setup for Average measurements > 5 nW

Procedure:

1. Connect the equipment as shown in Figure 4-4.
2. Set the Optical signal Source as follows:

MODE	NORM
FREQUENCY	100 Hz
WAVEFORM	sine
EXTINCTION RATIO	10
MESIAL POWER LEVEL	as required

3. Set the Optical/Electrical Transducer Standard to 1 V/mW.
4. Set the 8151A to AVG, +10 dBm range and 850 nm wavelength (λ -CAL = 0 dB)
5. Press the ZERO key.
6. Set the DVM to dc, Autorange and Lowpass Filter.
7. Connect the Optical Signal Source, via the Transducer Standard, to the DVM.
8. Adjust the MESIAL POWER LEVEL of the Optical Signal Source so that the DVM reads 1.000 V $\pm$ 5 mV.
9. Connect the Optical Signal Source to the 8151A/8151A.
10. Verify that $0.90 \text{ mW} < 8151A \text{ reading} < 1.10 \text{ mW}$
11. Repeat steps 7 to 10, using the settings listed in the following table. Verify that the 8151A readings are within the given limits.

Mesial Power Level (DVM Reading)	8151A Range	8151A Reading
0.500 V $\pm$ 2.5 mV	+00 dBm	471 μ W to 529 μ W
0.200 V $\pm$ 1.0 mV	+00 dBm	186 μ W to 215 μ W
0.100 V $\pm$ 0.5 mV	+00 dBm	90 μ W to 110 μ W
50.00 mV $\pm$ 0.25 mV	-10 dBm	47.1 μ W to 52.9 μ W

12. Set the Optical/Electrical Transducer Standard to 1 V/10 μ W.

13. Continue the procedure using the following table:

Mesial Power Level (DVM Reading)	8151A Range	8151A Reading
1.000 V $\pm$ 5 mV	-10 dBm	9.0 μ W to 11.0 μ W
0.500 V $\pm$ 2.5 mV	-20 dBm	4.71 μ W to 5.29 μ W
0.100 V $\pm$ 0.5 mV	-20 dBm	0.90 μ W to 1.10 μ W
50.00 mV $\pm$ 0.25 mV	-30 dBm	47.1 nW to 52.9 nW

14. Set the Optical/Electrical Transducer Standard to 1 V/100 nW.

15. Continue the procedure using the following table:

Mesial Power Level (DVM Reading)	8151A Range	8151A Reading
1.000 V $\pm$ 5.0 mV	-30 dBm	90 nW to 110 nW
0.500 V $\pm$ 2.5 mV	-40 dBm	47.1 nW to 52.9 nW
0.100 V $\pm$ 0.5 mV	-40 dBm	9.0 nW to 11.0 nW
50.00 mV $\pm$ 0.25 mV	-50 dBm	4.61 nW to 5.41 nW

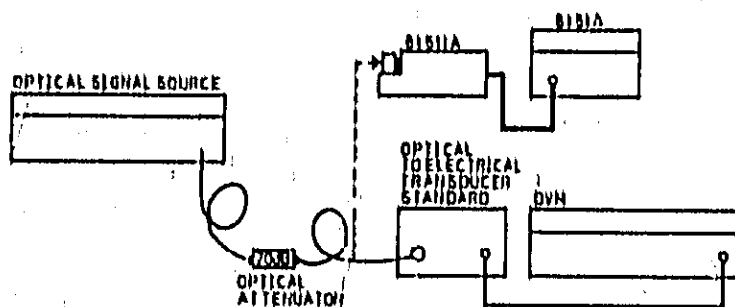


Figure 4-5. Test setup for Average measurements < 5 nW

16. Connect the equipment as shown in Figure 4-5.
17. Set the Optical Signal Source so that it outputs continuous light at a power level of approximately 100 nW.

MODE	E, WID
INPUT	☒
EXT. I/P vernier	c.w.
HIGH POWER LEVEL	as required
18. Set the DVM to dc, 1 V, Autozero and Filter off.
19. Adjust the high power level of the Optical Signal source to give a DVM reading of 0.01000 V +/- 0.00005 V, not forgetting to take into account the offset voltage of the Optical/Electrical Transducer Standard.
20. Set the 8151A to its -60 dBm range.
21. Connect the Optical Signal Source to the 8151A/8151A.
22. Verify that 881 pW < 8151A reading < 1123 pW.

MEASUREMENT FLATNESS

Specifications:

Range: 200 Hz to 9.99 MHz; ± 0.3 dB (opt) of amplitude
 (+10 dBm to 0 dBm) 10 MHz to 99.9 MHz; ± 0.3 dB (opt) of amplitude

(0 dBm to -10 dBm) 200 Hz to 9.99 MHz; ± 0.4 dB (opt) of amplitude
 10 MHz to 99.9 MHz; ± 0.6 dB (opt) of amplitude

Equipment:

Optical Signal Source
 VHF Signal Generator
 Optical/Electrical Transducer (9mW/mV, transition times < 1 ns)
 True rms Voltmeter (AC to DC converter)
 DVM
 Power Meter
 Power sensor (< 10 uW) reference attenuator
 Optical Cable Assembly (Diamond - Diamond)
 2 x Optical Cable Assembly (Diamond - NEC)
 Optical Attenuator 10 dB
 3 x Cable Assembly BNC
 Feedthrough Termination 50 Ohm

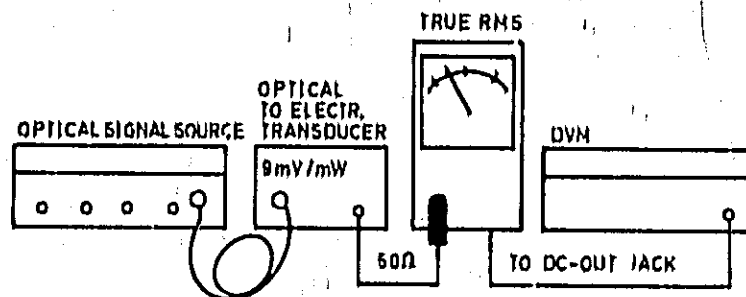


Figure 4-6. Test setup for establishing the flatness of the stimulating source

Procedure:

For this series of tests, it is necessary to know the flatness of the source to be used. Start the test procedure by establishing the flatness of the stimulating optical source as follows:

- a. Connect the equipment as shown in Figure 4-6.

- b. Set the Optical Signal Source as follows:

MODE	NORM
FREQUENCY	200 Hz
DUTY CYCLE	50%
WAVEFORM	sine
EXTINCTION RATIO	5.00
MESIAL POWER LEVEL	600 uW

- c. Set the True rms AC to DC converter to its 0.003 V range.
- d. Set the DVM to dc, 1 V range.
- e. The reading on the DVM is the reference for the following flatness tests. Record the reading for the 200 Hz reference for future use.
- f. Set the frequency of the Optical Signal Source to 1.0 kHz, 10 kHz, 100 kHz, 1.0 MHz and 9.99 MHz respectively, and convert the DVM voltage readings into db (opt) values using the following formula:

$$X = 10 \log[\text{DVM reading}/200 \text{ Hz reference}] \text{ dB}$$

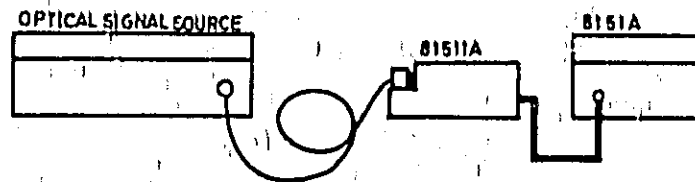


Figure 4-7. Test setup for measurement flatness tests to 9.99 MHz

1. Connect the equipment as shown in Figure 4-7.
2. Set the 850 nm Optical Signal Source as follows:

WAVELENGTH	850 nm
FREQUENCY	200 Hz
EXTINCTION RATIO	5.00
MESIAL POWER LEVEL	600 uW
3. Set the 8151A to "Full Bandwidth" mode, AMP and 00 dBm range.
4. Press the ZERO key, and wait for the 8151A to start measuring the power amplitude of the input signal.
5. Press the REF→DISP key

6. The 8151A reading should be 0.00 dBr. This is the reference for the next series of tests. As in step f, set the frequency of the Optical Signal Source to 1.0 kHz, 10.0 kHz, 100 kHz, 1.0 MHz and 9.99 MHz. List the 8151A readings for each frequency setting in the Test Record at the end of this section, and verify that the difference between the readings recorded in step f and those just recorded, are within the limits given in the table below.

Frequency setting	X(8151A) limits	
200 Hz	0.0 dB	
1.0 kHz	-0.3 dB	+0.3 dB
10 kHz	-0.3 dB	+0.3 dB
100 kHz	-0.3 dB	+0.3 dB
1.0 MHz	-0.3 dB	+0.3 dB
9.99 MHz*	-0.3 dB	+0.3 dB

*This value will be required for use in step 16.

7. Connect the Optical Signal Source to the 8151A/8151A via a 10 dB optical attenuator.
8. Set the 8151A to its -10 dBm range.
9. Repeat steps 1 to 6, and verify that the 8151A flatness values are within the limits given in the table below.

Frequency setting	X(8151A) limits	
200 Hz	0.0 dB	
1.0 kHz	-0.4 dB	+0.4 dB
10 kHz	-0.4 dB	+0.4 dB
100 kHz	-0.4 dB	+0.4 dB
1.0 MHz	-0.4 dB	+0.4 dB
9.99 MHz*	-0.4 dB	+0.4 dB

For tests at higher frequencies, the equipment needs to be changed. As in the preceding tests, the flatness of the stimulating source needs to be established.

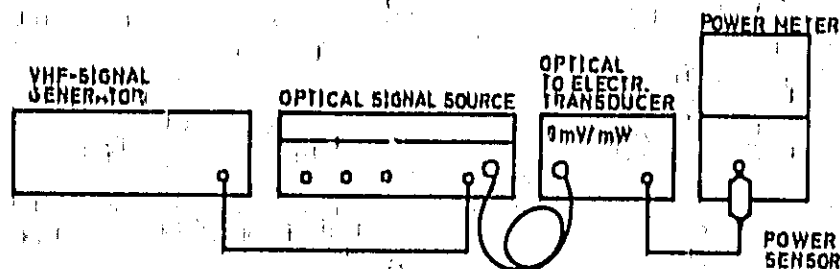


Figure 4-8. Test setup for establishing the flatness of the stimulating optical source at high frequencies.

8. Connect the equipment as shown in Figure 4-8.

- h. Prepare the Power Meter for accurate measurements by calibrating against the power reference and pressing the ZERO key.
- i. Set the Optical Signal source as follows:

TRANSDUCER MODE	ON
CONVERSION FACTOR	1.0 mW/V
OFFSET COMPENSATION	0.00 V
- j. Set the VHF generator as follows:

FREQUENCY	10 MHz
AMPLITUDE	0.8 Vpp
- k. Set the Power Meter to the correct cal. factor for 10 MHz.
- l. When the reading on the Power Meter has stabilized, press the db (rel) key to bring the 0 dB reference into display.
- m. Set the frequency of the VHF signal generator to 30 MHz, 50 MHz, and 99.9 MHz respectively, ensuring that the correct cal. factor is input to the Power Meter for each frequency. Record the dB value for each result, divide it by 2, and enter it into the Test Record.

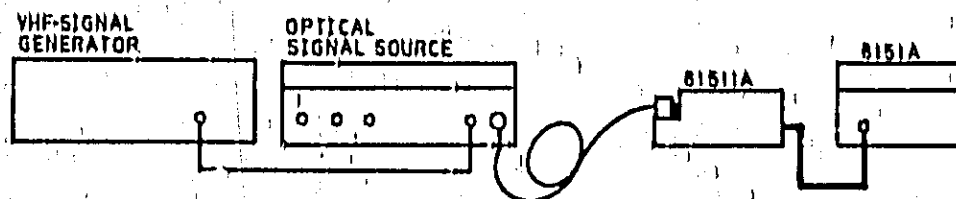


Figure 4-9. Test setup for VHF measurement flatness tests

10. Connect the equipment as shown in Figure 4-9.
11. Set the VHF generator frequency to 10 MHz.
12. Set the 8151A to its "Full Bandwidth" mode, AMP, dB(rel) and 00 dBm range.
13. Press the ZERO key, and wait until the 8151A starts to measure the power amplitude of its input signal.
14. Press the DISP→REF key to bring the 0 dB reference value into display.

16. As in step 8, set the frequency of the VHF signal generator to 30 MHz, 50 MHz and 99.9 MHz respectively. List the 8151A readings for each frequency setting in the Test Record and verify that the difference between the following readings and the previously-recorded values for the optical source are within the given limits. The formula for deriving the 8151A measurement flatness at high frequencies is as follows:

$$X(8151A) = X(8151A \text{ reading}) - X(\text{optical source}) + X(9.99 \text{ MHz}) \text{ (step 6)}$$

Frequency setting	X(8151A) limits	
10.0 MHz	same as at 9.99 MHz (step 6)	
30.0 MHz	-0.5 dB	+0.5 dB
50.0 MHz	-0.5 dB	+0.5 dB
99.9 MHz	-0.5 dB	+0.5 dB

16. Connect the optical source to the 8151A/8151A via a 10 dB optical attenuator.
17. Set the 8151A to its -10 dBm range.
18. Repeat the procedure of steps 10 to 15, and verify that the 8151A flatness values are within the limits given in the next table. The formula for calculating the measurement flatness of the 8151A at high frequencies is as follows:

$$X(8151A) = X(8151A \text{ reading}) - X(\text{optical source}) + X(9.99 \text{ MHz} - \text{step 9})$$

Frequency setting	X(8151A) limits	
10.0 MHz	same as at 9.99 MHz in step 9	
30.0 MHz	-0.6 dB	+0.6 dB
50.0 MHz	-0.6 dB	+0.6 dB
99.9 MHz	-0.6 dB	+0.6 dB

PULSE RESPONSE

Specifications:

Transition Times: ≤ 1.8 ns without filter
 ≤ 10 ns 50 MHz filter
 ≤ 100 ns 6 MHz filter

Overshoot and Ringing $\leq 10\%$

Equipment:

Optical Source (transition time < 1 ns)
Optical Cable Assembly (Diamond - Diamond)
Sampling Oscilloscope

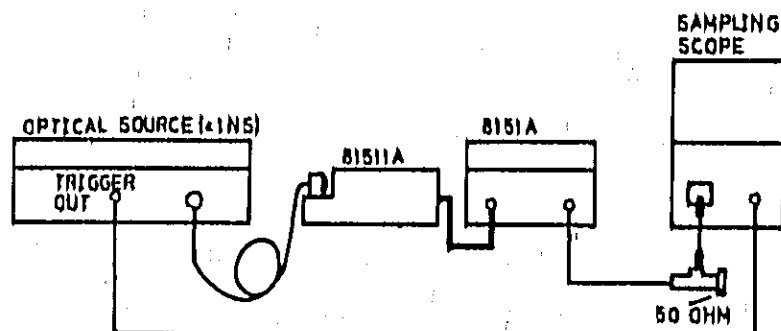


Figure 4-10. Test setup for Pulse Response tests

Procedure:

1. Connect the equipment as shown in Figure 4-10.
2. Set the frequency of the Optical Signal Source to approximately 1 MHz.
3. Set the 8151A to its +00 dBm range, AMP and "Full Bandwidth" mode (no filter).
4. Adjust the timebase of the sampling scope such that one cycle of the displayed signal fills the display. Verify that preshoot, overshoot, ringing and droop comprise less than 10% of pulse amplitude, as illustrated in Figure 4-11a.

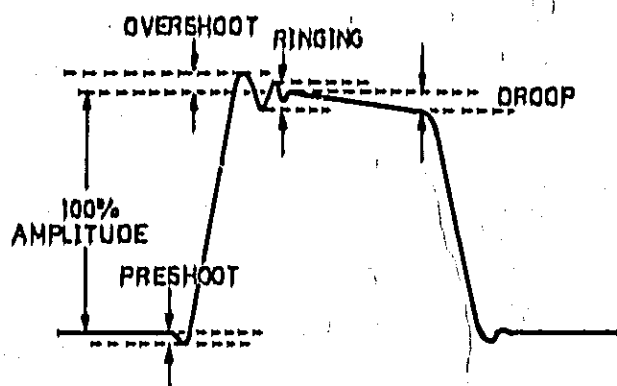


Figure 4-11a.

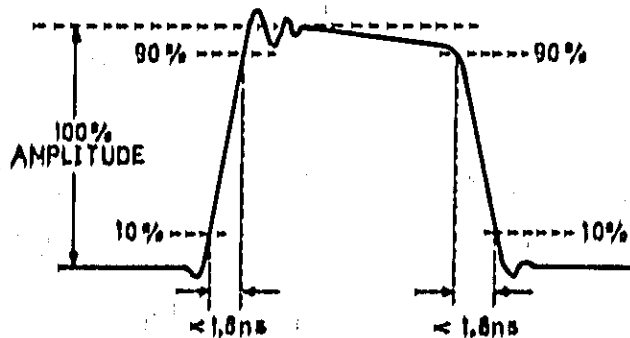


Figure 4-11b.

5. Expand the timebase of the sampling scope such that one transition completely fills the display. Verify that the transition time of first one edge, and then the other, is less than 1.8 ns, as in Figure 4-11b.
6. Select the 50 MHz lowpass filter of the 8151A.
7. Repeat step 5, and verify that the transition times of both edges are less than 10.0 ns.
8. Select the 6 MHz lowpass filter of the 8151A.
9. Repeat step 5, and verify that the transition times of both edges are less than 100 ns.

TRANSDUCER CONVERSION FACTOR

Specifications:

Accuracy is specified for output voltages in the range 0.1 V to 1.1 V, with the ZERO function activated prior to any measurements being taken, and a squarewave of frequency 30 Hz applied.

Range (dBm)	Conversion factor (dc)	Accuracy of Conversion
+10	1 V/10 mW	+/-0.3 dB (opt)+/-10 mV
+00	1 V/1 mW	+/-0.3 dB (opt)+/-10 mV
-10	1 V/100 uW	+/-0.35 dB (opt)+/-20 mV
-20	1 V/10 uW	+/-0.3 dB (opt)+/-20 mV
-30	1 V/1 uW	+/-0.3 dB (opt)+/-20 mV
-40	1 V/100 nW	+/-0.3 dB (opt)+/-20 mV
-50	1 V/10 nW	+/-0.3 dB (opt)+/-20 mV
-60	1 V/1 nW	+/-0.3 dB (opt)+/-20 mV

Equipment:

Optical/Electrical Transducer Standard
 Optical Signal Source
 DVM
 Optical Cable assembly (Diamond - Diamond)
 2 x Optical cable assembly (Diamond - NEC)
 Cable Assembly BNC
 50 Ohm Feedthrough Termination
 Optical attenuator

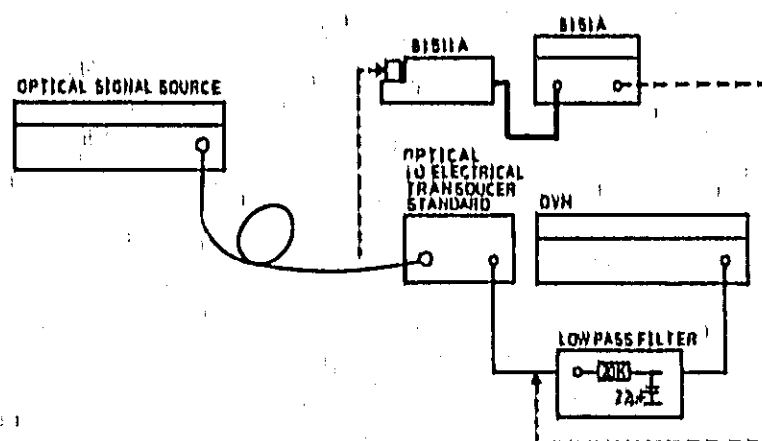


Figure 4-12. Test setup for Transducer Conversion Factor tests

Procedure:

- Set the 850 nm Optical Signal Source as follows:
 MODE NORM
 WAVEFORM square
 DUTY CYCLE 50%
 EXTINCTION RATIO 2.00
 MEASAL POWER LEVEL as required

2. Set the Optical/electrical Transducer Standard to 1 V/mW.
3. Set the 8151A to measure MESIAL POWER LEVEL in its +10 dBm range.
4. Press the ZERO key.
5. Set the DVM to dc, Autorange and Autozero.
6. Connect the Optical Signal Source, via the Transducer Standard, to the DVM, as shown in Figure 4-12. Select the built-in filter function of the DVM, or use an external lowpass filter as shown in Figure 4-12.
7. Adjust the MESIAL POWER LEVEL of the Optical Signal Source to give a reading of 1.000 V +/- 5 mV on the DVM.
8. Connect the Optical Signal Source to the 8151A/8151A and the Transducer output of the 8151A.
9. Verify that $83.33 \text{ mV} < \text{DVM reading} < 117.15 \text{ mV}$.
10. Repeat tests 6 to 8 using the settings listed in the following table. Verify that the Transducer output (DVM reading) is within the given limits.

Mesial Power Level DVM reading	8151A Range	Transducer Output DVM reading
0.500 V +/- 2.5 mV	+00 dBm	456.6 mV to 545.8 mV
50.00 mV +/- 0.25 mV	-10 dBm	441.3 mV to 562.0 mV

11. Set the Optical/Electrical Transducer Standard to 1 V/10 uW.
12. Continue the procedure using the following table, verifying for each test that the Transducer output is within the given limits.

Mesial Power Level DVM reading	8151A Range	Transducer Output DVM reading
0.500 V +/- 2.5 mV	-20 dBm	446.6 mV to 555.8 mV
50.00 mV +/- 0.25 mV	-30 dBm	446.6 mV to 555.8 mV

13. Set the Optical/Electrical Transducer Standard to 1 V/10 nW.
14. Continue the procedure using the following table, verifying for each test that the Transducer output is within the given limits.

Mesial Power Level DVM reading	8151A Range	Transducer Output DVM reading
0.500 V +/- 2.5 mV	-40 dBm	446.6 mV to 555.8 mV
50.00 mV +/- 0.25 mV	-50 dBm	446.6 mV to 555.8 mV

15. Connect the Optical Signal Source, via a 20 dB Optical Attenuator, to the Optical/Electrical Transducer Standard.

16. Connect the Transducer Standard to the DVM and adjust the MESIAL POWER LEVEL of the Optical Signal Source to give a reading of $8.00 \text{ mV} \pm 0.04 \text{ mV}$ on the DVM.
17. Connect the Optical Signal Source to the 8151A/8151A, and the 8151A Transducer output to the DVM.
18. Set the 8151A to its -60 dBm range.
19. Verify that $726.6 \text{ mV} < \text{DVM reading} < 877.2 \text{ mV}$

TRANSDUCER FLATNESS

Specifications:

Range: 30 Hz to 9.99 MHz; ± 0.3 dB (opt) of amplitude
 (+10 dBm to 0 dBm) 10 MHz to 99.9 MHz; ± 0.5 dB (opt) of amplitude
 100 MHz to 150 MHz; ± 1.0 dB (opt) of amplitude
 -3.0 dB cutoff at 250 MHz

(0 dBm to -10 dBm) 30 Hz to 9.99 MHz; ± 0.4 dB (opt) of amplitude
 10 MHz to 99.9 MHz; ± 0.6 dB (opt) of amplitude
 100 MHz to 150 MHz; ± 1.1 dB (opt) of amplitude

Equipment:

Optical Signal Source
 VHF Signal Generator
 Optical/Electrical Transducer (5mV/mW, transition time < 1 ns)
 True rms Voltmeter (AC to DC converter),
 DVM
 Power Meter
 Power Sensor (< 10 pW), reference attenuator
 Optical Cable Assembly (Diamond - Diamond)
 2 x Optical Cable Assembly (Diamond - NEC)
 Optical Attenuator 10 dB
 3 x Cable Assembly BNC
 Feedthrough Termination 50 Ohm
 2 x 20 dB Attenuator

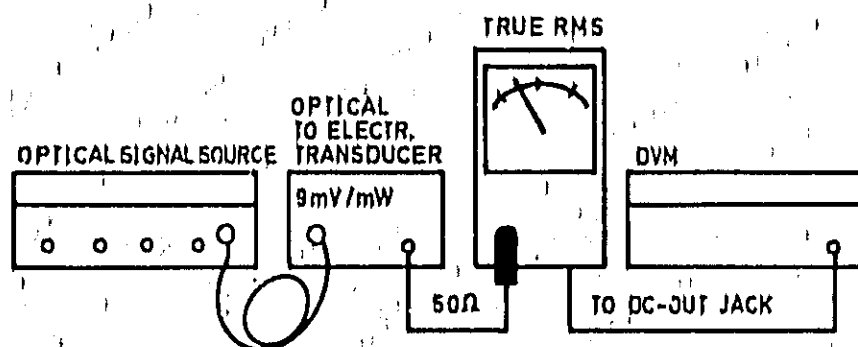


Figure 4-13. Test setup for establishing flatness of the stimulating source.

Procedure:

For this series of tests, it is necessary to know the flatness of the source to be used. Start the test procedure by establishing the flatness of the stimulating optical source as follows:

- a. Connect the equipment as shown in Figure 4-13.

- b. Set the Optical Signal Source as follows:

MODE	NORM
FREQUENCY	30 Hz
DUTY CYCLE	50%
WAVEFORM	sine
EXTINCTION RATIO	5.00
MESIAL POWER LEVEL	600 uW

- c. Set the True rms AC to DC converter to 0.003 V range.

- d. Set the DVM to dc, 1 V range.

- e. The reading on the DVM is the reference for the following flatness measurements. Record the reading (30 Hz reference) for future use.

- f. Set the frequency of the Optical Signal Source to 100 Hz, 1.0 kHz, 10 kHz, 100 kHz, 1.0 MHz and 9.99 MHz respectively, and convert the DVM voltage readings into dB(opt) values using the following formula:

$$X = 10 \log [\text{DVM reading} / 30 \text{ Hz reference}] \text{ dB}$$

List the recorded values in the Test Record.

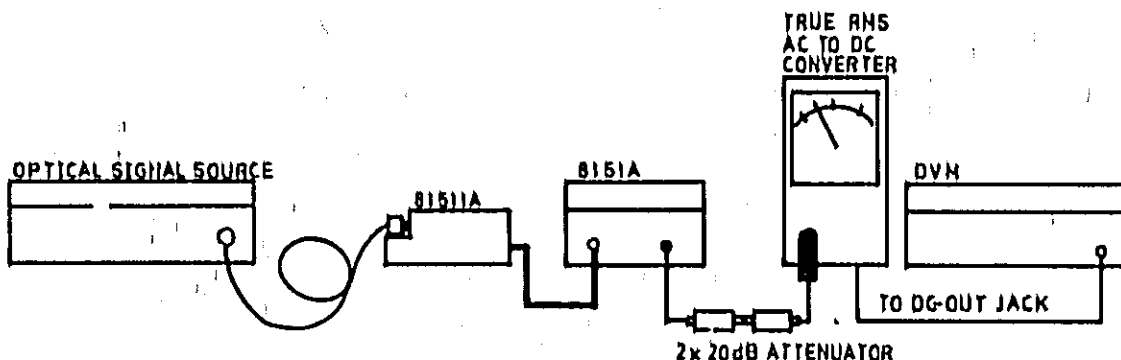


Figure 4-14. Test setup for Transducer flatness tests to 9.99 MHz

1. Connect the equipment as shown in Figure 4-14.
2. Set the Optical Signal Source as follows:

FREQUENCY	30.0 Hz
EXTINCTION RATIO	5.00
MESIAL POWER LEVEL	600 uW
3. Set the 8151A to "Full Bandwidth" mode, AMP, 00 dBm range.
4. Press the ZERO key.
5. Set the True rms AC to DC converter to 0.003 V range.

6. Set the DVM to dc, 1 V range.
7. The reading on the DVM is the reference for the following flatness measurements. As in steps e and f, note the reading, and take readings for 100 Hz, 1.0 kHz, 10 kHz, 100 kHz, 1.0 MHz and 9.99 MHz. Convert these readings into dB (opt) values, and list them in the Test Record. Verify that the difference between the following values and the previously-recorded values for the optical source are within the given limits.

The formula for deriving the 8151A flatness values is as follows:

$$X(8151A) = X(\text{optical source} + 8151A) - X(\text{optical source})$$

Frequency setting	X(8151A) limits	
30.0 Hz	0.0 dB reference	
100 Hz	-0.3 dB	+0.3 dB
1.0 kHz	-0.3 dB	+0.3 dB
10 kHz	-0.3 dB	+0.3 dB
100 kHz	-0.3 dB	+0.3 dB
1.0 MHz	-0.3 dB	+0.3 dB
9.99 MHz*	-0.3 dB	+0.3 dB

*This value will be required for test 19.

8. Connect the optical attenuator to the 8151A/8151A via the 10 dB optical attenuator.
9. Set the 8151A to its -10 dBm range.
10. Repeat steps 2 to 7, and verify that the 8151A flatness values are within the limits listed in the following table.

Frequency setting	X(8151A) limits	
30.0 Hz	0.0 dB reference	
100 Hz	-0.4 dB	+0.4 dB
1.0 kHz	-0.4 dB	+0.4 dB
10 kHz	-0.4 dB	+0.4 dB
100 kHz	-0.4 dB	+0.4 dB
1.0 MHz	-0.4 dB	+0.4 dB
9.99 MHz*	-0.4 dB	+0.4 dB

*This value will be required for test 23.

For tests at higher frequencies, the equipment needs to be changed, as in the preceding tests, the flatness of the stimulating source must be established.

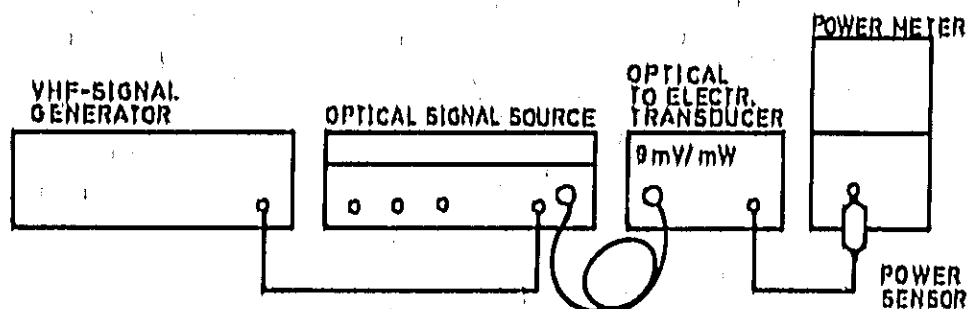


Figure 4-15. Test setup for establishing the flatness of the stimulating source at high frequencies.

- B. Connect the equipment as shown in Figure 4-15.
- h. Prepare the power meter/power sensor for accurate measurements by calibrating against the power reference, and pressing the ZERO key.
- i. Set the Optical Signal Source as follows:

TRANSDUCER MODE	ON
CONVERSION FACTOR	1.0 mW/V
OFFSET COMPENSATION	0.00 V
- j. Set the VHF signal generator as follows:

FREQUENCY	10 MHz
AMPLITUDE	0.8 Vpp
- k. Set the Power Meter to the correct cal. factor for 10 MHz.
- l. When the reading on the Power Meter has stabilized, press the dB (rel) key to bring the 0 dB reference into display.
- m. Set the frequency of the VHF generator to 30 MHz, 50 KHz and 99.9 MHz respectively, ensuring that the correct cal. factor is input to the Power Meter for each frequency. Record the dB value for each result, divide it by 2, and enter it into the Test Record at the end of this section.

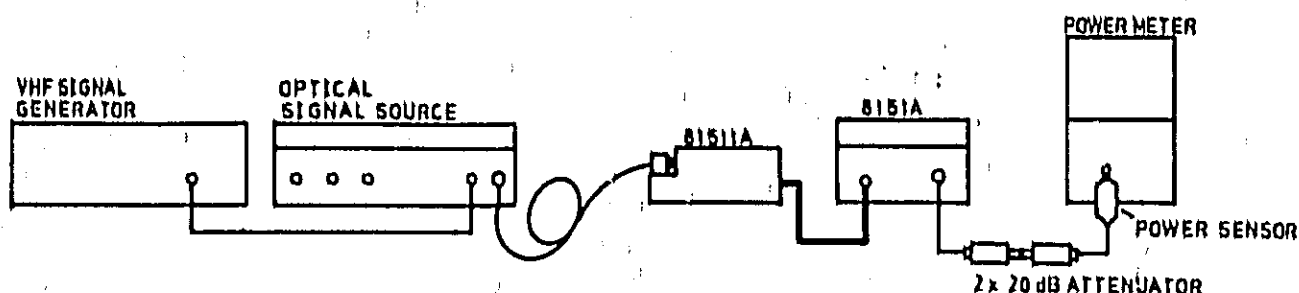


Figure 4-16. Test setup for VHF measurement flatness tests > 10 MHz.

11. Connect the equipment as shown in Figure 4-16.
12. Set the VHF generator frequency to 10 MHz.
13. Set the 8151A to "Full Bandwidth" mode, AMP and 00 dBm range.
14. Press the ZERO key, and wait until the 8151A starts to measure the power amplitude of the input signal.
15. Prepare the Power Meter for accurate measurements by calibrating against the power source and enabling the ZERO function.
16. Enter the correct cal. factor for 10 MHz into the Power Meter.
17. When the Power Meter reading has stabilized, press the dB (rel) key to bring the 0 dB reference into display.
18. Set the frequency of the VHF generator to 30 MHz, 50 MHz, 100 MHz, 150 MHz and 250 MHz respectively, taking care to enter the correct cal. factors for each frequency, and list the results [dB(rel) / 2] in the Test Record.
19. The flatness (X) of the 8151A is calculated as follows:

$$X(8151A) = X(8151A + \text{optical source}) - X(\text{optical source}) + X(9.99 \text{ MHz}) \text{ (step 7)}$$
20. Verify that the calculated values are within the given limits as follows:

Frequency setting	X(8151A) limits	
10.0 MHz	same as 9.99 MHz (step 7)	
30.0 MHz	-0.5 dB	+0.5 dB
50.0 MHz	-0.5 dB	+0.5 dB
100 MHz	-1.0 dB	+1.0 dB
150 MHz	-1.0 dB	+1.0 dB
250 MHz	-3.0 dB	

21. Connect the optical source to the 8151A/8151A via the 10 dB optical attenuator.
22. Set the 8151A to its -10 dBm range.
23. Repeat the procedure as in steps 12 to 18, verifying that the 8151A flatness values are within the following given limits:

The formula for calculating X(8151A) is as follows:

$$X(8151A) = X(8151A + \text{optical source}) - X(\text{optical source}) + X(9.99 \text{ MHz}) \text{ (step 10)}$$

Frequency setting	X(8151A) limits	
10.0 MHz	same as 9.99 MHz, step 10	
30.0 MHz	-0.6 dB	+0.6 dB
50.0 MHz	-0.6 dB	+0.6 dB
100 MHz	-1.1 dB	+1.1 dB
150 MHz	-1.1 dB	+1.1 dB
250 MHz	-3.0 dB	

HP-IB CAPABILITY

Equipment:

System Controller
HP-IB Cable Assembly

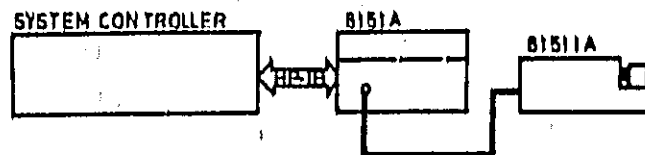


Figure 4-17. Test setup for HP-IB Capability tests

Procedure:

1. Connect the equipment as shown in Figure 4-17.
2. Set the 8151A's HP-IB address switch to address 18.
3. Enter and run the following BASIC program:

```

10 DIM S$(500)
20 DIM B$(6)
30 CLEAR
40 PRINT TAB(4)"*****"
50 PRINT TAB(4)"* HP-IB CAPABILITY *"
60 PRINT TAB(4)"*****"
70 REMOTE 7
80 CLEAR 718
90 A=SPOLL(718)
100 IF BIT(A,4)=0 THEN 70
110 OUTPUT 718;"IDF"
120 ENTER 718;B$
130 PRINT USING"2/,4X,19A,2/,9X,6A,2/"; "DEVICE UNDER TEST",B$
140 OUTPUT 718;"AR0,RNG 0DBM,WVL 850NM,AVG"
150 OUTPUT 718;"CST"
160 ENTER 718;S$
170 PRINT "CURRENT PARAMETER SETTING":
180 PRINT USING"/,162A,3/,12X,3A,5/"; S$,"END"
190 LOCAL 7
200 END
  
```

4. The printout from the controller should read as follows:

* HP-IB CAPABILITY *

DEVICE UNDER TEST:

8151A

CURRENT PARAMETER SETTING:

FO;UQ;ARQ;TQ;HD1#;RNG 00
DBM;REF + 0.00 DBM;CAL + 0.
00 DBR;WVL 850. NM;WCP +
0.00 DBR;AVG

END

PERFORMANCE TEST RECORD

Hewlett-Packard Company
Model 8151A/81511A
Optical Pulse Power Meter/Optical Head

Instrument Serial No. _____
Tested by _____
Date _____

Page No.	Description	Result		
		min.	actual	max.
4-2	High Peak Power	1.63 mW		1.98 mW
	1,000 V +/- 5 mV	0.88 mW		1.12 mW
	1,000 V +/- 5 mV	934 uW		1769 uW
	0,500 V +/- 2.5 mV	462 uW		540 uW
	0,100 V +/- 0.5 mV	87.3 uW		113.4 uW
	0,100 V +/- 0.25 mV	41.1 uW		59.2 uW
	1,000 V +/- 5 mV	9.45 uW		10.57 uW
	0,500 V +/- 2.5 mV	4.67 uW		5.34 uW
	0,100 V +/- 0.5 mV	945 nW		1057 nW
	0,050 V +/- 0.25 mV	467 nW		534 nW
	1,000 V +/- 5 mV	94.5 nW		105.7 nW
	0,500 V +/- 2.5 mV	46.7 nW		53.4 nW
	0,100 V +/- 0.5 mV	9.35 nW		10.67 nW
	0,050 V +/- 0.25 mV	4.57 nW		5.44 nW
		853 pW		1152 pW
4-5	Low Peak Power	1.35 mW		1.66 mW
	0,100 V +/- 0.5 mV	84 nW		116 uW
	0,050 V +/- 0.2 mV	41.1 uW		59.2 uW
	0,500 V +/- 2.5 mV	4.67 uW		5.34 uW
	0,100 V +/- 0.5 mV	0.85 uW		1.15 uW
	0,050 V +/- 0.25 mV	467 nW		534 nW
	1,000 V +/- 5 mV	85 nW		115 nW
	0,500 V +/- 2.5 mV	46.7 nW		53.4 nW
	0,100 V +/- 0.5 mV	8.5 nW		11.5 nW
	0,050 V +/- 0.25 mV	4.57 nW		5.44 nW
	8.00 mV +/- 0.08 mV	667 pW		937 pW
4-9	Average Power	0.90 mW		1.10 mW
	0,500 V +/- 2.5 mV	471 uW		529 uW
	0,200 V +/- 1.0 mV	186 uW		215 uW
	0,100 V +/- 0.5 mV	90 uW		110 uW
	50.00 mV +/- 0.25 mV	47.1 uW		52.9 uW
	1,000 V +/- 5 mV	9.0 uW		11.0 uW
	0,500 V +/- 2.5 mV	4.71 uW		5.29 uW
	0,100 V +/- 0.5 mV	0.90 uW		1.10 uW
	50.00 mV +/- 0.25 mV	47.1 nW		52.9 nW

Page No.	Description	Result		
		min.	actual	max.
4-12	Measurement Flatness	1,000 V $\pm$ 5 mV	90 nW	110 nW
		0,500 V $\pm$ 2.5 mV	47.1 nW	52.9 nW
		0,100 V $\pm$ 0.5 mV	9.0 nW	11.0 nW
		50.00 mV $\pm$ 0.25 mV	4.61 nW	5.41 nW
			881 pW	1123 pW
		Source		
		1.0 kHz	dB	
		10 kHz	dB	
		100 kHz	dB	
		1.0 MHz	dB	
		9.99 MHz	dB	
		200 Hz	0.00 dB	
		1.0 kHz	-0.3 dB	+0.3 dB
		10 kHz	-0.3 dB	+0.3 dB
		100 kHz	-0.3 dB	+0.3 dB
		1.0 MHz	-0.3 dB	+0.3 dB
		9.99 MHz*	-0.3 dB	+0.3 dB
4-17	Pulse Response	200 Hz	0.00 dB	
		1.0 kHz	-0.4 dB	+0.4 dB
		10 kHz	-0.4 dB	+0.4 dB
		100 kHz	-0.4 dB	+0.4 dB
		1.0 MHz	-0.4 dB	+0.4 dB
		9.99 MHz	-0.4 dB	+0.4 dB
		Source		
		30 MHz	dB	
		50 MHz	dB	
		99.9 MHz	dB	
		10.0 MHz	dB	
		30.0 MHz	-0.5 dB	+0.5 dB
		50.0 MHz	-0.5 dB	+0.5 dB
		99.9 MHz	-0.5 dB	+0.5 dB
		10.0 MHz	dB	
		30.0 MHz	-0.6 dB	+0.6 dB
		50.0 MHz	-0.6 dB	+0.6 dB
		99.9 MHz	-0.6 dB	+0.6 dB
4-17	Pulse Response	preshoot		
		overshoot		
		ringing		
		droop		10%

Page No.	Description	Result		
		min.	actual	max.
4-19	Transitions:			1.8 ns
	Leading edge			1.8 ns
	Trailing edge			10 ns
	Leading edge			10 ns
	Trailing edge			100 ns
	Leading edge			100 ns
	Trailing edge			100 ns
	Transducer Conversion Factor	83.33 mV		117.15 mV
	0.500 V $\pm$ 2.5 mV	446.6 mV		555.8 mV
	50.00 mV $\pm$ 0.25 mV	446.6 mV		555.8 mV
4-22	0.500 V $\pm$ 2.5 mV	446.6 mV		555.8 mV
	50.00 mV $\pm$ 0.25 mV	443.6 mV		555.8 mV
		726.6 mV		877.2 mV
	Transducer Flatness			
	Source		V	
	30 Hz		dB	
	100 Hz		dB	
	1.0 kHz		dB	
	10 kHz		dB	
	100 kHz		dB	
	1.0 MHz		dB	
	9.99 MHz		dB	
	30.0 Hz		0.00 dB	
	100 Hz	-0.3 dB		+0.3 dB
	1.0 kHz	-0.3 dB		+0.3 dB
	10 kHz	-0.3 dB		+0.3 dB
	100 kHz	-0.3 dB		+0.3 dB
	1.0 MHz	-0.3 dB		+0.3 dB
	9.99 MHz*	-0.3 dB		+0.3 dB
	30.0 Hz		0.00 dB	
	100 Hz	-0.4 dB		+0.4 dB
	1.0 kHz	-0.4 dB		+0.4 dB
	10 kHz	-0.4 dB		+0.4 dB
	100 kHz	-0.4 dB		+0.4 dB
	1.0 MHz	-0.4 dB		+0.4 dB
	9.99 MHz*	-0.4 dB		+0.4 dB
	Source			
	30 MHz		dB	
	50 MHz		dB	
	99.9 MHz		dB	

Page No.	Description	Result		
		min.	actual	max.
4-27	30 MHz		dB	
	50 MHz		dB	
	100 MHz		dB	
	150 MHz		dB	
	250 MHz		dB	
	10.0 MHz		dB	
	30.0 MHz	-0.5 dB		+0.5 dB
	50.0 MHz	-0.5 dB		+0.5 dB
	100 MHz	-1.0 dB		+1.0 dB
	150 MHz	-1.0 dB		+1.0 dB
	250 MHz	-3.0 dB		
	10.0 MHz		dB	
	30.0 MHz	-0.6 dB		+0.6 dB
	50.0 MHz	-0.6 dB		+0.6 dB
	100 MHz	-1.1 dB		+1.1 dB
	150 MHz	-1.1 dB		+1.1 dB
	250 MHz	-3.0 dB		
	HP-IB Capability			
	Output OK?		yes/no	

ADJUSTMENTS

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SECTION V

ADJUSTMENT PROCEDURE

5-1 INTRODUCTION

This section describes the adjustments which will return the instrument to peak operating condition after repairs are completed. An adjustment location diagram is given on a fold-out page at the end of this section.

5-2 SAFETY CONSIDERATIONS

Although this instrument has been designed in accordance with international safety standards, this manual contains information, cautions, and warnings which must be followed to ensure safe operation and to retain the instrument in safe condition (see Sections II and III).

WARNING

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

Any adjustment, maintenance or repair of an open instrument with voltage applied should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

5-3 EQUIPMENT REQUIRED

The test equipment required for the adjustment procedure is listed in Table 1-1, Recommended Test Equipment. The critical specifications of substitute test instruments must meet or exceed the standards listed in the table if the instrument is to meet the standards set forth in Table 1-2, Specifications.

5-4 ADJUSTMENT PROCEDURE

The adjustment procedure is divided into the following sections:

- 5-5 Average Path
- 5-6 LF-Peak Detectors
- 5-7 HF-Measuring Path
- 5-8 IIF-Amplifier
- 5-9 LF-Buffer

Before starting the adjustment procedure, set the HP-IB address switch to 18 and load the address by pressing the LOCAL key at the frontpanel.

All adjustments are done by using test cable 08151-61611 to give the required electrical input signals to the 8151A.

Allow a half-hour warm-up time prior to carrying out adjustments on the 8151A.

5-5 AVERAGE PATH**Equipment:****DVM**

Power Supply, 2 Volt fine adjustable

Test cable assembly 08151-61611

50 Ohm feedthrough termination

Procedure:**Offsets**

1. Connect test cable assembly to the 8151A head input connector.
2. Terminate the test cable BNC connector with a 50 Ohm load.
3. Set 8151A to AVG, - 50 dBm range.
4. Set DVM to DC, 10 V range (resolution = 100 uV)
5. Connect DVM low terminal to A5 TP3.
6. Connect DVM high terminal to A5 TP8.
7. Adjust A5 R7 for 0.0000 V reading on DVM.

Trend Meter Adjustment

8. Set test switch A5 S14 to its "on" position.
9. Wire-connect A5 TP7 to ground.
10. Connect DVM low terminal to GND pin next to A5 TP3.

11. Connect DVM high terminal to A5 TP3.
12. Connect fine adjustable power supply (approx. 2 V) to the 50 Ohm terminated BNC connector of the test cable assembly.
13. Adjust the power supply voltage to give a DVM reading of 10.0000 V +/- 0.0005 V.
14. Adjust A5 R5 to make the trend-meter indicator point to the white/red breakpoint.

ADC-gain

15. Adjust A5 R10 to bring 5.00 nW into the 8151A display.
16. Disconnect the power supply from the test cable assembly, but leave the test cable assembly terminated with the 50 Ohm load.
17. Remove the wire-connection between A5 TP7 and ground.
18. Reset the test switch A5 S14 to its "off" position.

ADC-offset

19. Adjust A5 R11 to bring 0.00 nW into the 8151A display.

5-6 LF-PEAK DETECTORS

Equipment:

Test cable assembly 08151-61611
50 Ohm feedthrough termination

Procedure:

Preparation

1. Connect test cable assembly to the 8151A head input connector.
2. Terminate the test cable BNC connector with a 50 Ohm load.
3. Set 8151A to HIGH, ~ 50 dBm range.
4. Turn A5 R3 clockwise to bring a positive value into the 8151A display (approximately 0.05 nW)

Low Peak Level

5. Set 8151A to LOW.
6. Adjust A5 R4 to bring 0.00 nW into the 8151A display.

High Peak Level

7. Set 8151A to HIGH
8. Readjust A5 R3 to bring 0.00 nW into the 8151A display.

5-7 HF-MEASURING PATH**Equipment:**

Test cable assembly 08151-61611

DVM

HP 85 F System Controller

HP-IB Interface

Real Time Oscilloscope

10:1 probe

50 Ohm feedthrough termination

Procedure:**HF-Averager Offset**

1. Connect test cable assembly to the 8151A head input connector.
2. Terminate the test cable BNC connector with a 50 Ohm load.
3. Connect DVM low terminal to the GND pin next to A5 TP5.
4. Connect DVM high terminal to A5 TP5.
5. Set DVM to DC, 10 V range (resolution = 100 μ V)
6. Adjust A5 R2 for 0.0000 V reading on DVM.

Ramp Generator DAC Offset

7. Connect an HP 85 F via HP-IB Interface to the 8151A.
8. Connect DVM low terminal to GND pin next to A5 TP6
9. Connect DVM high terminal to A5 TP6.
10. Execute the following commands on the HP 85 F System Controller:

OUTPUT 718; "SDA BST BHW 1C4B FF"
OUTPUT 718; "SDA BST BHW 1C5B FF"
OUTPUT 718; "SDA BST BHW 1C7B 00"
11. Adjust A5 R8 for - 0.5000 V reading on DVM.

Ramp Generator DAC Gain

12. Execute the following commands on the HP 85 F System Controller:

OUTPUT 718; "SDA BST BHW 1C4B 00"
OUTPUT 718; "SDA BST BHW 1C5B 00"
OUTPUT 718; "SDA BST BHW 1C7B 00"

13. Adjust A5R9 for 1.5470 V reading on DVM.

HF Peak Detector

14. Execute the following commands on the HP 85 F System Controller:

OUTPUT 718; "SDA BST BHW 1C4B 17"
OUTPUT 718; "SDA BST BHW 1C5B FC"
OUTPUT 718; "SDA BST BHW 1C7B 00"

15. Check that the DVM reads 0.0000 V +/- 0.0004 V

16. Connect Realtime Oscilloscope via 10:1 probe to the junction of A5R29 and A5R30.

17. Set Realtime Oscilloscope to DC, 5 us/div. and 50 mV/div.

18. Adjust A5 R1 to achieve a signal on the scope screen which lies in the middle between the ECL high level and ECL low level. At this point the signal may oscillate.

19. Repeat step 10 and check that the signal on the scope screen goes to ECL high level (approx. - 0.8 V).

20. Repeat step 12 and check that the signal on the scope screen goes to ECL low level (approx. - 1.6 V).

5-8 HF-AMPLIFIER

Equipment:

Pulse Generator
 Real Time Oscilloscope
 2 x DVM
 3 x Cable Assembly, BNC
 BNC (f) to SMB (m) Adapter
 BNC (m) to BNC (m) Adapter
 Test Cable Assembly 08151-61611
 2 x 50 Ohm feedthrough

Procedure:

LF Gain (x 4 Amplifier Transducer O/P)

1. Connect equipment as shown in figure 5-1.

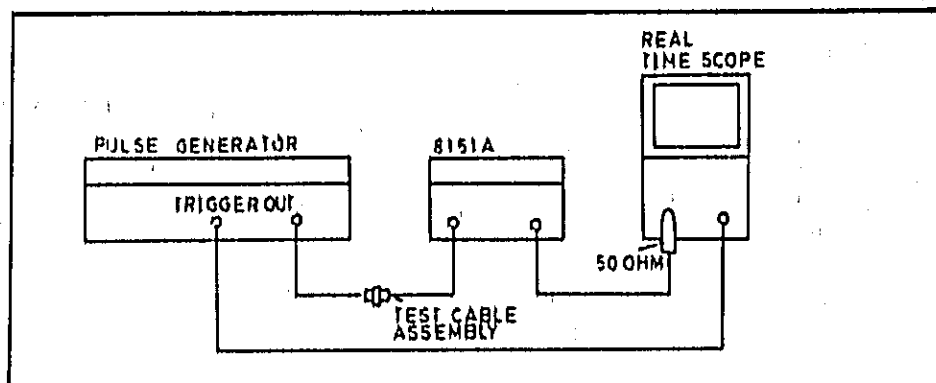


Figure 5-1

2. Set 8151A to HIGH, 00 dBm range.
3. Set Pulse Generator to generate a positive squarewave output signal

FREQUENCY	10 Hz
WIDTH	50 ms
AMPLITUDE	250 mVpp
BASELINE OFFSET	0.0 V

4. Adjust A3 R370 for an optimal squarewave signal on scope.

LF Gain (x 4 Amplifier Measuring O/P)

5. Unplug cable assembly A3W36 (J36) from A5J6 on the A5 Measuring Board and connect it via an SMB/BNC adapter and a 50 Ohm feedthrough termination to the oscilloscope input.
6. Adjust A3 R335 for an optimal squarewave signal on scope.
7. Reconnect A3W36 (J36) to A5J6.

x 10 Amplifier Offset

8. Connect the equipment as shown in figure 5-2.

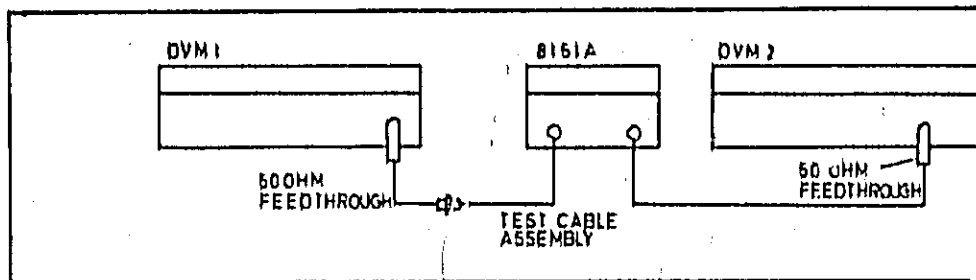


Figure 5-2

9. Set 8151A to HIGH, -10 dBm range.
10. Set DVM 1 to DC, 2V (or 10V) range, (resolution 100 μ V).
11. Set DVM 2 to DC, 0.1 V range

NOTE:

Steps 12 and 13 are interactive adjustments.

Repeat steps 12 and 13 until both DVM readings are within the given limits.

12. Adjust A3 R101 for 0.0000 V $\pm$ 0.0009 V on DVM 1.
13. Adjust A3 U100 R102 for 0.0 mV $\pm$ 3 mV on DVM 2.

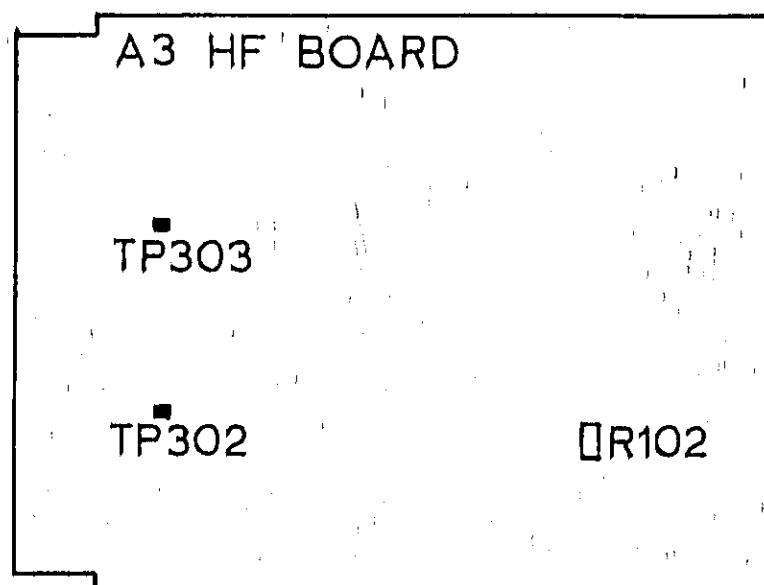
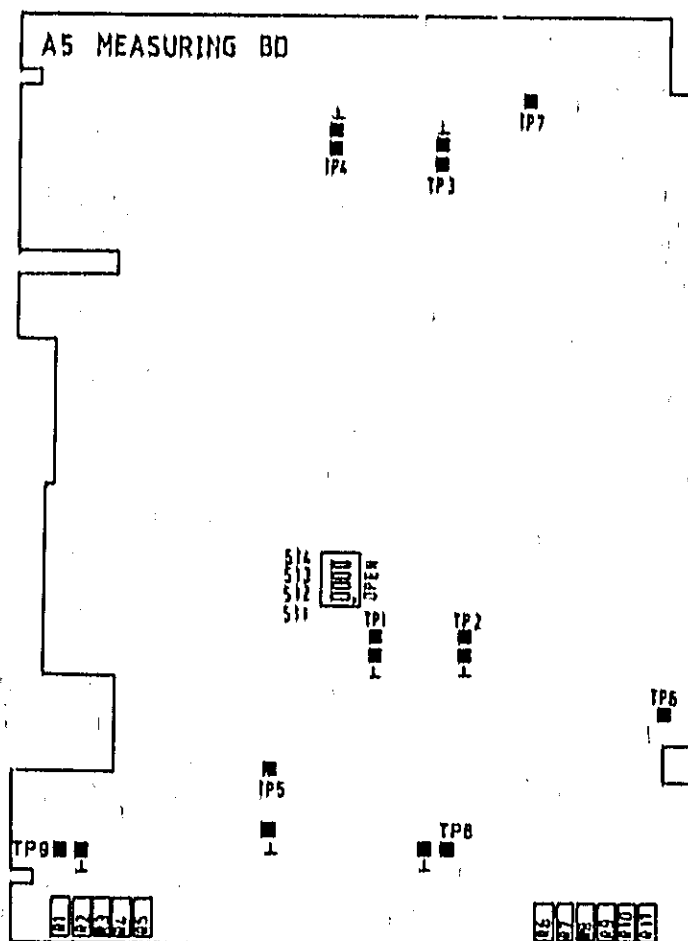
5-9 LF-BUFFER**Equipment:****DVM**

Test cable assembly 08151-61611

50 Ohm feedthrough termination

Offset

1. Turn instrument off and on again.
2. Connect test cable assembly to the 8151A head input connector and terminate the test cable BNC connector with a 50 Ohm load.
3. Set 8151A to AVG, - 50 dBm range.
4. Set DVM to DC, 10V range (resolution = 100 μ V)
5. Connect DVM to the Transducer Output connector.
6. Adjust A5R6 for 0.0000V reading on DVM



PARTS LIST

SECTION VI

REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts list and elsewhere in the manual. Table 6-2 lists all replaceable parts in reference designator order.

6-3 ABBREVIATIONS

6-4 Table 6-1 lists abbreviations used in the parts lists, schematics and elsewhere in 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, the same abbreviations may have both lower and upper case letters.

6-5 REPLACEABLE PARTS

6-6 Table 6-2 is a list of replaceable parts and is organized as follows:

- a. Mainframe (chassis) parts in alpha-numerical order by reference designation.
- b. Electrical assemblies and their components in alpha-numerical order by reference designation.

Reference designators are of the form A3R9 (ie. resistor 9 on assembly 3).

6-7 The data given for each part is as follows:

- a. Part number check digit
- b. Hewlett-Packard part number
- c. Item description

6-8 ORDERING INFORMATION

6-9 To order a part listed in the replaceable parts list, quote the Hewlett-Packard part number (with check digit), indicate the quantity required and address the order to the nearest Hewlett-Packard office (list of Sales/Service Offices at the rear of this manual). The check digit will ensure accurate and timely processing of the order.

6-10 To order a part that is not listed, include the instrument model number, serial number, a complete description of the part(s) required and the number of parts required. Address the order to the nearest Hewlett-Packard Sales/Service Office.

6-11 DIRECT MAIL ORDER SYSTEM (USA)

6-12 Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are as follows:

- a. Direct ordering and shipment from the HP Parts Center in Mountain View, California.
- b. No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP office when the parts require billing and invoicing).
- c. Pre-paid transportation (there is a small handling charge for each order).
- d. No invoices - to provide these advantages, a check or money order must accompany each order.

6-13 Mail order forms and specific ordering information is available through the local HP office. Addresses and phone numbers are given at the back of this manual.

Table 6-1. Abbreviations for Replaceable Parts List

REFERENCE DESIGNATIONS

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

ABBREVIATIONS

A ampere	CW continuous wave	h hour	MET OX metallic oxide
ac alternating current	cw clockwise	HET heterodyne	MF medium frequency; microfarad (used in parts list)
ACCESS accessory	cm centimeter	HEX hexagonal	MFR microfarad
ADJ adjustment	D/A digital-to-analog	HD head	mg milligram
A/D analog-to-digital	dB decibel	HDW hardware	MHz megahertz
AF audio frequency	dBm decibel referred to 1 mW	HF high frequency	mH millihenry
AFC automatic frequency control	dc direct current	HG mercury	mho mho
AGC automatic gain control	deg degree (temperature interval) or difference	HI high	MIN minimum
AL aluminum	° degree (plane angle)	HP Hewlett-Packard	min minute (time)
ALC automatic level control	°C degree Celsius (centigrade)	HPF high pass filter	minute (plane angle)
AM amplitude modulation	°F degree Fahrenheit	HR hour (used in parts list)	
AMPL amplifier	°K degree Kelvin	HV high voltage	MINAT miniature
APC automatic phase control	DEPC deposited carbon	Hz Hertz	mm millimeter
ASSY assembly	DET detector	IC integrated circuit	MOD modulator
AUX auxiliary	diam diameter	ID inside diameter	MOM momentary
avg average	DIA diameter (used in parts list)	IF intermediate frequency	MOS metal-oxide semiconductor
AWG American wire gauge	DIFF AMPL differential amplifier	IMPG impregnated	ms millisecond
BAL balance	div division	IN inch	MTG mounting
BCD binary coded decimal	DPDT double pole, double throw	INCD incandescent	MTR meter (measuring device)
BD board	DR drive	INCL includes	mV millivolt
BE CU beryllium copper	DSB double sideband	INS insulation	mVac millivolt, ac
BFO beat frequency oscillator	DTL diode transistor logic	INT internal	mVdc millivolt, dc
BH binder head	DVM digital voltmeter	IN inch	mVpk millivolt, peak
BKDN breakdown	FCL emitter coupled logic	lb pound	mVp p millivolt, peak-to-peak
BP bandpass	EMF electromotive force	LC inductance-capacitance	mVrms millivolt, rms
BPF bandpass filter	EDP electronic data processing	LED light-emitting diode	mW milliwatt
BRS brass	ELECT electrolytic	LF low frequency	MDX multiplex
BWO backward-wave oscillator	ENCAP encapsulated	LG long	MY mylar
CAL calibrate	EXT external	LH left hand	μA microampere
ccw counter-clockwise	F farad	LIM limit	μF microfarad
CER ceramic	FET field-effect transistor	LIN linear taper (used in parts list)	μH microhenry
CHAN channel	F/F flip-flop	lin linear	μmho micromho
cm centimeter	FH flat head	LK WASH lock washer	μs microsecond
CMO cabinet mount only	FIL H filar head	LO low; local oscillator	μV microvolt
COAX coaxial	FM frequency modulation	LOG logarithmic taper (used in parts list)	μVac microvolt, ac
COEF coefficient	FP front panel	log logarithmic	μVdc microvolt, dc
COM common	FREQ frequency	LPF low pass filter	μVp p microvolt, peak-to-peak
COMP composition	FXD fixed	LV low voltage	μVrms microvolt, rms
COMPL complete	g gram	m meter (distance)	μW microwatt
CONN connector	GE germanium	mA milliamperes	nA nanampere
CP cadmium plate	GHz gigahertz	MAX maximum	NC no connection
CRT cathode-ray tube	GL glass	MΩ megohm	N/C normally closed
CTL complementary transistor logic	GRD grounded	MEG meg (10 ⁶) (used in parts list)	NE neon
	H henry	MET FLM metal film	NEG negative

NOTE

All abbreviations in the parts list will be in upper case.

Table 6-1. Abbreviations for Replaceable Parts List (cont'd)

NORM normal	POT potentiometer	SI silicon	VFO variable frequency oscillator
NPH negative-positive	pp peak-to-peak	SIL silver	VHF very high frequency
negative	PP peak-to-peak (used in parts list)	SL slide	Vpk volts, peak
NPO negative-positive zero (zero temperature coefficient)	PPM pulse position modulation	SNR signal-to-noise ratio	Vp-p volts, peak-to-peak
NRFR not recommended for field replacement	PREF pulse repetition frequency	SPDT single-pole, double-throw	Vrms volts, rms
NSR not separately replaceable	PRR pulse repetition rate	SPQ spring	VSWR voltage standing wave ratio
ns nanosecond	 picosecond	SR split ring	VTO voltage-tuned oscillator
nW nanowatt	 point	SPST single-pole, single-throw	VTVM vacuum-tube voltmeter
OBD order by description	PTM pulse-time modulation	SSB single sideband	V(X) volts, switched
OD outside diameter	PWM pulse-width modulation	SSY stainless steel	W watt
OH oval head	PWV peak working voltage	STL steel	W with
OP AMPL operational amplifier	RC resistance-capacitance	SQ square	WIV working inverse voltage
OPT option	RECT rectifier	SWR standing wave ratio	WW wirewound
OSC oscillator	REF reference	SYNC synchronize	W/O without
OX oxide	REG regulated	T timed (slow-blow fuse)	YIG yttrium-iron garnet
oz ounce	REPL replaceable	TA tantalum	Z ₀ characteristic impedance
SL ohm	RF radio frequency	TC temperature compensating	
P peak (used in parts list)	RFI radio frequency interference	TD time delay	
PAM pulse amplitude modulation	RH round head; right hand	TERM terminal	
PC printed circuit	RLC resistance, inductance, capacitance	TFT thin-film transistor	
PCM pulse-code modulation; pulse-count modulation	RMO rack mount only	TGL toggle	
PDM pulse-duration modulation	rms root-mean square	THD thread	
pF picofarad	RND round	THRU through	
PH BRZ phosphor bronze	ROM read-only memory	TI titanium	
PHU Phillips	R&P rack and panel	TOL tolerance	
PIN positive-intrinsic-negative	RWV reverse working voltage	TRIM trimmer	
PIV peak inverse voltage	S scattering parameter	TSTR transistor	
pk peak	s second (time)	TTL transistor-transistor logic	
PL phase lock	 second (plane angle)	TV television	
PLO phase lock oscillator	S-B slow blow (fuse) (used in parts list)	TVI television interference	
PM phase modulation	SCR silicon controlled rectifier; screw	TWT traveling wave tube	
PNP positive-negative-positive	SE selenium	U micro (10 ⁶) (used in parts list)	
P/O part of	SECT sections	UF microfarad (used in parts list)	
POLY polystyrene	SEMICON semiconductor	UHF ultrahigh frequency	
PORC porcelain	SHF superhigh frequency	UNREG unregulated	
POS positive; position(s) (used in parts list)		V volt	
POSN position		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	

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 will be in upper-case.

Figure 6-1. Mechanical Parts

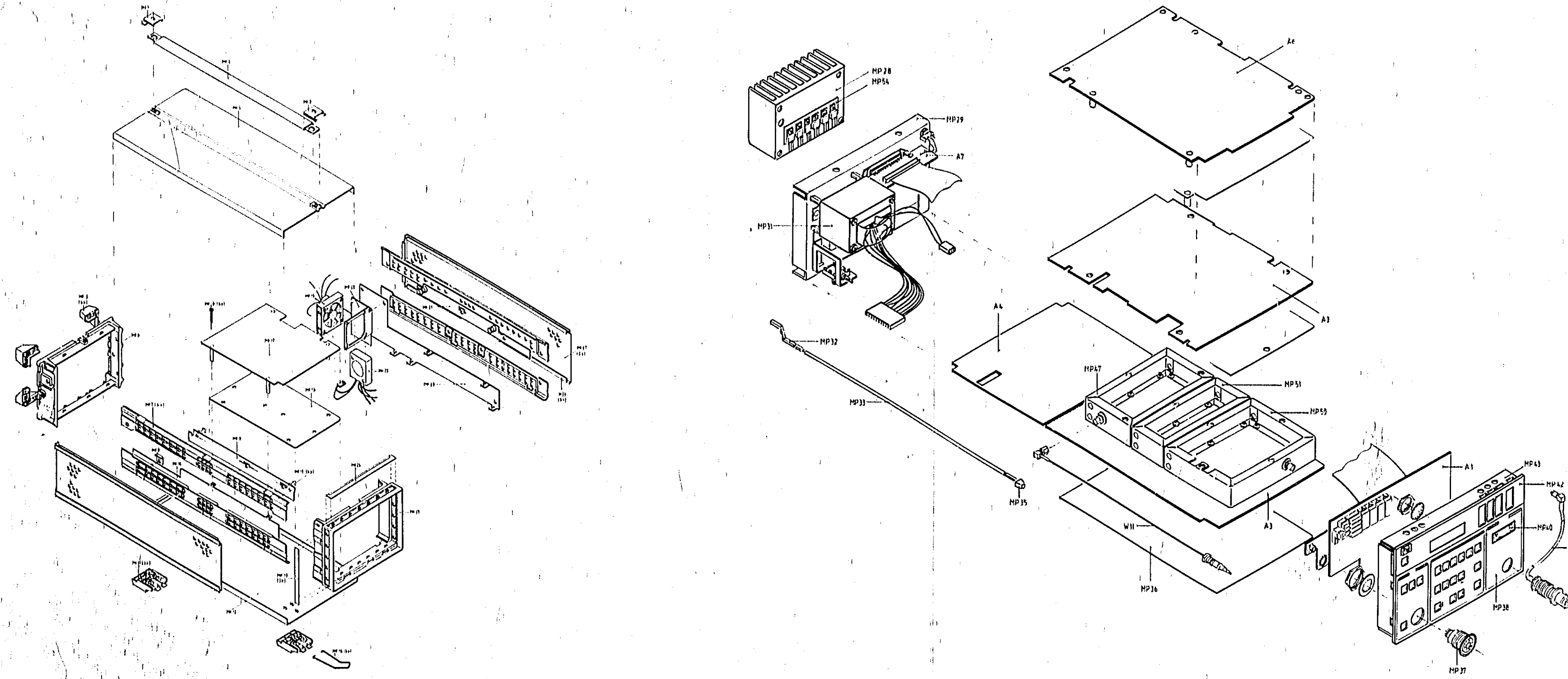


Table 6-2. Replaceable Parts

REFERENCE DESIGNATOR	C H-P PART NUMBER	DESCRIPTION
A1	6 08151-66501	BD AY DISP-KEY
A2	9 08151-66502	BD AY-VERN. KEY
A3	0 08151-66503	BD AY-VERN. KEY
A4	1 08151-66504	BD AY PWR SPLY
A5	2 08151-66505	BD AY MEASURING
A6	3 08151-66506	BD AY MICROPRCR
A7	4 08151-66507	BD AY HP-ID
A8	5 08151-66508	BD AY-CONNECTOR
F1	2 2110-0360	FUSE .75A
F1	6 2110-0421	FUSE .375A 250V
FL1	5 0960-0679	LINE MODULE FLTD
MP1	1 5040-7220	CAP. HANDLE-REAR
MP2	3 5060-9804	STRAP HDL 16IN
MP3	8 5040-7219	CAP. HANDLE-FRONT
MP4	0 5001-0431	TOP COVER HANDLE
MP5	2 5040-7221	FOOT REAR
MP6	1 5020-8816	REAR FRAME
MP7	6 5020-8837	CORNER STRUT
MP8	2 08151-01204	BRKT RECTIFIER
MP9	3 08151-01205	BRKT LEFT PCB
MP10	5 08151-02304	HOLDER PCB LEFT
MP11	8 5040-7201	FOOT
MP12	0 5060-9843	BOTTOM COVER
MP13	8 5001-0439	TRIM SIDE 5,25
MP14	5 1460-1345	TILT STAND
MP16	6 08151-00606	SHIELD HF VI
MP17	1 08151-00601	SHILD HF BD
MP18	9 0515-0551	SCR M3.5X50 PAN
MP19	3 3160-0265	FAN TUBE AXIAL
MP20	9 08151-01201	BRACKET FAN
MP21	1 08151-01203	BRACKET RIGHT
MP22	8 3160-0310	MODULE MOTOR CON
MP23	3 08151-02302	HOLDER PCB RIGHT
MP24	0 5040-7203	TRIM STRIP
MP25	0 5020-8815	FRAME-FRONT
MP26	9 5020-8848	TRIM COVER
MP27	4 5060-9912	COVER SIDE
MP28	0 08151-21101	HEAT SINK
MP29	3 08151-60201	AY-PANEL REAR
MP30	0 5040-1148	SHAFT-SHORT/GRAY
MP31	8 5040-7756	EXTENDER ROD PBT
MP32	5 5041-0551	KEY
MP33	7 08151-00607	SHIELD HF VII
MP37	4 1250-1886	CONNECTOR SOCKET
MP38	7 08151-00201	FRONT PANEL
MP40	4 1120-1899	METER
MP42	4 08151-28101	WINDOW
MP43	8 08151-00202	PANEL SUB
MP47	6 08151-65204	HOUSING AY RIGHT
MP48	5 08151-65203	HOUSING AY MIDDL
MP49	9 08151-05401	INSULATOR TRANS
S2	0 3101-1702	SW TOGGLE SPDT
W11	0 08151-61602	CBL AY RF RIGID
W12	9 08151-61601	CBL AY-SHIL CONN
W13	1 08151-61603	WIRE AY-PWR SPLY
W14	6 08151-61608	WIRE ASSY

REFERENCE DESIGNATOR	C H-P PART D NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C H-P PART D NUMBER	DESCRIPTION
A1	00151-66501	DD AY DISP-KEY	A2	00151-66502	DD AY-VERN, KEY
A1 DS0	3 1990-0665	LAMP-SOLID STATE	A2 S1	4 3101-2530	SW RKR
A1 DS10	3 1990-0665	LAMP-SOLID STATE	A2 S2	4 3101-2530	SW RKR
A1 DS11	3 1990-0665	LAMP-SOLID STATE	A2 S3	4 3101-2530	SW RKR
A1 DS12	3 1990-0665	LAMP-SOLID STATE	A2 S4	4 3101-2530	SW RKR
A1 DS13	3 1990-0665	LAMP-SOLID STATE			
A1 DS14	3 1990-0665	LAMP-SOLID STATE			
A1 DS20	3 1990-0665	LAMP-SOLID STATE			
A1 DS21	3 1990-0665	LAMP-SOLID STATE			
A1 DS23	3 1990-0665	LAMP-SOLID STATE			
A1 DS25	3 1990-0665	LAMP-SOLID STATE			
A1 DS28	3 1990-0665	LAMP-SOLID STATE			
A1 DS29	3 1990-0665	LAMP-SOLID STATE			
A1 DS30	3 1990-0665	LAMP-SOLID STATE			
A1 DS31	3 1990-0665	LAMP-SOLID STATE			
A1 DS32	3 1990-0665	LAMP-SOLID STATE			
A1 DS50	8 1990-0941	DISPLAY-SOLID ST			
A1 DS51	8 1990-0941	DISPLAY-SOLID ST			
A1 DS52	8 1990-0941	DISPLAY-SOLID ST			
A1 DS53	8 1990-0941	DISPLAY-SOLID ST			
A1 DS54	8 1990-0941	DISPLAY-SOLID ST			
A1 DS101	0 1990-0696	LED-VISIBLE			
A1 DS102	0 1990-0696	LED-VISIBLE			
A1 DS103	0 1990-0696	LED-VISIBLE			
A1 DS104	0 1990-0696	LED-VISIBLE			
A1 DS105	0 1990-0696	LED-VISIBLE			
A1 DS106	0 1990-0696	LED-VISIBLE			
A1 DS107	0 1990-0696	LED-VISIBLE			
A1 DS108	3 1990-0805	LED HLMP-2350RED			
A1 DS109	3 1990-0805	LED HLMP-2350RED			
A1 DS110	3 1990-0805	LED HLMP-2350RED			
A1 DS111	3 1990-0805	LED HLMP-2350RED			
A1 DS113	0 1990-0696	LED-VISIBLE			
A1 DS114	0 1990-0696	LED-VISIBLE			
A1 DS115	0 1990-0696	LED-VISIBLE			
A1 S9	7 5060-9436	SW P-BTN SINGLE			
A1 S10	7 5060-9436	SW P-BTN SINGLE			
A1 S11	7 5060-9436	SW P-BTN SINGLE			
A1 S12	7 5060-9436	SW P-BTN SINGLE			
A1 S13	7 5060-9436	SW P-BTN SINGLE			
A1 S14	7 5060-9436	SW P-BTN SINGLE			
A1 S16	7 5060-9436	SW P-BTN SINGLE			
A1 S17	7 5060-9436	SW P-BTN SINGLE			
A1 S19	7 5060-9436	SW P-BTN SINGLE			
A1 S20	7 5060-9436	SW P-BTN SINGLE			
A1 S21	7 5060-9436	SW P-BTN SINGLE			
A1 S22	7 5060-9436	SW P-BTN SINGLE			
A1 S23	7 5060-9436	SW P-BTN SINGLE			
A1 S25	7 5060-9436	SW P-BTN SINGLE			
A1 S28	7 5060-9436	SW P-BTN SINGLE			
A1 S29	7 5060-9436	SW P-BTN SINGLE			
A1 S30	7 5060-9436	SW P-BTN SINGLE			
A1 S31	7 5060-9436	SW P-BTN SINGLE			
A1 S32	7 5060-9436	SW P-BTN SINGLE			
A1 W1	3 5180-2424	CBL AY RIB 250MM			

REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION
A3 C330	5	0160-0576	C-F .1UF 20% CER	A3 R6	1	0698-3155	R-F 4.64K 1% .125
A3 C331	5	0160-0576	C-F .1UF 20% CER	A3 R7	4	0698-4453	R-F 402 1% .125W
A3 C332	5	0160-0576	C-F .1UF 20% CER	A3 R8	5	0757-0274	R-F 1.21K1%
A3 C333	5	0160-0576	C-F .1UF 20% CER	A3 R9	5	0757-0274	R-F 1.21K1%
A3 C334	5	0160-0576	C-F .1UF 20% CER	A3 R10	5	0757-0274	R-F 1.21K1%
A3 C335	3	0180-0374	C-F .10UF 20V	A3 R11	5	0757-0274	R-F 1.21K1%
A3 C336	5	0160-0576	C-F .1UF 20% CER	A3 R20	8	1810-0470	R-NETWORK 0X2.2K
A3 C337	3	0180-0374	C-F .10UF 20V	A3 R21	8	1810-0470	R-NETWORK 0X2.2K
A3 J1B	8	1251-4246	CONN-3 PIN	A3 R22	8	1810-0470	R-NETWORK 0X2.2K
A3 J33	2	1251-3119	CONN 20PIN RIBN	A3 R23	8	1810-0470	R-NETWORK 0X2.2K
A3 J34	2	1251-7666	CONN-POST 16 PIN	A3 R24	8	1810-0470	R-NETWORK 0X2.2K
A3 J38	8	1251-3751	CONN 8-PIN M	A3 R25	8	1810-0470	R-NETWORK 0X2.2K
A3 K100	0	0490-1398	RELAY TELEDYNE	A3 R100	2	0757-0453	R-F 30.1K1% .125W
A3 K200	0	0490-1398	RELAY TELEDYNE	A3 R101	7	2100-3253	R-V 50K 10% .5W
A3 K230	5	0490-1137	RELAY-REED 5V	A3 R103	5	0698-4123	R-F 499 1% .125W
A3 K231	5	0490-1137	RELAY-REED 5V	A3 R104	1	0698-4434	R-F 2.32K1%
A3 K240	5	0490-1137	RELAY-REED 5V	A3 R105	3	0757-0280	R-F 1K 1% .125W
A3 K241	5	0490-1137	RELAY-REED 5V	A3 R301	4	0698-7267	R-F 10.6K 1% .05
A3 K250	4	0490-0517	RLY-REED IC 250M	A3 R302	9	0698-7212	R-F 100 1% .05W
A3 K300	0	0490-1398	RELAY TELEDYNE	A3 R303	9	0698-7212	R-F 100 1% .05W
A3 L1	2	0140-0112	COIL CHOKE 4.7UH	A3 R304	8	0698-7279	R-F 51.9K 1% .05W
A3 L2	2	0140-0112	COIL CHOKE 4.7UH	A3 R305	8	0698-7279	R-F 51.9K 1% .05W
A3 L3	2	0140-0112	COIL CHOKE 4.7UH	A3 R306	7	0698-7236	R-F 1K 1% .05W
A3 L4	2	0140-0112	COIL CHOKE 4.7UH	A3 R307	6	0698-7227	R-F 422 1% .05W
A3 L5	2	0140-0112	COIL CHOKE 4.7UH	A3 R308	2	0699-1215	R-F 10 0HM 5%
A3 L6	2	0140-0112	COIL CHOKE 4.7UH	A3 R309	0	0757-0401	R-F 100 1% .125W
A3 L100	5	0100-1708	CHOKE	A3 R310	2	0699-1215	R-F 10 0HM 5%
A3 L101	5	0100-1708	CHOKE	A3 R311	1	0699-1214	R-F 33 0HM 5%
A3 L102	5	0100-1708	CHOKE	A3 R312	1	0699-1214	R-F 33 0HM 5%
A3 L103	5	0100-1708	CHOKE	A3 R313	4	0698-4453	R-F 402 1% .125W
A3 L201	5	0100-2249	COIL-CHOKE .15UH	A3 R314	4	0698-4453	R-F 402 1% .125W
A3 L202	5	0100-3551	COIL-FXD 1.00UH	A3 R315	7	0698-7236	R-F 1K 1% .05W
A3 L301	0	0170-0894	CORE MAGNETIC	A3 R316	6	0698-7227	R-F 422 1% .05W
A3 L302	0	0170-0894	CORE MAGNETIC	A3 R317	8	0698-7108	R-F 10 2% .050W
A3 L303	0	0170-0894	CORE MAGNETIC	A3 R318	7	0698-7236	R-F 1K 1% .05W
A3 L304	0	0170-0894	CORE MAGNETIC	A3 R319	9	0698-7197	R-F 23.7 1% .05W
A3 L305	0	0170-0894	CORE MAGNETIC	A3 R320	7	0698-0812	R-F 1 1% .125W
A3 L307	0	0170-0894	CORE MAGNETIC	A3 R321	5	0698-7218	R-F 170 1% .05W
A3 L308	0	0170-0894	CORE MAGNETIC	A3 R322	9	0698-4391	R-F 59.0 1%
A3 L310	0	0170-0894	CORE MAGNETIC	A3 R323	2	0698-4386	R-F 59.0 1/8W 1%
A3 L311	0	0170-0894	CORE MAGNETIC	A3 R324	9	0698-7212	R-F 100 1% .05W
A3 L312	0	0170-0894	CORE MAGNETIC	A3 R325	8	0757-0277	R-F 49.9 1%
A3 Q301	5	1854-0591	XSTR NPN SI	A3 R327	4	0757-0489	R-F 10 1% .25W F
A3 Q302	5	1853-0450	XSTR PNP SI	A3 R328	4	0757-0489	R-F 10 1% .25W F
A3 Q303	5	1853-0450	XSTR PNP SI	A3 R329	3	0757-0280	R-F 1K 1% .125W
A3 Q304	5	1854-0591	XSTR NPN SI	A3 R330	9	0757-0442	R-F 10K1% .125W
A3 Q305	3	1854-0720	XSTR SI NPN HF	A3 R331	5	0757-0703	R-F 39.2 1% .23W
A3 Q306	3	1854-0720	XSTR SI NPN HF	A3 R332	5	0757-0703	R-F 39.2 1% .25W
A3 Q307	9	1854-0704	XSTR NPN 2N3866A	A3 R334	9	0698-7288	R-F 147K 1% .05W
A3 Q308	5	1854-0591	XSTR NPN SI	A3 R335	6	2100-3253	RES-TRMR 5K 10%
A3 Q309	5	1853-0450	XSTR PNP SI	A3 R336	4	0698-7267	R-F 19.6K 1% .05
A3 Q310	5	1853-0450	XSTR PNP SI	A3 R337	9	0698-7197	R-F 23.7 1% .05W
A3 Q311	5	1854-0501	XSTR NPN SI	A3 R338	8	0698-7229	R-F 511 1% .05W
A3 Q312	3	1854-0720	XSTR SI NPN HF	A3 R339	1	0698-7254	R-F 14.7K 1% .05
A3 Q313	3	1854-0720	XSTR SI NPN HF	A3 R340	0	0698-7247	R-F 2.87K 1% .05
A3 Q314	9	1854-0704	XSTR NPN 2N3866A	A3 R341	4	0698-7267	R-F 19.6K 1% .05
A3 R1	1	0698-3155	R-F 4.64K 1% .125	A3 R342	6	0698-7227	R-F 422 1% .05W
A3 R2	1	0698-3155	R-F 4.64K 1% .125	A3 R343	7	0698-7236	R-F 1K 1% .05W
A3 R3	1	0698-3155	R-F 4.64K 1% .125	A3 R344	2	0699-1215	R-F 10 0HM 5%
A3 R4	1	0698-3155	R-F 4.64K 1% .125	A3 R345	0	0757-0401	R-F 100 1% .125W
A3 R5	1	0698-3155	R-F 4.64K 1% .125	A3 R346	1	0699-1214	R-F 33 0HM 5%

REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION
A3 R347	1	0690-1214	R-F 33 01M 5X	A4 C23	3	0160-0574	C-F .022UF CER
A3 R348	4	0690-4453	R-F 402 1X .125W	A4 C24	3	0160-0574	C-F .022UF CER
A3 R349	4	0690-4453	R-F 402 1X .125W	A4 C25	3	0160-0574	C-F .022UF CER
A3 R350	2	0690-1215	R-F 10 01M 5X	A4 C27	3	0160-0574	C-F .022UF CER
A3 R351	5	0690-7227	R-F 422 1X .05W	A4 C28	3	0160-0574	C-F .022UF CER
A3 R352	7	0690-7236	R-F 1K 1X .05W	A4 C29	3	0160-0574	C-F .022UF CER
A3 R353	8	0690-7188	R-F 10 2X .050W	A4 C30	3	0160-0574	C-F .022UF CER
A3 R354	8	0690-7197	R-F 23.7 1X .05W	A4 C31	3	0160-0574	C-F .022UF CER
A3 R355	7	0690-0812	R-F 1 1X .125W	A4 C32	3	0160-0574	C-F .022UF CER
A3 R356	7	0690-7236	R-F 1K 1X .05W	A4 C33	3	0160-0574	C-F .022UF CER
A3 R357	5	0690-7210	R-F 178 1X .05W	A4 C34	3	0160-0574	C-F .022UF CER
A3 R358	0	0690-4301	R-F 69.8 1X	A4 C35	3	0160-0574	C-F .022UF CER
A3 R359	2	0690-4306	R-F 69.0 1/8W 1X	A4 C36	0	0160-3508	C-F 1 UF 50V
A3 R360	9	0690-7212	A-F 100 1X .05W	A4 C40	5	0180-3403	C-F EL 10UF
A3 R361	0	0757-0277	R-F 49.0 1X	A4 C42	0	0160-3508	C-F 1 UF 50V
A3 R363	4	0757-0449	R-F 10 1X .25W F	A4 C43	0	0160-3508	C-F 1 UF 50V
A3 R364	4	0757-0480	R-F 10 1X .25W F	A4 C44	0	0180-2580	C-F 3.3UF 15V
A3 R365	3	0757-0280	R-F 1K 1X .125W	A4 C102	5	0160-0576	C-F 1UF 20% CER
A3 R366	0	0757-0442	R-F 10K 1X .125W	A4 C103	5	0160-0576	C-F 1UF 20% CER
A3 R367	5	0757-0703	R-F 39.2 1X .25W	A4 C104	1	0180-3325	C-F 15000UF 15V
A3 R368	5	0757-0703	R-F 39.2 1X .25W	A4 C105	1	0180-3325	C-F 15000UF 15V
A3 R369	9	0690-7240	R-F 147K 1X .05W	A4 C106	5	0160-0576	C-F 1UF 20% CER
A3 R370	6	2100-325	RES-TRMR 5K 10%	A4 C201	0	0180-2580	C-F 3.3UF 15V
A3 R371	4	0690-7257	R-F 18.8K 1X .05	A4 CR2	3	1901-0636	DIO AY-SI 100V
A3 R372	9	0690-7197	R-F 23.7 1X .05W	A4 CR3	3	1901-0636	DIO AY-SI 100V
A3 R373	0	0690-7229	R-F 511 1X .05W	A4 CR5	3	1901-0050	DIO 5W 80V 200MA
A3 R374	4	0690-7267	R-F 10.5K 1X .05	A4 CR6	3	1901-0050	DIO 5W 80V 200MA
A3 R375	0	0757-0401	R-F 100 1X .125W	A4 CR7	3	1901-0050	DIO 5W 80V 200MA
A3 R376	0	0757-0401	R-F 100 1X .125W	A4 CR8	7	1901-0731	DIO-PWR 400V 1A
A3 R377	9	0690-7212	R-F 100 1X .05W	A4 CR10	7	1901-0731	DIO-PWR 400V 1A
A3 R378	9	0690-7212	R-F 100 1X .05W	A4 CR11	3	1901-0050	DIO 5W 80V 200MA
A3 TP302	0	0360-0535	TERM-TEST POINT	A4 CR12	3	1901-0050	DIO 5W 80V 200MA
A3 TP303	0	0360-0535	TERM-TEST POINT	A4 CA13	5	1901-1060	DIO SCHOTTPY
A3 U2	5	1990-0732	OPTO-ISOLATOR	A4 CR43	7	1901-0731	DIO-PWR 400V 1A
A3 U3	5	1990-0732	OPTO-ISOLATOR	A4 CR102	3	1901-0702	DIO 1N5821
A3 U4	5	1990-0732	OPTO-ISOLATOR	A4 CR103	6	1901-0702	DIO 1N5821
A3 U5	2	1820-1976	IC MC 14050 BCP	A4 CR201	9	1901-0535	DIO SCHOT HP2311
A3 U6	5	1858-0047	XSTR ARY 16P-DIP	A4 F101	7	2110-0274	FUSE 3A 125V
A3 U100	0	0950-1673	VIDEO AMPLIFIER	A4 J2	8	1251-3751	CONN R-PIN M
A3 U301	7	1825-0111	IC 1458	A4 J3	0	1251-0305	CONN 4-PIN
A3 U302	0	1825-0535	IC OP-076	A4 J5	0	1251-3538	CONN 6PIN M POST
A3 U303	0	1825-0535	IC OP-076	A4 J6	5	1251-5383	CONN 2-PIN N
A3 W31	5	08151-61507	CBL AY-SHIELD	A4 J1A	7	1251-3750	CONN 10PIN POST
A3 W35	2	08151-61504	CBL AY-SHIELD	A4 J1B	8	1251-4245	CONN-3 PIN
A3 W36	4	08151-61506	CBL AY-SHIELD	A4 J4A	1	1251-5155	CONTACT-CONN
A3 W37	4	08151-61506	CBL AY-SHIELD	A4 J4B	7	1251-5007	CONN-UTIL FASXT
A3 W39	3	08151-61505	CBL AY-SHIELD	A4 Q1	7	1853-0006	XSTR 2N5087
A4		08151-66504	BD AY PWR 3PLY	A4 Q2	2	1854-0828	XSTR NPN S T220
A4 C3	3	0160-0574	C-F .022UF CER	A4 Q3	2	1853-0234	XSTR T1F 42A
A4 C4	3	0160-0574	C-F .022UF CER	A4 Q4	2	1854-0628	XSTR NPN S T220
A4 C5	3	0160-0574	C-F .022UF CER	A4 Q5	7	1854-0039	XSTR 2N3055 51
A4 C6	3	0160-0574	C-F .022UF CER	A4 Q40	7	1853-0437	XSTR PNP 2N6520
A4 C8	1	0180-3325	C-F 15000UF 15V	A4 Q41	7	1853-0437	XSTR PNP 2N6520
A4 C9	7	0180-3158	C-F 6800UF 15V	A4 Q42	7	1853-0437	XSTR PNP 2N6520
A4 C10	4	0180-3402	C-F EL 4700UF	A4 Q43	7	1853-0437	XSTR PNP 2N65
A4 C11	4	0180-3006	C-F .01F 35V AL	A4 Q400	7	1854-0081	XSTR 2N6239
A4 C12	5	0160-0576	C-F 1UF 20% CER	A4 R1	5	0690-3520	R-F 100 5X 2W MO
A4 C15	3	0180-3401	ALU EL CAP 470PF	A4 R5	6	0690-3409	R-F 40.2K1X
A4 C16	3	0180-3401	ALU EL CAP 470PF	A4 R6	7	0757-0415	R-F 511 1X .125W
A4 C17	3	0180-3401	ALU EL CAP 470PF	A4 R8	7	0690-3268	R-F 11.5K1X
A4 C19	3	0180-3401	ALU EL CAP 470PF	A4 R9	3	0757-0290	R-F 1K 1X .125W
A4 C20	3	0180-3401	ALU EL CAP 470PF				
A4 C22	3	0160-0574	C-F .022UF CER				

Replaceable Parts

Model 3151A

REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION
A4 R10	1	0757-0401	R-F 100 1% .125W	A5		08151-66505	RD AY MEASURING
A4 R11	0	0690-4409	R-F 127 1% .125W	A5 C1	2	0160-4385	C-F 15PF 200V
A4 R12	0	0690-0085	R-F 2.61K1%	A5 C2	3	0160-0574	C-F .022UF CER
A4 R13	0	0690-0085	R-F 2.61K1%	A5 C3	5	0160-4040	C-F 1000PF 100V
A4 R15	3	0757-0280	R-F 1K 1% .125W	A5 C4	5	0160-0576	C-F .1UF 20% CER
A4 R16	3	0757-0280	R-F 1K 1% .125W	A5 C5	5	0160-4040	C-F 1000PF 100V
A4 R17	3	0757-0280	R-F 1K 1% .125W	A5 C6	5	0160-0576	C-F .1UF 20% CER
A4 R18	3	0757-0280	R-F 1K 1% .125W	A5 C7	4	0160-4387	C-F 47PF 200V
A4 R19	3	0757-0280	R-F 1K 1% .125W	A5 C8	7	0160-3879	C-F .01UF 100V
A4 R20	3	0757-0280	R-F 1K 1% .125W	A5 C9	7	0160-3879	C-F .01UF 100V
A4 R21	3	0757-0280	R-F 1K 1% .125W	A5 C10	5	0160-0576	C-F .1UF 20% CER
A4 R22	3	0757-0280	R-F 1K 1% .125W	A5 C11	5	0160-4040	C-F 1000PF 100V
A4 R23	5	0811-3470	R-F .1 3% 3W PW	A5 C12	7	0180-0229	C-F 33UF 10V
A4 R24	5	0811-3470	R-F .1 3% 3W PW	A5 C13	7	0180-0220	C-F 33UF 10V
A4 R25	3	0757-0121	R-F 34.0K 1%	A5 C14	5	0160-0576	C-F .1UF 20% CER
A4 R26	1	0690-4452	R-F 147K1% .125W	A5 C15	3	0160-0574	C-F .022UF CER
A4 R28	1	0757-0459	R-F 61.0K 1%	A5 C16	5	0160-0576	C-F .1UF 20% CER
A4 R29	9	0812-0072	R-F .23 5% 3W	A5 C17	3	0160-0574	C-F .022UF CER
A4 R30	6	0690-0849	3.07K 1% .125W	A5 C18	1	0160-4350	C-F 50PF 200V
A4 R31	3	0690-6614	R-F 7.5K 1%	A5 C19	2	0160-3874	C-F 10PF 200V
A4 R32	1	0690-6323	R-F 100 1% .125W	A5 C21	5	0160-4040	C-F 1000PF 100V
A4 R33	0	0690-6320	R-F 5K 1% .125W	A5 C22	1	0160-4350	C-F 50PF 200V
A4 R34	0	0690-0063	R-F 5.2K 1%	A5 C23	2	0160-4385	C-F 15PF 200V
A4 R35	5	0690-0063	R-F 4.0K 1%	A5 C24	3	0160-0574	C-F .022UF CER
A4 R36	0	0757-0401	R-F 100 1% .125W	A5 C25	3	0160-0574	C-F .022UF CER
A4 R37	2	0757-0346	R-F 10 1% .125W	A5 C30	5	0160-4040	C-F 1000PF 100V
A4 R38	7	0757-0424	R-F 1.1K1% .125W	A5 C31	6	0160-5684	C-F 0.1UF 10%
A4 R40	7	0757-0160	R-F 511 1% .25	A5 C32	6	0160-5684	C-F 0.1UF 10%
A4 R41	4	0690-0827	R-F 1M 1% .125W	A5 C33	3	0160-0574	C-F .022UF CER
A4 R42	0	0757-0442	R-F 10K1% .125W	A5 C34	3	0160-0574	C-F .022UF CER
A4 R43	8	0690-3152	R-F 3.40K 1%	A5 C35	4	0160-4387	C-F 47PF 200V
A4 R44	4	0690-0827	R-F 1M 1% .125W	A5 C36	3	0160-0574	C-F .022UF CER
A4 R45	0	0757-0442	R-F 10K1% .125W	A5 C37	3	0160-0574	C-F .022UF CER
A4 R46	8	0690-3152	R-F 3.40K 1%	A5 C42	5	0160-4040	C-F 1000PF 100V
A4 R107	2	0757-0437	R-F 4.75K1%	A5 C43	5	0160-0576	C-F .1UF 20% CER
A4 R201	2	0690-4477	R-F 10.5K1%	A5 C44	5	0160-4040	C-F 1000PF 100V
A4 TP2	0	0360-0535	TERM-TEST POINT	A5 C45	7	0160-3879	C-F .01UF 100V
A4 U1	0	1826-0445	IC UA7905UC	A5 C46	5	0160-0576	C-F .1UF 20% CER
A4 U3	0	1826-0356	IC UA781UC	A5 C47	5	0160-0576	C-F .1UF 20% CER
A4 U4	3	1826-0315	IC 348	A5 C48	5	0160-0576	C-F .1UF 20% CER
A4 U6	8	1326-0700	IC REF-01CP	A5 C49	7	0160-3879	C-F .01UF 100V
A4 U8	2	1826-0512	IC MC76M15CG	A5 C50	5	0160-0576	C-F .1UF 20% CER
A4 U9	9	1826-0220	IC LM320H-5	A5 C51	7	0160-3879	C-F .01UF 100V
A4 U51	0	1826-0346	IC 358	A5 C52	5	0160-0576	C-F .1UF 20% CER
A4 U52	7	1826-0111	IC 1458	A5 C53	7	0160-3879	C-F .01UF 100V
A4 VR3	5	1902-0960	DIO-2NR 12V 5%	A5 C54	8	0160-3879	C-F 2.2UF 10%
A4 VR4	5	1902-0522	DIO 5V 5% 5W	A5 C58	7	0160-3879	C-F .01UF 100V
A4 VR5	5	1902-0522	DIO 5V 5% 5W	A5 C59	7	0160-3879	C-F .01UF 100V
A4 VR6	5	1902-0522	DIO 5V 5% 5W	A5 C60	4	0160-4387	C-F 47PF 200V
A4 VR8	9	1902-0532	DIO 17V 5% 5W	A5 C61	5	0160-0576	C-F .1UF 20% CER
A4 VR9	9	1902-0532	DIO 17V 5% 5W	A5 C62	5	0160-0576	C-F .1UF 20% CER
A4 VR11	3	1902-0959	DIO-2NR 11V 5%	A5 C63	5	0160-0576	C-F .1UF 20% CER
A4 VR40	7	1902-0953	DIO 2NR 0.12V	A5 C64	5	0160-0576	C-F .1UF 20% CER
A4 VR41	7	1902-0953	DIO-2NR 6.2V	A5 C65	5	0160-0576	C-F .1UF 20% CER
A4 VR42	1	1902-0931	DIO 2NR 120V 5%	A5 C74	5	0160-3879	C-F .01UF 100V
A4 VR43	1	1902-0931	DIO 2NR 120V 5%	A5 C75	5	0160-0576	C-F .1UF 20% CER
				A5 C76	7	0160-3879	C-F .01UF 100V
				A5 C77	5	0160-5198	C-F .22UF 10%

REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION
A5		08161-66605	BD AY MEASURING				
A5 C78	3	0160-3726	C-F 1UF 10% 100V	A5 R10	9	2100-3502	R-VAR 200 10%
A5 C79	9	0160-3722	C-F .22UF 160V	A5 R11	9	2100-3502	R-VAR 200 10%
A5 C81	6	0160-4040	C-F 1000PF 100V	A5 R12	2	0757-0346	R-F 10 1% .125W
A5 C82	3	0160-3726	C-F 1UF 10% 100V	A5 R13	9	0757-0442	R-F 10K1% .125W
A5 C83	7	0160-3079	C-F .01UF 100V	A5 R14	2	0757-0346	R-F 10 1% .125W
A5 C84	7	0160-3079	C-F .01UF 100V	A5 R15	2	0698-3429	R-F 10.5 1%
A5 C85	3	0160-0574	C-F .022UF CER	A5 R16	7	0698-3151	R-F 2.07K1%
A5 C86	3	0160-0574	C-F .022UF CER	A5 R17	3	0757-0280	R-F 1K 1% .125W
A5 C87	6	0180-2240	C-F 47UF 20VDC	A5 R18	7	0698-3151	R-F 2.07K1%
A5 C88	6	0100-2240	C-F 47UF 20VDC	A5 R19	2	0698-3429	R-F 10.5 1%
A5 C89	7	0160-3079	C-F .01UF 100V	A5 R20	9	0757-0442	R-F 10K1% .125W
A5 C90	7	0160-3079	C-F .01UF 100V	A5 R21	6	0757-0472	R-F 200K1% .125W
A5 C91	7	0160-3079	C-F .01UF 100V	A5 R22	2	0757-0479	R-F 302K 1% 1/8W
A5 C92	7	0160-3079	C-F .01UF 100V	A5 R23	2	0698-3453	R-F 106K1% .125W
A5 C93	1	0160-0572	C-F 2200PF CER	A5 R24	8	0698-3540	R-F 15.4K1%
A5 C96	6	0180-1746	C-F 15UF 20V TA	A5 R27	9	0757-0442	R-F 10K1% .125W
A5 CR1	3	1901-0050	DIO SW 80V 200MA	A5 R28	9	0757-0442	R-F 10K1% .125W
A5 CR2	3	1901-0050	DIO SW 80V 200MA	A5 R29	2	0698-3437	R-F 133 1% .125W
A5 CR3	3	1901-0050	DIO SW 80V 200MA	A5 R30	6	0757-0399	R-F 82.5 1% .125W
A5 CR4	3	1901-0050	DIO SW 80V 200MA	A5 R31	2	0698-3437	R-F 133 1% .125W
A5 CR5	3	1901-0050	DIO SW 80V 200MA	A5 R32	6	0757-0399	R-F 82.5 1% .125W
A5 CR6	3	1901-0050	DIO SW 80V 200MA	A5 R33	6	0698-6360	R-F 10K 1% .125W
A5 CR7	3	1901-0050	DIO SW 80V 200MA	A5 R34	6	0698-6360	R-F 10K 1% .125W
A5 CR8	3	1901-0050	DIO SW 80V 200MA	A5 R35	9	0757-0442	R-F 10K1% .125W
A5 CR9	6	1901-0376	DIO LOW LEAKAGE	A5 R36	9	0757-0442	R-F 10K1% .125W
A5 CR10	6	1901-0376	DIO LOW LEAKAGE	A5 R37	6	0698-4123	R-F 499 1% .125W
A5 CR11	6	1901-0376	DIO LOW LEAKAGE	A5 R38	4	0757-0439	R-F 6.81K1% .125
A5 CR12	6	1901-0376	DIO LOW LEAKAGE	A5 R39	3	0757-0420	R-F 750 1% .125W
A5 CR15	3	1901-0050	DIO SW 80V 200MA	A5 R40	1	0698-3155	R-F 4.64K 1% .125
A5 CR16	3	1901-0050	DIO SW 80V 200MA	A5 R41	0	0698-3270	R-F 4.09K1%
A5 CR17	3	1901-0050	DIO SW 80V 200MA	A5 R42	3	0698-3511	R-F 655 1% .125W
A5 CR18	3	1901-0050	DIO SW 80V 200MA	A5 R43	7	0757-0424	R-F 1.1K1% .125W
A5 J1	2	1251-3110	CONN 20PIN RIDN	A5 R44	7	0698-7236	R-F 1K 1% .05W
A5 J2	2	1251-3110	CONN 20PIN RIDN	A5 R45	8	0757-0442	R-F 10K1% .125W
A5 J3	0	0360-2094	CBL TRANSITION	A5 R46	9	0757-0442	R-F 10K1% .125W
A5 J4	0	1251-3638	CONN 6PIN M POST	A5 R49	6	0698-6624	R-F 2K 1% .125W
A5 J5	8	1250-0543	CONN RF M SM-SNP	A5 R51	6	0698-6624	R-F 2K 1% .125W
A5 J6	8	1250-0543	CONN RF M SM-SNP	A5 R53	8	0757-0277	R-F 49.9 1%
A5 J7	8	1250-0543	CONN RF M SM-SNP	A5 R54	8	0757-0277	R-F 49.9 1%
A5 K8	0	0490-1308	RELAY TELEDYNE	A5 R55	7	0698-6361	R-F 8K 1% .125W
A5 K9	6	0490-1137	RELAY-REED 5V	A5 R56	7	0698-6361	R-F 8K 1% .125W
A5 L1	4	9100-2891	COIL-MLD 50NH	A5 R58	1	0698-4526	R-F 107K1% .125W
A5 Q1	1	1854-0537	XSTR SI 2N2219A	A5 R61	4	0757-0439	R-F 6.81K1% .125
A5 Q2	9	1853-0314	XSTR 2N2905A PNP	A5 R62	9	0757-0442	R-F 10K1% .125W
A5 Q3	2	1853-0086	XSTR 2N5087	A5 R63	3	0698-3264	R-F 11.8K1%
A5 Q4	6	1854-0392	XSTR 2N 5088	A5 R66	4	0757-0421	R-F 825 1% .125W
A5 Q5	6	1854-0503	XSTR MPS A18	A5 R67	8	0757-0442	R-F 10K1% .125W
A5 Q7	6	1854-0392	XSTR 2N 5088	A5 R68	4	0757-0421	R-F 825 1% .125W
A5 Q8	2	1853-2086	XSTR 2N5087	A5 R69	8	0757-0277	R-F 49.9 1%
A5 Q9	6	1854-0392	XSTR 2N 5088	A5 R71	6	0757-0449	R-F 20K1% .125W
A5 R1	7	2100-3559	R-VAR 20K 10%	A5 R72	9	0757-0442	R-F 10K1% .125W
A5 R2	6	2100-3096	R-VAR 50K 10%	A5 R73	6	0757-0449	R-F 20K1% .125W
A5 R3	6	2100-3096	R-VAR 50K 10%	A5 R74	9	0757-0442	R-F 10K1% .125W
A5 R4	6	2100-3096	R-VAR 50K 10%	A5 R75	9	0757-0442	R-F 10K1% .125W
A5 R5	7	2100-3089	R-VAR 5K 10%	A5 R76	3	0698-4501	R-F 59K1% .125W
A5 R6	6	2100-3286	R-VAR 10K 10%	A5 R77	9	0757-0442	R-F 10K1% .125W
A5 R7	6	2100-3096	R-VAR 50K 10%	A5 R78	3	0698-4501	R-F 59K1% .125W
A5 R8	6	2100-3096	R-VAR 50K 10%	A5 R79	9	0757-0442	R-F 10K1% .125W
A5 R9	8	2100-3296	R-VAR 1K 20%				

Replaceable Parts

Model 8151A

REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION	REFERENCE DESIGNATOR	C	H-P PART NUMBER	DESCRIPTION
A5 R90	6	0698-4363	R-F 16.0 1%	A5 U22	0	3101-2063	SW TOL DIL
A5 R91	0	0698-6320	R-F 5K 1% .125W	A5 U23	0	1020-1641	IC 74LS365AN
A5 R92	0	0698-6320	R-F 5K 1% .125W	A5 U24	6	1020-1730	IC SN74LS273N
A5 R93	0	0757-0277	R-F 49.9 1%	A5 U25	1	1026-0926	IC REF 01 EJ
A5 R94	6	0757-0340	R-F 22.6K 1% .125W	A5 U26	3	1020-1216	IC-SN74LS130N
A5 R95	6	0757-0340	R-F 22.6K 1% .125W	A5 U27	1	1026-1040	IC OP-07C
A5 R96	6	0757-0449	R-F 20K 1% .125W	A5 U28	6	1026-0609	IC D/A0-BIT
A5 R97	6	0698-3499	R-F 40.2K 1%	A5 U29	6	1020-1730	IC SN74LS273N
A5 R98	6	0698-3169	R-F 26.1K 1%	A5 U30	6	1020-1144	IC SN74LS02N
A5 R99	6	0698-6624	R-F 2K 1% .125W	A5 U31	3	1020-1216	IC-SN74LS130N
A5 R90	7	0698-6361	R-F 8K 1% .125W	A5 U32	6	1020-1730	IC SN74LS273N
A5 R92	2	0698-4451	R-F 340 1% .125W	A5 U33	6	1020-1730	IC SN74LS273N
A5 R93	0	0757-0442	R-F 10K 1% .125W	A5 U34	3	1020-2024	IC SN74LS244N
A5 R94	0	0698-3540	R-F 15.4K 1%	A5 U35	6	1013-0267	IC AD 12-BIT
A5 R95	6	0698-3498	R-F 8.66K 1% .125W	A5 U36	2	1026-1114	D/A 12-BIT
A5 R96	0	0698-3162	R-F 46.4K 1% .125W	A5 U37	1	1020-1109	IC SN74LS04N
A5 R97	4	0698-8027	R-F 1M 1% .125W	A5 U38	1	1010-0316	R-NETWORK 8X10K
A5 R98	1	0757-0444	R-F 12.1K 1% .125W	A5 U39	4	1020-1374	ANLG SW
A5 R99	9	0757-0442	R-F 10K 1% .125W	A5 U40	4	1020-1374	ANLG SW
A5 R100	9	0757-0442	R-F 10K 1% .125W	A5 U41	8	1010-0280	R-NETWORK 8X10K
A5 R102	3	0698-6630	R-F 20K 1% .125W	A5 U42	9	1026-0916	IC 34001B
A5 R103	9	0698-4424	R-F 1.4K 1% .125W	A5 U43	0	1020-1197	IC SN74LS00N
A5 R104	0	0757-0442	R-F 10K 1% .125W	A5 U44	1	1026-1048	IC OP-07C
A5 R105	7	0698-8012	R-F 1 1% .125W	A5 U45	1	1025-1048	IC OP-07C
A5 R106	3	0698-4501	R-F 59K 1% .125W	A5 U46	2	1026-1049	IC OP-27G
A5 R107	0	0757-0401	R-F 100 1% .125W	A5 U47	1	1026-1048	IC OP-07C
A5 R108	9	0757-0442	R-F 10K 1% .125W	A5 U48	1	1026-1048	IC OP-07C
A5 R109	6	0698-4413	R-F 154 1% .125W	A5 U49	0	1026-0180	IC NE555
A5 R110	6	0698-4413	R-F 154 1% .125W	A5 U50	8	1010-0280	R-NETWORK 8X10K
A5 R111	6	0698-3499	R-F 40.2K 1%	A5 U51	8	1010-0280	R-NETWORK 8X10K
A5 R112	0	0757-0443	R-F 11K 1% .125W	A5 U52	1	1026-1048	IC OP-07C
A5 R113	1	0698-6323	R-F 100 1% .125W	A5 VR1	0	1902-0948	DIO ZNR 3.9V 5%
A5 R114	1	0698-6323	R-F 100 1% .125W	A5 W3	0	5100-2,39	CBL AY-RIB 130MM
A5 R115	0	0698-6364	R-F 50 1% 1/8W				
A5 R116	6	0698-7277	R-F 51.1K 1% .05W				
A5 R117	5	0698-7218	R-F 178 1% .05W				
A5 R118	9	0698-7212	R-F 100 1% .05W				
A5 R119	9	0698-7212	R-F 100 1% .05W				
A5 R120	0	0698-6364	R-F 50 1% 1/8W				
A5 R121	9	0757-0277	R-F 49.9 1%				
A5 U1	1	1026-0976	IC 9685	A5		00151-66506	BD AY MICROPRCR
A5 U2	0	1020-2849	IC MC10H131P	A5 BT1	6	1420-0251	BATTERY-NICAD
A5 U3	2	1026-1049	IC OP-27G	A5 C1	3	0160-4493	C-F 27PF 5% 200V
A5 U4	2	1026-1049	IC OP-27G	A5 C2	3	0160-4493	C-F 27PF 5% 200V
A5 U5	1	1026-1048	IC OP-07C	A5 C3	9	0160-5471	C-F 0.1UF 5%
A5 U6	4	1020-1374	ANLG SW	A5 C4	9	0160-5471	C-F 0.1UF 5%
A5 U7	9	1026-0916	IC 34001B	A5 C5	9	0160-0174	C-F .47UF 25V CER
A5 U8	1	1026-0371	IC 256	A5 C6	5	0180-2984	C-F 47UF 50V 20%
A5 U9	1	1026-0371	IC 256	A5 C7	5	0180-2297	C-F 100UF 10V
A5 U10	6	1026-0888	IC 353A	A5 C8	5	0180-2984	C-F 47UF 50V 20%
A5 U11	1	1026-0371	IC 256	A5 C9	6	0160-3456	C-F 1000PF 1000V
A5 U12	6	1026-0888	IC 353A	A5 C11	9	0160-5471	C-F 0.1UF 5%
A5 U13	4	1020-1374	ANLG SW	A5 C12	9	0160-5471	C-F 0.1UF 5%
A5 U14	4	1020-1374	ANLG SW	A5 C13	9	0160-5471	C-F 0.1UF 5%
A5 U15	1	1310-0316	R-NETWORK 8X10K	A5 C14	9	0160-5471	C-F 0.1UF 5%
A5 U16	1	1310-0316	R-NETWORK 8X10K	A5 C15	9	0160-5471	C-F 0.1UF 5%
A5 U17	7	1026-0161	IC 324	A5 C16	9	0160-5471	C-F 0.1UF 5%
A5 U18	6	1020-1730	IC SN74LS273N	A5 C17	9	0160-5471	C-F 0.1UF 5%
A5 U19	6	1026-0699	IC D/A0-BIT	A5 C18	9	0160-5471	C-F 0.1UF 5%
A5 U20	6	1026-0699	IC D/A0-BIT	A5 C19	9	0160-5471	C-F 0.1UF 5%
A5 U21	3	1020-1216	IC-SN74LS130N	A5 C20	9	0160-5471	C-F 0.1UF 5%
				A5 C21	9	0160-5471	C-F 0.1UF 5%

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Replaceable Parts

Model 8151A

REFERENCE DESIGNATOR		C	H-P PART D NUMBER	DESCRIPTION
AB	CR6	1	1001-1000	DIO-1N4150 50V
AB	CR7	1	1001-1000	DIO-1N4150 50V
AB	CR8	1	1001-1000	DIO-1N4150 50V
AB	CR9	1	1001-1000	DIO-1N4150 50V
AB	CR10	1	1001-1000	DIO-1N4150 50V
AB	L1	6	9100-1700	CHOKES
AB	L2	1	9140-0129	IDCTR 220UN 5%
AB	L3	1	9140-0129	IDCTR 220UN 5%
AB	L4	1	9140-0129	IDCTR 220UN 5%
AB	L5	1	9140-0129	IDCTR 220UN 5%
AB	MP1	7	1251-1556	SKT SGL-CONT
AB	MP2	7	1251-1556	SKT SGL-CONT
AB	MP3	7	1251-1556	SKT SGL-CONT
AB	MP4	7	1251-1556	SKT SGL-CONT
AB	MP5	7	1251-1556	SKT SGL-CONT
AB	MP6	7	1251-1556	SKT SGL-CONT
AB	MP7	7	1251-1556	SKT SGL-CONT
AB	MP8	7	1251-1556	SKT SGL-CONT
AB	MP9	7	1251-1556	SKT SGL-CONT
AB	MP10	7	1251-1556	SKT SGL-CONT
AB	MP11	7	1251-1556	SKT SGL-CONT
AB	MP12	7	1251-1556	SKT SGL-CONT
AB	MP13	7	1251-1556	SKT SGL-CONT
AB	W1	9	5100-2430	CBL AY-RIB 100MM

BACK DATING MANUAL CHANGES

SECTION VII

BACKDATING

7-1 INTRODUCTION

7-2 This section contains backdating information, which adapts this manual to instruments with serial numbers lower than that shown on the title page.

7-3 Changes are listed in the serial number order that they occurred in the manufacture of the instrument. However, in adapting this manual to an instrument with serial number lower than that shown on the title page, apply the changes in reverse order. That is, begin with the latest change that applies to the serial number in question; Table 7-1 lists the serial number to which each change applies. Where changes to components occur, alter the associated schematic and layout diagrams as necessary.

Table 7-1 Manual backdating changes

Instrument Number	Make Changes
2308GCJ140 and lower	1

CHANGE 1

Substitute the A4 component layout on page 7-3 for that in Section 8 page 8-12.

Substitute the A5 component layout on page 7-4 and the following schematics 4B and 4C (pages 7-5 and 7-7) for the corresponding layout and schematics given in Section 8 (pages 8-28, 8-49 and 8-51).

In Table 6-2, make the following changes to the A5 Parts List.

Add the following components:

C55	0160-4521	12 pF
C56	0160-4386	33 pF
Q6	1854-0392	XSTR 2N5088
R47	0757-0442	10 kOhm
R48	0757-0442	10 kOhm
U15	1826-0888	CF256

Delete the following components:

R6	2100-3286	RVAR 10k
R102	0698-6625	6 kOhm
R103	0698-6624	2 kOhm

Change the following components to read:

C23	0160-4385	15 pF
R3	2100-3659	RVAR 20 kOhm
R4	2100-3659	RVAR 20 kOhm
R21	0757-0442	10 kOhm
R64	0698-6619	15 kOhm
R65	0698-6320	5 kOhm
R120	0757-0472	200 kOhm
U5	1826-0371	CF256
U9	1826-0644	
U10	1826-0371	LF357
U11	1826-0644	
U12	1826-0371	LF357
VR2	1902-0957	9.1 V

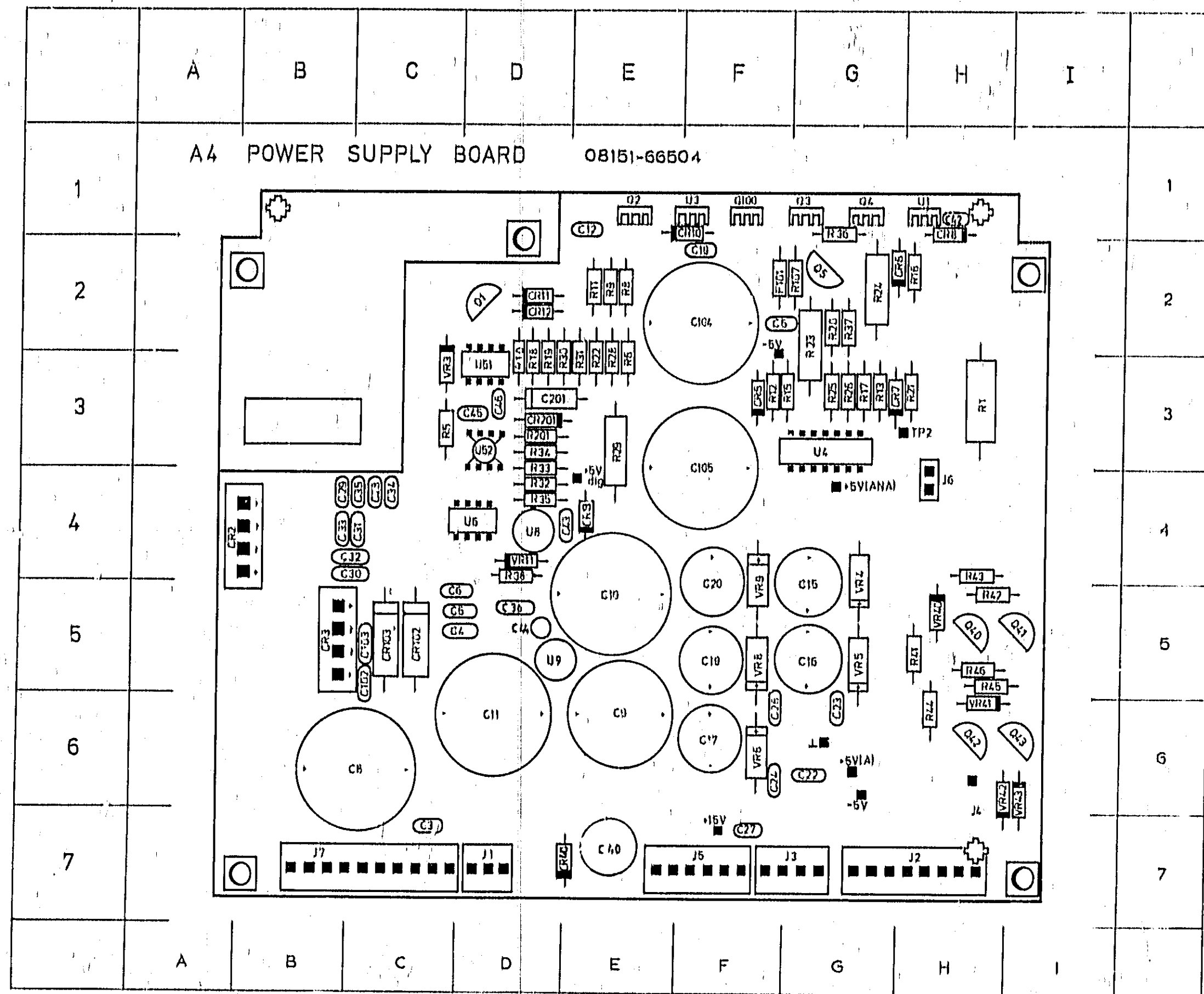
In paragraph 5-5, change steps 6, 9, and 17 to read:

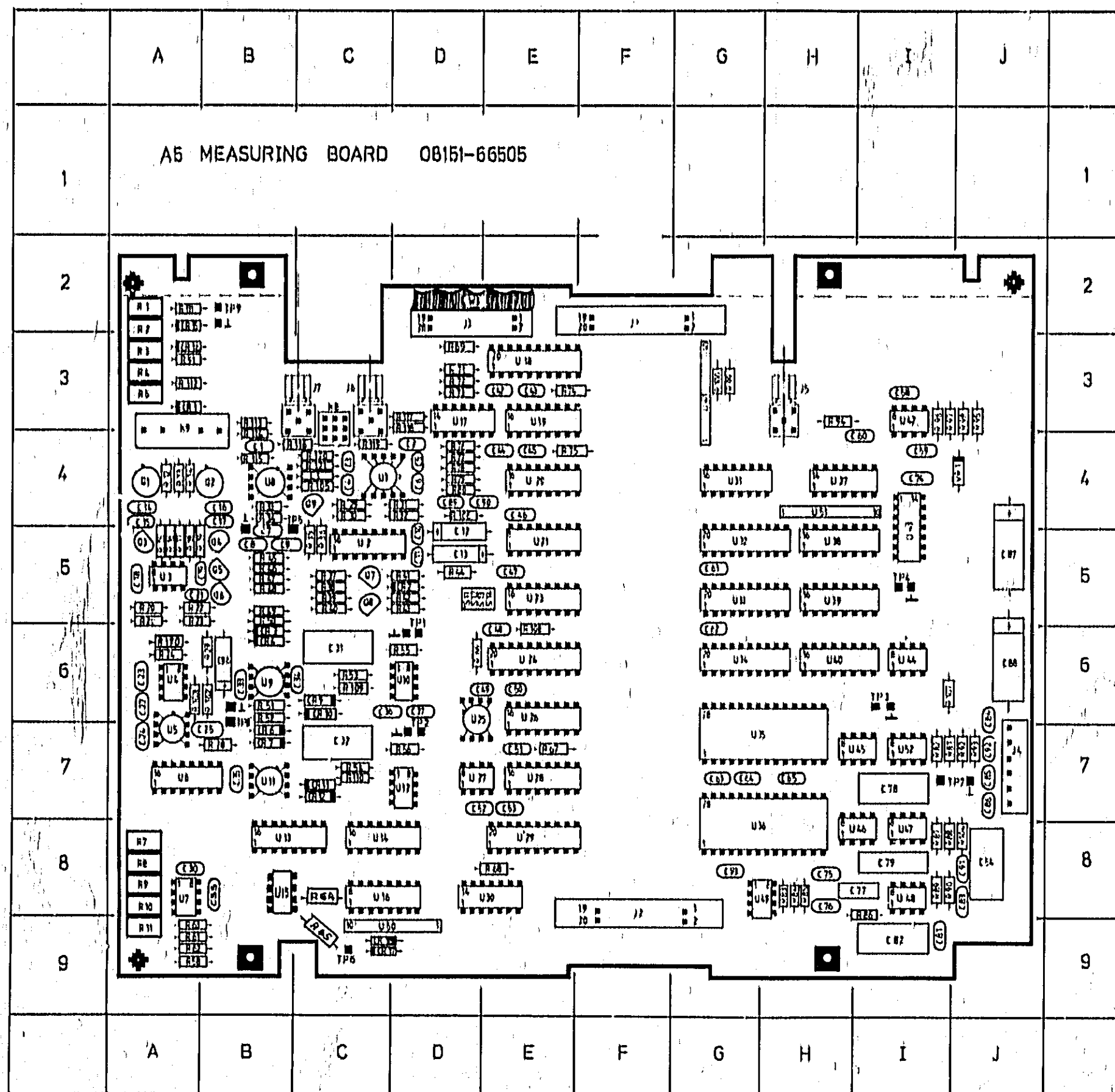
6. Connect DVM high terminal to A5 U15 pin 7.
9. Wire-connect A5 U45 pin 3 to ground.
17. Remove the wire-connection between A5 U45 pin 3 and ground.

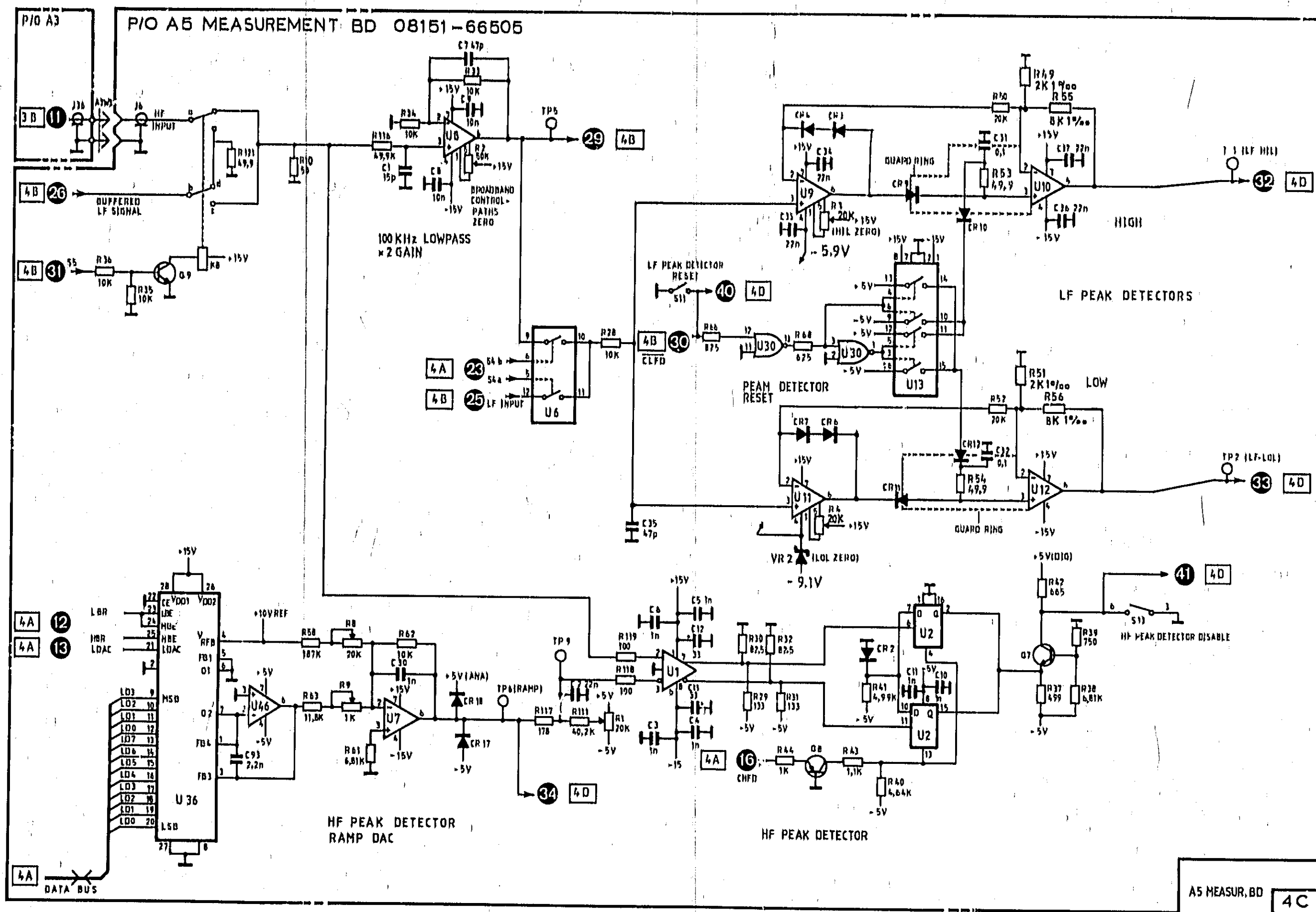
In paragraph 5-7, change steps 3, 4, 8 and 9 to read:

3. Connect DVM low terminal to ground.
4. Connect DVM high terminal to A5 U8 pin 6.
8. Connect DVM low terminal to ground.
9. Connect DVM high terminal to the connection between A5 CR17 and A5 CR18.

Delete paragraph 5-9.







SERVICE INFORMATION

SECTION VIII

SERVICE

8-1 INTRODUCTION

8-2 This section contains the information required to service the HP Model 8151A. The information includes theory of operation, troubleshooting information, schematics, component layouts and block diagrams.

8-3 The schematics and component layouts are organized as Service Sheets which are identified by a large number within a square in the lower corners. A table relating these Service Sheets to board assemblies is given in Table 8-1. Table 8-2 relates Service Sheets to instrument function and Table 8-3 gives an explanation of the symbols used in the schematics.

Table 8-1 Index of assemblies

Assembly	Service Sheet
A1 Disp-Key Bd.	6B
A2 Vernier Key Bd.	6B
A3 HF Board	3A, 3B
A4 Power Supply Bd.	2A
A5 Measuring Bd.	4A, 4B, 4C, 4D
A6 μ -Processor Bd.	5A, 6A
A7 HP-IB Board	5A
A8 Connector Bd.	3A

8-4 SAFETY CONSIDERATIONS

8-5 This section contains warnings and cautions that must be followed for your protection and to avoid damage to the equipment.

WARNING

Maintenance described herein is performed with power supplied to the instrument, and 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. When servicing is complete, the After Service Check must be performed.

8-6 AFTER SERVICE CHECK

8-7 Perform the following checks when servicing is completed.

8-8 Disconnect power cord from line. Visually inspect interior of instrument for any sign of abnormally generated heat, such as discolored printed circuit boards or components, damaged insulation or evidence of arcing. Determine cause and remedy.

8-9 Check cabinet/ground pin continuity in accordance with IEC/VDE. Flex the power cord while making the measurement to detect any intermittent discontinuity. Check internal ground connections on boards and frame. Also check resistance of any front or rear panel terminals marked.

8-10 Check cabinet/line isolation in accordance with IEC/VDE. Replace any component which results in a failure or refer to Production Memo or Service Note issued by product division for alternative action.

8-11 Check line fuse to verify that the correct value is installed.

8-12 Check that safety covers are installed.

8-13 Check that the co-axial and flat cables are properly connected. Check that all boards are correctly fitted and all heatsinks are in place.

8-14 Inform Hewlett-Packard (internally, the responsible product division) of any repeated failures in the above tests or any other safety feature.

8-15 SERVICE BLOCKS (THEORY/ TROUBLESHOOTING)

8-16 The theory of operation and troubleshooting is divided into Service Blocks corresponding to a complete function within the instruments. An instrument block diagram is given in this section to allow a means of isolating a fault down to a particular function. The technician should then proceed to the relevant Service Block which provides detailed theory of operation and trouble shooting hints for that function.

8-17 Tables and Figures within each Service Block are given three-digit codes eg. Figure 8-3-1. The first digit refers to the manual section (8), the second digit refers to the Service Block and the third digit refers to the order of the figure or table in the Block.

Table 8-2 Index to Service Blocks

Service Block	Functions
1	General Troubleshooting
2	Power Supply
3	HF Board A3
4	Measuring Bd. A5
5	μ -Processor Bd A6
6	Key & Display Bds. A1/A2

Table B-3. Schematic Diagram Notes (1 of 2)

The following symbols conform, as far as possible, with ANSI Y 32.2, IEEE No. 315 and ANSI Y32.14 (for the logic symbols). These standards should be consulted when further information is required.

Units	General	Components
P/O	Part of	Normally open toggle switch. Circles (O) are used for the contacts to indicate a locking type switch.
*	Asterisk denotes a factory selected value. The value shown is the nominal value.	Spring return, 2 position transfer switch. Triangle (Δ) are used for the contacts to indicate a non locking type switch.
	Enclosed front panel nomenclature.	2 position, 2 pole slide switch
	Enclosed rear panel nomenclature.	Air cored inductor.
	Heavy line indicates signal path.	Air cored transformer. The dot (•) is used, when necessary, to indicate instantaneous polarity.
	Heavy dashed line indicates primary feedback path.	Iron core
BC7	Wire colour code. Same as resistor colour code. First number is wire body colour.	Ferrite core
	Wire or plug used at link.	Ferrite bead
	Test point in a circuit. Point may/may not be identified on P.C. board.	Varactor diode
	Used with trimmer potentiometers or capacitors to indicate screwdriver adjustment.	Multi junction diode
	Direct connection to earth.	Diode
	Ground connection to instrument chassis or frame.	Zener diode
	Used when a number of common return connections are at the same potential. If there is more than one push system in the same circuit, numbers are written in the triangles so that all connections with the same potential have the same number.	Schottky diode
xV	Specific potential difference with respect to a potential reference level, eg.	Light Emitting Diode (LED)
		Photo diode
		Fuse
		Neon
		Filament lamp

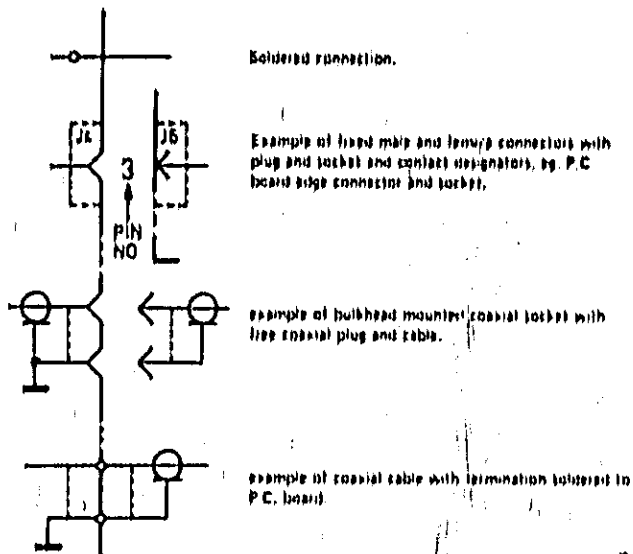
Schematic Referencing

These references on a signal leaving a schematic diagram indicate the signal destination. The circle contains the signal number and the square contains the number of the schematic to which that signal goes.

These references on a signal entering a schematic diagram indicate the signal origin. The circle contains the signal number and the square contains the number of the schematic to which that signal originates.

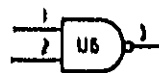
Table B-3, Schematic Diagram Notes (2 of 2)

Terminals and Connectors

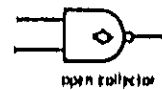


Logic Symbols

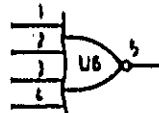
Positive logic is used unless otherwise specified.



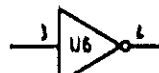
2 input NAND gate



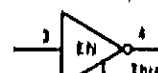
open collector



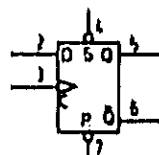
4 input NOR gate



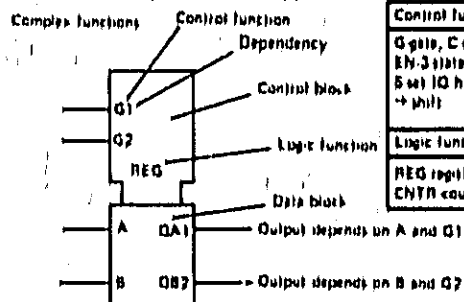
Inverter



Three state device.
Output is high impedance when EN is false, irrespective of input. Normal operation when EN is true.

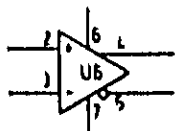


Flip flop



Control functions:
G gate, C clock
EN: 3 state, R reset (Q low)
S set (Q high), 1 (1) count up (down)
→ shift > edge triggered.
Logic function:
REG register, SEL selector
CNTR counter, IDEMUX Ideal multiplexer

Analog Symbols



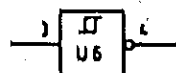
Operational amplifier



Voltage source



Current source



Schmitt trigger



Wired AND connection



Wired OR connection

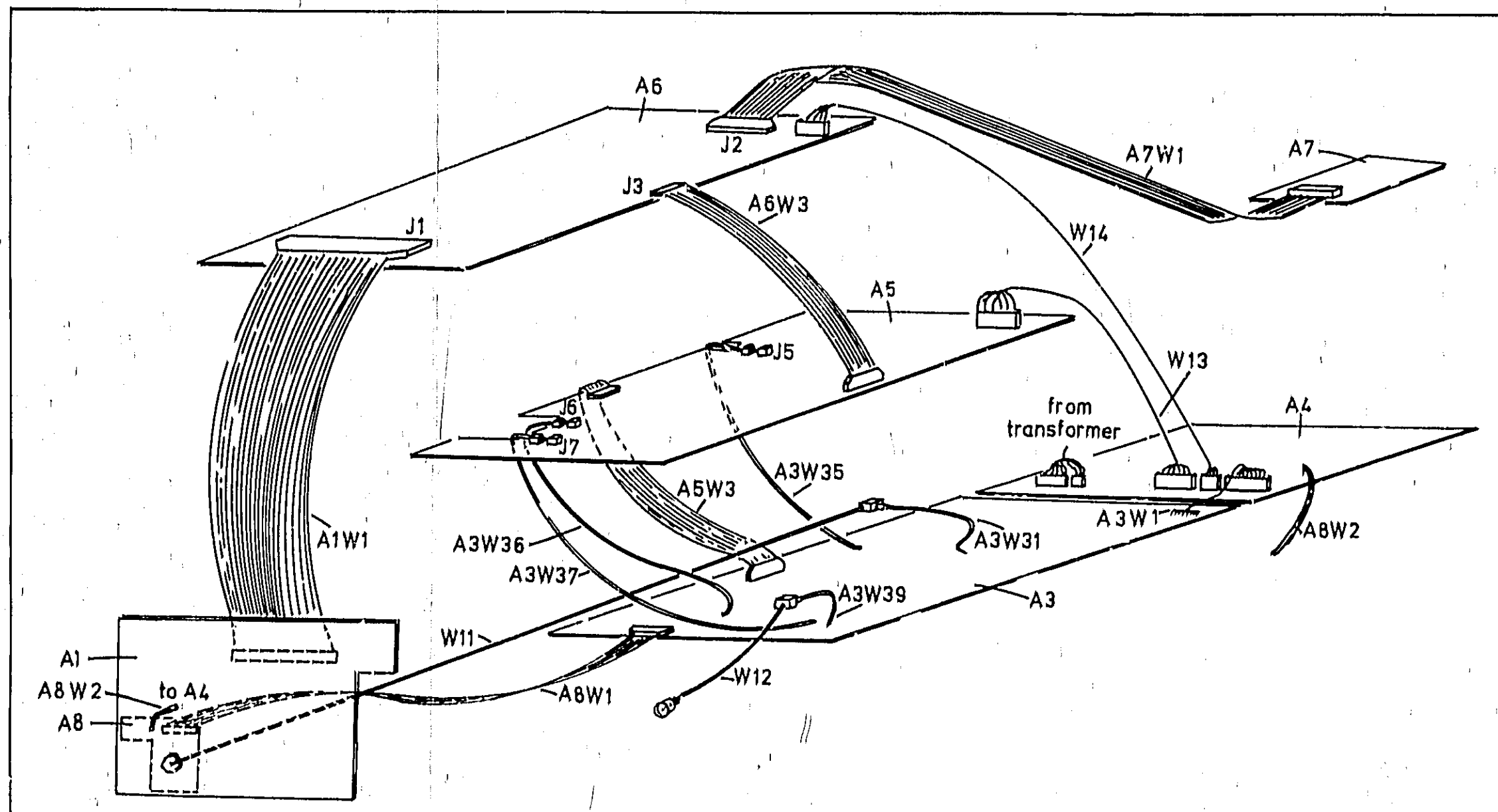


Figure 8-1-1. 8151A Cabling Diagram.

SERVICE BLOCK 1

OVERVIEW AND TROUBLESHOOTING GUIDE

Introduction

The purpose of this Service Block is to provide a brief overview of instrument functions, thus enabling the technician to quickly isolate faults to a specific area in order to perform effective troubleshooting.

Service Blocks 2 to 6 deal with instrument functions in depth - each Block containing operational theory and a comprehensive troubleshooting guide. Service Block titles and the functions covered in each are as follows:

SERVICE BLOCK 2 Power Supply	Rectification, regulation, over-voltage protection
SERVICE BLOCK 3 HF Board	High frequency amplifiers, filters, relay control
SERVICE BLOCK 4 Measuring Board	Inputs, outputs, signal paths, AVG, LF transducer, ZERO LF peak detectors, analog to digital conversion, self-test, HF peak detectors
SERVICE BLOCK 5 Microprocessor	CPU, ROM's, RAM's, GPIA, address decoders, RESET circuit, RAM battery supply
SERVICE BLOCK 6 Latched Data Bus Keyboard and Display Board	Latched data bus, display driver, address decoder, key scanner bus, key and display boards.

Cabling Information

Figure 8-1-1 shows the internal cabling of the 8151A. In most cases, a cable connected between 2 boards is soldered at one end and plugged at the other end. The soldered end determines the reference designator e.g. A1W1 indicates cable W1 is soldered on board A1. If no board designator is given, e.g. W14, the cable is plugged at both ends and is listed in the frame parts list.

Instrument Self-Test

At instrument switch-on, the 8151A performs a self-test to ascertain that all circuits are functioning correctly. Should a fault be detected, an error message will be displayed automatically.

Error Recognition Flowchart

Figure 8-1-2 is a flowchart designed to aid the technician in diagnosing the general area of a detected fault. In each case, a service block reference is given alongside the error message. The technician should then turn to that Service Block to begin troubleshooting the fault.

The flowchart covers 3 routines listed as follows:

1. The self-test routine performed at power switch-on.
2. The zero-test routine performed when the 'ZERO' button is pressed.
3. The continuous check routine performed continually as long as power is applied to the instrument and an Optical Head is connected.

Description

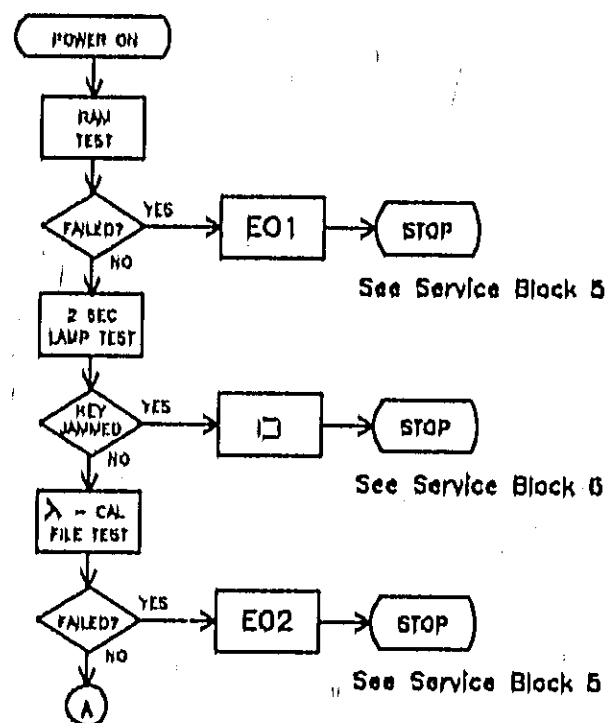
Whether under HP-IB control or Local (frontpanel) control, the microprocessor is responsible for all data processing in the instrument. It addresses ROM's to access stored data, and RAM's for current operating data. The main Data Bus provides a highway for information between the microprocessor (with associated memory) and two secondary buses.

The first of these, the latched data bus, is the link between the microprocessor and all front panel functions. These are: all LED's, RANGE and MODIFY rocker keys, all remaining keys and the digital display.

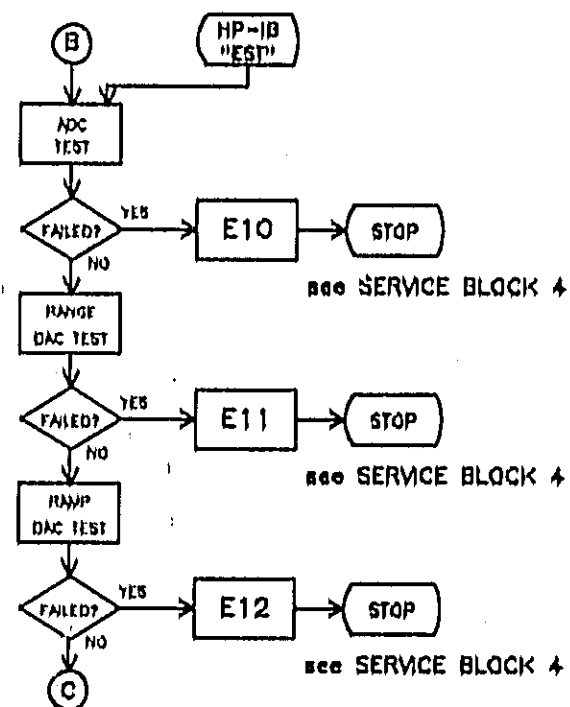
The second bus is the device bus, which handles all control data. This is data which is routed to the HF and Measuring Boards for controlling relays, DAC's etc., and their support circuits.

Regarding analog signals, there are two signal paths - one for LF signals and one for HF signals. These paths are switched in via various switch-control signals in accordance with the frontpanel settings. A table listing the signals and settings is given in the overall block diagram (Service Sheet 1).

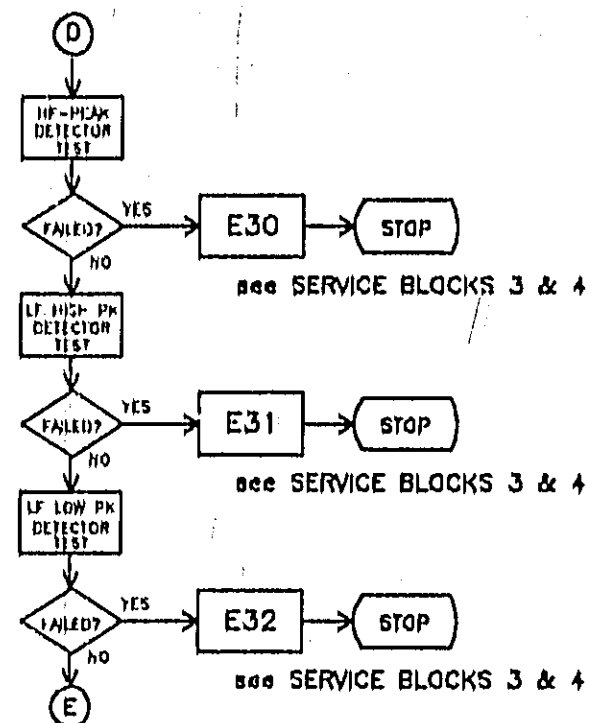
0161A SELF-TEST ROUTINE



0161A SELF-TEST ROUTINE

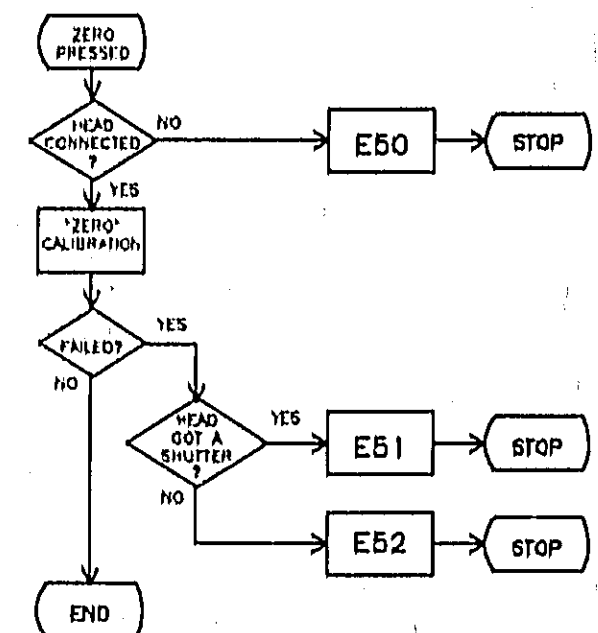


0161A SELF-TEST ROUTINE

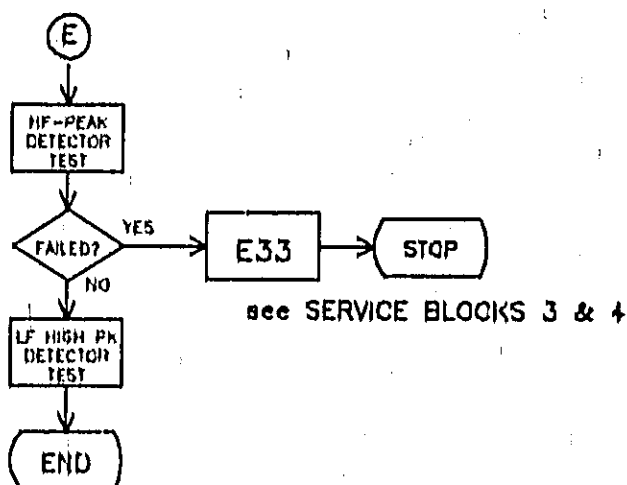
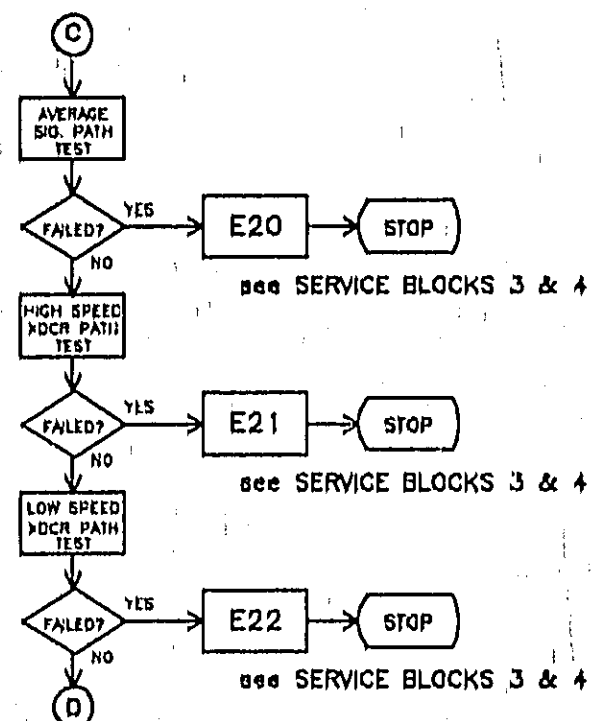
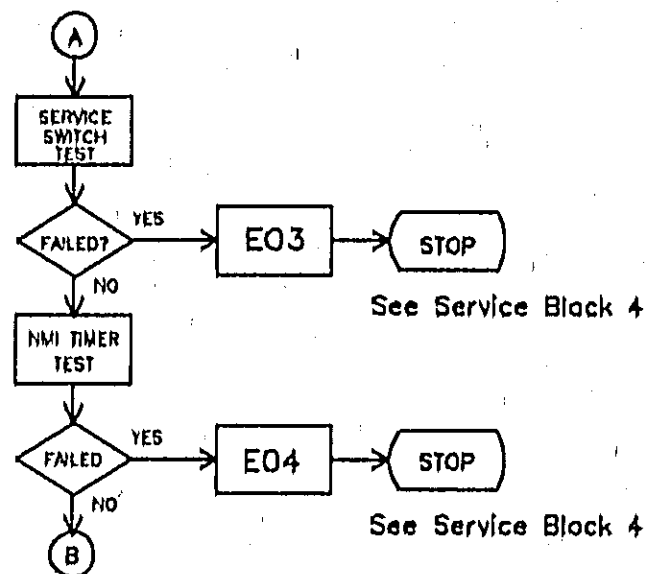


ZERO ROUTINE

(Initiated when 'ZERO' button is pressed)



Turn instrument off and on again. If no error occurs during the self-test routine, refer to the Optical Head Manual



CONTINUOUS CHECK ROUTINES

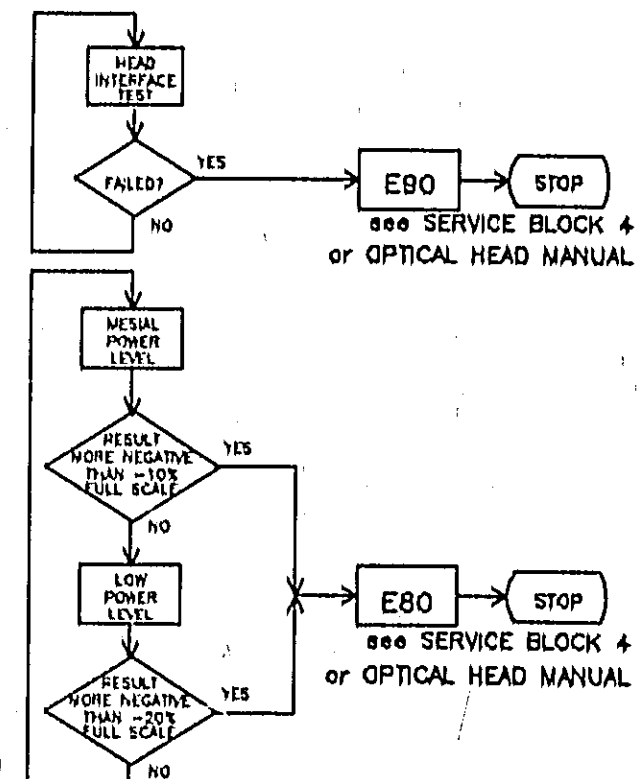


Figure 8-1-2. Error Flowchart

TROUBLESHOOTING

Whenever an instrument fault is suspected, it is recommended that the 8151A be switched OFF and ON again. The self-test routine will then be executed, any fault detected being represented by an error display on the instrument front panel.

Figure 8-1-2 is a flowchart describing the order in which tests are performed, the error codes displayed and the Service Block reference for further information on the possible fault. It should be noted that if a multiple fault occurs, the error code displayed will relate only to the first fault detected. On successful diagnosis and remedy of the first fault, the instrument will display, upon switch-on, the next error code if a fault still exists.

Preparing the Instrument for Service

1. Switch instrument off and remove power cord.
2. Remove all four feet at the rear of the instrument by unscrewing the fastening screws.
3. Remove the single screw securing the top cover to the rear panel.
4. Slide the top cover backwards to reveal the inside of the instrument.
5. Remove the four screws securing board A6/assy. Carefully lift the board into a vertical position, and locate the cut-outs on the board edge onto the locating lugs on the right-hand side member of the instrument.
6. Remove the metal shield separating board A6 from A5, and locate A5 board assembly onto the locating lugs on the left side of the instrument as shown in figure 8-1-3.

Board assembly A5 is now positioned on the left when viewing the instrument from the front, with the components facing outwards. Board assembly is similarly located on the right with the components facing outwards.

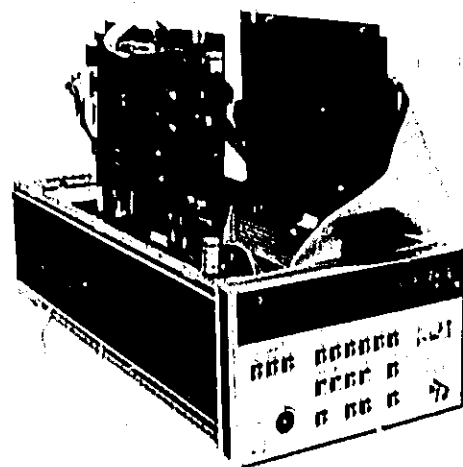


Figure 8-1-3. Service Position

Firmware Revisions

Each revision of the installed firmware (ROM 1 - ROM 6) can be identified via HP-IB by a date code which is written into the firmware. Run the following BASIC program:

```
10 DIM IS(28)
20 OUTPUT 718;"IDF"
30 ENTER 718;IS
40 PRINT IS
50 END
```

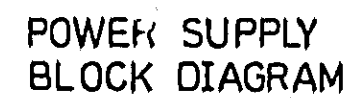
Any documentation concerning the 8151A firmware (Service Notes, Bug Reports etc.) refers to the date code of the respective firmware revision.

Direct Hardware Access

Part of the troubleshooting is supported by the Direct Hardware Access capability of the 8151A microprocessor.

NOTE

Use of the Direct Hardware Access is recommended for troubleshooting only. Follow, very carefully, the programming steps given in the troubleshooting part of the various Service Blocks. Any errors in programming the Direct Hardware Access can cause a microprocessor hang-up which can only be freed by turning the instrument off.



8-11

SERVICE BLOCK 2

A4 POWER SUPPLY BOARD

THEORY OF OPERATION

General

The power supply board comprises the following main circuits:

- a) Power line module (FL1) and power transformer (T1).
- b) Power supply rectifiers and regulator circuits.

These circuits provide dc output voltages of -15 V, -5 V, +15 V, +5 V(analog), +5 V(digital), 4 V and 250 V for operation of the Power Meter.

POWER LINE MODULE and TRANSFORMER

The Power Meter requires a power source of 100, 120, 220 or 240 V ac, (+5%/-10%), 48 to 440 Hz, single phase. It has a power consumption of approximately 80 VA. The line voltage selection is accomplished via the line voltage selector switch integrated in the power line module FL1. The power transformer, T1, then supplies the correct voltages to the rectifier and regulator circuits.

REC. RIER and REGULATOR CIRCUITS

Diodes CR2, CR3, CR102 and CR103 comprise three full-wave rectifiers, and diode CR43 a half-wave rectifier. Capacitors C8 to C11, C40, C104 and C105 then provide filtering of the rectified voltages.

+15 V and -5 V Regulators

Regulation of the +15 V and -5 V supplies is accomplished via IC's U3 and U1 respectively, both being mounted on the rear panel heat sink. CR10 and CR8 protect the IC's against higher reverse voltages than V_{in} .

-15 V, +5 V(Digital) and +5 V(Analog) Regulators

Reference Voltages: The reference voltages for the -15 V, +5 V(dig) and +5 V(ana) regulators are derived from a single reference voltage (10 V +/- 50 mV) generated at U6. This voltage is divided down via resistors R35, R32 and R33 to generate V1 [+5.1 V for +5 V(dig)] and V2 [+5 V for +5 V(ana)]. A third reference voltage, V3, (-5.2 V for -15 V regulator) is generated at the U52A output pin 1.

-15 V Regulator: The output voltage is divided down via R31 and R30 and compared with V3. U51A drives the difference to zero via the regulating transistor Q2. Q1 drives the current into Q2. In conjunction with R6, R22, R28 and R29, U51B functions as a current limiter. As long as the load current remains within the allowed limit, the potential at the inverting input of U51B is more positive than that at the non-inverting input due to the voltage divider. If an overcurrent condition now occurs, the inverting input of U51B goes more negative, while the non-inverting input main-

tains its potential. As a result, U51 pin 7 goes positive relative to U51 pin 1, the base-emitter voltage of Q1 drops causing a drop in base current of Q2, which in turn reduces the output current. During power-up, this current limiter is disabled via R5 and Zener diode VR3 until the output rail has reached -15 V.

+5 V(digital) Regulator: The operation of the +5 V(digital) regulator is similar to the -15 V regulator. The output voltage is compared with reference voltage V1 via U4A, which drives the difference to zero via Q3. U4D in conjunction with R20, R23 and R25 functions as a current limiter. (The function of the current limiter is as described above for the -15 V regulator).

+5 V(analog) Regulator: The output voltage is compared to reference voltage V2 via U4B, which drives the difference to zero via darlington transistor Q4. U4C in conjunction with R21, R24 and R26 functions as a current limiter. (The function of the current limiter is as described above for the -15 V regulator, with the exception that there is no driver transistor, Q4 being a darlington transistor).

Over-voltage Protection

Zener diodes VR4, VR5, VR6, VR8 and VR9 protect the load circuits against over-voltages.

Peltier Supply Regulator

This supply provides power for heating the photo-diode located in the Optical Head. It is derived from the +5 V(digital) supply via emitter follower Q100.

Op-amp Supplies

All op-amps located on board A4 are supplied via U8 (+15 V) and U9 (-16 V) in conjunction with VR11.

Optical Head Supply (240 V/2 mA)

The Optical Head supply consists of two 2 mA current sources connected in series. Via CR43, capacitor C40 is charged up to approximately 350 V. As long as no load current is drawn at J4, the output voltage is limited to 240 V via diodes VR42 and VR43. Zener diode VR40 is included in the circuit to reduce the temperature drift of the base-emitter diode of Q40. For safety reasons, (under no circumstances must the load current exceed 2 mA e.g. a defective component causing a short circuit) the current source is duplicated via Q42, Q43 and R44 and connected in series.

TROUBLESHOOTING

Troubleshooting Hints

If a power rail is down, disconnect W13, W14 and A3W1. Also, disconnect any Optical Head which is connected to the instrument. This helps determine whether the power supply itself is defective, or if excessive current is being drawn by one of the boards. NOTE: An exception to this fault isolation technique is when the +5 V(digital) supply goes down while an Optical Head is connected to the instrument. In this case, there is a fault in the Optical Head and the blown fuse, A4F101, causes the +5 V(digital) to go down.

Check the following voltages at the socket pins of A4J5:

Connector A4J5 Pin	Voltage
1	-15 V +/- 600 mV
2	+15 V +/- 750 mV
3	-5 V +/- 250 mV
4	+5 V +/- 100 mV
5	+5.1 V +/- 100 mV

Peltier Power Supply

Check the voltage at A4J2 pin 1 for approximately 4.8 V with no Optical Head connected. Check voltage at TP1 for approximately 7.8 V, and in the event of a large deviation, check fuse A4F101.

240 V/2 mA Supply

Measure the voltage at A4J4 using a DVM with $1k\Omega$ +/- 1% shunt resistor. The voltage should be approximately 1.9 V, but must not exceed 2.0 V otherwise check Q40 thru Q43, VR40, VR41 and surrounding components.

If the fault has been isolated to the power supply board A4, it must be removed from the instrument for further troubleshooting using the following disassembly procedure.

Disassembly Procedure

The following procedure assumes that the top cover has been removed as described in Service Block 1.

1. Remove left (as seen from front) side cover.
2. Disconnect cables W13, W14 and A3W1.
3. Disconnect fan cable (A4J6).
4. Remove bottom cover.
5. Disconnect A4W1 from board A4.
6. Remove the 4 holding screws from rearpanel heatsink, and remove heatsink assembly.
7. Remove holding screw from A4CR2.
8. Remove the 5 holding screws on circuit side of A4 and remove A4 assembly.
9. Attach heatsink assembly to board A4 by plugging regulating transistors into their sockets.
10. Re-connect transformer cables to board A4 (J1 and J7)

The service position is now as shown in figure 8-2-1.

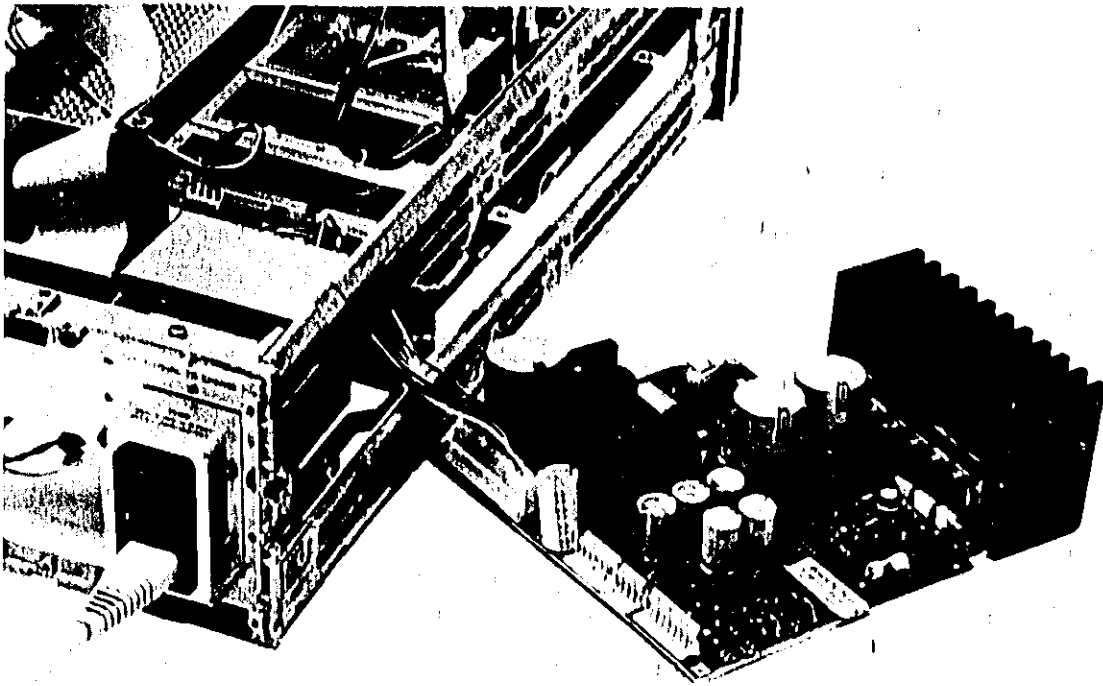
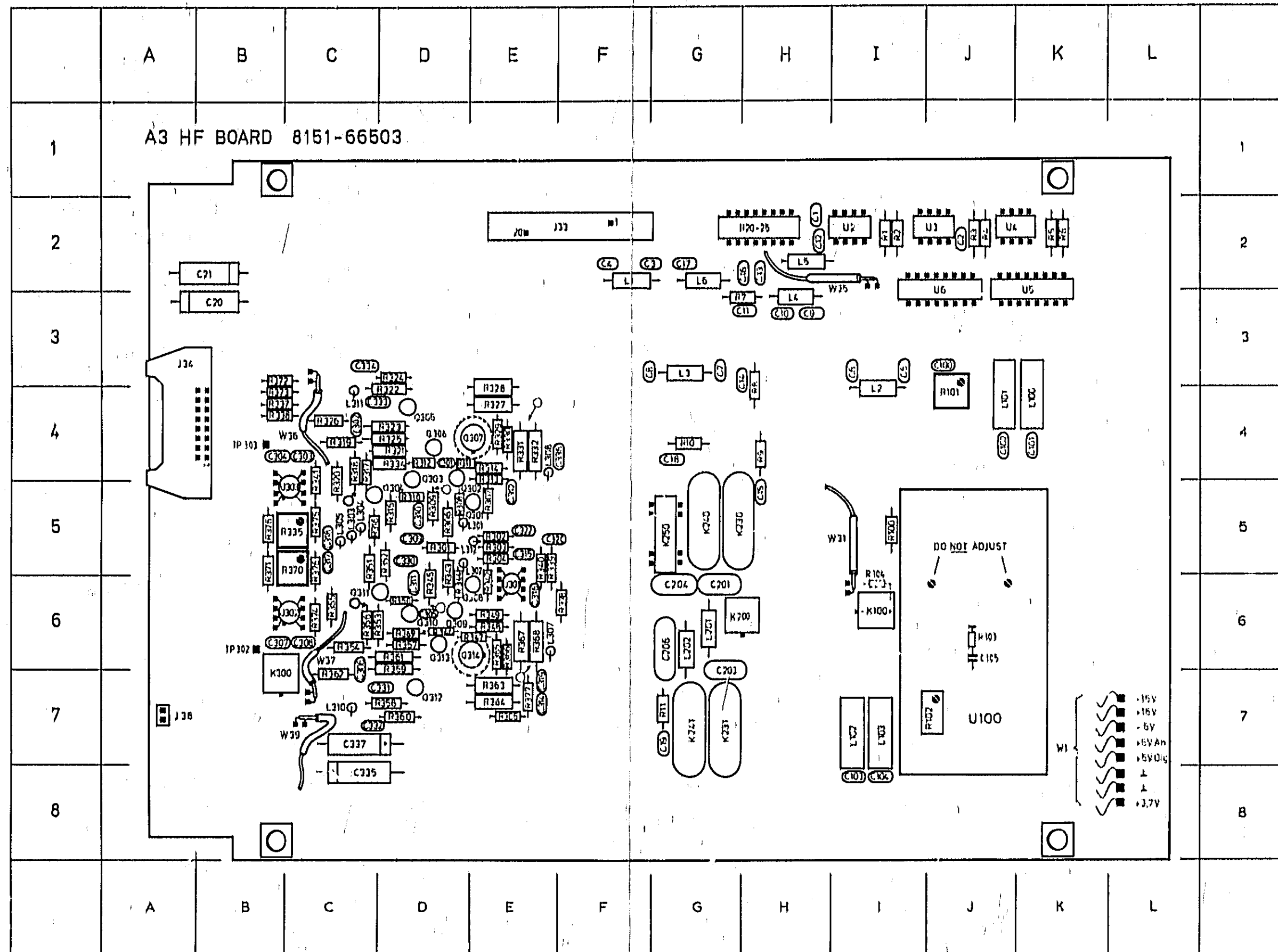


Figure 8-2-1. Power Supply Service Position.



GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG
C1	H2	C332	C7	Q312	D7	R329	E4	U5	K3
C2	J2	C333	D4	Q313	D6	R330	E4	U6	J3
C3	F2	C334	C3	Q314	E6	R331	E4	U100	J7
C4	F2	C335	C8	R1	I2	R332	E4	U301	E6
C5	I3	C336	I4	R2	I2	R334	D4	U302	C6
C6	I3	C337	C7	R3	J2	R335	C5	U303	C5
C7	G3	J33	F2	R4	J2	R336	B5	W31	I5
C8	F3	J34	A3	R5	K2	R337	B4	W35	I3
C9	H3	J38	A7	R6	K2	R338	B4	W36	B4
C10	H1	K100	I6	R7	G3	R339	E5	W37	C6
C11	I5	K200	H6	R8	H4	R340	E5	W39	C7
C12	H2	K230	G5	R9	H4	R341	C4		
C13	H2	K231	G7	R10	G4	R342	E6		
C14	G3/4	K240	G5	R11	G7	R343	D5		
C15	H5	K241	G7	R20	H2	R344	D6		
C16	H2	K250	G5	R21	H2	R345	D6		
C17	G2	K299	G6	R22	H2	R346	D6		
C18	G4	K300	B7	R23	H2	R347	D6		
C19	G7	L1	F2	R24	H2	R348	E6		
C20	B3	L2	I4	R25	H2	R349	E6		
C21	B2	L3	G3	R100	I5	R350	C6		
C100	J3	L4	H3	R101	J4	R351	C5		
C101	K4	L5	H2	R102	J7	R352	D6		
C102	J4	L6	G2	R103	J6	R353	C6		
C103	I8	L100	K4	R104	I5	R354	C6		
C104	I8	L101	J4	R301	D5	R355	C6		
C105	J7	L102	I7	R302	E5	R356	C6		
C201	G6	L103	I7	R303	E5	R357	D6		
C203	G6	L201	G6	R304	E5	R358	D7		
C204	C6	L202	G6	R305	E7	R359	D7		
C206	G6	L301	D5	R306	D5	R360	D7		
C301	D4	L302	D5	R307	E5	R361	D6		
C303	C4	L303	C5	R308	D5	R362	C7		
C304	B4	L304	C5	R309	D5	R363	E7		
C305	D6	L305	C5	R310	D5	R364	E7		
C307	B6	L307	E6	R312	D4	R365	E6		
C308	C6	L308	E4	R313	E4	R366	E6		
C309	D5	L308	E4	R314	E4	R367	E6		
C310	D5	L310	C7	R315	D5	R368	E6		
C311	D6	L311	C4	R316	C5	R369	D6		
C312	E5	L312	D5	R317	C4	R370	C5		
C313	C5	Q301	E5	R318	C4	R371	B5		
C314	E7	Q302	E5	R319	C4	R372	B3		
C315	E5	Q303	D4	R320	C4	R373	B4		
C316	E6	Q304	D5	R321	D4	R374	C6		
C317	C5	Q305	D4	R322	D4	R375	C5		
C318	C5	Q306	D4	R323	D4	R376	C5		
C319	E7	Q307	E4	R324	D3	R377	E7		
C320	E5	Q308	E6	R325	D4	R378	F6		
C322	E5	Q309	D6	R326	C4	U2	I2		
C330	D5	Q310	D6	R327	E4	U3	J2		
C331	D7	Q311	C6	R328	E4	U4	J2		

SERVICE BLOCK 3

HF BOARD A3

THEORY OF OPERATION

This board comprises 3 individually shielded circuits and separately located relay control elements. Each relay is controlled via an opto-coupler (U2 to U4), a buffer (U5), a relay driver (U6) and a C-L-C filter, thus avoiding any undesired feedback effects on the power supply and other circuits. With reference to the relay operation, the ideal function as expressed by "0V -> no current through the relay" is also realized.

The shielding case 1 (encasing components with 100-series reference designators) contains a 20 dB amplifier with a bandwidth of 0-500MHz. The maximum input voltage is ± 30 mV for an output swing ± 1.2 V. The output voltage is adjusted via R102. NOTE: This adjustment affects the input bias current, and the resultant input offset voltage must be compensated by adjusting R101, which in turn affects the output voltage. Due to the interaction of these 2 adjustments, an adjustment of one must be followed by an adjustment of the other, and repeated until the output voltages are within tolerance.

Shielding case 2 encloses two filters with 3dB (optical) cutoff frequencies of 6MHz and 50MHz.

Shielding case 3 (encasing 300-series components) encloses two 12dB amplifiers which exhibit a 320 MHz bandwidth with input voltages +300 mV to -150 mV (unsymmetrical due to the non-existence of negative light), and impedance matched to 50 Ω .

As both amplifiers are functionally identical, only one is described here. Transistor Q301 functions as an impedance converter to raise the input resistance of the following differential amplifier by the current amplification factor β . This eliminates undesired feedback effects of a changing output load on the input. Resistors R314 and R315, together with capacitor C314, compensate the bias current of Q301 (and Q308).

A functional diagram of the case 3 amplifier is given in figure 8-3-1.

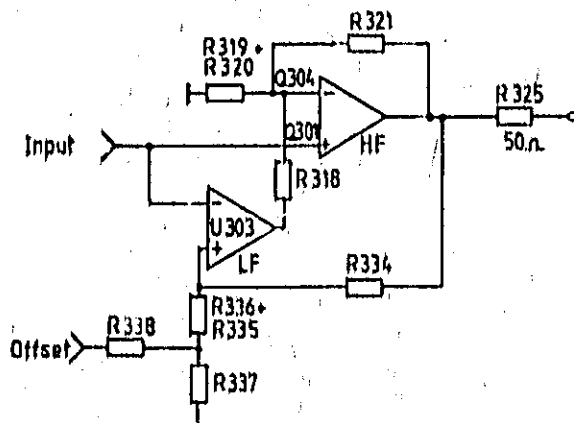


Figure 8-3-1. Simplified Block Diagram of HF Amplifier.

The differential amplifier, Q302/Q303, works with a summing current of approximately 50 mA and an amplification factor >20 . For symmetry reasons, Q303 is decoupled from the input via Q304 whose base is tied to ground potential via R317, R319 and R320. At high frequencies, the amplification of this stage is reduced, the cutoff frequency being primarily determined by the time constant of C301 (R311, R312). The collector potential of this stage controls the second stage differential amplifier comprising Q305, Q306. The output signal at Q306 collector is in phase with the input signal, and fed back to Q304 via R321 and R317. When the voltage at node R317, R318 and R319 is equal to the input voltage, then the regulating function of the amplifier has settled, and the voltage at Q306 collector corresponds to the resistor ratio of R319, R320 and R321 i.e 8 times the input voltage.

A printed circuit inductance located between R319 and R320 enables the amplifier overshoot to be reduced by increasing the inductance as necessary. The current for the second stage is delivered by the constant current source, Q307/U301, which improves the common mode rejection.

The bandwidth can be altered via the printed circuit inductances at Q305 and Q306 emitters. These inductances are adjusted at the factory so that the amplifier operates just within the ringing limits. At dc and low frequencies, the output amplitude is compared with the input amplitude at U303 and post regulated. NOTE: The time constants for the input voltages to U303 must be the same. Via R335, the LF amplification can be adjusted to correspond to the HF amplification. It is also possible to correct for offset (± 100 mV) on the output by applying an external voltage to R335.

TROUBLESHOOTING

Error Display E20 (E22, E30, E31, E32 and E33)

These error displays are generally the result of 8151A selftest routines carried out on the Measuring Board A5 (see Service Block 4). However, a pre-condition for carrying out these tests correctly is that the LF input (J5) of the Measuring Board has been shorted to ground. This is also accomplished by the selftest routine which activates relay A3K250 located on the HF Board A3.

The only possibility for Board A3 to cause any of these errors therefore, is a malfunction of A3K250 or its controlling circuits U3A, U5 and U6.

Carry out the following test to determine whether or not the error is caused by the HF Board.

1. Disconnect any Optical Head or test cable assy from the HEAD input connector.
2. Program the following command (Direct Hardware Access) via HP-IB (address switch must set to 18).

OUTPUT 718,"SDA BST BHW 1CDB 00" - sets all HF relays to non-energized state.

3. Disconnect the BNC cable A3W35 from the connector A5J5 and measure the resistance between the A3W35 conductor and ground. It must be 0 Ohm, otherwise troubleshoot relay K250 and its controlling circuits as described under paragraph heading "Relays and Relay Control"
4. Re-connect A3W35.

Error Display E21

Because most of the functional blocks that can cause an Error 21 are located on the Measuring Board A5, a detailed description of the transducer path test is given in Service Block 4. The only functional block on the HF Board A3 that is involved in the high speed transducer path is the x4 amplifier (Q301 thru Q306 and surrounding components) together with relays K200, K230, K231, K240, K241 and their controlling circuits U3, U4, U5 and U6.

Carry out the following tests to determine whether the error E21 is caused by the HF Board.

Test 1

Program the following commands (Direct Hardware Access) via HP-IB (address switch must be set to 18).

OUTPUT 718,"SDA BST BHW 1CDB 04" - sets relays so that no input signal is given to the x4 amplifier.

OUTPUT 718,"SDA BST BHW 1CD3 80" - sets the HF-Offset DAC to 0.0V.

Check the output voltage at A3W36. It must not exceed +25mV or -25mV. (A3W36 connected to A5 Measuring Board)

Test 2

Execute the following command (Direct Hardware Access):

OUTPUT 718;"SDA BST BHW 1CD3 00" - sets the HF-Offset DAC to full positive output.

Measure voltage at A3W36 (approximately 120 mV).

Execute the following command:

OUTPUT 718;"SDA BST BHW 1CD3 FF" - sets the HF-Offset DAC to full negative output

Measure voltage at A3W36 (approximately -120 mV)

The difference between both output voltages must exceed 200 mV

	Possible Reasons	Possible Faulty Components
Test 1, 2 passed	Failure is not on HF Board A3	See Service Block 4
Test 1 failed	HF-Offset DAC does not deliver 0 volt. Voltage at junction A3R338/R373 exceeds + or -10mV Any offset voltage at x4 amplifier input. Voltage at junction A3R301/R303/R308 exceeds + or -1mV x4 amplifier produces too much offset.	HF-Offset DAC (see Service Block 4) Relays and Relay Control: K200, K230/31, K240/41 U3, U4, U5 or U6. x4 Amplifier Input Stage: R302 thru R308, Q301, Q308 x4 Amplifier: U303, Q301 thru Q306 etc.
Test 2 failed	Swing between HF-Offset DAC min. and max. setting less than 200mV Offset input of x4 amplifier (A3R338) is open.	HF-Offset DAC (see Service Block 4) R338

Relays and Relay Control

Execute the following command (Direct Hardware Access) with address switch set to 18:

OUTPUT 718;"SDA BST BHW 1CDB 00" - sets all HF relays to non-energized state.

HF relay control signals K0 thru K5 must be at TTL low potential. Check output voltages at U6 pins 11 thru 16 for 0 V. Check that the relay switches are in the positions as shown in schematics 3A and 3B.

Execute the following command:

OUTPUT 718,"SDA BST BHW ICDB FF" - sets all HF relays to energized state.

HF relay control signals K0 thru K5 must be at TTL high potential. Check output voltages at I/O pins 11 thru 16 for -1.5 V. Check that the relay switches are the opposite position to that shown in schematics 3A and 3B.

x10 Amplifier U100

The amplifier module U100 is a non-repairable unit. If U100 is defective or does not meet specifications, the complete module U100 has to be replaced.

On the assumption that all HF relays are functioning correctly (see paragraph headed "Relays and Relay Control"), it is possible to test U100 with an input signal applied to the frontpanel HEAD input via test cable assy (U8151-61611) and monitored at A3W35. Note that A3W35 must first be disconnected from A5J5 and terminated with 50 Ω .

Set the relays to the x10 amplifier test position by executing the following command (Direct Hardware Access) via HP-IB (address switch must be set to 18):

OUTPUT 718,"SDA BST BHW ICDB 26" - sets HF relays to x10 amplifier test position (see figure 8-3-2)

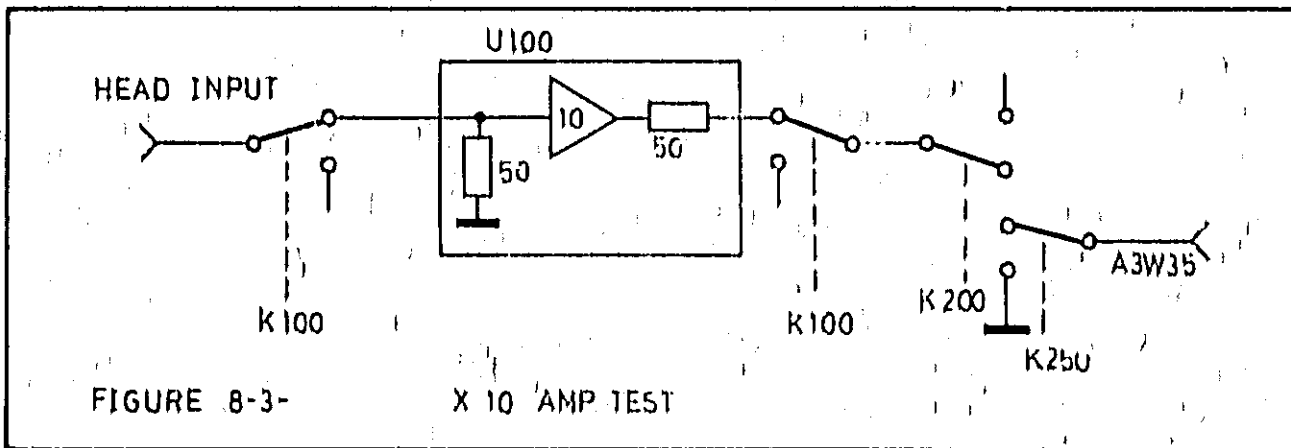


Figure 8-3-2. x10 Amplifier Test

U100 Specifications

Input Voltage Max.	+/- 30 mV
-3 dB Bandwidth	475 MHz
Transition Times 10% to 90%	750 ps
Gain	20 dB typical
Gain Flatness (dc to 300 MHz)	+/- 0.15 dB

x4 Amplifiers

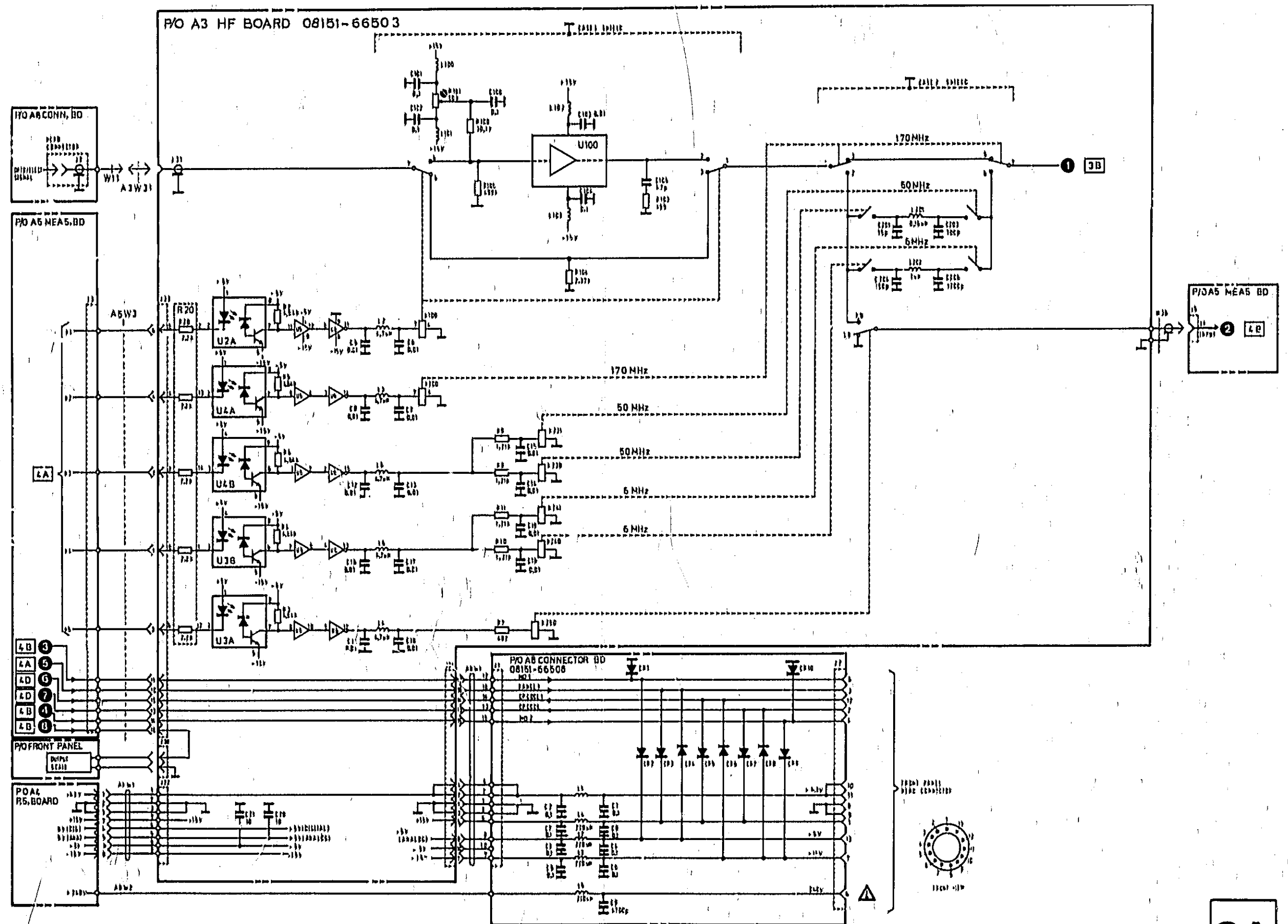
Both x4 amplifiers can be tested with an input signal applied to the frontpanel HEAD connector via test cable assy (08151-61611). One output signal is then monitored at the Transducer Output and the other monitored at A3W36. Note that A6W36 must first be disconnected from A5J5 and terminated with 50 Ω .

Set the 8151A to AMP, 00 dBm range, no filter function.

Maximum Input Voltage (50 Ω)	+300 mV/-150 mV
3 dB Bandwidth	320 MHz
Gain	12 dB

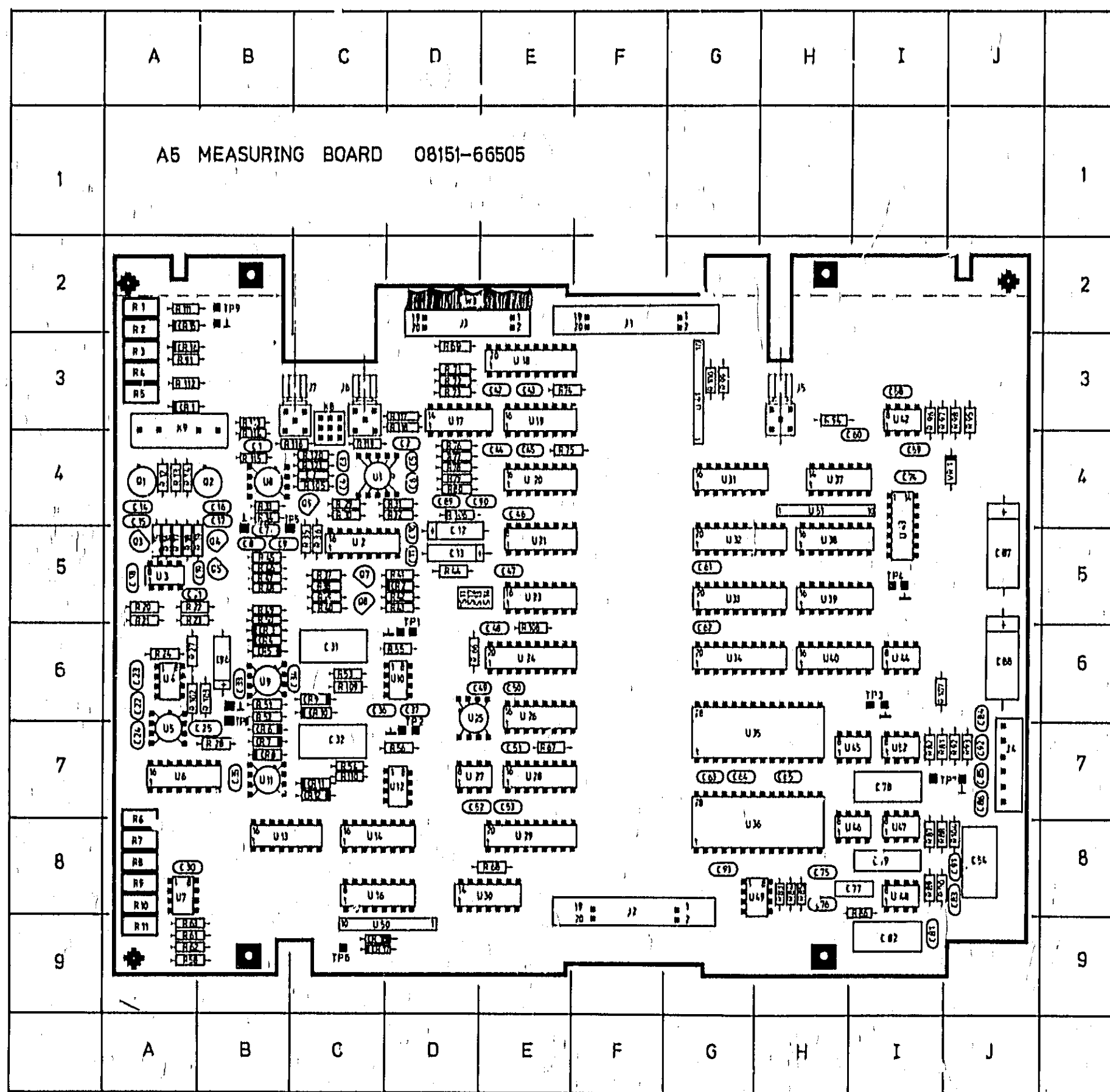
Blue Stripe Exchange Program

Because the two x4 amplifiers are designed similar to a hybrid, the HF board is not completely repairable down to component level. If chip components or microwave transistors are defective, it is recommended that the complete board is exchanged. The Blue Stripe exchange board number is 08151-69503.



HF - BOARD

8-27



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C1	B4	C61	G5	L1	C4	R42	D5	R98	J3	U33	G5
C2	D4	C62	G5	L2	C4	R43	D5	R99	G3	U34	G6
C3	C4	C63	G7			R44	D5	R100	G3	U35	G7
C4	C4			Q1	A4	R45	B5			U36	G8
C5	D4	C64	G7	Q2	B4	R46	B5	R102	A6	U37	H4
C6	D4	C65	H7	Q3	A5	R47	B5	R103	B6	U38	H5
C7	B5	C74	I4	Q4	B5	R48	B5	R104	J8	U39	H5
C8	B5	C75	H8	Q5	B5	R49	B5	R106	D4	U40	H6
C9	B5	C76	H8	Q6	B5	R50	B5	R107	I6	U41	G3
C10	D5	C77	I8	Q7	C5	R51	B6	R111	A2	U42	I3
C11	D5	C78	I7	Q8	C5	R52	B6	R112	A3	U43	I4
C12	D5	C79	I8	Q9	C4	R53	C6	R113	B3	U44	I6
C13	D5	C81	I9			R54	C7	R114	B4	U45	H7
C14	A4	C83	J8	R1	A2	R55	D6	R115	B4	U46	H8
C15	A4	C84	J6	R2	A2	R56	D7	R116	C4	U47	I8
C16	B4	C85	J7	R3	A3	R58	A9	R117	D3	U48	I8
C17	B4	C86	J7	R4	A4			R118	D3	U49	H8
C18	A5	C87	J5	R5	A5			R119	C4	U50	C9
C19	A5	C88	J6	R6	A8	R61	A9	R120	C4	U51	H4
C20	A6	C89	D4	R7	A8	R62	A9	R121	C4	U52	I7
C21	A5	C90	E4	R8	A8	R63	A9				
C22	A6	C91	J8	R9	A8			U1	C4	TP1	D6
C23	B6	C92	J7	R10	A8			U2	C5	TP2	D7
C24	A7	C93	G8	R11	A9	R66	D6	U3	A5	TP3	I6
C25	B7			R12	A4	R67	E7	U4	A6	TP4	I5
C26	B6			R13	A4	R68	E8	U5	A7	TP6	C9
C30	A8	CR1	A3	R14	A4	R69	D3	U6	A7	TP7	J7
C31	C6	CR2	D5	R15	A5	R71	D3	U7	A8	VR1	J4
C32	C7	CR3	B5	R16	A5	R72	D3	U8	B4	W3	D2
C33	B6	CR4	B6	R17	A5	R73	D3	U9	B6		
C34	C6	CR5	B6	R18	A5	R74	E3	U10	D6		
C35	B7	CR6	B7	R19	A5	R75	E4	U11	B7		
C36	C6	CR7	B7	R20	A5	R76	D4	U12	D7		
C37	D6	CR8	B7	R21	A5	R77	D4	U13	B8		
C42	E3	CR9	C6	R22	A5	R78		U14	C8		
C43	E3	CR10	C6	R23	A5	R79	D4	U16	D8		
C44	E4	CR11	C7	R24	A6	R80	D4	U17	D3		
C45	E4	CR12	C7			R81	I7	U18	E3		
C46	E4	CR15	A2	R27	A6	R82	H8	U19	E3		
C47	E5	CR16	A3	R28	B7	R84	H8	U20	E4		
C48	E6	CR17	C9	R29	C4	R85	H8	U21	E4		
C49	D6	CR18	C9	R30	C4	R86	I8	U22	D5		
C50	E6			R31	D4	R87	I8	U23	C5		
C51	E7	J1	F2	R32	D4	R88	I8	U24	E6		
C52	E7	J2	F9	R33	B4	R89	I8	U25	D6		
C53	E7	J3	D2	R34	B4	R90	I8	U26	E6		
C54	J8	J4	J7	R35	C5	R91	A3	U27	D7		
		J5	H3	R36	C5	R92	J7	U28	E7		
		J6	C3	R37	C5	R93	J7	U29	E8		
		J7	C3	R38	C5	R94	H3	U30	D8		
				R39	C5	R95	J3	U31	G4		
C58	I3	K8	C3	R40	C5	R96	I3	U32	G5		
C59	I4	K9	A3	R41	D5	R97	I3				
C60	I4										

SERVICE BLOCK 4

MEASURING BOARD A5

THEORY OF OPERATION

General

The Measuring Board A5 is the interface between the various Optical Heads and the microprocessor, and as such, performs all analog and hybrid signal processing in the 8151A.

Inputs

As can be seen in figure 8-4-1, there is an LF and an HF input to board A5. Signals originating from Optical Heads with high sensitivity, wide dynamic range and limited bandwidth, are routed to the LF input. Signals originating from broadband Optical Heads, delivering amplitudes of 0 to 250 mV (or 0 to 25 mV) for full scale, are first amplified 4 (or 40) times respectively on the HF Board A3, and then routed to the HF input of board A5.

LF signal format is 0...2 V for full range from low impedance source into high impedance load. Drift and peak noise of ± 0.4 V total will be accepted without causing an overload condition. The bandwidth of the LF processing chain is dc to 100 kHz; the corner frequency being switchable to 10 kHz to limit detector noise interference at very low light levels.

HF signal format is 0 to 1 V for full range from 50 Ohm source into 50 Ohm load. Acceptable drift plus peak noise is ± 0.2 V.

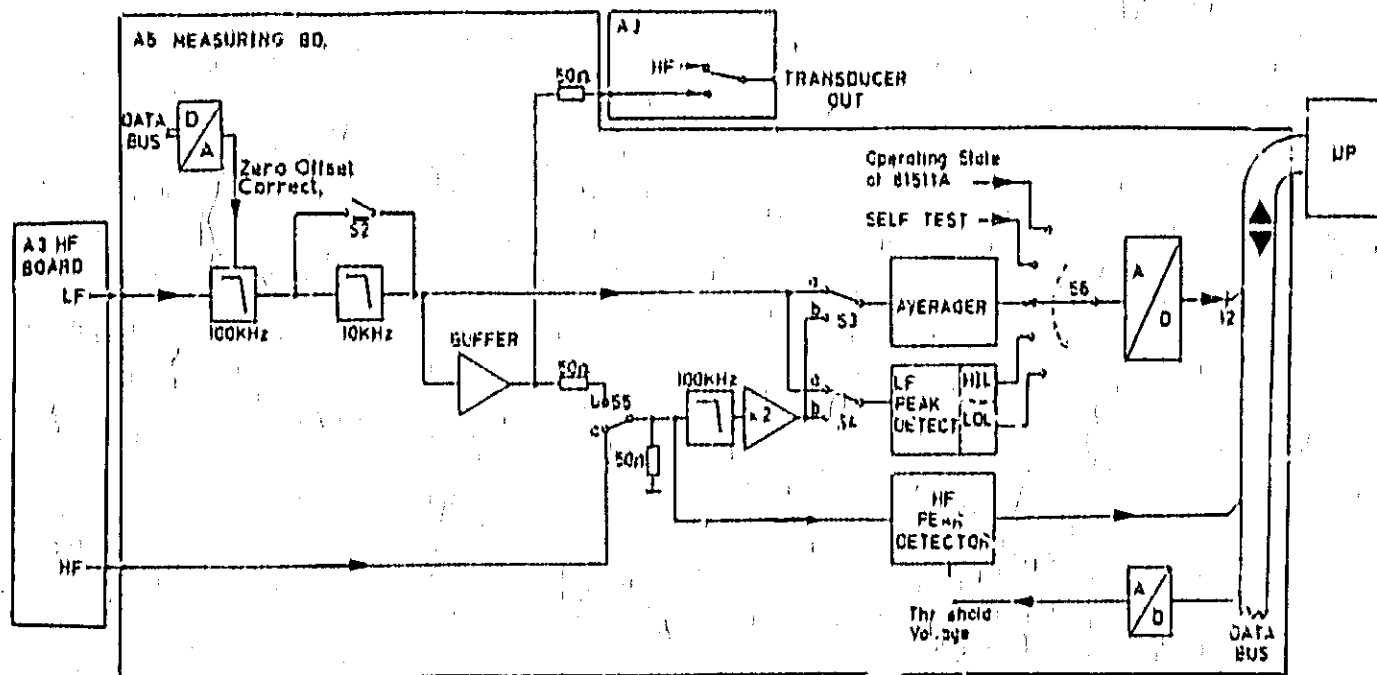


Figure 8-4-1: A5 Block Diagram

Outputs

Outputs from the Measuring Board comprise digitized information concerning peak high level, peak low level and average signal level. Amplitude, mesial and extinction values are calculated from peak high level and peak low level by the microprocessor:

$$\text{AMP} = \text{HI} - \text{LO} \quad \text{MESIAL} = 1/2 (\text{HI} + \text{LO}) \quad \text{EXTINC} = \text{HI}/\text{LO}$$

LF signals are buffered in a parallel signal path to provide a 50 Ohm source for transducer operation of the 8151A. (with HF signals, this feature is part of the HF board)

To prevent noise spikes, caused by microprocessor activity, from reaching the sensitive HF amplifiers, the device data bus is not connected to the HF board. All control signals for the HF board (relays, offset correction) and the Optical Heads (e.g. operating mode, range control) are therefore decoded and generated on the Measuring board. Similarly, Optical Heads send identification and operating state signals to the 8151A, which are also digitized on the Measuring board before transmission to the microprocessor.

Signal Paths

A more detailed block diagram as given in figure 8-4-2 facilitates tracing of the measured signals throughout the analog processing circuits (schematics 4A, 4B, 4C, 4D). Table 8-4-1 indicates how circuit blocks are linked together in the various measuring modes and power ranges of the 8151A. Ranges apply to Optical Head 81511A.

Table 8-4-1. Signal Path Switching Matrix

Measuring Modes	Ranges	Switches Closed					
AVG (signal <25% full scale)	all						
AVG (signal >25% full scale)	all						
HIGH (peak high level)	-60..-20 dBm						
LOW (peak low level)	-60..-20 dBm						
HIGH and LOW	-10..+10 dBm						
Auxiliary Functions							
Enable LF transducer	-60..-20 dBm						
Reset LF peak detectors	-60..-20 dBm						
LF offset correction	-60..-20 dBm						
HF offset correction	-10..+10 dBm						

**SERVICE
INFORMATION
CON'T**

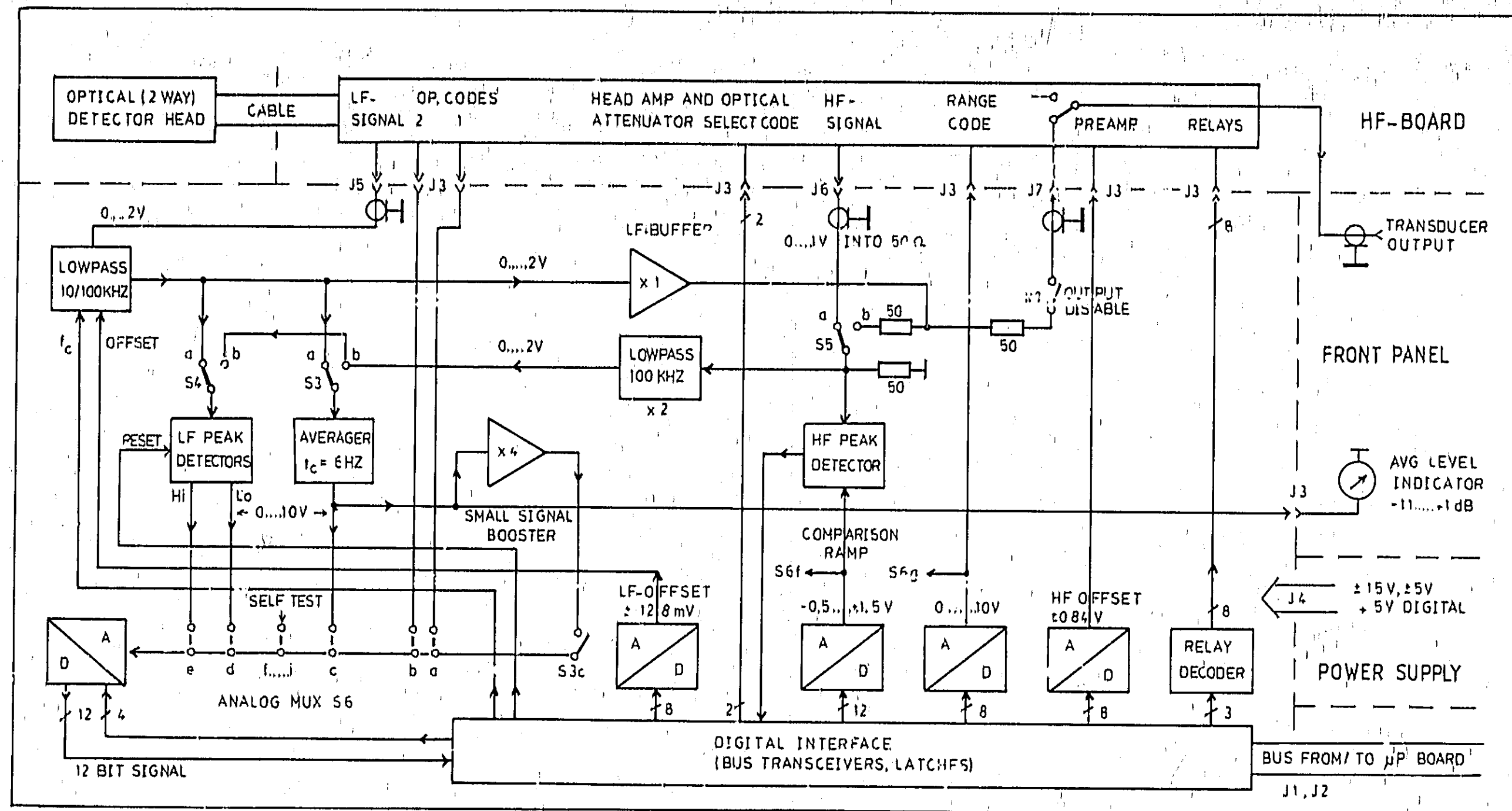


Figure 8-4-2. A5 Functional Diagram.

AVG, LF Transducer, ZERO

Because 'low frequency' detector electronics in Optical Heads cover the full dynamic range with better accuracy, information on the signal average is derived from this path in all power ranges.

Arriving at J5, the signal passes through a buffer stage (U4). Time constants R24/C22, R27/C23 and R20/C18 (or R28/C35) determine the overall frequency limit $f_c = 100 \text{ kHz}$. f_c is lowered to 10 kHz when Q5 is conducting.

Dark current and other electronic offsets are compensated by introducing a suitable dc current at the inverting input of U4 via R23 and R22. R23 is driven from the 'LF offset DAC' (U27, U28); R22 provides bipolar operation of the DAC circuit. While the offset is measured, light has to be cut off from the photodiode. (In the 81511A Optical Head, this is done automatically by a motor driven shutter). The offset correction circuit then raises the amplification of the voltage follower, U4, from 1 to 1.017 $(1 + R27(R23+R22)/R23 \times R22)$, this effect being compensated by voltage divider R24/R21.

The low impedance signal from U4 is branched to:

1. The averager (U48, U47).
2. The LF peak detectors (U9 thru U13).
3. The LF buffer (U3, Q1 thru Q4) which functions as a current booster and has a very low output impedance. Together with R113/R114, this provides a precise, low distortion 50 Ω source at the TRANSDUCER output in LF ranges.

The averager (U48, U47) is a steep low pass filter comprising a passive pole (R86/C82), x5 linear amplifier (U48) and a second order low pass filter (U47, R82, R87, C78, C79). Features include the ability to follow signal frequencies up to the maximum display refresh rate (4Hz), suppression of ac signals of 50 Hz and higher with 50 db or more, and the ability to provide a flicker free display of the average value (even with signals swinging from zero to full range level).

The averaged signal is passed on to the ADC circuit (U35, U44, U45, U52) via an analog multiplexer 'S6' (U40, U39), and monitored by a moving coil indicator on the front panel.

LF Peak Detectors

Two analog peak detectors, U9/U10 and U11/U12, detect the high and low peak levels, respectively, of LF signals from J5 (U4). Both detectors are basically track-hold circuits (e.g. in the case of the high level peak detector, the 'track' phase lasts for as long as the input voltage rises; then as soon as this voltage drops, the 'hold' phase begins automatically). In order to raise the frequency limit above 100 kHz (50% cut-off), the following refinements have been made to the basic track-hold circuit (due to the similarity of both detectors, only the high level detector is described):

1. Clamping diode CR5 prevents saturation of U9 during the 'hold' phase - i.e. when CR9 is reversed biased.
2. Loading current for the 'hold' capacitor C31 in the 'track' phases is limited by CR3/CR4 and R53, again preventing saturation of U9.
3. Stability of the feedback loop around U9/U10 is improved by insertion of R109 to give smooth, fast tracking.

After each digitization cycle, the LF peak detectors are reset. This is done by momentarily closing switches on U13 pins 10 and 14, which in turn reverses the bias on storage capacitors C31 and C32. Low leakage diodes CR10 and CR12 are included in the reset current path to prevent discharge of the storage capacitors via the leakage currents of the analog switches (U13). In normal operation, these diodes are reverse biased via switches on U13 pins 11 and 15.

Analog to Digital Conversion, Self-Test

The signal from the MUX is buffered (U44) and digitized linearly in steps of 1/2 of a display unit. To ensure that resolution is not sacrificed too much in logarithmic display modes (dBm, dB (rel)), a x4 pre-amplifier stage (U5) is automatically inserted whenever the signal level falls below 21% of full scale, and by-passed again when the signal rises to 25% or more of full scale.

A precise 10 V reference is generated by U25. Because digitizing steps of exactly 5 mV are needed for ease of calculation, the reference voltage for the 12-bit ADC is raised from 10 V to 10.34 V via U52 and trimmed down to 10.24 V $(5 \text{ mV} \times 2^{10})$ with R10. The ADC input range of 20.47 V total $(5 \text{ mV} \times 2^{11})$ is shifted down by 5 V via U45 (adjustable via R11), thus allowing a $\pm 5 \text{ V}$ overrange on both sides of the 0 .. 10.00 V full scale in linear WATT mode.

In addition to measuring average (and LF peak) signal values, the ADC and the analog MUX are used to read two operating code voltages sent by the Optical Head. These voltages provide identification and operating information for the microprocessor.

During automatic ZERO adjust phases, an additional self-test is carried out on 4 critical voltages. (See troubleshooting)

HF Peak Detectors

This circuit is activated in the HF power ranges e.g. -10 dBm...+10 dBm, using Optical Head HP81511A. It detects peak levels of pulses with a 4 ns minimum pulse top or pulse base, and a minimum repetition rate of 200 Hz.

The signal arriving at J6 is routed to a high speed comparator U1. Flat frequency response to 250 MHz is achieved by including L1 in the terminating impedance. Figure 8-4-3 shows how the signal is then compared to a step voltage pattern, and using successive approximation (12 steps although only 4 shown), how the highest and lowest levels are determined.

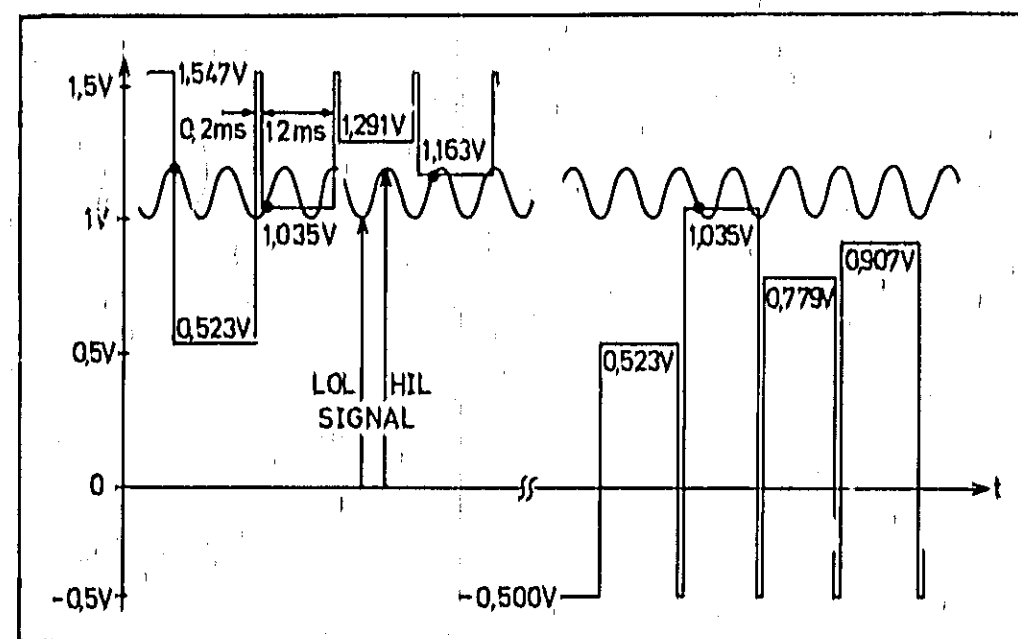


Figure 8-4-3. Timing Diagram for HF Peak Detector.

The comparator U1 has complementary ECL outputs and any transition on these outputs will clock one of the U2 flip-flops, depending on the direction of transition. The outputs of these flip-flops are wire-ORed and translated into TTL format via Q7. For the duration of the applied comparison voltage, therefore, any transition in the comparator is transmitted to the device data bus via U2, Q7 and U23. When a new comparison voltage (next step) is applied, the flip-flops are reset.

The HF peak detector also checks signal peak levels for autoranging and overload/overrange conditions - see table 8-4-2 for details.

Table 8-4-2. Ranging and Overload Criteria

Condition	Average Mode	Peak LF Mode	Peak HF Mode
Range Up	(HF-HIL) and (LF-HIL) > 1100	(LF-HIL) > 1100	(HF-HIL) > 1100
Range Down	(HF-HIL) and (LF-HIL) < 95	(LF-HIL) < 95	(HF-HIL) < 95
Overload	(HF-HIL) or (LF-HIL) > 1100	(LF-HIL) > 1100	(HF-HIL) > 1100
Overrange	AVG > 1200	(LF-HIL) > 1200	(HF-HIL) > 1200
Error 80	AVG < -100	(LF-MESIAL) < -100 or (LF-LOL) < -200	(HF-MESIAL) < -100 or (HF-LOL) < -200

TROUBLESHOOTING

Error Display 03

Error E03 indicates that one of the service switches (with S13 as exception) is still set to service position (gnd).

If all service switches are in normal operating position, but E03 appears, then possible faults are U23, U24 or one of the latched data lines LD2, LD5 or LD6 is being held to gnd.

Error Display 04

Error E04 indicates that the timer (U49 and surrounding components) is not running when it is enabled (ENMI low). Verify that jumper S8 is connected to the Measuring Board A5. Disconnect any optical head or test cable assy from the HEAD input connector, and switch the λ -CAL Entry switch into "ON" position. Signal at 'NMI' testpoint on μ -Processor Board should be a squarewave signal (approx. 100 Hz, TTL-levels).

If not, check U30 pins 8 and 9 for TTL low signal.

Check CNT Z control signal signature.

Possible faults: U30, U24, U49 or connection to μ -Processor Board open.

Error Display 10

The A/D converter cannot convert two levels (0 V gnd and + 10 Vref) within an accuracy of $\pm 10\%$.

Note: With any failure on the latched data bus (LD0 to LD7 being held to gnd or +5V), if it does not cause E03 then it causes an E10.

Carry out the following test to isolate the failure:

Check the +15 V and -15 V power supply.

Check that all latched data lines (LD0 to LD7) toggle when μ -Processor is set to "free run routine".

Test 1

1. Program the following commands (Direct Hardware Access) via HP-IB with address switch set to 18.

OUTPUT 718; "SDA BST BIW 1C73 04"	- sets the analog switches U14, U39,
OUTPUT 718; "SDA BST BIW 1CE3 02"	U40 to apply gnd potential to ADC
	input U44

2. Measure the voltage at U35 pin 14. It should be 0.00 V $\pm$ 1 mV.

Test 2

1. Program the following command:

OUTPUT 718; "SDA BST BIW 1C73 04"	- sets the analog switches U14, U39,
OUTPUT 718; "SDA BST BIW 1CE3 01"	U40 to apply 10 Vref to the ADC
	input U44.

2. Measure the voltage at U35 pin 14. It should be 10.00 V $\pm$ 100 mV.

	Possible Reason	Possible Faulty Components
Test 1,2 passed	- A/D Conversion is wrong - Chip Select Signals READC or READC are wrong	A/D Converter: U35, U45, U52, U34 Control Signals: U26, U37
Test 1 failed, Test 2 passed	- Analog Switch S6i (U14 pins 11, 12) is not closed - Voltage follower U44 produces too much offset	Analog Switches: U14, U29, U16, U50 U44
Test 1 passed, Test 2 failed	- Analog Switch S6h (U14 pins 9, 10) is not closed or S3c and S6i are not open - 10 Vref is down	Analog Switches: U14, U29, U16, U50 U25
Test 1,2 failed	- Analog switches do not switch correctly - Control Signals CNT I or CNT J are wrong	Analog Switches: U14, U39, U40 Control Signals: U21, U31

Error Display E11

The Range Code DAC (U19, U17) is not able to provide 0.00 V +/- 400 mV or 10.00 V +/- 400 mV.

Check the signature of the control signal PRNG. If PRNG is not wrong, U17 and/or U19 must be faulty.

The following Direct Hardware Access commands may help to isolate the fault:

OUTPUT 718; "SDA BST BHW ICCB 00" - sets the Range Code DAC to 0.0 V

OUTPUT 718; "SDA BST BHW ICCB FF" - sets the Range Code DAC to 10.0 V

Error Display E12

The HF Peak Detector Ramp DAC is not able to produce the necessary output swing of 2V (-0.5V to +1.5V).

Check the +5V (analog) supply voltage.

For further fault isolation execute the following commands (Direct Hardware Access) via HP-IB with the address switch set to 18, and measure the voltage at TP 6 using a DVM.

OUTPUT 718; "SDA BST BHW 1C4B FF" - sets the HF-Peak Detector Ramp DAC
 OUTPUT 718; "SDA BST BHW 1C5B FF" to - 0.50 V
 OUTPUT 718; "SDA BST BHW 1C7B 00"

Voltage at TP 6 should be - 0.500 V +/- 10 mV.

OUTPUT 718; "SDA BST BHW 1C4B 00" - sets the HF Peak Detector Ramp DAC
 OUTPUT 718; "SDA BST BHW 1C5B 00" to + 1.547 V
 OUTPUT 718; "SDA BST BHW 1C7B 00"

Voltage at TP 6 should be + 1.547 V +/- 10 mV

	Possible Reasons	Possible faulty components
Voltage at TP6 o.k.	- analog switch is open - Control Latch 1 has no control over U39 - Control Signal CNTT is wrong	U39 U32, U38, U51 U31
Voltage at TP6 wrong	- Ramp DAC is defective - Clamping diodes are short-circuiting - Control Signals LBR, HBR or LDAC are wrong	U36, U46, U7 CR17, CR18 U37, U31

Error Display E20

Error Display E20 indicates a failure in the Average measuring path, which is shown in figure 8-4-4. During the test, the input (J5) of the Measuring Board is shorted to gnd via HF-relay K250. Error E20 is caused if the voltage at the A/D converter exceeds 250 mV (S6c on, gain = 5) or 1 V (S3c on, total gain = 20) with the LF-Offset DAC set to 0.0 V. If this test passed, the self-test checks that the gain of the x 4 amplifier is +/- 20 % by setting the LF Offset DAC to give an offset, and comparing the voltages with the x 4 amplifier switched on and then off.

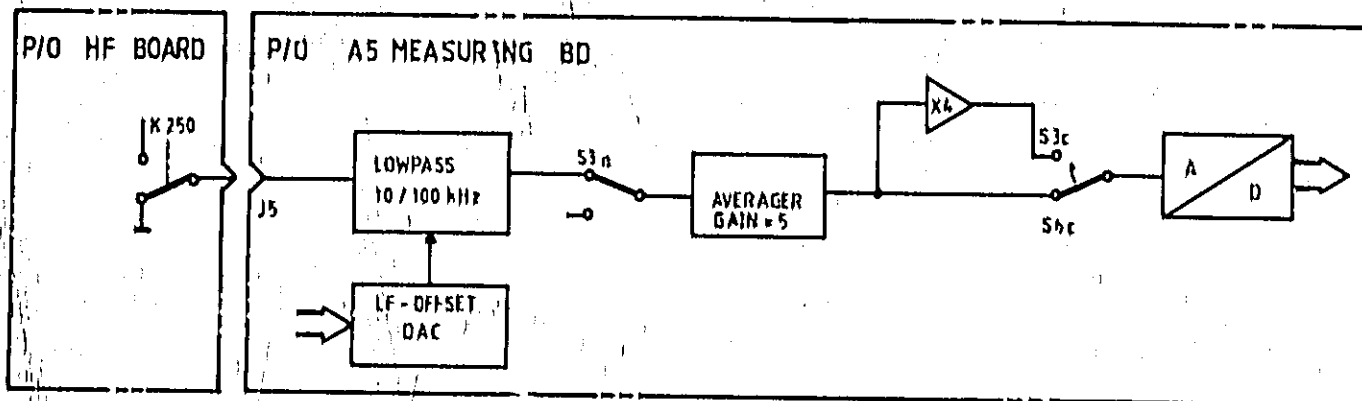


Figure 8-4-4. Average Measuring Path

See Service Block 3 to verify function of the relay K250.

If the fault is not located on the IIF board, check the "Average" signal path as described under paragraph headings "AVG Measurement Path" and "LF-OFFSET DAC".

Error Display E21

Error E21 indicates a failure in the high speed transducer path, which is shown in figure 8-4-5.

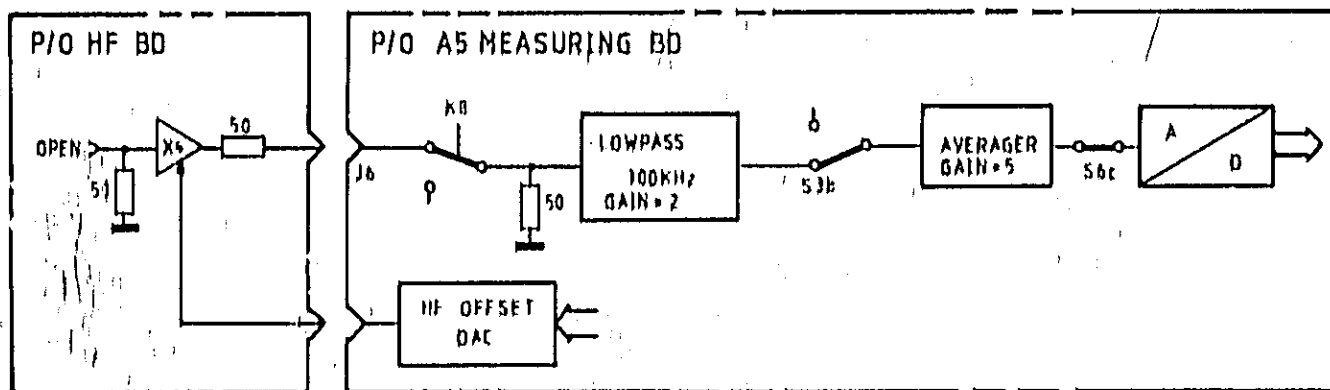


Figure 8-4-5. High Speed Transducer Path.

During the High Speed Signal Path Test, all switches to the input of the $\times 4$ amplifier on the HF Board A3 are open, so that the input voltage is 0 Volt (via 50 Ohm termination). The HF-Offset DAC is programmed to 0.0 Volt. Error E21 is caused if the voltage at the A/D converter exceeds + 250 mV or - 250 mV, corresponding to an offset voltage of ± 25 mV at the measuring input J6 (total gain = 10). If this test passed, the self-test checks whether the HF Offset DAC is able to provide a voltage swing of at least 200 mV.

See Service Block 3 to isolate the fault at board level. If the failure turns out to be located on the Measuring Board A5, check the high speed signal path as described under paragraph headings "100 kHz Lowpass U8" and "HF-Offset DAC".

Error Display E22

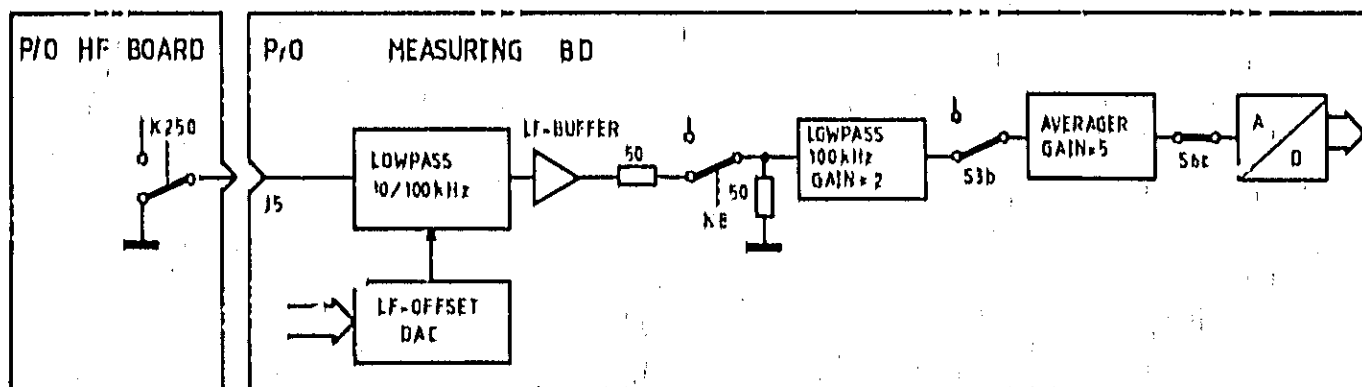


Figure 8-4-6. Low Speed Signal Path.

With the measuring input shorted (J5) to ground and the LF Offset DAC set to 0.0 V, this part of the self-test checks the offset of the LF Buffer (U3, Q1 through Q4). If it exceeds + or - 50 mV at the LF Buffer output (+/- 500 mV at A/D input), Error 22 is displayed. If this test passed, the self-test checks whether the LF Offset DAC is able to provide a voltage swing of at least 200 mV when programmed to min and max setting. The only areas where E22 can occur are the LF Buffer, the LF Offset DAC and the relay K8. All other functional blocks that are involved in this test are already tested before.

Check relay K8 as described under paragraph heading "Analog Switches and Relays". Program the following commands (Direct Hardware Access) via HP-IB with the address switch set to 18:

OUTPUT 718; "SDA BST BHW 1CDB 00" - shorts the measuring input J5 to gnd.

OUTPUT 718; "SDA BST BIW 1CFB 80" - sets LF Offset DAC to 0.0 V.

To determine whether the LF-Buffer produces too much offset, measure the buffer input voltage at U4/pin 6 (+/- 2.5 mV max.) and the buffer output voltage at R115 (pointer 26 in schematic 4B). It should not exceed +/- 5 mV, otherwise troubleshoot the LF-Buffer.

If the LF-Buffer is alright, troubleshoot the LF-Offset DAC as described under paragraph heading "LF-Offset DAC".

Error Display E30

Error E30 indicates that the HF Peak Detector is not able to detect any transition at its input, or Service Switch S13 is still set to service position (gnd).
See paragraph heading "HF Peak Detector".

Error Displays E31, E32

Error displays E31 and E32 indicate a failure in the High Level LF Peak Detector and Low Level LF Peak Detector, respectively.

During the test, a dc signal (approx. 100 mV) is generated at the LF Offset DAC, which is first measured via the Averager, and then via the LF Peak Detector. If the result from the LF Peak Detectors differs more than 20% from the result of the Averager, an error is displayed. For troubleshooting, refer to paragraph heading "LF Peak Detector".

Error 33

Since the HF Peak Detector test that results in E30 is only a rough functional test, a second test which is similar to that for the LF Peak Detector is done for the HF Peak Detector. Two dc levels (+ 100 mV and - 100 mV) are measured via the Averager and via the HF Peak Detector, and then compared. Error E33 appears if the results given from the HF Peak Detector differ more than +/- 20 % from the result when measuring with the Averager. For troubleshooting, refer to "HF Peak Detector".

Error Display E90/HEAD Interface

Error E90 indicates a fault in the HEAD interface. The interface consists of the three analog lines, Range Code (transmitted data), OP Code 1 and OP Code 2 (both received data), and two digital data lines MD1 and MD2 (transmitted data).

WARNING

Before troubleshooting the HEAD interface, disconnect cable ABW2 from connector J4 of the Power Supply Board A4 to remove the hazardous 240 V supply from the HEAD input connector.

1. Switch instrument off and on again. A failure of the Range Code DAC would be indicated by Self-Test Error E11.
2. Program the following command (Direct Hardware Access) via HP-IB with the address switch set to 18.

OUTPUT 718; "SDA BST BHW ICEB 31" - sets MD1 and MD2 low (TTL)

Verify that pins 4 (MD2) and 5 (MD1) of the Head input connector are at TTL low potential.

3. OUTPUT 718; "SDA BST BHW ICEB 37" - sets MD1 and MD2 high (TTL)

Verify that pins 4 (MD2) and 5 (MD1) of the HEAD input connector are at TTL high potential.

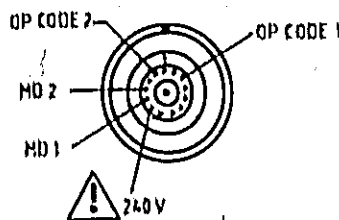


Figure 8-4-7. Head Input Connector (Front View).

4. OUTPUT 718; "SDA BST BHW ICE3 A0" - sets analog switches to give OP
OUTPUT 718; "SDA BST BHW IC73 84" Code 1 to the A/D converter input

Apply any voltage (0...10V) to the input connector pin 12. Verify that this voltage arrives at the A/D converter input U35/14 via analog switches S6a (U39/13,14) and S6 MUX (U40/11,12), otherwise troubleshoot the analog switches and their control signals.

5. OUTPUT 718; "SDA BST BHW ICE3 A0" - sets the analog switches to give
OUTPUT 718; "SDA BST BHW IC73 24" OP Code 2 to the A/D Converter input

Apply any voltage (0...10V) to the HEAD input connector pin 2. Verify that this voltage arrives at the A/D converter input U35/14 via analog switches S6b (U39/15, 16) and S6 MUX (U40/11, 12), otherwise troubleshoot the analog switches and their control signals.

If none of the tests failed, the failure must be located in the Optical Head. (refer to Optical Head Manual for troubleshooting).

Control Signals for Latches, DACs, A/D Converter and Detectors

The digital control signals on the Measuring BD A5 for Latches etc. can be checked with signature analysis.

Set the μ -Processor into the free run routine as follows:

1. Remove jumper S8 from Measuring Board A5.
2. Set Jumper A6W1 into position "P1" on μ -Processor Board.
3. Reset the μ -Processor by momentarily shorting 'RES' to gnd.

NOTE: Due to irregular switching of the analog switches, U39 and U14 caused by the free running μ -Processor, IC's U5, U7, U10, U2, U17, U25 and U47 become hot. After finishing the free run routine, allow a cool-down time of 5 minutes for normal operation.

Connect the Signature Analyzer Timing Pod to the μ -Processor Board as shown in table 8-4-3.

Table 8-4-3 Timing Pod connections to A6 μ -Processor Board

Timing Pod	A6 Testpoints
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"

Set the Signature Analyzer as follows:

Signature Mode	Norm
Data Threshold Levels	TTL: 2.00 H, 0.80 L
Clock Threshold Level	TTL: 1.40
Start/Stop Threshold Level	TTL: 1.40
Start Slope	✓
Stop Slope	✓
Clock Slope	✓

Check that the signature at +5V gives a 0003 reading on the signature analyzer. If not, either the μ -Processor is not free running or the timing pod is connected wrongly.

Check the signatures of the A5 control signals against the readings in table 8-4-4.

Table 8-4-4. A5 Control Signals - Mnemonics, Description and Signatures

Mnemonic	Description	Area	Free Run Signature
CNT 1	Load Control Latch 1	U31/9, U32/11	C3FA
CNT 2	Load Control Latch 2	U21/10, U24/11	68A1
CNT 3	Load Control Latch 3	U21/11, U29/11	U619
HFRLY	Load HF-Relay Control Latch	U21/12, U18/11	AUCC
PRNG	Load Range Code DAC	U21/14, U19/12	FUFU
OFSHF	Load HF-Offset DAC	U21/13, U20/12	U9CC
OFSLF	Load LF-Offset DAC	U21/7, U28/12	PFFU
LBR LBR	Load Ramp DAC (Low Byte)	U37/8, U36/23,24 U31/14, U37/9	3810 3813
HBR HBR	Load Ramp DAC (High Byte)	U37/10, U36/25 U31/12, U37/11	8PHP 8PHH
LDAC LDAC	Latch Low/High Byte Data into Ramp DAC Register	U37/4, U36/21 U31/7, U37/3	273F 273U
CHFD CHFD	Clear HF Peak Detector	U37/12, R44 U31/11, U37/13	P54F P54U
HFSTP	HF Peak Detector Stop Signal	U26/15, U23/15	A3F0
CHDOE	Clear Head Overload Detector	U31/10, U43/1	U859
ADST	Load A/D Converter Latch	U31/13, U33/11	C10F
READC READC	Read A/D Converter	U37/2, U35/6 U26/12, U37/1, U34/1,19	IP34 IP37

Analog Switches and Relays

All analog switches on the Measuring Board are controlled via Control Latches 1, 2 and 3. Check the signatures of the control signals **CNT1**, **CNT2** and **CNT3** as described in paragraph heading "Control Signals for Latches, DAC's, A/D Converter and Detectors".

Program the following commands (Direct Hardware Access) via HP-IB with the address switch set to 18:

OUTPUT 718: "SDA BST BHW IC73 00" - sets all analog switches and relays
 OUTPUT 718: "SDA BST BHW ICE3 00" on Board A5 to non-energized state
 OUTPUT 718: "SDA BST BHW ICEB 31"

All outputs of Control Latches 1 and 3 (U32, U29) must be at TTL low level. Control Latch 2 output Q5 (U24/15) must be at TTL high level, and Q7 (U24/19) must be at TTL low level.

Check that all analog switches and relays are in the position as shown in schematics 4B, 4C and 4D.

Table 8-4-5 shows a list of Direct Hardware Access commands that enable the various analog switches and relays.

Table 8-4-5. Direct Hardware Access Commands

OUTPUT 718, "SDA BST BHW...	Control Signals	Energized switch/relay
"ICE300BHWIC73 80"	U32/19 high	S6a (U39/13,14)
"ICE300BHWIC73 20"	U32/15 high	S6b (U39/15,16)
"ICE300BHWIC73 01"	U32/2 high	S6f (U39/11,12)
"ICE300BHWIC73 02"	U32/5 high	S6g (U39/9,10)
"IC7300BHWICE3 04"	U29/6 high	S6h (U14/13,14)
"IC7300BHWICE3 01"	U29/2 high	S6h (U14/9,10)
"IC7300BHWICE3 02"	U29/5 high	S6i (U14/11,12)
"ICE300BHWIC73 04"	U32/6 high	S6 MUX (U40/11,12)
"ICE300BHWIC73 40"	U32/16 high	S6e (U40/13,14)
"ICE300BHWIC73 10"	U32/12 high	S6d (U40/15,16)
"ICE300BHWIC73 08"	U32/9 high	S3a (U40/9,10)
"IC7300BHWICE3 20"	U29/15 high	S3b (U14/13,14)
"IC7300BHWICE3 08"	U29/9 high	S4a (U14/15,16)
"IC7300BHWICE3 80"	U29/19 high	S4a (U6/11,12)
"IC7300BHWICE3 40"	U29/16 high	S4b (U6/9,10)
"ICEBB1"	U24/19 high	K8
"IC7B11"	U24/15 low	K9

LF Offset DAC

Check the signature of control signal **UFSLF** as described in "Control Signals for Latches, DAC's, A/D Converter and Detectors".

For analog troubleshooting, de-solder R23 to avoid any influence of the LF-Input circuits.
 The LF-Offset DAC can be programmed via Direct Hardware Access.

OUTPUT 718: "SDA BST BHW ICEB 00" - sets the LF-Offset DAC to minimum

Measure the voltage at U27/pin6. It must be 0.0 V with R23 de-soldered.

OUTPUT 718; "SDA BST BHW 1C1-B F1" - sets the LF-Offset DAC to maximum

The output voltage of U27 (pin 6) should be ~ 10.0 V (R23 de-soldered)

HF Offset DAC

Check the signature of control signal **DFSIF** as described in "Control Signals for Latches, DAC's, A/D Converter and Detector".

If the control signal is alright, the HF-Offset DAC can be programmed via Direct Hardware Access as follows (address switch set to 18):

OUTPUT 718; "SDA BST BHW 1CD3 00" - sets the HF Offset DAC to minimum

Measure the voltage at U17 pin 1. It should be approx. ~ 0.82 V.

Check voltage at U17 pin 7 for 0.0 V.

OUTPUT 718; "SDA BST BHW 1CD3 F1" - sets the HF Offset DAC to maximum

Voltage at U17 pin 1 should be approx. $+ 0.82$ V.

Voltage at U17 pin 7 should be ~ 10.0 V.

100 kHz Lowpass U8

This path is only used during the self-test procedure. Any failure of U8 and its surrounding components causes an Error E21, even if it has no influence on the instrument's performance in normal operation.

Connect test cable assy (08151-61611) to the HEAD input. Turn the instrument off and on again, and set the 8151A to:AMP, 00 dBm-Range, no filter.

Terminate the test cable assy with 50 Ohm (no input signal) and measure the input voltage to the Lowpass at the junction of R116 and R119. It should be less than ± 10 mV, otherwise troubleshoot the $\times 4$ amplifier on the HF Board A3. Then measure the output voltage of U8 (pin 6, TP5). It should exceed ± 5 mV plus twice the input voltage (max. ± 25 mV).

Apply an input signal (sine, 1 kHz, swing between 0 and 250 mV) to the test cable assy (without 50 Ohm feedthrough).

With an oscilloscope, observe the signal at the lowpass input R116/119 and at the lowpass output (U8 pin 6, TP5). The lowpass should have a gain of 2.

AVG Measurement Path

For troubleshooting the AVG measurement path, connect test cable assy (08151-61611) to the head input, switch instrument off and on again, and then set the 8151A to AVG.

Figure 8-4-8 shows the signals along the AVG measurement path with the following squarewave input signal:

Frequency	50Hz
Amplitude	1.00 Vpp into open
Baseline Offset	0.0 V

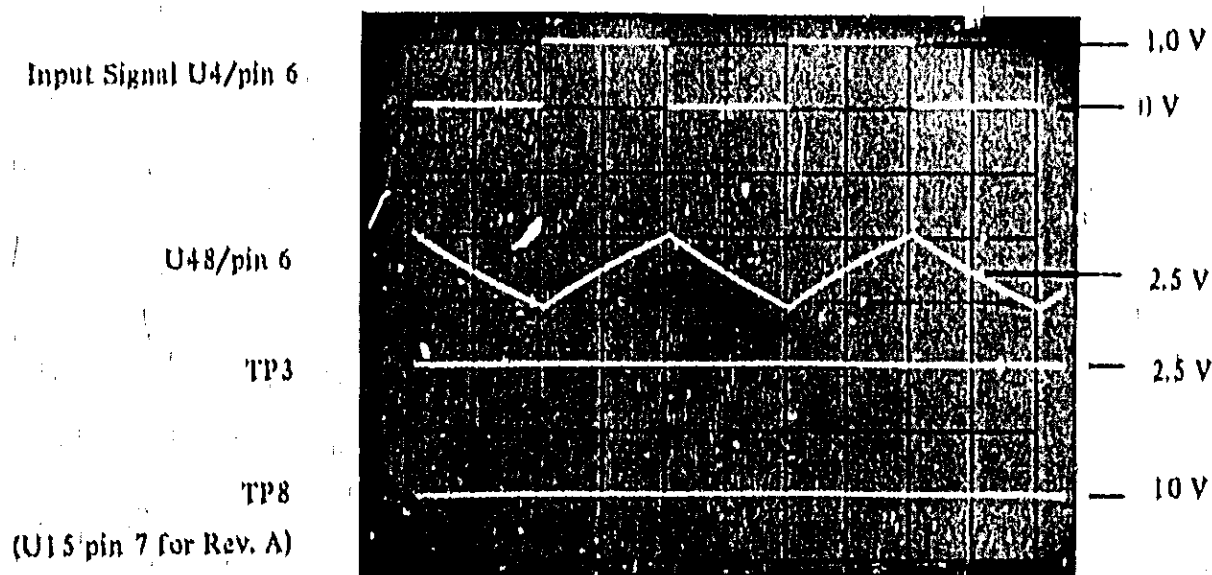


Figure 8-4-8. Signals for AVG Measurement Path.

LF Peak Detector

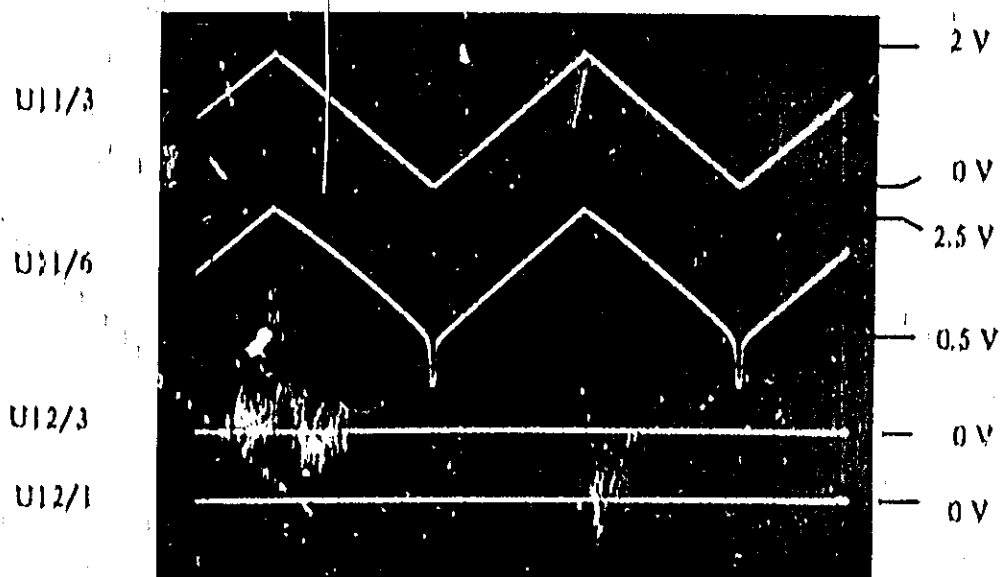
Set service switch S11 to service position (gnd).
 Check voltage at the cathode of CR10 for -5 V.
 Check voltage at the anode of CR12 for +5 V.

For analog troubleshooting, connect test cable assy (08151-61611) to the HEAD input, switch the instrument off and on again, and set the 8151A to: AMP, -40 dBm range, no filter.

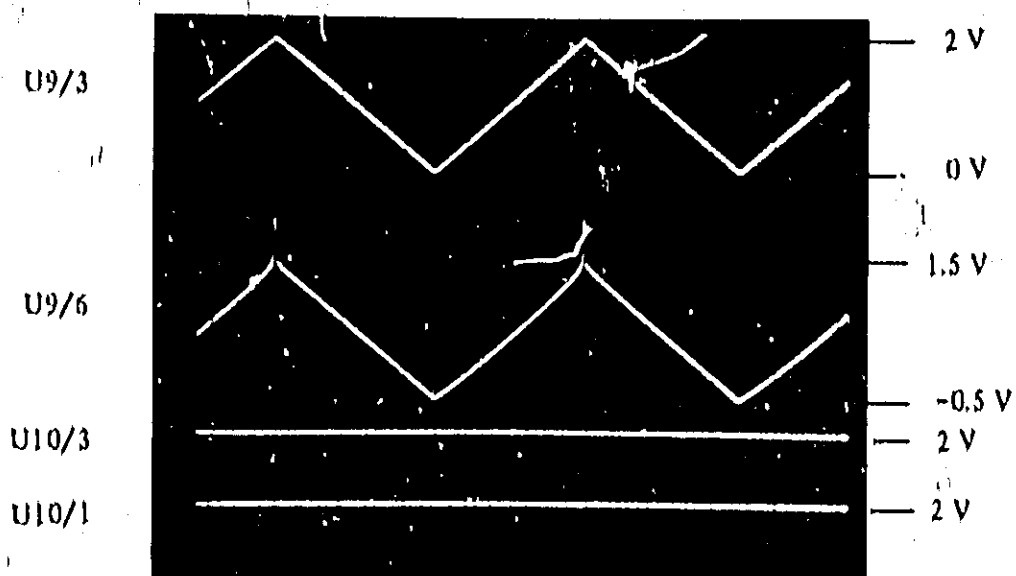
Set all service switches back to normal position.
 Apply the following input signal to the test cable (no 50 Ω feedthrough):

Waveform	triangle
Frequency	1 kHz
Amplitude	2.00 Vpp into open
Baseline Offset	0.0 V

Figure 8-4-9 shows the signals for the LF Peak Detectors.



Low Level LF Peak Detector



High Level LF Peak Detector

Figure 8-4-9. Signals for LF Peak Detectors.

HF Peak Detector

For troubleshooting, connect U1 pin 3 to ground thus applying 0 V to one input of the comparator. Switch the 8151A off and on again, then connect test cable assy 08151-61611 to the HEAD input. Set the 8151A to: AMP, 00 dBm range.

Using an ECL logic probe, check that the 'Clear' signal toggles for flip-flops U2/pins 4 and 13. If not, troubleshoot Q8 and check the signature of the CHFD signal.

Apply a negative voltage (approximately -20 mV) to the HEAD input via the test cable.

Reset the HF Peak Detector flip-flops by executing the following Direct Hardware Access command via HP-IB (address switch set to 18):

OUTPUT 718;"SDA BST BHW 1C63 00"

Check the following voltages:

U1 pin 7	-1.7 V
U1 pin 8	-0.8 V
U2 pins 2, 15	-1.2 V
Q7 collector	0.1 V

Change the input voltage to approximately +20 mV.

Check the following voltages:

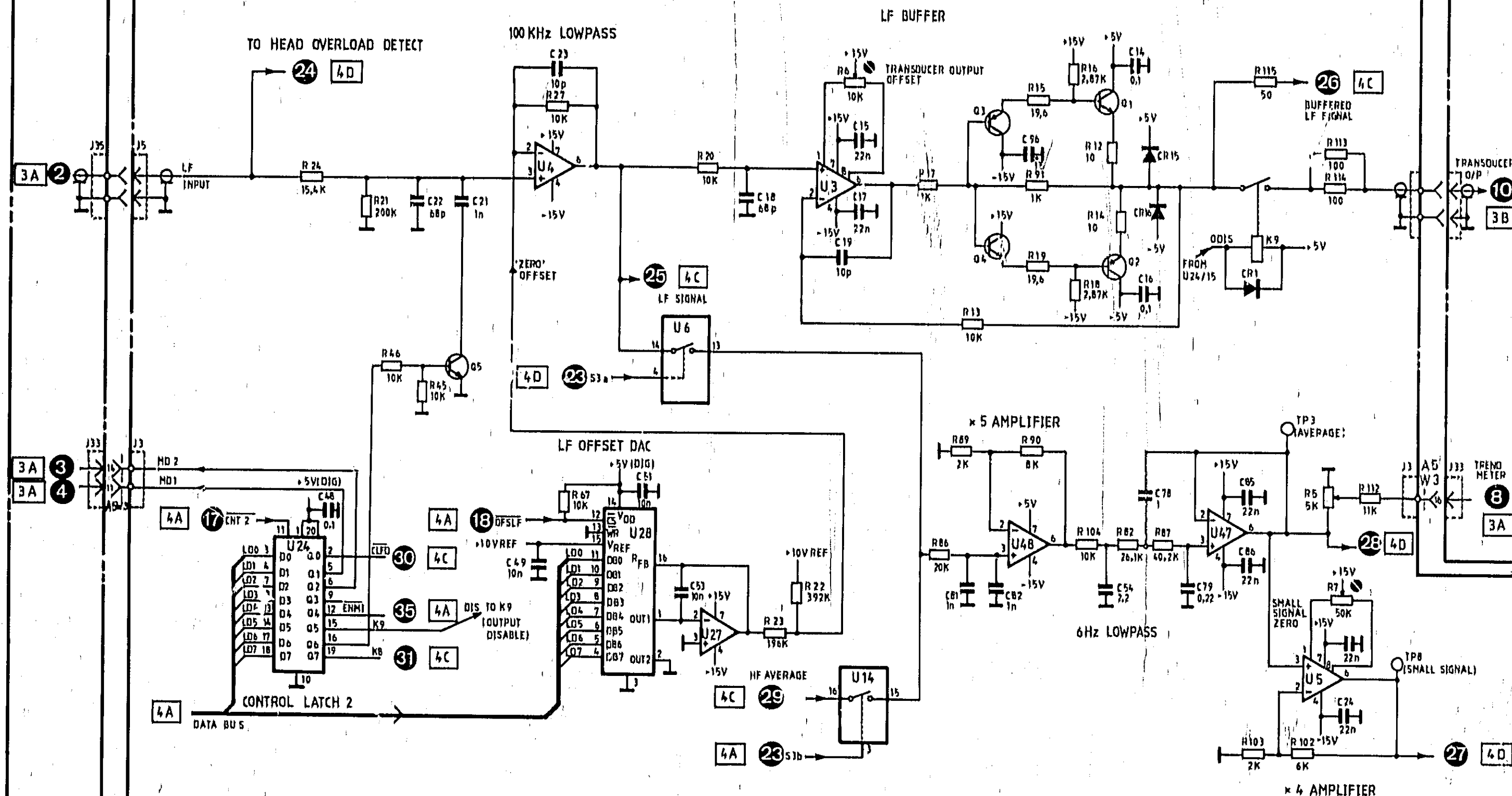
U1 pin 7	-0.8 V
U1 pin 8	-1.7 V
U2 pins 2, 15	-0.8 V
Q7 collector	5 V

Reset the Peak Detector flip-flops by executing the Direct Hardware Access command again. The voltage at Q7 collector must go to TTL low.

P/O A3
HF BD

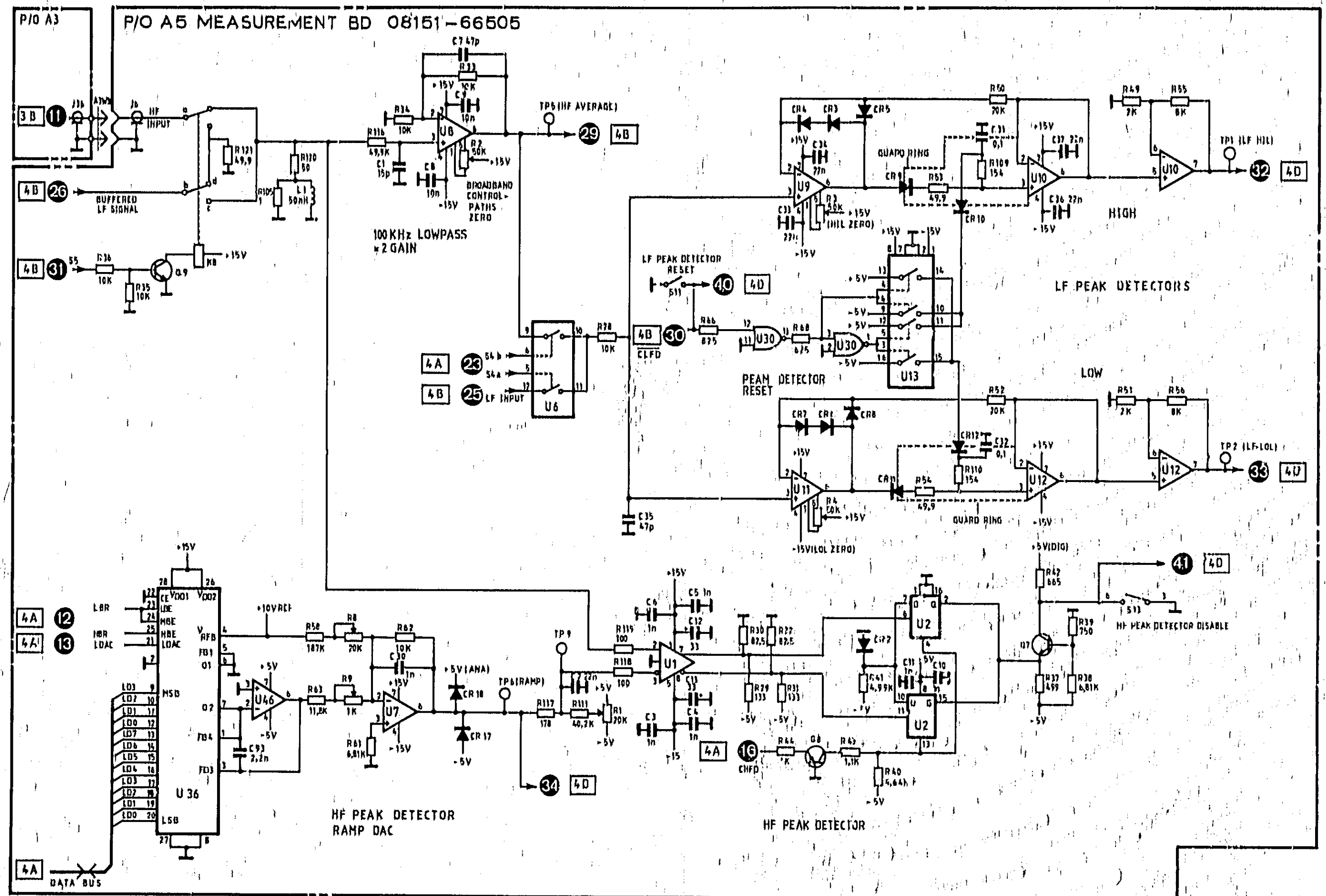
P/O A5 MEASURING BD 08151-66505

P/O A3
HF BD



MEASUREMENT
BOARD

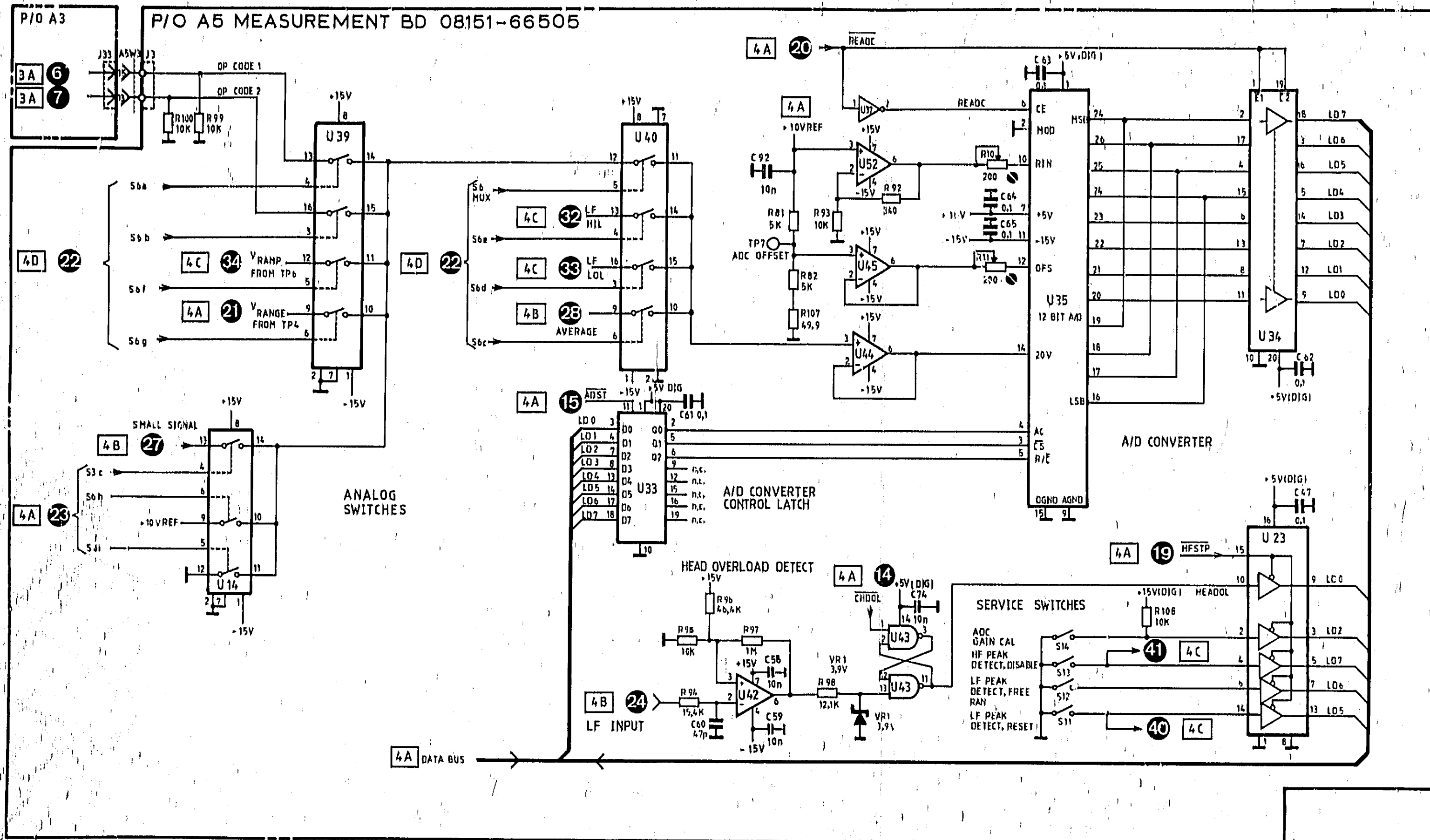
4B



MEASUREMENT
BOARD

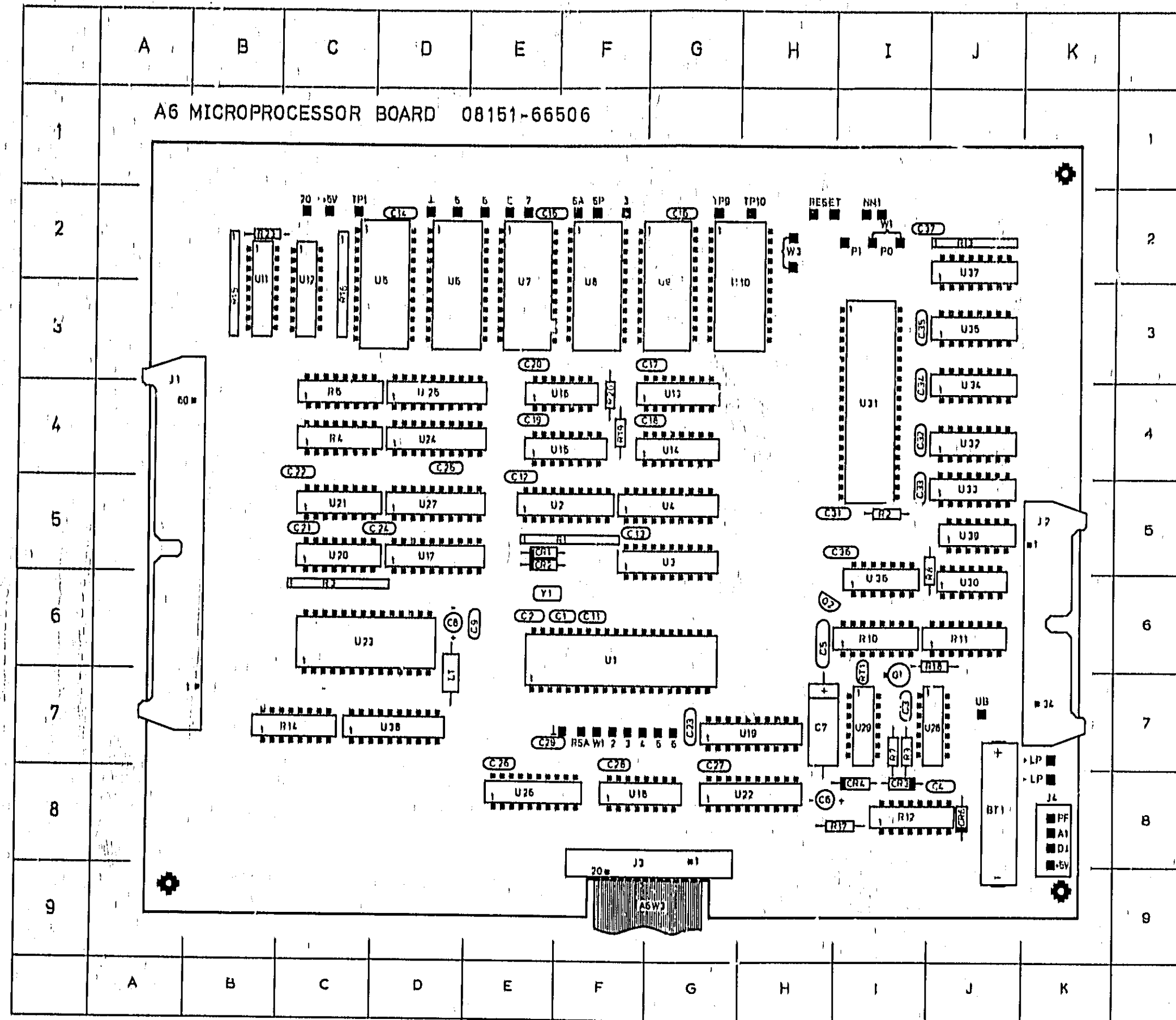
4C

8-51

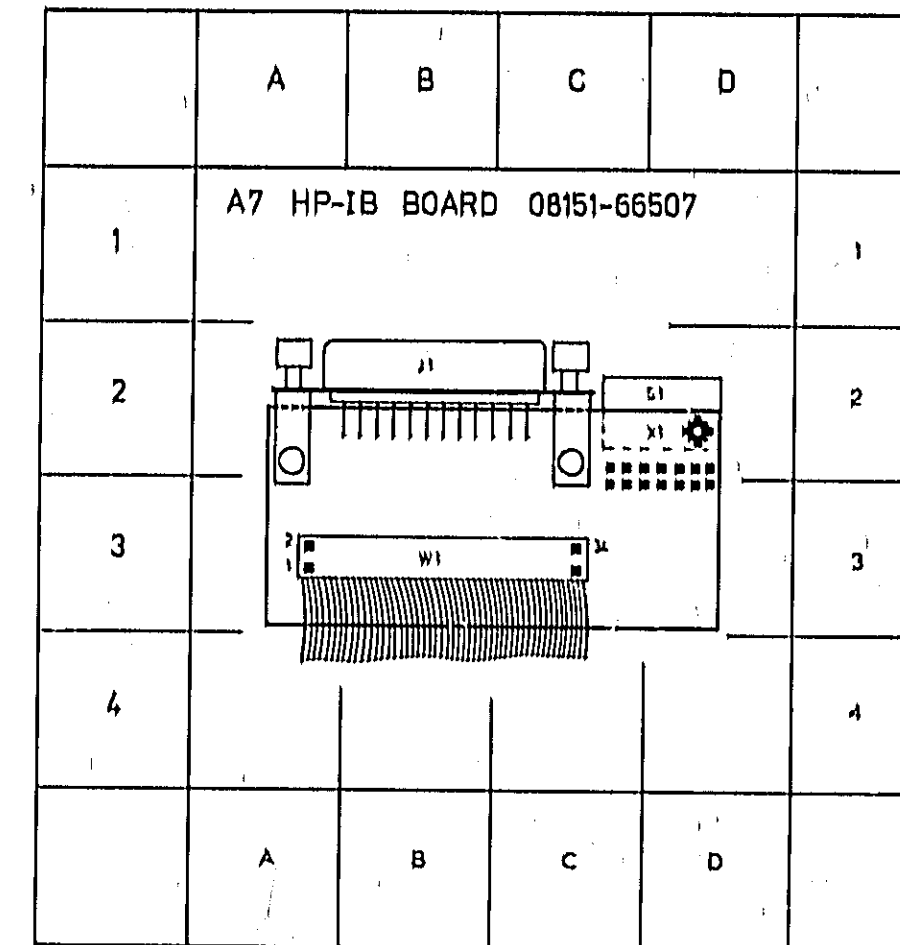


MEASUREMENT
BOARD

4D



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
BT1	J8	R7	I7	U37	J2
C1	F6	R8	J5/6	U38	D7
C2	E6	R9	I7	U39	J5
C3	I7	R10	I6	W1	I2
C4	J8	R11	J6	W3	H2
C5	H6	R12	I8	Y1	E6
C6	H8	R13	J2		
C7	H7	R14	C7		
C8	D6	R15	B3		
C9	E6	R16	C3		
C11	F6	R17	I8		
C12	E4	R18	J6		
C13	F5	R19	F4		
C14	D2	R20	F4		
C15	E2	R23	B2		
C16	G2	RT1	I6/7		
C17	G3	U1	F6		
C18	G4	U2	E5		
C19	E4	U3	G5		
C20	E3	U4	G5		
C21	C5	U5	D2		
C22	C4	U6	D2		
C23	G7	U7	E2		
C24	D5	U8	F2		
C25	D4	U9	G2		
C26	E7	U10	G2		
C27	G7	U11	B3		
C28	F7	U12	C3		
C29	E7	U13	G4		
C31	H/I5	U14	G4		
C32	I4	U15	F4		
C33	I5	U16	F4		
C34	I3/4	U17	D5		
C35	I3	U18	F8		
C36	I5	U19	H7		
C37	I2	U20	C5		
CR1	E5	U21	C5		
CR2	E5	U22	H8		
CR3	I8	U23	C6		
CR4	I8	U24	D4		
CR6	J8	U25	D4		
J1	A3	U26	E8		
J2	K5	U27	D5		
J3	F9	U28	J7		
L1	D7	U29	I7		
Q1	I7	U30	J6		
Q2	H6	U31	I4		
R1	F5	U32	J4		
R2	I5	U33	J5		
R3	C6	U34	J3		
R4	C4	U35	J3		
R5	C4	U36	I6		



SERVICE BLOCK 5

MICROPROCESSOR BD, A6

THEORY OF OPERATION

Introduction

The microprocessor is the data processing and information control center of the 8151A. All control information for instrument functions is generated here, depending upon inputs from one of two sources.

- Frontpanel inputs when the instrument is under manual control.
- HP-IB inputs when the instrument is under remote control.

During operation, inputs from one of these sources program the desired parameters.

As shown in Figure 8-5-1, the microprocessor can be conveniently divided into the following areas for descriptive purposes:

- Central Processor Unit (CPU)
- Read Only Memory (ROM)
- Random Access Memory (RAM)
- HP-IB Interface (GPIA)
- Address Decoders
- MPU Reset circuit
- RAM back-up battery supply

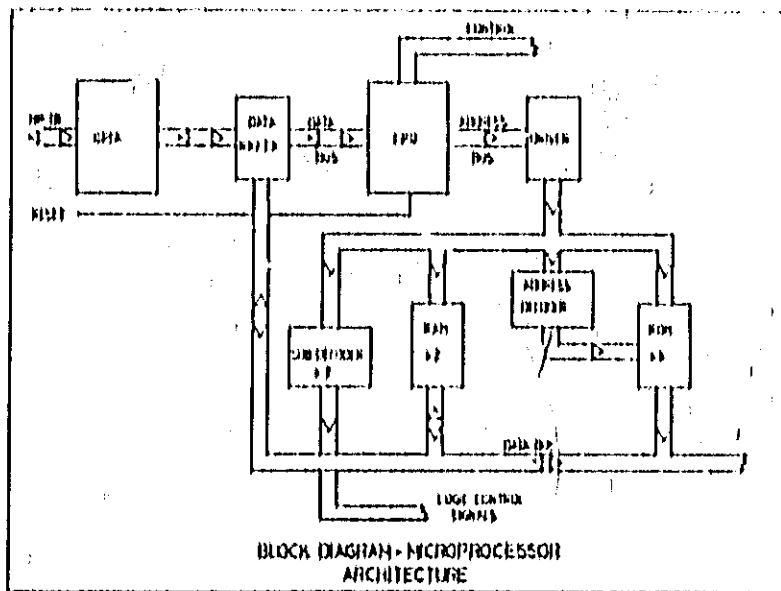


Figure 8-5-1. Block Diagram - Microprocessor

Central Processor Unit

The CPU executes the commands which have been programmed into the six ROM's. It first generates an address code which is sent to the respective ROM. The ROM then outputs data from the location addressed, and the CPU acts upon the data received. This is usually a continuous process, and is referred to as a routine. The content of the six ROM's contain many such routines.

Figure 8-5-2 illustrates in basic terms, the input and output signals of the CPU. Inputs and outputs are sent and received via two buses. Data to and from the CPU travels along an eightbit bidirectional data highway, while generated addresses are sent via a sixteen-bit unidirectional bus. The address bus is routed to all six ROM's, both RAM's and the GPIA. When addressed, each of these elements outputs data from memory locations onto the data highway, or bus, for processing by the CPU, or use as logic control signals for various instrument functions.

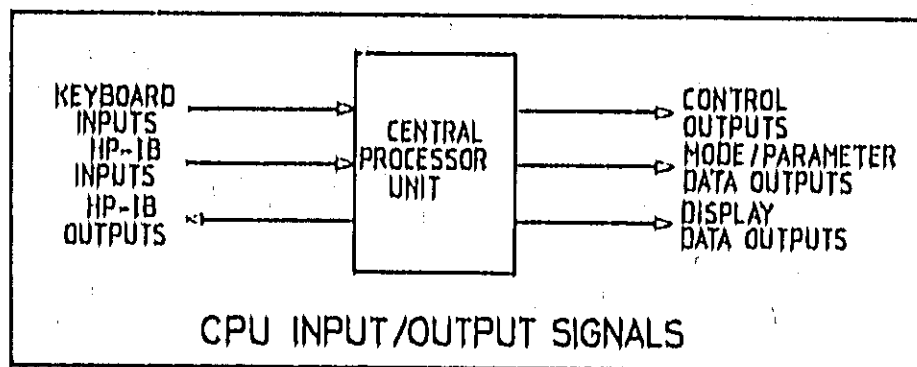


Figure 8-5-2. CPU Input/Output Signals.

Read Only Memory

The ROM is a device in which all operational data for the instrument is stored at the time of manufacture. Data can be read from but not written into a ROM, and is accessed from a memory location by first enabling the device and then sending the address of that location in the form of a twelve-bit binary code. The addressing of memory locations and the reading of data take place on the address bus and data bus respectively. For each of the ROM's in the 8151A microprocessor, there are 4096 individual memory locations.

A ROM can be considered as a data decoder for practical purposes, as it transforms any given input address into a specific output instruction. A set of output instructions which collectively accomplish a specific task is commonly referred to as a routine. To perform a routine, the CPU enables the ROM, then addresses a memory location. The CPU responds to the instruction output to the data bus, then addresses the next location in the ROM to access the next instruction. This process is repeated as often as is necessary for the CPU to execute the complete routine. Some instructions may branch into a sub-routine, while others will be dedicated to instrument functions which require logic inputs to accomplish their tasks (DAC's for example).

Random Access Memory

The task of the RAM is to provide workspace for the CPU, so the device can be described as the 'scratchpad element' of the microprocessor. Data can be written into, as well as read out of a RAM memory location, and is finally destroyed by new data. Furthermore, the RAM has what is commonly

referred to as a 'volatile memory'. This implies that all stored data is either corrupted or lost when the power source for the RAM is withdrawn. Both of the RAM's in the 8151A microprocessor are backed-up by a battery supply which is switched in when the main supply to the instrument is switched off. Therefore, data held in the RAM is preserved as long as there is sufficient charge in the battery to maintain the minimum amount of power required to keep the RAM operational.

Two buses are needed for the operation of a RAM. For 8151A applications, the first of these is a ten-bit address bus, for the addressing of a particular memory location, and the second is a four-bit bidirectional data bus for writing data into memory in 'write' mode, and retrieving data in 'read' mode. Read and write functions are controlled by the CPU directly - without intervention from any other microprocessor elements. Both buses are connected to the address and data buses as shown in Figure 8-5-1.

HP-IB General Purpose Interface Adapter

The GPIA is part of the HP-IB section of the instrument and is merely an interface element between the microprocessor and any other devices operating on the HP-IB. Signals to and from the GPIA fall into three groups:

- a) Microprocessor interface
- b) Interfacing between the 8151A and other devices on the HP-IB
- c) Control signals

Table 8-5-1 describes the functions of signals within each of the three groups.

Table 8-5-1 Signal Functions

a. MPU Interface	b. Interface with the HP-IB
Bidirectional data lines (D0 D7) - allows the transfer of data between MPU and GPIA. The output drivers are tri-state devices. Chip Select ($\overline{CS}$) - used to select the GPIA via subdecoder. A negative-going edge selects the GPIA. READ/WRITE line (R/W) - connected to the MPU's R/W signal and controls register access and direction of data transfer on the bus. This signal is used in conjunction with the Register Select lines. Register Select lines (RS0, RS1, RS2) - connected to the three lowest address lines A0, A1, A2 to provide selection of the different GPIA registers.	Signal lines ID0 ID7 allow the flow of ASCII interface messages and device dependent messages. Byte transfer lines (DAC, RFD, DAV) - provide the three-line handshake between source and acceptor. Positive-going RFD indicates that all acceptors are "Ready For Data". A source will indicate that data is valid by pulling DAV low. Upon reception of valid data, DAC will go high, indicating that an acceptor has accepted data. Bus management lines ($\overline{ATN}$, $\overline{IFC}$, $\overline{SRQ}$, $\overline{EOI}$, $\overline{REN}$) are used to manage the flow of information over the interface lines.
c. Control Signal group	
Interrupt Request ($\overline{IRQ}$) - connected to the common interrupt bus line for the MPU. $\overline{RESET}$ Input used to initialize the GPIA during power-up. The $\overline{RESET}$ signal is generated in the same manner as for the MPU. (See Service Block 2 - Power Supply). E (Enable Clock, 0) - activates the address inputs, R/W inputs and enables data transfer to the MPU data bus. Also used internally as a state counter, allowing the device to change interface states. E is connected to the MPU clock output.	Address Switch Enable ($\overline{ASE}$) is used to enable the tri-state buffer that connects the instrument address switch to the MPU data bus. TRIG, DMA Grant and DMA Request are not used. GPIA Internal Register. The MPU has access to the GPIA internal registers via the register select lines and the R/W line.

a) MICROPROCESSOR INTERFACE

Bidirectional data lines D0...D7 allow the transfer of data between CPU and GPIA.

Address lines A0...A2 select the various registers inside the GPIA. Used in conjunction with the read/write input, they access a register into which data is to be written or retrieved. There are a total of fifteen registers within the GPIA - seven of which are write only, and eight which are read only.

b) 8151A TO HP-IB INTERFACE

Signal lines IB0...IB7 allow the flow of ASCII interface and device-dependent data.

Byte transfer lines RFD, DAC and DAV provide the three-line handshake between the HP-IB and GPIA. When RFD goes positive, it is an indication that the GPIA is ready to accept data. A data source will indicate that data is valid by pulling DAV low. Upon receipt of valid data, DAC will go high, indicating that data has been accepted.

Bus management lines ATN, SRQ, REN, IFC and EOI are used to manage the flow of data over the interface lines.

Signals T/R1 and T/R2 control the quad transceivers driving the interface bus. When the signals are high, data can be transmitted to the interface bus via the transceivers, and when low, data can be received.

c) CONTROL SIGNAL GROUP

Address Switch Enable, ASE, is used to enable the tri-state buffer that connects the 8151A address switches to the microprocessor data bus.

Chip Select, CS, when low, enables the GPIA. This signal is derived from the address bus via the address decoder and a sub-decoder.

Read/Write, R/W, is used in conjunction with signals A0...A2 to control register access and the direction of data transfer on the bus.

Interrupt Request, IRQ, is connected to the CPU IRQ line.

Enable, E, activates address inputs R/W, CS, and A0...A2 and data transfer on the data bus.

The Reset signal is described in detail later in the text.

Address decoders

As shown in Figure 8-5-3, there are three address decoders within the microprocessor. The decoders are three-to-eight line devices, which in effect transform an octal input to a decimal output. The primary decoder, or Main Decoder is employed to enable the six ROM's. The main decoder is itself enabled via the signal VMA, which comes directly from the CPU. This main decoder is also used to enable two Sub-Decoders, in conjunction with the VMA and EVMA signals.

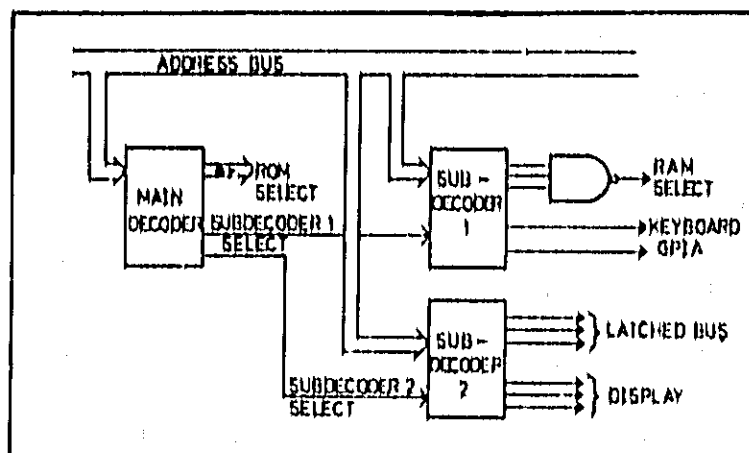


Figure 8-5-3, Address Decoders

Sub-decoder U14 provides the RAM select signal, which indirectly enables both RAM's, the Chip Select, **CS**, signal for the GPIA, and a further logic control signal which is used by digital circuits on the Key Scanner Bus (see Service Block 6).

Sub-decoder U15 also provides logic control signals which enable various data latches on and around the Latched Data and Device buses (see Service Block 6).

MPU Reset circuit

When the instrument is first switched on, some time elapses before all power rails become fully established. In order to compensate for this delay, a CR network has been incorporated into the microprocessor RESET circuit. This network (R201 and C201) is located on the Power Supply board A4, and produces a delay of 135 ms between switch-on and the RESET signal at A4U52 going low. At this time, C3 discharges through R9 until its voltage falls below that of the inverting input of U28b (0.4V). The output of U28b then goes low, switching transistor U30b off, thereby enabling C4 to charge via resistor network R10/R12. When the voltage across C4 reaches 0.4V, the output of U28d goes low. This has the effect of switching Q2 off, and the **RESET** signal goes false (high).

When the instrument is switched off, the **RESET** signal must be received by the microprocessor before the supply rails decay sufficiently to cause loss or corruption of data. Immediately the primary reset circuit in the power supply recognizes that the power-down sequence has been initiated, the output of comparator A4U52 switches high. The MPU RESET circuit then responds in the following manner:

Comparator U28/b output switches high, causing transistor U30/b to conduct. As a result, U28/d output goes high, causing transistor Q2 to switch on, pulling the **RESET** line low, causing the CPU and GPIA to be reset.

Devices U28/a, U28/c, U30/a and U31/b are concerned with the RAM supply, although they rely upon the primary reset signal.

RAM back-up battery supply

The battery supply circuit ensures that the volatile RAM's in the microprocessor retain all current operational data when power is withdrawn. As stated previously, the stimulus required to switch the battery supply in comes from the primary reset circuit in the power supply.

When power is being supplied from the mains, and the instrument is operational, the circuit performs as follows:

Comparator U28/a and U28/c outputs are high, causing transistors U30/a and U31/b to conduct. U30/a drives transistor Q1, which supplies power to both RAM's. U31/b draws current through R18, causing the potential at the CS inputs to be low when the conditions of the wired-AND configuration at the transistor base are satisfied.

The transistor combination of U29/c, U29/d and U30/c do not draw any power from the battery because the potential at Q1 collector is twice that of the battery (+5.2V). The battery charges via R7 and U29/a/b for as long as the +5V rail is available.

When the primary reset signal is sent from the power supply, the normally high output of comparators U28/a/c switch low, causing transistors U30/a, U31/b and Q1 to be switched off. When the potential at Q1 collector deteriorates to +2.5V, the battery supply takes over via transistor U29/c. With the instrument switched off, the battery supply should be able to maintain the data stored in the RAM's for up to two weeks.

TROUBLESHOOTING

Error Display E01

The μ -Processor is unable to load the test pattern into the RAM's (U11, U12) and verify. Switch off the instrument and disconnect the device bus cable, A6W3, from the Measuring Board A5. This ensures that any faults on the Measuring Board will have no effect on the μ -Processor Board. Switch on the instrument again, and if error E01 still occurs, the fault must be located on the μ -Processor Board. The possible faulty components are: U11, U12, U14, U16, U28 and U30d.

Check U14 as given in paragraph headed 'Address Bus, Main Decoder and Subdecoder'. The CS (Chip Select) signal for U11 and U12 can be checked via signature analysis. Set the μ -Processor to free-run routine as already described, and connect the Signature Analyzer timing pod to board A6 as given in table 8-5-2. Set the Signature Analyzer as given in paragraph headed 'Address Bus, Main Decoder and Subdecoder'.

The signature at U11/U12 pin 8 should read HUP7.

The RAM SELECT signal at U16/pin 8 can also be checked via signature analysis. Set the Signature Analyzer data threshold levels as follows:

Data Threshold Levels	0.60 H, 0.30 L
-----------------------	----------------

The Signature Analyzer should read HUP4.

The voltage at U28/pin 7 should be approximately 3.6 V.

Error Display E02

Generally, error E02 indicates that the RAM's have lost stored data. This happens when the RAM's are not continuously supplied with voltage during 'power off'. One reason for this could be that the battery, BT1, is discharged, in which case the battery only needs to be charged up again by switching on the instrument for 8 hours.

Press the λ -key and switch the instrument off and on again. If error 02 still occurs, either BT1 or U29 is defective.

Unintelligible Display

An unintelligible display indicates that the μ -Processor cannot even start the self-test routine. This fault is often due to a malfunction of the RAM's and surrounding components. Check U11, U12, U29, U30d and Q1.

Free-Run Routine for Signature Analysis

For Signature Analysis purposes, the μ -Processor is set to a free-run routine which makes it increment continuously. This is achieved by giving some hardware programmed commands to the μ -Processor via wire P1, which must be set to the "P1" position. The μ -Processor then increments the address register by one continuously via CR1 and CR2.

To avoid undesired effects from the device bus, disconnect cable A6W3 from the Measuring Board A5.

Before the μ -Processor accepts the hardware programmed command, it has to be reset by momentarily shorting RES to ground.

Address Bus Driver, Main Decoder and Subdecoder

Set the μ -Processor to free-run routine. Connect the Signature Analyzer timing pod to the μ -Processor Board A6 as shown in table 8-5-2

Table 8-5-2. Timing Pod Connections to μ -Processor Board

Timing Pod	A6 Testpoints
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"
	

Set the Signature Analyzer as follows:

Signature Mode	Norm
Data Threshold Levels	TTL: 2.00 H, 0.80 L
Clock Threshold Levels	TTL: 1.40
Start/Stop Threshold Level	TTL: 1.40
Start Slope	
Stop Slope	
Clock Slope	

Check that the signature at +5 V gives a 0003 reading on the Signature Analyzer. Any other reading indicates either the μ -Processor is not free-running or the timing pod is connected wrongly.

Check the signatures of the address bus (U1, U3, U4), main decoder (U13) and subdecoders (U14, U15, U16) against the signatures given in table 8-5-3.

Table 8-5-3. Signatures for Address Bus, Main Decoder and Subdecoders.

Signal Mnemonic	Free Run Signature	U1 Pin	U3 Pin	U4 Pin	U13 Pin	U14 Pin	U15 Pin	U16 Pin
A0	UUUU	9	2 18					
A1	FFFF	10	4 16					
A2	8484	11	6 14					
A3	P763	12	8 12					
A4	1U5P	13	11 9					
A5	0356	14	13 7					
A6	U759	15	15 5					
A7	6F9A	16	17 3					
A8	7791	17		2 18				
A9	6321	18		4 16				
A10	37C5	19		6 14				
A11	6U28	20		8 12				
A12	4FCA	22		11 9				
A13	4868	23		15 7				
A14	9UP1	24		15 5				
A15	0002	25		17 3				
<u>ROM1</u>	18117				13			
<u>ROM2</u>	20U0				12			
<u>ROM3</u>	4685				11			
<u>ROM4</u>	36F8				10			
<u>ROM5</u>	31AC				9			
<u>ROM6</u>	41P4				7			
	2340				15	4		
	1C66				14		4	
<u>GPIO CS</u>	A92P					7		
<u>Keyboard</u>	73U6					10		
	9AC8					15		9
	9PP8					14		10
	HCC7					13		11
<u>LB</u>	89C7						14	
<u>ADD</u>	C898						12	
<u>READ</u>	6P25						11	
<u>LATCH 1</u>	HC8A						10	
<u>LATCH 2</u>	C6P1						9	
<u>LATCH 3</u>	PHCC						7	

ROM's

The data that is stored in each ROM and read out when the ROM is enabled can be checked using signature analysis. The Enable signal of each ROM is used as the Start/Stop signal for the Signature Analyzer.

Set the μ -Processor to free-run routine, and connect the Signature Analyzer timing pod to the μ -Processor Board A6 as shown in table 8-5-4. NOTE: The connection of the Start and Stop probes is different for each ROM.

Table 8-5-4. Timing Pod Connections for Checking ROM Signatures.

Timing Pod	A6 Testpoints					
	U5	U6	U7	U8	U9	U10
Start	TP5	TP6	TP7	TP8	TP9	TP10
Stop	TP5	TP6	TP7	TP8	TP9	TP10
Clock	TP "E"					

Set the Signature Analyzer as follows:

Signature Mode
Data Threshold Levels
Clock Threshold Level
Start/Stop Threshold Level
Start Slope
Stop Slope
Clock Slope

Norm
TTL: 2.00 H, 0.80 L
TTL: 1.40
TTL: 1.40

Check that the signature of +5 V gives a P254 reading on the Signature Analyzer. Any other reading indicates either the μ -Processor is not free-running or the timing pod is connected wrongly.

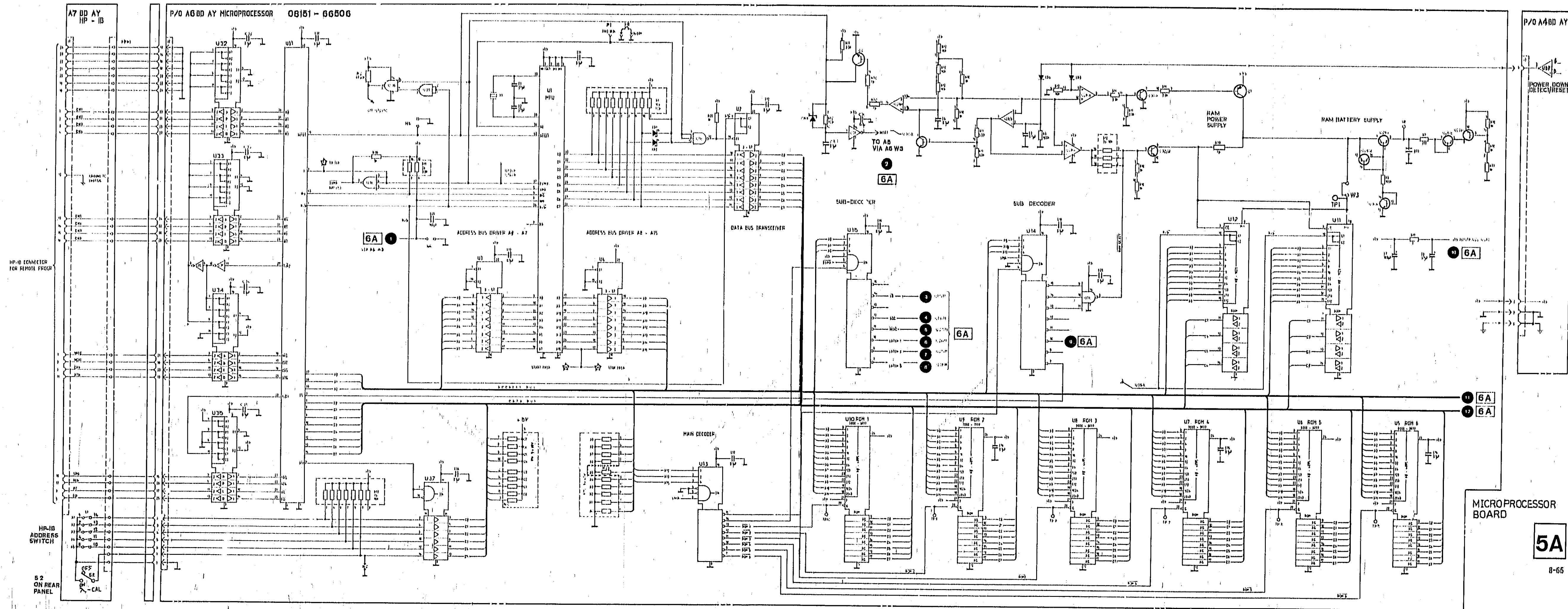
Check the signatures of ROM's 1 through 6 against the readings given in table 8-5-5. NOTE: The 8151A firmware (data permanently stored in the ROM's) is subject to change. The signatures given in table 8-5-5 are valid for 8151A firmware 23 JAN 1984 (Part Nos. 08151-82901 through 08151-82906). For signatures relating to any other 8151A firmware, refer to the Manual Change Sheet.

Table 8-5-5. ROM Signatures

Pin	ROM 6 U5	ROM 5 U6	ROM 4 U7	ROM 3 U8	ROM 2 U9	ROM 1 U10
9	1A14	3107	9118A	5FCA	9A66	208P
10	3C52	8685	3721	16C11	073F	6AP1
11	31115	98U2	7C60	24411	8549	836H
13	46UH	7113F	1148P	C628	9HF1	A11U6
14	U897	P946	303A	9683	4213	46FF
15	0552	2P60	63A4	2C9F	AC59	221A
16	P06U	2779	95CC	4F211	63FF	4H33
17	PC0A	59U8	679U	9C9P	C682	2PU0

Replaceable ROM's

A label is attached to the underside of each ROM indicating the ROM's part number. A defective ROM must be replaced by a ROM with the same part number, otherwise it cannot be guaranteed that the ROM's will continue to function together correctly. Should the installed firmware have to be updated with the latest firmware revision, the complete set of ROM's (ROM1 to ROM6) must be exchanged.



SERVICE BLOCK 6

LATCHED DATA BUS, KEYBOARD AND DISPLAY BOARD

THEORY OF OPERATION

Introduction

The latched data bus is a subsidiary section of the microprocessor and is situated on the same board. This eight-bit bus provides the necessary interfacing between the microprocessor and two functional areas:

- Measurement board (A5) data bus, via the Device bus.
- Frontpanel displays

As shown in Figure 8-6-1, the circuits in this section can be divided into the following functional blocks:

Latched data bus and associated devices
 Display Driver and latches
 Measuring Board Address Decoder
 Key Scanner bus
 Keyboard
 Display board

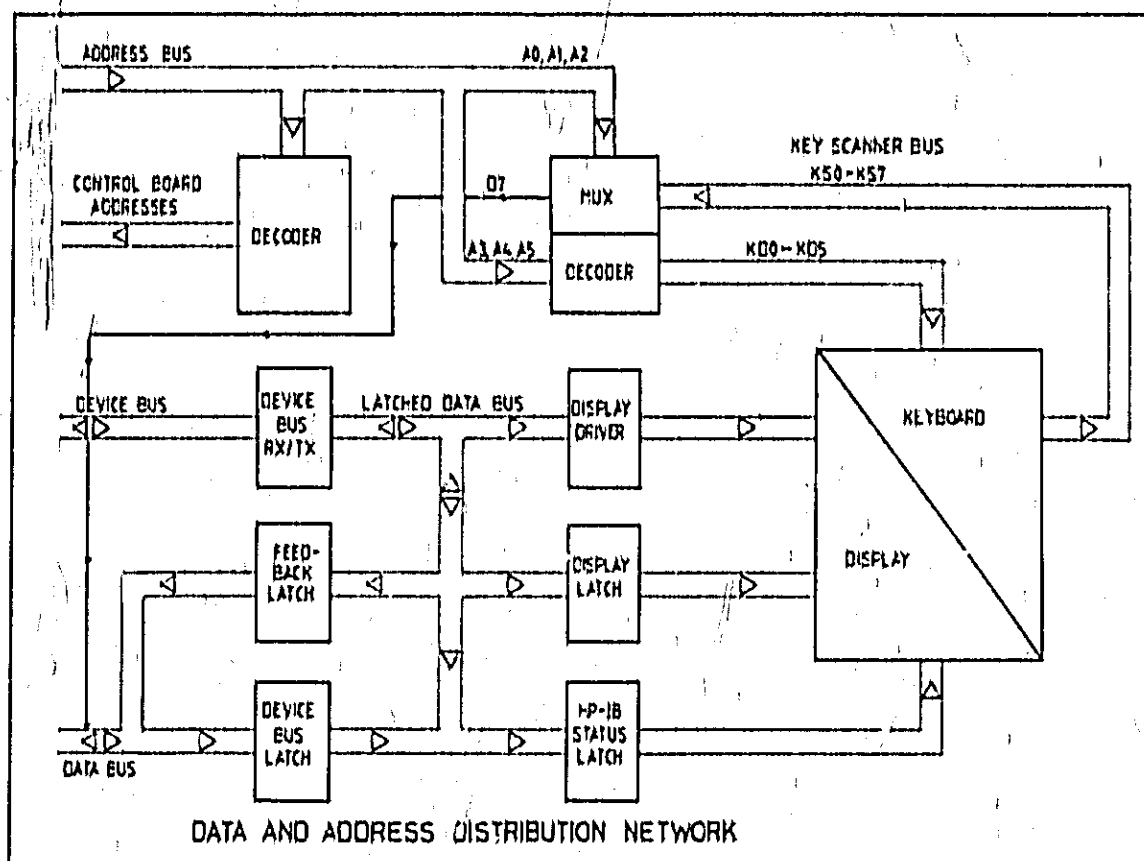


Figure 8-6-1. Data and Address Distribution Network.

Latched data bus and associated devices

The latched data bus is a secondary bus which has three functions:

- Distribution of data from the data bus to parameter backlighting, control, mode, units and IIP-IB status LED's, via the keyboard display latches and the IIP-IB status latch.
- The feeding of data from the data bus to the Device bus, via the Device bus transceiver, for use by the DAC's on the Measurement board.
- Provision of data to the numerical displays and frontpanel key LED's via the Display Driver.

Data from the data bus to the eight-bit Latched data bus is first latched through U17. Once through this latch, data is distributed via further latches to its destinations. All latches in this section are enabled by sub-decoders U14 and U15 (see Service Block 5), which are fed by the Address bus.

Display Driver and Latches

The display driver switches the key, control, mode and units LED's and digital display by way of a matrix switching technique. Outputs DIG0 to DIG7 form the vertical signal paths of the matrix, and outputs a to g and DP, the horizontal paths, in addition to driving the display segments. The display driver has an 8 x 8 static RAM, which permits the storage of eight sets of display data at any given time.

Table 8-6-1. Control Instructions.

CONTROL INPUT	PIN	STATUS	FUNCTION
WRITE	8	HIGH LOW	Data not loaded into RAM Data loaded into RAM
MODE	9	HIGH LOW	Load control word on WRITE pulse, Load data on WRITE pulse.

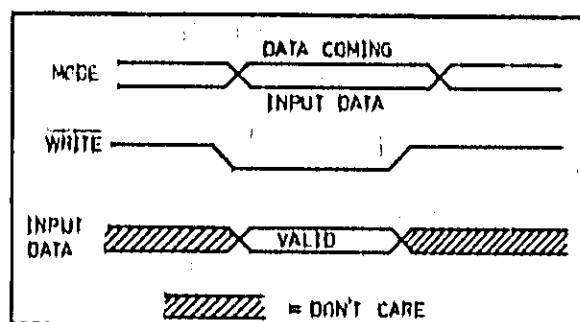


Figure 8-6-2. Switching Waveforms.

Control instructions are read from the latched data bus when **MODE** is high and **WRITE** is low. After control instructions have been received, display data can be written into memory with each successive negative-going transition of **WRITE - MODE** being low. After all eight memory locations have been filled, additional transitions of **WRITE** are ignored. Table 8-6-1 shows control instructions and Figure 8-6-2 illustrates switching waveforms.

The display latches are responsible for the latching of data to frontpanel backlighting LED's.

Measuring Board Address Decoder

Address decoding for Measurement board functions is performed by the three-to-eight line decoder U18. After being latched through U19, address bits A3 to A9 are passed to bus driver U22. A3, A4 and A5 now become latched addresses LA3, LA4 and LA5. Bits A6 to A8 take the form of an octal input to the decoder, while A9 is used to enable the device. The output Write Select signals **WS1** to **WS6** are used to enable various decoders and DAC's on the Measurement board. The **WRITE** signal for the Display Driver is also generated by U18.

Key Scanner Bus

The key scanner bus is employed to examine the status of the keyboard assembly. When a frontpanel key is pressed, the key scanner bus determines which one it is, and informs the microprocessor. The technique is as follows:

The frontpanel keyboard connections are arranged in a matrix. Address bits A3 to A5 together form the octal inputs to decoder U21. From the eight outputs of this device, 4(KD0 to KD3) are used to form the horizontal signal paths of the keyboard matrix. The inputs to U21 are continuously cycled from 0 to 7 in an octal fashion, causing each output in turn to go low for a set period of time.

Address bits A0 to A2 are used to select one of the eight inputs to multiplexer U20. These inputs (KS0 to KS7) form the vertical signal paths of the keyboard matrix. With address bits A0 to A2 being continuously cycled, the inverting output, D7, of the multiplexer is always representative of the currently selected input line. When a key is pressed, and the logic status of the address lines are, for example:

A0 A1 A2 A3 A4 A5 D7

0 1 0 0 1 0 1

↑__KS2__↑ ↑__KD2__↑

the microprocessor can tell from the high state of D7 (with KS2 and KD2 selected) that the dB key has been pressed.

Thus, having control over address bits A0 to A5, the microprocessor can determine from the logic state of D7 the status of every key on the frontpanel.

Key and Display boards

The key and display boards are panels upon which all frontpanel keys and display media are situated. There are two keyboards; one for the vernier and range keys, and another for all keys. The latter of the two boards is also where all display hardware is to be found.

TROUBLESHOOTING

Error Display ☐

This error display generally indicates that a frontpanel key is either pressed or sticking during the 'power-up' routine. If no frontpanel key is sticking, troubleshoot the key scanner circuits U20 and U21.

Signature Analysis

Most troubleshooting in Service Block 6 can be done with Signature Analysis. Using Signature Analysis methods, the μ -Processor has to be forced into a free running loop:

1. Remove cable A6W3 from Measuring Board A5
2. Set jumper W1 into position "P1" on μ -Processor Board A6
3. Reset the μ -Processor by shortening TP "RES" to gnd for a short time.

Connect the Signature Analyzer Timing Pod to the μ -Processor Board A6 as shown in table 8-6-2.

Table 8-6-2. Timing Pod connections to A6 μ -Processor Board

Timing Pod	A6 Testpoints
Start	TP "SA"
Stop	TP "SP"
Clock	TP "E"

Set the Signature Analyzer as follows:

Signature Mode
Data Threshold Levels
Clock Threshold Level
Start/Stop Threshold Level
Start Slope
Stop Slope
Clock Slope

Norm
TTL: 2.00 H, 0.80 L
TTL: 1.40
TTL: 1.40

Check that the signature at +5V gives a 0003 reading on the signature analyzer, otherwise, either the μ -Processor is not free running or the timing pod is connected wrongly.

KEY SCANNER, KEYBOARD

The key Scanner/Keyboard can be checked with Signature Analysis at A6 TP20. Connect the Signature Analyzer Data Probe to TP20, press each front panel key, in turn, and check the signatures obtained against the readings in table 8-6-3.

Table 8-6-3 Keyboard switch operation signatures

Key	TP20 reading
no key pressed	0003
LCL	1572
LOWP 50 MHz	0U3P
LOWP 6 MHz	3FU7
LOWP 10 kHz	6143
AMP	4634
HIGH	F460
LOW	5F45
MESIAL	5712
EXTINC	118P
AVG	711C
dBm-WATT	055U
dB (rel)	4056
REF	1406
DISP - REF	8502
AUTO RANGE	5016
CAL	4617
λ	FU45
λ -CAL	U3H2
ZERO	3H1C
MODIFY MSD UP	3753
MODIFY SSD UP	8HH7
MODIFY LSD UP	6376
RANGE UP	11142
MODIFY MSD DOWN	11411
MODIFY SSD DOWN	7507
MODIFY LSD DOWN	18HP
RANGE DOWN	5049

If TP20 shows wrong signatures, the scanner IC's U20 and U21 can be checked separately.

Check that U20 and U21 get the correct control input signals.

Table 8-6-4 U20, U21 Input Signal Signatures

Input Signal	U20 Pin	U21 Pin	Signature
KEYBOARD	7		73U6
A0	11		UUUU
A1	10		FFFF
A2	9		8484
A3		15	P763
A4		14	1U5P
A5		13	0356

Connect Signature Analyzer Data Probe via a pull-up resistor (1k, 10k) to +5V. Check the signatures at U21 scanner outputs against the readings in table 8-6-5.

Table 8-6-5 U21 Output Signal Signatures

Scanner Output Signal	U21 Pin	Signature
KD0	1	41199
KD1	2	1C90
KD2	3	0112C
KD3	4	5877
KD4	5	87CP

Check the signatures at U20 inputs against the readings in table 8-6-6. NOTE: The corresponding key must be pressed during signature measurement.

Table 8-6-6 U20 Input Data

Pressed Key	Input Data	U20 Pin	Signature
Range Up	KS3	1	41199
MODIFY SSD DOWN	KS2	2	
MODIFY MSD DOWN	KS1	3	
RANGE DOWN	KS0	4	
MODIFY MSD UP	KS4	15	
MODIFY SSD UP	KS5	14	
MODIFY LSD UP	KS6	13	
MODIFY LSD DOWN	KS7	12	

BUS DRIVER, DISPLAY DRIVER AND LATCHES, CONTROL SUBDECODER

The input signal and output signal of the logic circuits can be tested with signature analysis. Check the signatures at the various IC pins against the readings in tables 8-6-7 and 8-6-8.

Table 8-6-7 Signature analysis

Signal's Mnemonic	U19 Pin	U22 Pin	U18 Pin	U23 Pin	U17 Pin	Signature
ADD	11					C898
LA3	2	3,17				P50H
LA4	5	2,18				CH9U
LA5	6	4,16				8759
RA		9,11				9H1P
	9	5,15	1			3P76
	12	8,12	2			65A5
	15	6,14	3			FF4H
	16	7,13	5		1	9H1H
MODE	19			9		HPAU
WS1			14			1P50
WS2			13			PU99
WS3			12			79HU
WS4			11			55F4
WS5			10			8U9S
WS6			9			1FH6
WRITE			7	8		5U3F
LB					11	89C7

Table 8-6-8 Signature analysis

Signal's Mnemonic	U24 Pin	U25 Pin	U38 Pin	U27 Pin	Signature
LATCH 1	11				HC8A
LATCH 2		11			C6P1
LATCH 3			11		PHCC
READ				1,19	6P25

Display/Keyboard Disassembly Procedure

1. Unscrew connector A3J31.
2. Unplug trend meter cable.
3. Unplug flat cable A8W1.
4. Unplug transducer output cable W12.
5. Remove the 4 screws indicated by 'A' in figure 8-6-3.

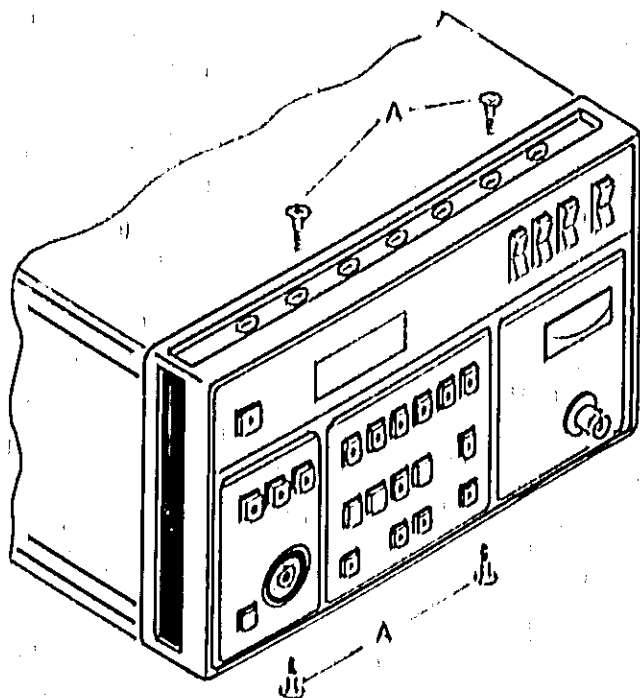


Figure 8-6-3. Frontpanel Disassembly.

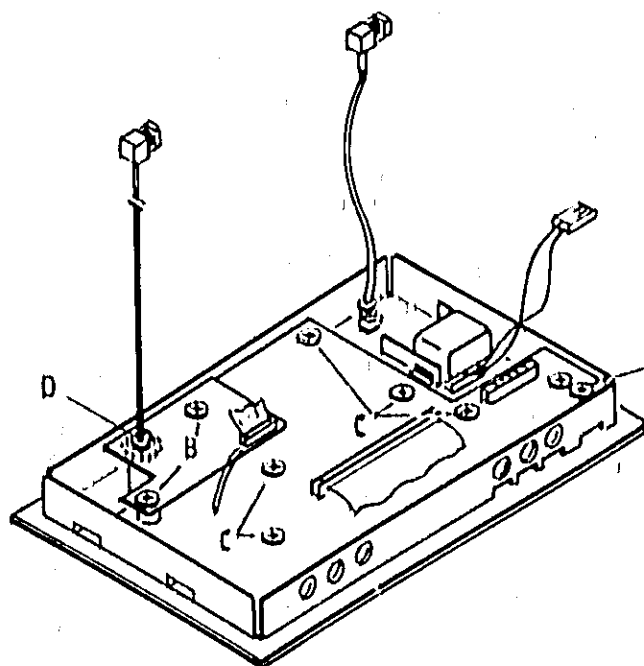


Figure 8-6-4. A8 Removal.

6. Remove the complete frontpanel assembly.
7. Unscrew hex nut D (figure 8-6-4) and remove copper pipe, W11.
8. To remove Connector Board A8 (08151-66508), unscrew the 2 screws marked 'B' in figure 8-6-4.

CAUTION

Connector Board A8 is plugged onto the head connector. The connector sockets can easily be damaged if care is not taken when removing the board.

9. Using extreme care, remove the Connector Board A8 from the head connector.
10. To remove the Key/Display Board A1, unscrew the 5 screws marked 'C' in figure 8-6-4.

