

SERVICE MANUAL

**AUTORANGING
SYSTEM DC POWER SUPPLY
HP MODELS 6033A and 6038A**

HP Part No. 5959-3346

FOR INSTRUMENTS WITH SERIAL NUMBERS

HP Model 6033A; Serials US38320231 and above

HP Model 6038A; Serials US38310401 and above

For instruments with higher serial numbers, a change page may be included.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at 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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This Hewlett-Packard hardware product is warranted against defects in material and workmanship for a period of three years from date of delivery. HP software and firmware products, which are designated by HP for use with a hardware product and when properly installed on that hardware product, are warranted not to fail to execute their programming instructions due to defects in material and workmanship for a period of 90 days from date of delivery. During the warranty period Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective. HP does not warrant that the operation of the software, firmware, or hardware shall be uninterrupted or error free.

For warranty service, with the exception of warranty options, this product must be returned to a service facility designated by HP. Customer shall prepay shipping charges by (and shall pay all duty and taxes) for products returned to HP for warranty service. Except for products returned to Customer from another country, HP shall pay for return of products to Customer.

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EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

The above statements apply only to the standard product warranty. Warranty options, extended support contracts, product maintenance agreements and customer assistance agreements are also available. Contact your nearest Hewlett-Packard Sales and Service office for further information on HP's full line of Support Programs.

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.

BEFORE APPLYING POWER.

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

GROUND THE INSTRUMENT.

This product is a Safety Class 1 instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the ac power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. For instruments designed to be hard wired to the ac power lines (supply mains), connect the protective earth terminal to a protective conductor before any other connection is made. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earth pole) of the ac power lines (supply mains).

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT EXCEED INPUT RATINGS.

This instrument may be equipped with a line filter to reduce electromagnetic interference and must be connected to a properly grounded receptacle to minimize electric shock hazard. Operation at the line voltage or frequencies in excess of those stated on the data plate may cause leakage currents in excess of 5.0mA peak.

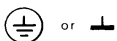
SAFETY SYMBOLS.



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



Indicates hazardous voltages.



Indicate earth (ground) terminal.

WARNING

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

CAUTION

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

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

Instruments which appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

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Introduction

Scope

This manual contains information for troubleshooting the HP 6033A/6038A 200W Autoranging Power Supply to the component level. Wherever applicable, the service instructions given in this manual refer to pertinent information provided in the Operation Manual (P/N 5959-3301). Both manuals cover HP Models 6033A/6038A; differences between models are described as required.

The following information is contained in this manual.

Calibration and Verification

Contains calibration procedures for HP Models 6033A/6038A. Also contains verification procedures that check the operation of the supplies to ensure they meet the specifications of Chapter 1 in the Operating Manual.

Troubleshooting

Contains troubleshooting procedures to isolate a malfunction to a defective component on the main circuit board or to a defective assembly (front panel, power transformer, or cable assembly). Board and assembly level removal and replacement procedures are also given in this section.

Principles of Operation

Provides block diagram level descriptions of the supply's circuits. The primary interface, secondary interface, and the power mesh and control circuits are described. These descriptions are intended as an aid in troubleshooting.

Replaceable Parts

Provides a listing of replaceable parts for all electronic components and mechanical assemblies for HP Models 6033A/6038A.

Circuit Diagrams

Contains functional schematics and component location diagrams for all HP 6033A/6038A circuits. The names that appear on the functional schematics also appear on the block diagrams in Chapter 2. Thus, the descriptions in Chapter 2 can be correlated with both the block diagrams and the schematics.

Safety Considerations

This product is a Safety Class 1 instrument, which means that it is provided with a protective earth terminal. Refer to the Safety Summary page at the beginning of this manual for a summary of general safety information. Safety information for specific procedures is located at appropriate places in the manual.

Manual Revisions

Hewlett-Packard instruments are identified by a 10-digit serial number. The format is described as follows: first two letters indicate the country of manufacture. The next four digits are a code that identify either the date of manufacture or of a significant design change. The last four digits are a sequential number assigned to each instrument.

| Item | Description |
|-------------|--------------------|
|-------------|--------------------|

| | |
|-----------|---|
| US | The first two letters indicates the country of manufacture, where US = USA. |
|-----------|---|

| | |
|-------------|---|
| 3648 | This is a code that identifies either the date of manufacture or the date of a significant design change. |
|-------------|---|

| | |
|-------------|---|
| 0101 | The last four digits are a unique number assigned to each power supply. |
|-------------|---|

If the serial number prefix on your unit differs from that shown on the title page of this manual, a yellow Manual Change sheet may be supplied with the manual. It defines the differences between your unit and the unit described in this manual. The yellow change sheet may also contain information for correcting errors in the manual.

Note that because not all changes to the product require changes to the manual, there may be no update information required for your version of the supply.

Older serial number formats used with these instruments had a two-part serial number, i.e. 2701A-00101. This manual also applies to instruments with these older serial number formats. Refer to Appendix E for backdating information.

Firmware Revisions

The primary and secondary interface microcomputer chips inside of your supply are identified with labels that specify the revision of the supply's firmware. This manual applies to firmware revisions A.00.00, A.00.01, and A.00.02.

Calibration and Verification

Introduction

This section provides test and calibration procedures. The operation-verification tests comprise a short procedure to verify that the unit is performing properly, without testing all specified parameters. After troubleshooting and repair of a defective power supply you can usually verify proper operation with the turn-on checkout procedure in the Operating Manual. Repairs to the A1 main board, the A2 control board and the A8 HP-IB board can involve circuits which, although functional, may prevent the unit from performing within specified limits. So, after A1, A2 or A8 board repair, decide if recalibration and operation verification tests are needed according to the faults you discover. Use the calibration procedure both to check repairs and for regular maintenance.

Test Equipment Required

Table 2-1 lists the equipment required to perform the tests of this section. You can separately identify the equipment for performance tests, calibration and troubleshooting using the USE column of the table.

Operation Verification Tests

To assure that the unit is performing properly, without testing all specified parameters, first perform the turn-on checkout procedure in the Operating Manual. Then perform the following performance tests, in this section.

- Voltage Programming And Readback Accuracy
- Current Programming And Readback Accuracy
- CV Load Effect
- CC Load Effect

Calibration Procedure

Calibrate the unit twice per year and when required during repair. The following calibration procedures should be performed in the sequence given.

Note: Some of the calibration procedures for this instrument can be performed independently, and some procedures must be performed together and/or in a prescribed order. If a procedure contains no references to other procedures, you may assume that it can be performed independently.

To return a serviced unit to specifications as quickly as possible with minimal calibration, the technician need only perform calibration procedures that affect the repaired circuit. Table 2-2 lists various power supply circuits with calibration procedures that should be performed after those circuits are serviced.

If the HP-IB board (A8) has been replaced, you must first initialize the board before you can calibrate the unit. Refer to Page 28.

Table 2-1. Test Equipment Required

| TYPE | REQUIRED CHARACTERISTICS | USE | RECOMMENDED MODEL |
|--------------------------------|--|------------|--|
| Oscilloscope | Sensitivity: 1 mV Bandwidth: 20MHz & 100MHz Input: differential, 50 Ω & 10MΩ | P,T | HP54504A |
| RMS Voltmeter | True rms, 10MHz bandwidth Sensitivity: 1 mV Accuracy: 5% | P | HP3400A |
| Logic Pulser | 4.5 to 5.5Vdc @ 35mA | T | HP546A |
| Multimeter | Resolution: 100nV Accuracy: 0.0035%, 6½ digit | P,C,T | HP 3458A |
| Signature Analyzer | -- | T | HP 5004A |
| HP-IB Controller | Full HP-IB capabilities | C,T,P | HP Series, 200/300 |
| Current Probe | No saturation at 30Adc Bandwidth: 20Hz to 20MHz | P | Tektronix P6303 Probe/ AM503 Amp/ TM500 Power Module |
| Electronic Load | Voltage range: 60Vdc Current range: 30Adc Power range: 250W Open and short switched | P,C | HP 6060A |
| Power Resistor* | Value: 0.25Ω >200W (6033A) Value: 2.3Ω >200W (6038A) | P,C | |
| Current-Monitoring Shunts | Value: 10mΩ ± 0.04% @ 100W (6033A) PC: 0.0004%/W Value: 100mΩ ± 0.04% @ 25W (6038A) PC: 0.0004%/W | P,C** | Guildline 9230/100 Guildline 9230/15 |
| Calibration and Test Resistors | Value: 100Ω, 5%, 1W 1Ω, 5%, ½W 1KΩ, 5%, ¼W 2KΩ, 0.01%, ¼W | C,T | |
| Terminating Resistors (2) | Value: 50Ω ±5%, noninductive | P | |
| Blocking Capacitors (2) | Value: 0.01μF, 100Vdc | P | |
| Common-mode Toroidal Core | ≥3.7μH/turn ² ≅23mm I.D. | P | Ferrox-Cube 500T600-3C8, HP 9170-0061 |
| Switch* | SPST, 30A @60V | P | |
| DC Power Supply | Voltage range: 0-60Vdc Current range: 0-3Adc | C,T | HP 6024A |

P = performance testing C = calibration adjustments T = troubleshooting

* Not required if using electronic load.

** Less accurate, and less expensive, current-monitor resistors can be used, but the accuracy to which current programming and readback can be checked must be reduced accordingly.

Table 2-2. Guide to Recalibration After Repair

| Printed Circuit Board | Block Name | Ref. Desig. | Perform These Procedures |
|------------------------------|---|--------------------|---|
| A1 Main Board | | R3 | Current Monitor Full Scale Calibration Constant Current Full Scale Calibration |
| A1 Main Board | | T1 | Power Limit Calibration |
| A4 Power Mesh Board | | T3 | Power Limit Calibration |
| A4 Power Mesh Board | | CR7 | Power Limit Calibration |
| A2 Control Board | Constant Voltage Circuit (All Except Current Source) | All | Voltage Monitor Zero Calibration Common Mode Calibration Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration |
| A2 Control Board | Constant Voltage Circuit (Current Source) | All | Resistance Programming Full Scale Calibration |
| A2 Control Board | Constant Current Circuit | All | Current Monitor Zero Calibration Constant Current Zero Calibration Current Monitor Full Scale Calibration Constant Current Full Scale Calibration |
| A2 Control Board | Power Limit Comparator | All | Power Limit Calibration |
| A2 Control Board | Bias Power Supplies (+ & -15V Supplies) | All | All Calibration Procedures |
| A8 HP-IB Board | Voltage Monitor Buffer | All | Voltage Monitor Zero Calibration Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration |
| A8 HP-IB Board | Analog Multiplexer | All | Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration |
| A8 HP-IB Board | Readback DAC | All | Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration |

Table 2-2. Guide to Recalibration After Repair (continued)

| Printed Circuit Board | Block Name | Ref. Desig. | Perform These Procedures |
|-----------------------|-------------|-------------|---|
| A8 HP-IB Board | Voltage DAC | All | Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration |
| A8 HP-IB Board | Current DAC | All | Constant Current Zero Calibration Constant Current Full Scale Calibration |
| A8 HP-IB Board | | U5 | Remote Readback Zero Calibration Constant Voltage Full Scale Calibration Voltage Monitor and Remote Readback Full Scale Calibration Constant Voltage Zero Calibration Constant Current Full Scale Calibration |

Initial Setup

- a. Unplug the line cable and remove the top cover by removing the three screws; the rear handle screw and the two top-rear-corner screws. Do not remove the front handle screw as the retaining nut will fall into the unit.
- b. Slide the cover to the rear.
- c. Plug a control board test connector A2J3 onto the A2J3 card-edge fingers.
- d. Turn OVERVOLTAGE ADJUST control A3R59 fully clockwise.
- e. Disconnect all loads from output terminals.
- f. Connect power supply for local sensing, and ensure that MODE switches are set as shown below.



- g. Connect an HP-IB controller to the power supply.
- h. Reconnect line cable and turn on ac power.
- i. Allow unit to warm up for 30 minutes.
- j. When attaching the DVM, the minus lead of the DVM should be connected to the first node listed, and the plus lead should be connected to the second node listed.
- k. At the beginning of each calibration procedure, the power supply should be in its power-on state (turn ac power off and back on), with no external circuitry connected except as instructed.
- l. The POWER LIMIT adjustment (A2R25) must be adjusted at least coarsely before many of the calibration procedures can be performed. If you have no reason to suspect that the Power Limit circuit is out of adjustment, do not change its setting. Otherwise, center A2R25 before you begin to calibrate the power supply.
- m. Turn off ac power when making or removing connections to the power supply.

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by trained service 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.

Voltage Monitor Zero Calibration

- Send string "VSET 0; ISET 0; OUT OFF".
- Short power supply output terminals.
- Attach the DVM from ∇ M on the rear panel through a $1k\Omega$ resistor to A2P3 pin 3 (V-MON1).
- Adjust A2R22 (V-MON ZERO) to $0V \pm 20\mu V$.

Common Mode Calibration

- Send string "VSET 0; ISET 0; OUT OFF".
- Short power supply sense terminals (+ S to - S) at rear panel.
- Attach the DVM from ∇ M on the rear panel through a $1k\Omega$ resistor to A2J3 pin 3 (V-MON).
- Take initial reading from DVM.
- Remove both local sensing straps from rear-panel terminal block, and connect a 1-volt external power supply with its + lead to - S and its--lead to - Out. See Figure 2-1.
Adjust A2R21 (CV LOAD REG) to Initial Reading $\pm 20\mu V$.
- Replace local sense straps after removing external power supply.

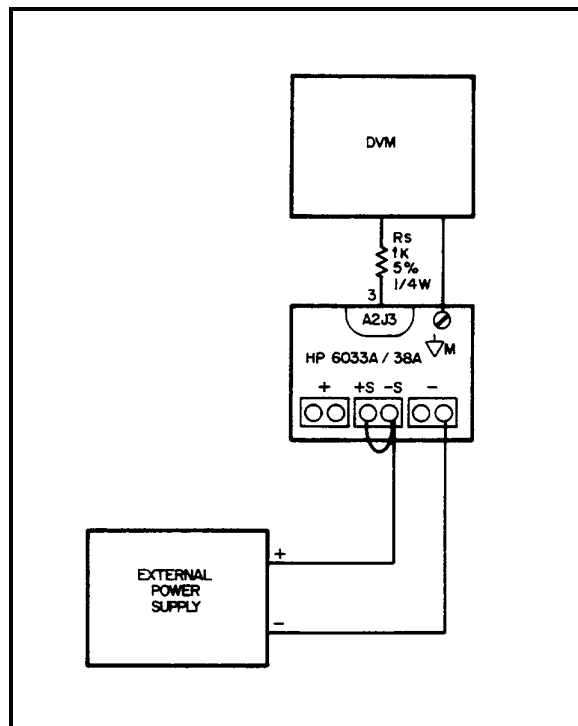


Figure 2-1. Common Mode Setup

Remote Readback Zero Calibration

Note: This procedure and the following three procedures must be done as a set, without omitting any of the four procedures. Also, the following four procedures require that V-MON ZERO (A2R22) be adjusted within specifications. If it is not, perform the Voltage Monitor Zero Calibration before proceeding.

- a. Connect an external supply to the power supply as shown in Figure 2-2.
- b. Send string "VSET 0; ISET 5; OUT ON".
- c. Attach the DVM from ∇ M on the rear panel through a $1\text{K}\Omega$ resistor to A2J3 pin 3 (V-MON).
- d. Adjust A8R40 (CV PROG ZERO) to $625\mu\text{V} \pm 30\mu\text{V}$.
- e. Remove the DVM.
- f. Enter and run the following program and begin noting the controller's display:
10 OUTPUT 705; "VOUT"
20 ENTER 705; A
30 DISP A
40 GOTO 10
50 END
- g. Adjust A8R51 (READBACK ZERO) until the value displayed on the controller toggles between:
0 and 5mV (6033A).
0 and 15mV (6038A).
- h. After adjusting A8R51 you must continue the calibration procedure through to the completion of Constant Voltage Zero Calibration. Remember to disconnect the external power supply and resistor.

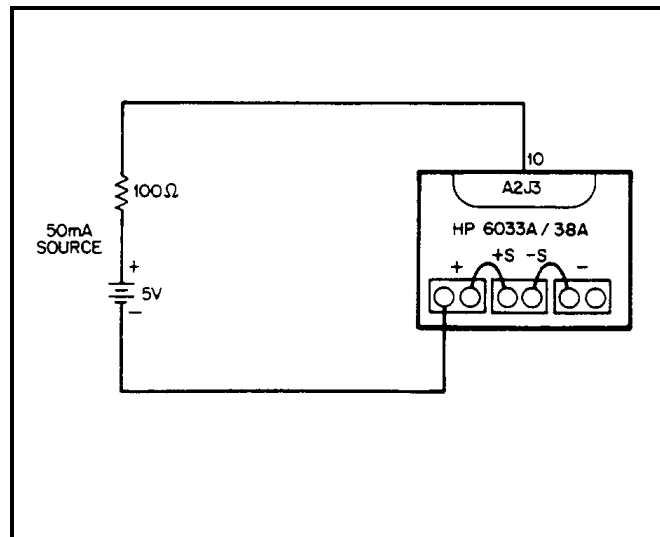


Figure 2-2. Remote Readback Zero And CV Zero Calibration Setup

Constant Voltage Full Scale Calibration

Note: Perform this procedure only after completing Remote Readback Zero Calibration.

- a. Remove all external test circuits.
- b. Send string:
"VSET 200; ISET 5; OUT ON" (6033A).
"VSET 60; ISET 5; OUT ON" (6038A).

- c. Attach the DVM from - S to + S terminals on rear panel.
- d. Adjust A8R58 (CV PROG F.S.) to:
 - 20.0025 \pm 600 μ V (6033A).
 - 60.0075 \pm 1.82mV (6038A).
- e. After adjusting A8R58 you must continue the calibration procedure through to the completion of Constant Voltage Zero Calibration.

Voltage Monitor and Remote Readback Full Scale Calibration

Note: Perform this procedure only after completing Constant Voltage Full Scale Calibration.

- a. Attach the DVM from ∇ M on the rear panel to A2J3 pin 3 (V-MON). See DVM connection in Figure 2-1.
- b. Send string:
 - "VSET 20; ISET 5; OUT ON" (6033A).
 - "VSET 60; ISET 5; OUT ON" (6038A).
- c. Adjust A8R75 (V-MON F.S.) to 5.000625V \pm 100 μ V.
- d. Disconnect the DVM.
- e. Enter and run the following program and begin noting the controller's display.


```

10 OUTPUT 705; "VOUT?"
20 ENTER 705; A
30 DISP A
40 GOTO 10
50 END
      
```
- f. Adjust A8R61 (READBACK F.S.) until the value displayed on the controller toggles between:
 - 20V and 20.005V (6033A).
 - 60V and 60.015V (6038A).
- g. After adjusting A8R61 you must continue the calibration procedure through to the completion of Constant Voltage Zero Calibration.

Constant Voltage Zero Calibration

Note: Perform this procedure only after completing Voltage Monitor and Remote Readback Full Scale Calibration.

- a. Send string "VSET 0; ISET 5; OUT ON".
- b. Connect an external supply to the power supply as shown in Figure 2-2.
- c. Attach the DVM from - S to + S on the rear panel.
- d. Adjust A8R40 (CV PROG ZERO) to 0 \pm 120 μ V.

Current Monitor Zero Calibration

- a. Send string "VSET 0; ISET 0; OUT OFF".
- b. Connect a short across power supply output terminals.
- c. Attach the DVM from ∇ M to IM on the rear panel.
- d. Allow several minutes (3 or more) to ensure thermal settling.
- e. Adjust A2R8 (I-MON ZERO) to:
 - 0V \pm 100 μ V (6033A).
 - 0V \pm 25 μ V (6038A).

Constant Current Zero Calibration

- Connect the test setup shown in Figure 2-3.
- Send string "VSET 5; ISET 0; OUT ON".
- Allow several minutes (3 or more) to ensure thermal settling.
- Adjust A8R29 (CC PROG ZERO) to:
 - 0V \pm 1mV (6033A).
 - 0V \pm 350 μ V (6038A).

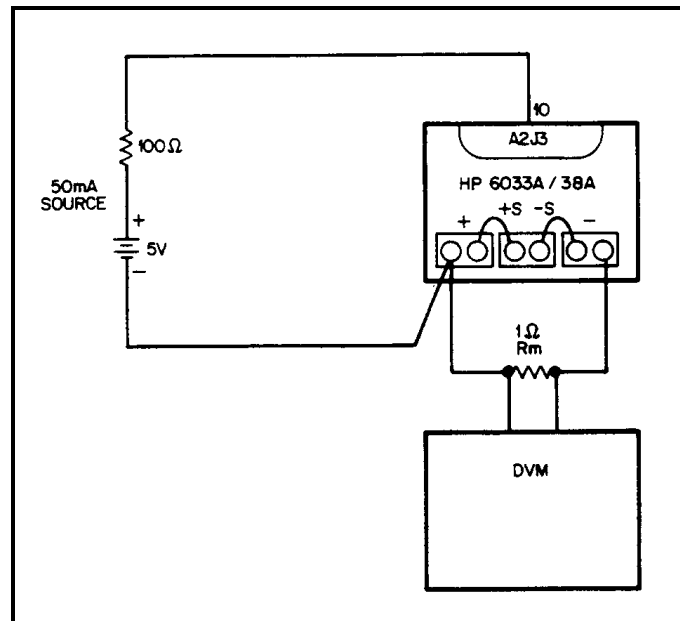


Figure 2-3. CC Zero Calibration Setup

Current Monitor Full Scale Calibration

Note: This procedure requires that I-MON ZERO (A2R8) be adjusted within specifications. If it is not, perform the Current Monitor Zero Calibration before proceeding.

- Connect Rm current-monitoring shunt:
 - (10 milliohm, 6033A)
 - (100 milliohm, 6038A)
 - 0.05% or better across power supply output terminals.
- Send string:
 - "VSET 5; ISET 30; OUT ON" (6033A).
 - "VSET 5; ISET 10; OUT ON" (6038A).
- Attach DVM from ∇ M to IM on the rear panel. Use six-digit display on HP 3458A DVM.
- Take initial reading from DVM.
- Attach DVM across Rm. Allow several minutes (3 or more) to ensure thermal settling. This can be noted as a stable reading on the DVM.
- Adjust A2R9 (I-MON F.S.) to:
 - 0.060 x initial reading \pm 0.4mV (6033A).
 - 0.200 x initial reading \pm 1.0mV (6038A).

Constant Current Full Scale Calibration

Note: This procedure requires that CC PROG ZERO (A8R29) and I-MON F. S. (A2R9) be adjusted within specifications. If they are not, perform Constant Current Zero and/or Current Monitor Full Scale Calibration before proceeding.

- a. Connect Rm current-monitoring shunt:
 - (10 milliohm, 6033A)
 - (100 milliohm, 6038A)
 - 0.05% or better across power supply output terminals.
- b. Send string:
 - "VSET 5; ISET 30; OUT ON" (6033A).
 - "VSET 5, ISET 10; OUT ON" (6038A).
- c. Attach DVM across Rm. Allow several minutes (3 or more) to ensure thermal settling.
- d. Adjust A8R55 (CC PROG F.S.) to:
 - 300mV \pm 30 μ V (6033A).
 - 100mV \pm 100 μ V (6038A).

Power Limit Calibration

Note: This procedure requires that CC PROG F. S. (A8R55) be adjusted within specifications. If it is not, perform Constant Current Full Scale Calibration before proceeding.

- a. Connect the power supply to the ac power line through a variable autotransformer which is set to the minimum for your line voltage (e.g. 104V for nominal 120V line).
- b. Turn A2R25 (POWER LIMIT) fully counterclockwise.
- c. Connect a electronic load across the output terminals, or use a:
 - 0.25 Ω 200W resistor (6033A).
 - 2.3 Ω 200W resistor (6038A).
- d. Set the electronic load for:
 - 30 amperes (6033A).
 - 10 amperes (6038A).
 - in the constant Current mode.
- e. Turn on power supply and send string:
 - "VSET 9; ISET 30.5; OUT ON" (6033A).
 - "VSET 23; ISET 10.2; OUT ON" (6038A).
- f. Adjust A2R25 (POWER LIMIT) clockwise until CV LED on front panel turns on.

Resistance Programming Full Scale Calibration

- a. Send string "OUT OFF".
- b. Connect a 2-kilohm calibration resistor from ∇ P to VP on rear panel.
- c. Set rear-panel MODE switches for resistance programming:



- d. Attach the DVM from ∇ P to VP on the rear panel.
- e. Adjust A2R23 (R-PROG F.S.) to $2.5V \pm 4mV$.
- f. Remember to reset MODE switches to original settings.

Performance Tests

The following paragraphs provide test procedures for verifying the unit's compliance with the specifications of Table 1-1 in the Operating Manual. Please refer to CALIBRATION PROCEDURE or TROUBLESHOOTING if you observe out-of-specification performance. The performance test specifications are listed in the Performance Test Record in Appendix C and D. You can record the actual measured values in the columns provided.

Measurement Techniques

Setup For All Tests. Measure the output voltage directly at the + S and - S terminals. Connect unit for local sensing, and ensure that MODE switches are set as shown below. Select an adequate wire gauge for load leads using the procedures given in the Operating Manual for connecting the load.

Electronic Load. The test and calibration procedures use an electronic load to test the unit quickly and accurately. If an electronic load is not available, you may substitute:

2 Ω 200W load resistor (6033A).

18 Ω 200W load resistor (6038A).

for the electronic load in these tests:

CV Source Effect (Line Regulation).

CC Load Effect (Load Regulation).

You may substitute:

0.25 Ω 200W load resistor (6033A).

2.3 Ω 200W load resistor (6038A).

in these tests:

CV Load Effect (Load Regulation)

CV PARD (Ripple and Noise)

CC Source Effect (Line Regulation)

CC PARD (Ripple and Noise)

The substitution of the load resistor requires adding a load switch and making minor changes to the procedures. The load transient recovery time test procedure is not amenable to modification for use with load resistors.

An electronic load is considerably easier to use than a load resistor. It eliminates the need for connecting resistors or rheostats in parallel to handle the power, it is much more stable than a carbon-pile load, and it makes easy work of switching between load conditions as is required for the load regulation and load transient-response tests.

Current-Monitoring Resistor. To eliminate output current measurement error caused by voltage drops in the leads and connections, connect the current-monitoring resistor between -OUT and the load as a four-terminal device. Figure 2-4 shows correct connections. Connect the current-monitoring test leads inside the load-lead connections directly at the monitoring resistor element.

Note: A current-monitoring resistor with 1% accuracy is suitable for all tests except current programming accuracy and current readback accuracy. For these tests, use the shunt listed in Table 2-1.

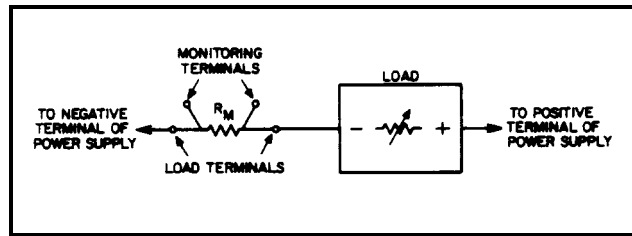


Figure 2-4. Current-Monitoring Resistor Setup

HP-IB Controller. Most performance tests can be performed using only front-panel controls. However, an HP-IB controller is required to perform the voltage and current programming accuracy tests and the voltage and current readback accuracy tests.

Constant Voltage (CV) Tests

CV Setup. If more than one meter or a meter and an oscilloscope are used, connect each to the + S and - S terminals by a separate pair of leads to avoid mutual coupling effects. Connect only to + S and -S because the unit regulates the output voltage between + S and - S, not between + OUT and -OUT. Use coaxial cable or shielded 2-wire cable to avoid pickup on test leads. For all CV tests set the output current at full output to assure CV operation.

Voltage Programming And Readback Accuracy. This procedure verifies that the voltage programming and readback functions are within specifications. An HP-IB controller must be used for this test.

- a. Connect digital voltmeter between + S and - S.
- b. Turn on ac power to the power supply.
- c. Send string:
"VSET 0.1; ISET 30" (6033A).
"VSET 0.09; ISET 10" (6038A).
- d. The DVM reading should be in the range:
0.090 to 0.109Vdc (6033A).
0.050 to 0.130Vdc (6038A).
Note the reading.
- e. Enter and run the following program:
10 OUTPUT 705; "VOUT?"
20 ENTER 705;A
30 DISP A
40 GOTO 10
50 END
- f. The value displayed by the controller should be the value noted in step d:
 $\pm 0.006\text{Vdc}$ (6033A).
 $\pm 0.015\text{Vdc}$ (6038A).
- g. Send string:
"VSET 20; ISET 30" (6033A).
"VSET 60; ISET 10" (6038A).
- h. The DVM reading should be in the range:
19.984 to 20.016Vdc (6033A).
59.939 to 60.061Vdc (6038A).
Note the reading.

- i. Run the program listed in step e. The value displayed by the controller should be the value noted in step h:
 - $\pm 0.02\text{Vdc}$ (6033A).
 - $\pm 0.092\text{Vdc}$ (6038A).

Load Effect (Load Regulation). Constant-voltage load effect is the change in dc output voltage (E_o) resulting from a load-resistance change from open-circuit to full-load. Full-load is the resistance which draws the maximum rated output current at voltage E_o . Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-5. Operate the load in constant resistance mode (Amps/Volt) and set resistance to maximum.
- b. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up current setting to full output.
- c. Turn up output voltage to:
 - 7.0Vdc (6033A).
 - 20.0Vdc (6038A).
 as read on the digital voltmeter.

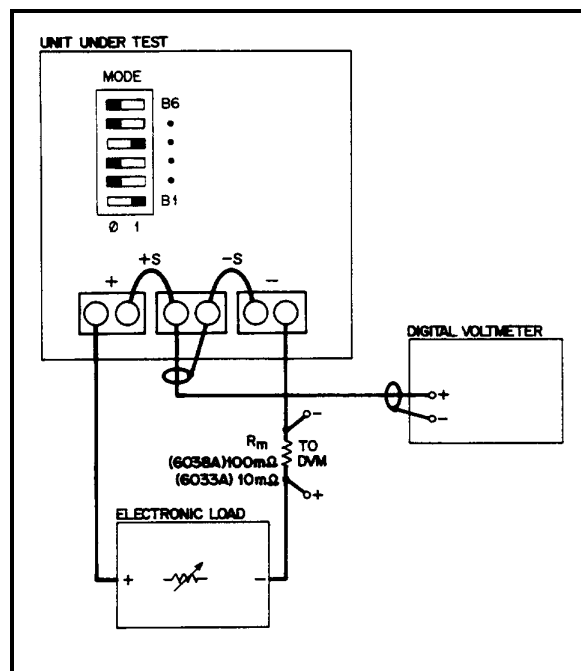


Figure 2-5. Basic Test Setup

- d. Reduce the resistance of the load to draw an output current of:
 - 29Adc (6033A).
 - 10 Adc (6038A).
 Check that the unit's CV LED remains lighted.
- e. Open-circuit the load.
- f. Record the output voltage at the digital voltmeter.
- g. Reconnect the load.
- h. When the reading settles, record the output voltage again. Check that the two recorded readings differ no more than:
 - $\pm 0.0027\text{Vdc}$ (6033A).
 - $\pm 0.005\text{Vdc}$ (6038A).

Source Effect (Line Regulation). Source effect is the change in dc output voltage resulting from a change in ac input voltage from the minimum to the maximum value as specified in Input Power Requirements in the Specifications Table, in the Operating Manual. Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-5. Operate the load in constant resistance mode (Amps/Volt) and set resistance to maximum.
- b. Connect the unit to the ac power line through a variable autotransformer which is set for nominal line voltage.
- c. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up current setting to full output.
- d. Turn up output voltage to:
 - 20.0Vdc (6033A).
 - 60.0Vdc (6038A).
 as read on the digital voltmeter.
- e. Reduce the resistance of the load to draw an output current of:
 - 10Adc (6033A).
 - 3.3Adc (6038A).
 Check that the unit's CV LED remains lighted.
- f. Adjust autotransformer to the minimum for your line voltage.
- g. Record the output voltage at the digital voltmeter.
- h. Adjust autotransformer to the maximum for your line voltage.
- i. When the reading settles record the output voltage again. Check that the two recorded readings differ no more than:
 - $\pm 0.003\text{Vdc}$ (6033A).
 - $\pm 0.008\text{Vdc}$ (6038A).

PARD (Ripple And Noise). Periodic and random deviations (PARD) in the unit's output-ripple and noise-combine to produce a residual ac voltage superimposed on the dc output voltage. Constant-voltage PARD is specified as the root-mean-square (rms) or peak-to-peak (pp) output voltage in a frequency range of 20Hz to 20MHz.

RMS Measurement Procedure. Figure 2-6 shows the interconnections of equipment to measure PARD in V_{rms} . To ensure that there is no voltage difference between the voltmeter's case and the unit's case, connect both to the same ac power outlet or check that the two ac power outlets used have the same earth-ground connection.

Use the common-mode choke as shown to reduce ground-loop currents from interfering with measurement. Reduce noise pickup on the test leads by using 50Ω coaxial cable, and wind it five turns through the magnetic core to form the common-mode choke. Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-6. Operate the load in constant resistance mode (Amps/Volt) and set resistance to maximum.
- b. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up current setting to full output.
- c. Turn up output voltage to:
 - 7Vdc (6033A).
 - 20Vdc (6038A).
- d. Reduce the resistance of the load to draw an output current of:
 - 29Adc (6033A).
 - 10Adc (6038A).
 Check that the unit's CV LED remains lighted.
- e. Check that the rms noise voltage at the true rms voltmeter is no more than 30mV rms.

Peak-To-Peak Measurement Procedure. Figure 2-7 shows the interconnections of equipment to measure PARD in V_{pp} . The equipment grounding and power connection instructions on Page 23 apply to this setup also. Connect the oscilloscope to the + S and - S terminals through $0.01\mu\text{F}$ blocking capacitors to protect the oscilloscope's input from the unit's output voltage. To reduce common-mode noise pickup, set up the oscilloscope for a differential, two-channel voltage measurement. To reduce normal-mode noise pickup, use matched-length, 1 meter or shorter, 50Ω coaxial cables with shields connected to the oscilloscope case and to each other at the other ends. Proceed as follows:

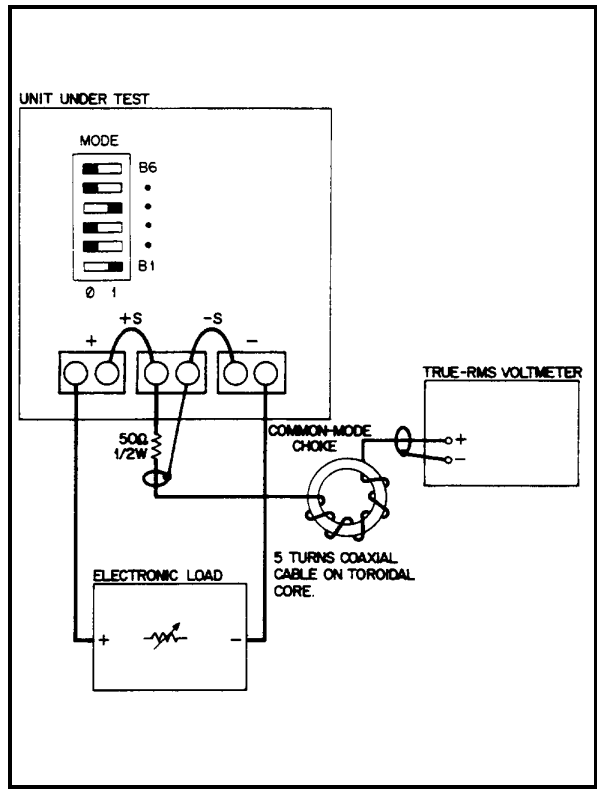


Figure 2-6. RMS Measurement Test Setup, CV PARD Test

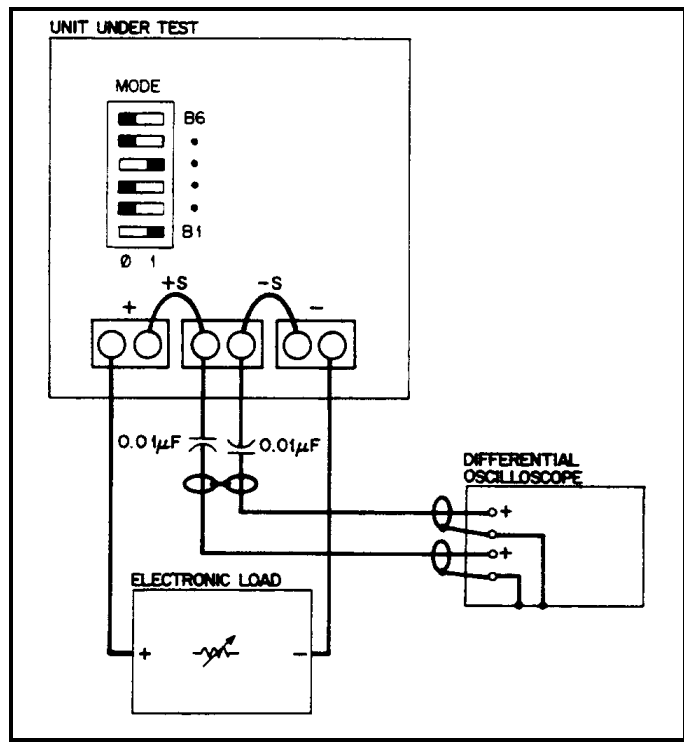


Figure 2-7. Peak-To-Peak Measurement Test Setup, CV PARD Test

- a. Connect the test equipment as shown in Figure 2-7. Operate the load in constant resistance mode (Amps/Volt) and set resistance to maximum.
- b. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up current setting to full output.
- c. Turn up output voltage to:
 - 7Vdc (6033A).
 - 20Vdc (6038A).
- d. Turn up output current setting to full output and reduce the resistance of the load to draw an output current of:
 - 29Adc (6033A).
 - 10Adc (6038A).
 Check that the unit's CV LED remains lighted.
- e. Set the oscilloscope's input impedance to 50Ω and bandwidth to 20MHz. Check that the peak-to-peak is no more than 30mV.

Load Transient Recovery Time. Specified for CV operation only; load transient recovery time is the time for the output voltage to return to within a specified band around its set voltage following a step change in load.

Use the equipment setup of Figure 2-5 to display output voltage transients while switching the load between 10% with the output set at:

- 6.7Vdc (6033A).
- 20Vdc (6038A).

Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-5. Operate the load in constant-current mode and set for minimum current.
- b. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up current setting to full output.
- c. Turn up output voltage to:
 - 6.7Vdc (6033A).
 - 20.0Vdc (6038A).
 as read on the digital voltmeter.
- d. Set the load to vary the load current between:
 - 27Adc and 30Adc (6033A).
 - 9Adc and 10 Adc (6038A).
 at a 30Hz rate for the 10% RECOVERY TEST.
- e. Set the oscilloscope for ac coupling, internal sync and lock on either the positive or negative load transient.
- f. Adjust the oscilloscope to display transients as in Figure 2-8.
- g. Check that the amplitude of the transient pulse at 1 ms is no more than:
 - 50mV (6033A).
 - 75mV (6038A).

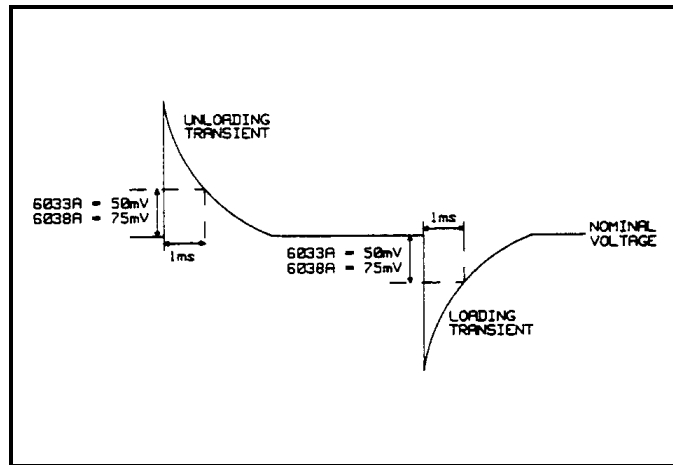


Figure 2-8. Load Transient Recovery Waveform

Constant Current (CC) Tests

CC Setup. Constant-current tests are analogous to constant-voltage tests, with the unit's output short circuited and the voltage set to full output to assure CC operation. Follow the general setup instructions of Page 20.

Current Programming And Readback Accuracy. This procedure verifies that the current programming and readback functions are within specifications. An HP-IB controller must be used for this test. The accuracy of the current shunt resistor (R_m) must be 0.02% or better. Proceed as follows:

- a. Connect test setup shown in Figure 2-5, except replace the load with a short circuit.
- b. Turn on ac power to the power supply.
- c. Send string:
 "VSET 20; ISET 1.0" (6033A).
 "VSET 60; ISET 0.5" (6038A).
- d. Check that the voltage across R_m is in the range:
 9.79mV to 10.22mV (6033A).
 48.9mV to 51.0mV (6038A).
 Note the reading.
- e. Enter and run the following program:
 10 OUTPUT 705; "IOUT?"
 20 ENTER 705; A
 30 DISP A
 40 GOTO 10
 50 END
- f. The value displayed by the controller should be the actual output current $\pm 0.025\text{A}_{dc}$.
- g. Send string:
 "VSET 20; ISET 30" (6033A).
 "VSET 60; ISET 10" (6038A).
- h. Check that the voltage across R_m is in the range:
 0.29935 to 0.30065Vdc (6033A).
 1.0019 to 0.9982Vdc (6038A).
 Note the reading.
- i. Run the program listed in step e.
- j. The value displayed by the controller should be the actual output current:
 $\pm 0.115\text{A}_{dc}$ (6033A).
 $\pm 0.031\text{A}_{dc}$ (6038A).

Load Effect (Load Regulation). Constant current load effect is the change in dc output current (I_o) resulting from a load-resistance change from short-circuit to full-load, or full-load to short-circuit. Full-load is the resistance which develops the maximum rated output voltage at current I_o . Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-5. Operate the load in constant resistance mode (Amps/Volt) and set resistance to minimum.
- b. Turn the unit's power on, and, using DISPLAY SETTINGS pushbutton switch, turn up voltage setting to full output.
- c. Turn up output current to:
10Adc (6033A).
3Adc (6038A).
- d. Increase the load resistance until the output voltage at +S and -S decreases to:
20Vdc (6033A).
60Vdc (6038A).
Check that the CC LED is lighted and AMPS display still reads ≈ 10 amps.
- e. Short-circuit the load and allow the voltage across R_m to stabilize.
- f. Record voltage across R_m .
- g. Disconnect short across load.
- h. When the reading settles (≈ 10 s), record the voltage across R_m again. Check that the two recorded readings differ no more than:
 $\pm 100\mu\text{Vdc}$ (6033A).
 $\pm 530\mu\text{Vdc}$ (6038A).

Source Effect (Line Regulation). Constant current source effect is the change in dc output current resulting from a change in ac input voltage from the minimum to the maximum values listed in the Specifications Table in the Operating Manual. Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-5. Operate the load in constant resistance mode (Amps/Volt) and set resistance to minimum.
- b. Connect the unit to the ac power line through a variable autotransformer set for nominal line voltage.
- c. Switch the unit's power on and turn up output voltage setting to full output.
- d. Turn up output current to:
30Adc (6033A).
10Adc (6038A).
- e. Increase the load resistance until the output voltage between + S and - S decreases to:
7.0Vdc (6033A).
20.0Vdc (6038A).
Check that the CC LED is still on.
- f. Adjust autotransformer to the minimum for your line voltage.
- g. Record the voltage across R_m .
- h. Adjust autotransformer to the maximum for your line voltage.
- i. When the reading settles record the voltage across R_m again. Check that the two recorded readings differ no more than:
 $90\mu\text{Vdc}$ (6033A).
 $300\mu\text{Vdc}$ (6038A).

PARD Ripple And Noise. Periodic and random deviations (PARD) in the unit's output (ripple and noise) combine to produce a residual ac current as well as an ac voltage super-imposed on the dc output. The ac voltage is measured as constant-voltage PARD, Page 23. Constant-current PARD is specified as the root-mean-square (rms) output current in a frequency range 20Hz to 20MHz with the unit in CC operation. To avoid incorrect measurements, with the unit in CC operation, caused by the impedance of the electronic load at noise frequencies, use a:

- 0.25 Ω (6033A)
- 2.3 Ω (6038A)

load resistor that is capable of safely dissipating 200 watts. Proceed as follows:

- a. Connect the test equipment as shown in Figure 2-9.
- b. Switch the unit's power on and turn the output voltage all the way up.
- c. Turn up output current to:

29Adc (6033A).

10Adc (6038A).

Check that the unit's CC LED remains lighted.

- d. Check that the rms noise current measured by the current probe and rms voltmeter is no more than:
- 15mA rms (6033A).
 - 5mA rms (6038A).

Initialization Procedure

Follow the procedure if either the HP-IB assembly has been replaced, or the EEPROM (U70) has been replaced:

1. Install the HP-IB assembly in the unit.
2. Turn the power on and depending on your unit's model number, send string:
"EEINIT 6033"
or
"EEINIT 6038".
3. Turn the power off, wait 5 seconds, then turn the power back on.
4. If the HP-IB assembly has been replaced, calibrate the unit.

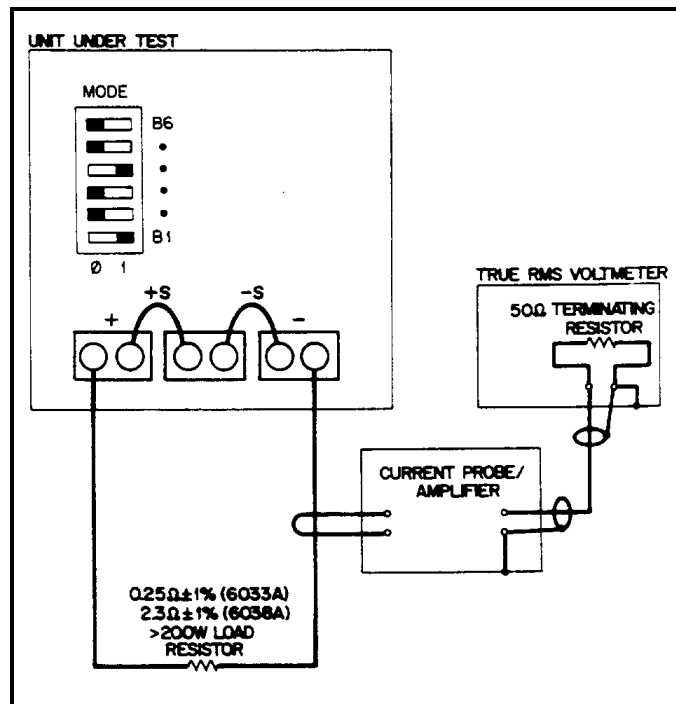


Figure 2-9. CC PARD Test Setup

Troubleshooting

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.

Introduction

Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument itself and not with an associated circuit. The performance test enables this to be determined without having to remove the covers from the supply.

The most important aspect of troubleshooting is the formulation of a logical approach to locating the source of trouble. A good understanding of the principles of operation is particularly helpful, and it is recommended that Chapter 4 of this manual be reviewed before attempting to troubleshoot the unit. Often the user will then be able to isolate a problem simply by using the operating controls and indicators. Once the principles of operation are understood, refer to the following paragraphs.

Table 2-1 lists the test equipment for troubleshooting. Chapter 6 contains schematic diagrams and information concerning the voltage levels and waveforms at many of the important test points. Most of the test points used for troubleshooting the supply are located on the control board test "fingers", which are accessible close to the top of the board. See Table 3-9.

If a component is found to be defective, replace it and re-conduct the performance test. When a component is replaced, refer to Calibration Procedure (Chapter 2). It may be necessary to perform one or more of the adjustment procedures after a component is replaced.

Initial Troubleshooting Procedures

If a problem occurs, follow the steps below in sequence:

- a. Check that input power is available, and check the power cord and rear-panel line fuse.
- b. Check that the settings of mode switch A2S1 are correct for the desired mode of operation. (See Operating Manual).
- c. Check that all connections to the power supply are secure and that circuits between the supply and external devices are not interrupted.
- d. Check that the rear-panel HP-IB address switch A8S1 is properly set. (See Operating Manual).
- e. If the power supply fails turn-on self-test or gives any other indication of malfunction, remove the unit from the operating system before proceeding with further testing.

WARNING

Some circuits on the power mesh are connected directly to the ac power line. Exercise extreme caution when working on energized circuits. Energize the supply through an isolation transformer to avoid shorting ac energized circuits through the test instrument's input leads. The isolation transformer must have a power rating of at least 4KVA. During work on energized circuits, the safest practice is to disconnect power, make or change the test connections, and then re-apply power.

Make certain that the supply's ground terminal (\perp) is securely connected to an earth ground before applying power. Failure to do so will cause a potential shock hazard that could result in personal injury.

Electrostatic Protection

The following caution outlines important precautions which should be observed when working with static sensitive components in the power supply.

CAUTION

This instrument uses components which can be damaged by static charge. Most semiconductors can suffer serious performance degradation as a result of static charges, even though complete failure may not occur. The following precautions should be observed when handling static-sensitive devices.

- a. Always turn power off before removing or installing printed-circuit boards.
- b. Always store or transport static-sensitive devices (all semiconductors and thin-film devices) in conductive material. Attach warning labels to the container or bag enclosing the device.
- c. Handle static-sensitive devices only at static-free work stations. These work stations should include special conductive work surfaces (such as HP Part No. 9300-0797) grounded through a one-megohm resistor. Note that metal table tops and highly conductive carbon-impregnated plastic surfaces are too conductive; they can act as large capacitors and shunt charges too quickly. The work surfaces should have distributed resistance of between 10^6 and 10^{12} Ω per square.
- d. Ground all conductive equipment or devices that may come in contact with static-sensitive devices or sub-assemblies containing same.
- e. Where direct grounding of objects in the work area is impractical, a static neutralizer should be used (ionized air blower directed at work). Note that this method is considerably less effective than direct grounding and provides less protection for static-sensitive devices.
- f. While working with equipment on which no point exceeds 500 volts, use a conductive wrist strap in contact with skin. The wrist strap should be connected to ground through a one-megohm resistor. A wrist strap with insulated cord and built-in resistor is recommended, such as 3M Co. No. 1066 (HP Part No. 9300-0969 (small) and 9300-0970 [large]).

WARNING

Do not wear a conductive wrist strap when working with potentials in excess of 500 volts; the one-megohm resistor will provide insufficient current limiting for personal safety.

- g. All grounding (device being repaired, test equipment, soldering iron, work surface, wrist strap, etc.) should be done to the same point.
- h. Do not wear nylon clothing. Keep clothing of any kind from coming within 12 inches of static-sensitive devices.
- i. Low-impedance test equipment (signal generators, logic pulsers, etc.) should be connected to static-sensitive inputs only while the components are powered.
- j. Use a mildly activated rosin core solder (such as Alpha Metal Reliacor No. 1, HP Part No. 8090-0098) for repair. The flux residue of this type of solder can be left on the printed circuit board. Generally, it is safer not to clean the printed-circuit board after repair. Do not use Freon or other types of spray cleaners. If necessary, the printed-circuit board can be brushed using a natural-bristle brush only. Do not use nylon-bristle or other synthetic-bristle brushes. Do not use high-velocity air blowers (unless ionized).
- k. Keep the work area free of non-conductive objects such as Styrofoam-type cups, polystyrene foam, polyethylene bags, and plastic wrappers. Non-conductive devices that are necessary in the area can be kept from building up a static charge by spraying them with an anti-static chemical (HP Part No. 8500-3397).
- l. Do not allow long hair to come in contact with static-sensitive assemblies.
- m. Do not exceed the maximum rated voltages specified for the device.

Repair and Replacement

Repair and replacement of most components in the power supply require only standard techniques that should be apparent to the technician. The following paragraphs provide instructions for removing certain assemblies and components for which the procedure may not be obvious upon inspection.

WARNING

To avoid the possibility of personal injury, remove the power supply from operation before opening the cabinet. Turn off ac power and disconnect the line cord, HP-IB plug, load, and remote sense leads before

attempting any repair or replacement.

CAUTION

When replacing any heatsink-mounted components except thermostat, smear a thin coating of heatsink compound between the component and heatsink. If a mica insulator is used, smear a thin coating of heatsink compound on both sides of the mica insulator.

Do not use any heatsink compound containing silicone, which can migrate and foul electrical contacts elsewhere in the system. An organic zinc oxide cream, such as American Oil and Supply Company Heatsink Compound #100, is recommended.

CAUTION

Most of the attaching hardware in this unit is metric. The only non-metric (sometimes called English or inch) fittings are listed below. Be careful when both types of screws are removed not to get them mixed up.

- a. Rear-panel fuseholder.
- b. Rear-panel ground binding post.

Top Outside Cover Removal. Remove one screw - the rear handle screw using a Size 2, Pozidriv screwdriver. A Phillips head screwdriver does not fully seat into Pozidriv screws and risks stripping the heads. (Do not remove the front handle screw, as the retaining nut will fall into the unit.) Remove the top cover by sliding it to the rear and lifting at the front.

Bottom Cover Removal. Remove only for repair of main board. Remove two bottom-rear-corner screws (Pozidriv, M4x.7), and remove the bottom cover by sliding it to the rear. You do not need to remove the unit's feet.

Inside Top Cover Removal. The unit includes an inside cover which secures the vertical board assemblies. Remove the inside cover for repair but not for calibration.

Remove the six mounting screws (Pozidriv, M4x.7) - three on each side - and the five board-fastening screws (Pozidriv, M4x.17) - all on top. Remove the inside cover by lifting at the front edge.

When installing the inside cover, insert it first at the right side. While holding it tilted up at the left, reach through the cutouts in the cover and fit the top tabs of the A8 HP-IB board into the mating slots in the cover. Then repeat the process for the A2 control board tabs and slots. With the top cover in place reach through the cutout above the A3 power mesh board, align the board-fastening screw holes, and replace the rear-most screw to secure the A3 board. Press the inside cover down firmly while tightening screws that secure cover to chassis. Complete the installation by replacing the remaining ten screws.

A2 Control Board Removal

After removing the inside cover, unplug the W5 and W6 ribbon cables at the top edge of the A2 control board. Remove the A2 board by lifting first at the front edge and then pulling it up and out of the unit. Two connectors hold the A2 board at its bottom edge.

When installing the A2 board, insert it first at the rear of the unit. While holding it tilted up at the front, fit the A2TB1 terminal strip into the mating cutout in the rear panel. Then lower the A2 board's bottom connectors into the mating connectors on the main board. Press the A2 board into the connectors, and reinstall the W5 and W6 ribbon cables.

A4 FET Board Removal

After removing the inside cover, remove the A4 mesh board by lifting, using the large aluminum heatsink as a handle. Two connectors hold the A4 board at its bottom edge.

When installing the A4 power mesh board, lower it into its connectors and press in place.

A8 HP-IB Board Removal

Remove the A8 board as follows:

- a. Remove the two screws (Pozidriv, M3x.5) which attach the A8 HP-IB board to the rear panel. Remove the single screw (Pozidriv, M4x.7) that secures the HP-IB board to the side frame near the front corner.
- b. After removing the inside cover, unplug the W5 and W6 ribbon cables at the top edge of the A8 board, the W2 3-wire cable from connector A8J10 and the W1 ribbon cable from connector A8J9.
- c. Remove the A8 board lifting it straight up.

Install the A8 board by reversing the above steps. Lower the rear side of the board into the unit first and fit the bottom tabs into their mating slots.

A3 Front-Panel Board Removal

Remove the A3 front-panel board by first removing the entire front panel assembly. You do not need to remove the top cover. Follow this procedure:

- a. Remove the top plastic insert by prying up with a flat-blade screwdriver.
- b. Remove the four front-panel assembly mounting screws on the top and bottom at the corners.
- c. Gently pull the front-panel assembly away from the unit as far as permitted by the connecting cables.
- d. Remove the ground-wire screw (Pozidriv, M4x.7) holding the green-yellow ground wire.
- e. Note the locations of the four power-wire connections to the power switch and then unplug the quick-connect plugs.
- f. Unplug the W3 3-wire cable from connector A1J3 to the A1 main board, and unplug the W1 ribbon cable from connector A8J1 on the A8 HP-IB board.
- g. Remove the A3 board from the front-panel assembly by removing the five mounting screws (Pozidriv, M4x.7).

Install the A3 Board by reversing the above steps. Connect the power switch wires in the exact locations from which they were removed.

A1 Main Board Removal

Removing the A1 main board requires removing the rear-panel, all boards except the A3 front-panel board, and 17 A1 board mounting screws, two standoffs, and an interface bracket. Component-access cutouts in the bottom inside cover allow unsoldering most A1-board components for repair without removing the A1 board.

Proceed as follows:

- a. Remove the A2, A4, and A8 boards according to the above instructions.
- b. Detach the rear panel by removing the four mounting screws (Pozidriv, M4x.7)-two on each side. Gently pull the rear panel away from the unit as far as permitted by the four wires connected to the A1 board.
- c. Remove the A8 bracket by removing three screws (Pozidriv, M4x.7) - two on bracket, one on side of the unit.
- d. Unplug the W2 3-wire ribbon cable from connector A1J2, and unplug the W3 3-wire cable from connector A1J3.
- e. Remove the A1 board by removing the 17 mounting screws (Pozidriv, M4x.7).
- f. Note locations and then unplug the two ac power wires and the two fan wires to the A1 board.

Install the A1 board by reversing the above steps. Plug the two ac-power wires onto the two spade terminals in the left-rear corner of the A1 board. Use the table below to choose the correct terminal for each wire.

| AC POWER WIRE | | PLUG ONTO TERMINAL | |
|-----------------|-------------|--------------------|------------------|
| from | color | desig. | located |
| F1 fuse | wht/brn/gry | L | left-rear corner |
| FL1 line module | white/gry | N | right of above |

Plug the fan wires, ignoring color codes if any, onto the remaining pair of terminals.

Overall Troubleshooting Procedure

The overall troubleshooting procedure for the unit involves isolating the problem to one of several circuit blocks and troubleshooting the block individually. The HP-IB/ microprocessor related circuit blocks are located on the A3 (front panel) and the A8 (HP-IB) boards. They are referred to collectively as the HP-IB section. The power supply circuit blocks are on the A1 (main), the A2 (control), the A4 (FET), and the A5 (diode) boards. They are referred to collectively as the power section.

The flowchart of Figure 3-1 provides troubleshooting isolation procedures to guide you either to the appropriate circuit or to one of the detailed troubleshooting procedures in this section. The purpose of the flowchart is only to isolate the problem to a specific area of the power supply. If you have already isolated the problem, proceed directly to the applicable troubleshooting section.

Table 3-1 lists the error codes that may appear on the front panel when the unit performs its internal selftest. Along with the error codes, the table also identifies various circuits or components that may have caused that error code to appear.

In the Power Section Troubleshooting, Tables 3-10 and 3-11 give various power supply symptoms that identify the corresponding board, circuit or components that may have caused that symptom. The symptoms in Table 3-10 may become apparent when running the Performance Tests in Section 2.

HP-IB Section Troubleshooting

The HP-IB section troubleshooting consists of primary and secondary interface troubleshooting. Signature analysis is required to troubleshoot the primary and secondary processor as well as the front panel board. Other circuits on the HP-IB board, such as the voltage and current DACs, can be checked using either signature analysis or the front panel controls. The readback circuits cannot be checked using signature analysis. Figure 3-2 illustrates the test setup that allows access to the HP-IB board components for troubleshooting.

To remove the HP-IB board, perform the HP-IB board removal procedure discussed earlier in this section. Lay out the board as shown in Figure 3-2 with a piece of insulating material under the board. Reconnect connectors W1, W2, W5, and W6 after the board is on the insulating material.

Note: The HP-IB board can be placed alongside the unit for troubleshooting by using extender cables provided in service kit HP P/N 06033-60005.

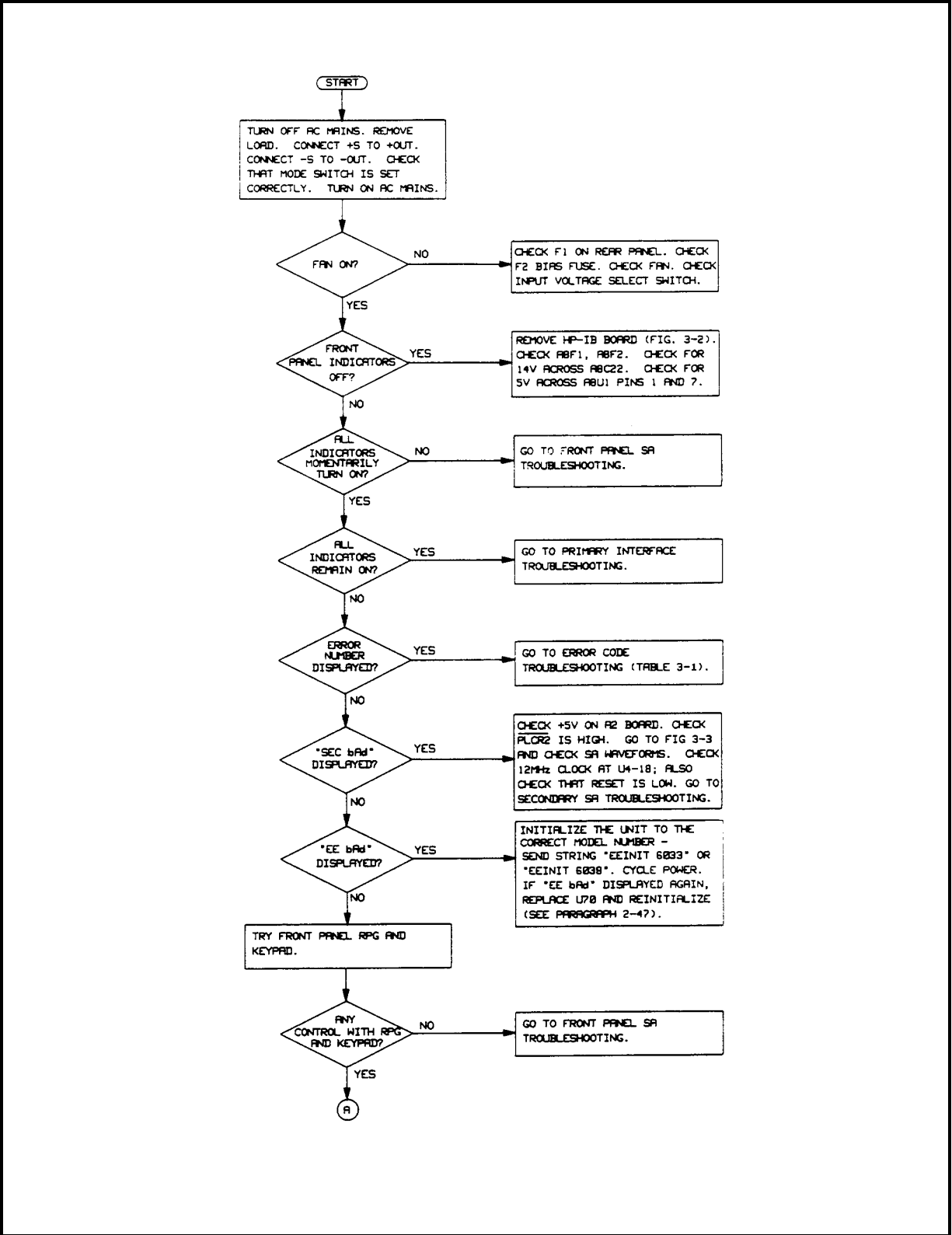


Figure 3-1. Troubleshooting Isolation

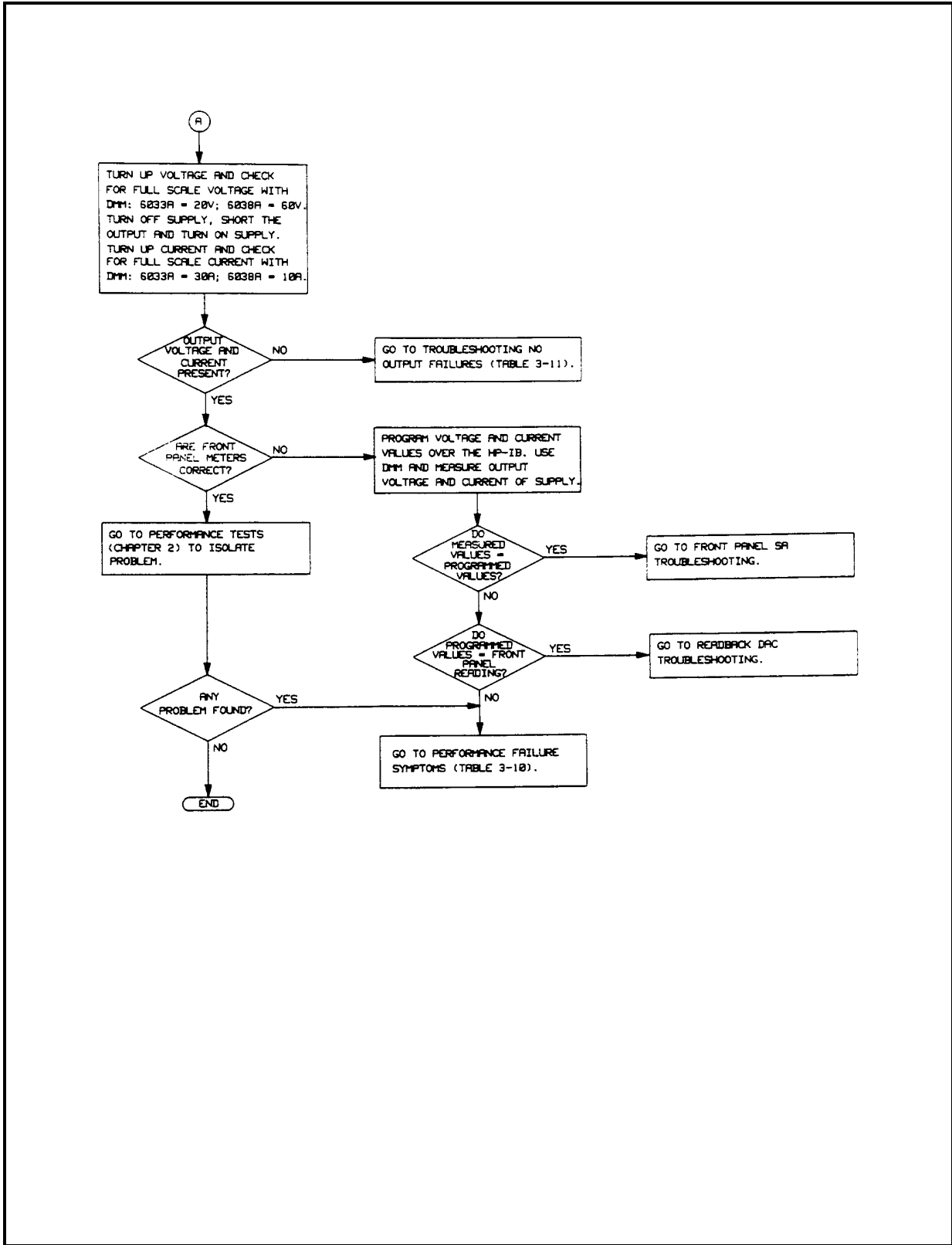


Figure 3-1. Troubleshooting Isolation (continued)

Table 3-1. Selftest Error Code Troubleshooting

| Error Code | Description | Check Functional Circuit |
|------------|-----------------------------|---|
| ERROR 4 | External RAM Test | Replace A8U8 |
| ERROR 5 | Internal RAM Test | Replace A8U14 |
| ERROR 6 | External ROM Test | Replace A8U6 |
| ERROR 7 | HP-IB Test | Replace A8U17 |
| ERROR 8 | HP-IB address set to 31 | |
| ERROR 10 | Internal ROM Test | Replace A8U4 |
| ERROR 12 | ADC Zero Too High | Check U11,20,24,66,67; go to Readback DAC Troubleshooting |
| ERROR 13 | Voltage DAC Full Scale Low | Check U2,7,64,69 |
| ERROR 14 | Voltage DAC Full Scale High | Check U2,7,64,69 |
| ERROR 15 | Voltage DAC Zero Low | Check U2,7,64,69 |
| ERROR 16 | Voltage DAC Zero High | Check U2,7,64,69 |
| ERROR 17 | Current DAC Full Scale Low | Check U9,65,68 |
| ERROR 18 | Current DAC Full Scale High | Check U9,65,68 |
| ERROR 19 | Current DAC Zero Low | Check U9,65,68 |
| ERROR 20 | Current DAC Zero High | Check U9,65,68 |

Go to Secondary SA Troubleshooting

Primary Interface Troubleshooting

Primary interface troubleshooting checks for the presence of bias voltages, clock signals (see Figure 3-3), and activity on the data lines. Primary signature analysis may be used to further troubleshoot these circuits, but since the address and data lines go to so many IC's, it may not be cost-effective to narrow an incorrect signature to a specific chip. HP-IB board replacement may be the most cost-effective solution.

Note: The initialization procedure in Page 28 must be performed when the HP-IB board is replaced.

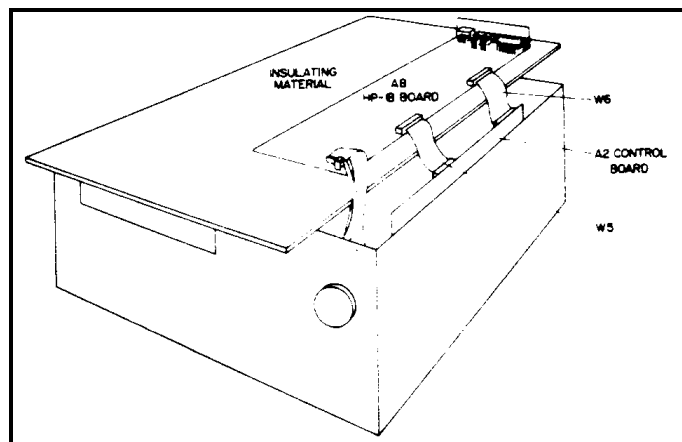


Figure 3-2. HP-IB Board Test Setup

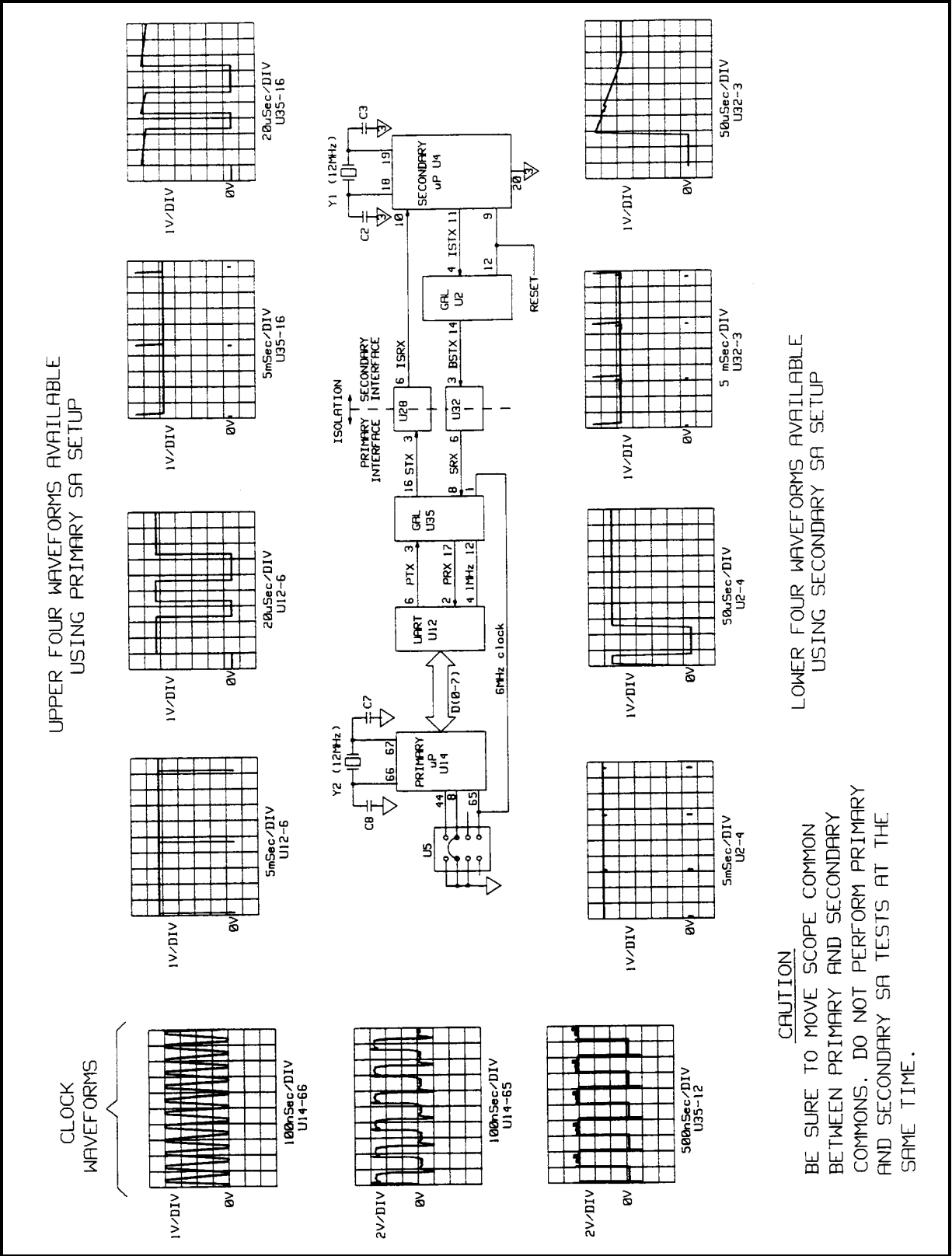


Figure 3-3. Clock and Primary SA Waveforms

+5V and PCLR Circuits:

| Node | Measurement |
|------|-------------|
| U1-8 | ≈ 3.5Vdc |
| U1-2 | = 4Vdc |
| U1-3 | = 4.2Vdc |
| U1-4 | = 4.2Vdc |
| U1-6 | ≈ 50mVdc |

Clock Signals (see clock waveforms in Figure 3-3)

| Node | Measurement | Source |
|---------|-------------------------|--------|
| C7+,C8+ | = 12MHz (see waveform) | Y2 |
| J5-8 | = 6MHz (see waveform) | U14 |
| U35-12 | ≈ 50mVdc (see waveform) | U35 |

Data Lines Check that all data and address lines are toggling. Address and data lines go to the following IC's:

| Address Lines | Data Lines |
|----------------|---------------|
| U6: A0 to A15 | U6: D0 to D7 |
| U8: A0 to A15 | U8: D0 to D7 |
| U12: A0 to A4 | U12: D0 to D7 |
| U14: A8 to A15 | U14: D0 to D7 |
| U16: A0 to A7 | U16: D0 to D7 |
| U17: A0 to A2 | U17: D0 to D7 |
| U36: A7 to A15 | |

Note: Data and address lines may not toggle if one line is shorted either high or low. If no short is found, replace all socketed IC's. If the data lines still do not toggle, replace the HP-IB (A8) assembly.

| Node | Measurement |
|-----------|-------------|
| A0 to A15 | Toggling |
| D0 to D7 | Toggling |

Secondary Interface Troubleshooting

Secondary interface troubleshooting checks the operation of the voltage, current, and readback DACs as well as analog multiplexer and secondary microprocessor. The analog multiplexer is checked in the Readback DAC troubleshooting procedure. The secondary microprocessor can only be checked using secondary SA (refer to Signature Analysis).

Voltage and Current DAC

The voltage and current DACs can be checked either from the front panel or by secondary SA. Refer to Signature Analysis to troubleshoot the voltage and current DACs in this manner.

Note: To troubleshoot the voltage and current DACs from the front panel if the unit has failed selftest, place jumper A8J5 in the skip selftest position (see Table 3-2). This lets you operate the unit even though it fails the internal selftest.

Use the front panel controls to vary the output voltage and current from zero to full-scale output. Remember to turn off the unit and connect a short across the output before programming the current from zero to full scale. Use a DMM and check the voltages at the following nodes:

CV DAC Circuits

| Node | Setup | Measurement |
|-------|---------------------|-------------|
| U69-6 | Voltage set to 0. | 0V |
| | Voltage set to max. | + 5V |
| U64-6 | Voltage set to 0. | 0V |
| | Voltage set to max. | -10V |

CC DAC Circuits

| Node | Setup | Measurement |
|-------|---------------------|-------------|
| U68-6 | Current set to 0. | 0V |
| | Current set to max. | + 5V |
| U65-6 | Current set to 0. | 0V |
| | Current set to max. | -10V |

Readback DAC Circuits

Refer to Figure 3-4 for the waveforms to troubleshoot the readback circuits.

The turn-on selftest waveform at U24-7 is obtained by toggling the on/off switch repeatedly to perform the selftest routine. If this waveform is not correct, isolate the problem either to the readback DAC or the multiplexer.

Note: To troubleshoot the readback DAC from the front panel if the unit has failed selftest, place jumper A8J5 in the skip selftest position (see Table 3-2). This lets you operate the unit even though it fails the internal selftest.

Use the front panel controls to vary the output voltage from zero to full-scale output to obtain the waveforms at U67-6. These waveforms check the operation of the readback DAC.

To check the multiplexer, use the front panel controls to obtain the waveforms at the output of the multiplexer (U24-2). Remember to turn off the unit and connect a short across the output before programming the current from zero to full scale. Press "OVP DISPLAY" on the front panel to display the OV_MON portion of the waveforms.

If the waveforms are not correct, use the front panel controls and a DMM to check the multiplexer input voltages at the following nodes:

Readback Multiplexer (U20):

| Node | Setup | Measurement |
|--------|---------------------|-------------|
| U20-9 | Voltage set to 0. | 0V |
| | Voltage set to max. | + 5V |
| U20-10 | Current set to 0. | 0V |
| | Current set to max. | + 5V |
| U20-11 | OV set to 0. | 0V |
| | OV set to max. | +2.2V |

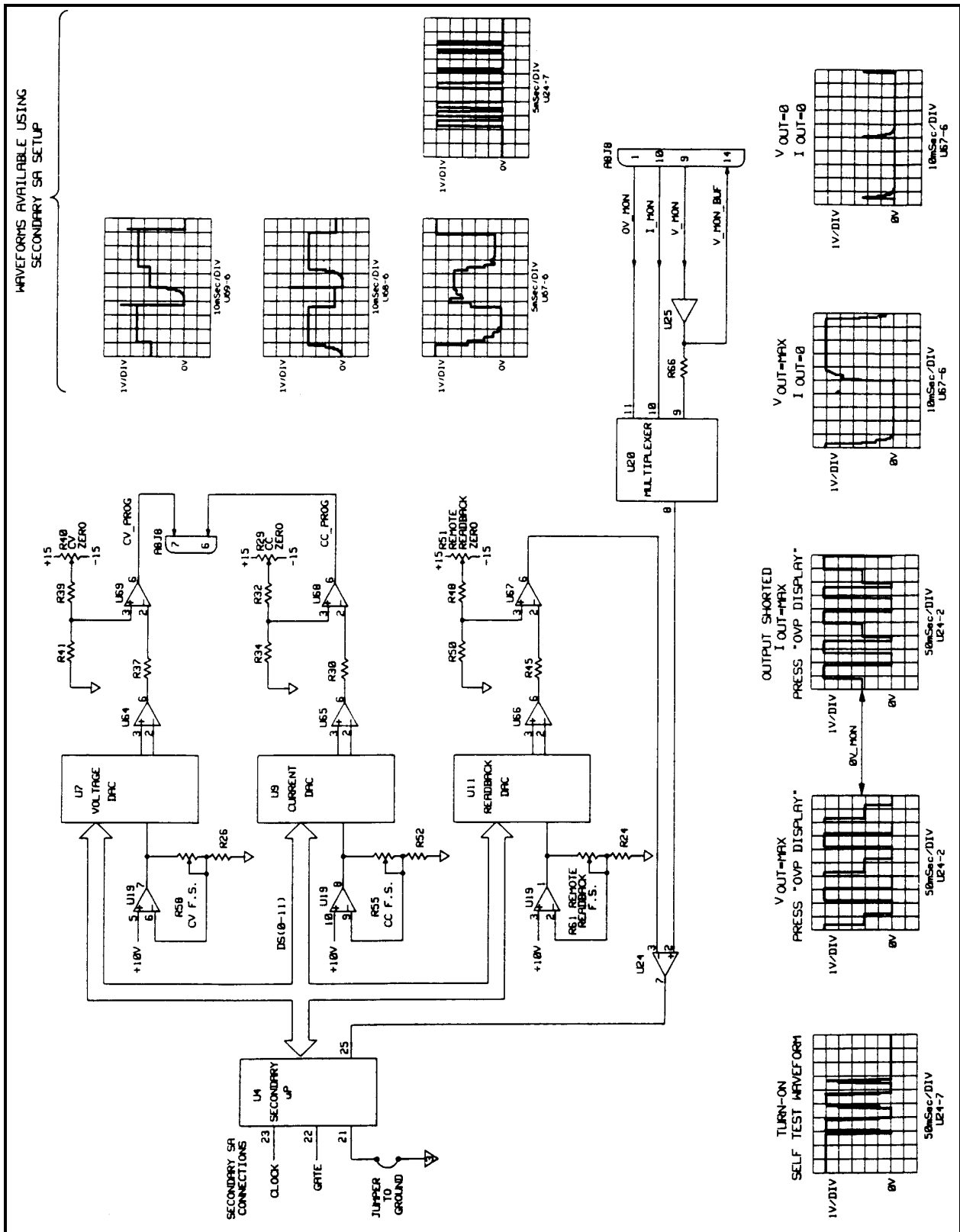


Figure 3-4. Readback and Secondary SA Waveforms

Signature Analysis

Perform the signature analysis only after you have completed the Primary Processor Troubleshooting.

The easiest and most efficient method of troubleshooting microprocessor-based instruments is signature analysis. Signature analysis is similar to signal tracing with an oscilloscope in linear circuits. Part of the microcomputer memory is dedicated to signature analysis and a known bit stream is generated to stimulate as many nodes as possible within the circuit. However, because it is virtually impossible to analyze a bit stream with an oscilloscope, a signature analyzer is used to compress the bit stream into a four-character signature that is unique for each node. By comparing signatures of the unit under test to the correct signatures for each node, faults can usually be isolated to one or two components. Note that signature analysis provides only go/no-go information; *the signature provides absolutely no diagnostic information.*

The following general notes apply to signature analysis of the power supply.

1. Be certain to use the correct setup for the signature being examined.
2. Most signatures are taken on the HP-IB, and front panel assemblies.
3. Note the signatures for Vcc and ground on the I.C. being examined. If an incorrect signature is the same as that of Vcc or ground, that point is probably shorted to Vcc or ground.
4. If two pins have identical signatures, they are probably shorted together. If two signatures are similar, it is only coincidence. For example, if the signature at a certain point should be 65C4, a signature of 65C3 is not "almost right". No diagnostic information can be inferred from an incorrect signature.
5. If a signature is incorrect at an input pin, but is correct at its source (output of previous I.C.), check for printed circuit and soldering discontinuity.
6. An incorrect signature at an output could be caused by a faulty component producing that output; or, a short circuit in another component or on the board could be loading down that node.

Tables 3-2 and 3-3 show the primary, front panel, and secondary signature analyzer connections that are required to perform the SA tests in Tables 3-4 through 3-8. Remember that the primary and secondary circuits each reference a different circuit common.

Primary SA

Place the unit in primary SA mode by moving the J5 jumper as shown in Table 3-2. Connect the signature analyzer as shown in the table. The front panel display should indicate: "SA SA", and all LED's will be on. If the display is different, replace U14.

Note: The power supply will not go into SA mode if one of the data and address lines is shorted either high or low. Refer to Data Lines troubleshooting.

When the unit is in SA mode, check for the waveforms shown in Figure 3-3. Refer to Table 3-4 for the primary SA signatures. Return the J5 jumper to its normal position when the primary signature analysis is complete.

Front Panel SA

To place the unit in SA mode for Front Panel SA troubleshooting, follow the procedure for Primary SA troubleshooting. When the unit is in SA mode, check the signatures in Tables 3-5 through 3-7.

The signatures in Table 3-5 check the registers that drive the 7-segment LED displays. Most problems will involve only one display or LED indicator. Table 3-6 checks the address latches and decoders. Address latch U15 forwards address data to the address decoders, which enable the shift registers. Table 3-7 checks flip-flop U12, shift register U11, and gate U18. U12 decodes the output of the RPG. U11 and U18 are used by the microprocessor to read the status of the RPG and front panel switches.

Return the J5 jumper to its normal position when the front panel signature analysis is complete.

Secondary SA

For secondary SA troubleshooting, connect the signature analyzer as shown in Table 3-3. Use a jumper wire and short U4 pin 21 to common (U4 pin 20). Check for the waveforms in Figure 3-4 and the signatures in Table 3-8 for the secondary SA. When the secondary signature analysis is complete, disconnect the jumper on U4 pin 21.

Table 3-2. Primary and Front Panel Signature Analyzer Test Setups

| SIGNATURE ANALYZER INPUT | EDGE SETTING | PRIMARY SA CONNECTIONS |
|--|--------------|------------------------|
| CLOCK | | A8J5 pin 8 |
| START | | A8U37 pin 16 |
| STOP | | A8U37 pin 16 |
| GROUND | | A8J5 pin 5 |
| A8J5 (in SA mode) | | |
| | | |
| <p>A8J5 JUMPER POSITIONS</p> <p>Jumpering pins 1 and 2 skips the internal selftest when the unit is turned on.</p> <p>Jumpering pins 3 and 4 places U37 in SA mode.</p> <p>Jumpering pins 5 and 6 is the normal/operating position of the jumper.</p> | | |

Table 3-3. Secondary Signature Analyzer Test Setups

| SIGNATURE ANALYZER INPUT | EDGE SETTING | SECONDARY SA CONNECTIONS |
|---|--------------|--------------------------|
| CLOCK | | A8U4 pin 23 |
| START | | A8U4 pin 22 |
| STOP | | A8U4 pin 22 |
| GROUND | | A8U4 pin 20 |
| A8U4 (in SA mode) | | |
| | | |
| <p>A8U4 JUMPER POSITIONS</p> <p>Use a jumper wire and connect A8U4 pin 21 to pin 20 (ground).</p> <p>Use a 40-pin test clip (Pomona Model 5240 or eq.) to facilitate test connections to A8U4.</p> | | |

**Table 3-4. Primary Processor Signature Table
(A8U6 = P/N 5080-2160 REV A.00.00, A.00.01, A.00.02 and A.00.04)**

| | A.00.04 | A.00.02 | A.00.01 | A.00.00 | | | | | | |
|----------|----------------|----------------|----------------|----------------|--------|--------|-------|-------|--------|--------|
| A(0) | A46A | A46A | A46A | A46A | | U16-12 | U6-12 | U8-12 | U12-11 | U17-21 |
| A(1) | 4148 | UH8O | UH8O | UH8O | | U16-13 | U6-11 | U8-11 | U12-13 | U17-22 |
| A(2) | 72F5 | 82H5 | UO39 | 4FU1 | | U16-14 | U6-10 | U8-10 | U12-9 | U17-23 |
| A(3) | PAU8 | 9899 | HOPF | 86C2 | | U16-15 | U6-9 | U8-9 | U12-10 | |
| A(4) | A4A7 | 3088 | O7FA | 5A37 | | U16-16 | U6-8 | U8-8 | U12-8 | |
| A(5) | 45OP | 48H5 | 5823 | PHHO | | U16-17 | U6-7 | U8-7 | | |
| A(6) | C3UU | UF3H | 2682 | 3F6U | | U16-18 | U6-6 | U8-6 | | U36-11 |
| A(7) | HOU4 | HOU4 | F6OP | HFP3 | | U16-19 | U6-5 | U8-5 | | U36-9 |
| A(8) | 4U39 | 4U39 | 17AF | 17AF | U14-52 | | U6-27 | U8-27 | | U36-8 |
| A(9) | 45A8 | 45A8 | 62H1 | 62H1 | U14-51 | | U6-26 | U8-26 | | U36-7 |
| A(10) | 278A | 278A | OOU3 | OOU3 | U14-50 | | U6-23 | U8-23 | | U36-6 |
| A(11) | 6OA3 | 6OA3 | 6OA3 | 6OA3 | U14-49 | | U6-25 | U8-25 | | U36-5 |
| A(12) | 7826 | 7826 | 7826 | 7826 | U14-48 | | U6-4 | U8-4 | | U36-4 |
| A(13) | 5850 | 5850 | 5850 | 5850 | U14-47 | | U6-28 | U8-28 | | U36-3 |
| A(14) | F93H | F93H | F93H | F93H | U14-46 | | U6-29 | U8-3 | | U36-2 |
| A(15) | 79UA | 79UA | 79UA | 79UA | U14-45 | | U6-3 | U8-31 | | U36-1 |
| | | | | | | | | | | |
| D(0) | PH2F | 48P2 | 48P2 | 48P2 | U14-60 | U16-9 | U6-13 | U8-13 | U12-22 | U17-12 |
| D(1) | HU9O | 6O84 | 6O84 | 6O84 | U14-59 | U16-8 | U6-14 | U8-14 | U12-21 | U17-13 |
| D(2) | U665 | 74UH | 96C5 | HA6P | U14-58 | U16-7 | U6-15 | U8-15 | U12-20 | U17-14 |
| D(3) | 53PP | 16A9 | UH79 | 8OC2 | U14-57 | U16-6 | U6-17 | U8-17 | U12-19 | U17-15 |
| D(4) | C9C2 | 196F | AA13 | U64C | U14-56 | U16-5 | U6-18 | U8-18 | U12-18 | U17-16 |
| D(5) | C27C | 132C | 8A9F | 89AP | U14-55 | U16-4 | U6-19 | U8-19 | U12-17 | U17-17 |
| D(6) | HO18 | 4387 | 497F | 2C5F | U14-54 | U16-3 | U6-20 | U8-20 | U12-16 | U17-18 |
| D(7) | P97H | 4FC3 | 33AO | U44P | U14-53 | U16-2 | U6-21 | U8-21 | U12-15 | U17-19 |
| | | | | | | | | | | |
| WR* | FP65 | FP65 | FP65 | FP65 | U14-40 | | | U8-29 | | U36-12 |
| RD* | unstable | 3PPH | 3PPH | 3PPH | U14-61 | | U6-24 | U8-24 | | U36-13 |
| ALE | U665 | 4OAP | 4OAP | 4OAP | U14-62 | U16-11 | | | | |
| READY | 26C3 | 26C3 | 26C3 | 26C3 | U14-43 | | | | | U36-15 |
| | | | | | | | | | | |
| BANK_SEL | unstable | 5AHH | unstable | unstable | U14-27 | | | | | U36-14 |
| | | | | | | | | | | |
| EE(0) | 7CF1 | 7CF1 | 7CF1 | 7CF1 | U14-19 | | | | | U70-1 |
| EE(1) | AH32 | AH32 | AH32 | AH32 | U14-20 | | | | | U70-2 |
| EE(2) | HCCH | HCCH | HCCH | HCCH | U14-21 | | | | | U70-3 |
| EE(3) | 9P5F | 9P5F | 9P5F | 9P5F | U14-22 | | | | | U704 |
| | | | | | | | | | | |
| APC | 9361 | 9361 | 9361 | 9361 | U14-23 | | | | | U15-22 |
| UART | CHU5 | CHU5 | CHU5 | CHU5 | | | | | U12-14 | U36-16 |
| HPIB | 2688 | 2688 | 2688 | 2688 | | | | | | U36-17 |
| ROM | C95F | C95F | C95F | C95F | | | U6-22 | | | U36-19 |
| RAM | 9UPU | 9UPU | 9UPU | 9UPU | | | | U8-22 | | U36-18 |

Table 3-5. Front Panel LED Display and Indicator Drivers
(A8U6 = P/N 5080-2160 REV A.00.00, A.00.01, A.00.02 and A00.04 Inputs)

| Inputs: | | | | | | | | | | |
|-----------------|---|------|------|------|------|---|------|------|------|------|
| Node | Measurement | | | | | | | | | |
| U1 to U10-1 | 6H15 | | | | | | | | | |
| U1 to U10-9 | Cycle power to unit--Lo to Hi after approx. 160 ms | | | | | | | | | |
| U1 to U10-2,14 | +5V | | | | | | | | | |
| U1 to U10-7 | common | | | | | | | | | |
| U1-8 | F05U | | | | | | | | | |
| U2-8 | 50A9 | | | | | | | | | |
| U3-8 | 6F42 | | | | | | | | | |
| U4-8 | AH52 | | | | | | | | | |
| U5-8 | 51U7 | | | | | | | | | |
| U6-8 | PHFF | | | | | | | | | |
| U7-8 | 5730 | | | | | | | | | |
| U8-8 | 8U73 | | | | | | | | | |
| U9-8 | HU9C | | | | | | | | | |
| U10-8 | 5AHH | | | | | | | | | |
| Outputs: | | | | | | | | | | |
| | Current Display | | | | | Voltage Display | | | | |
| | 6 <u>u</u> u <u>u</u> u <u>u</u> 7 <u>u</u> u <u>u</u> u <u>u</u> u | | | | | 6 <u>u</u> u <u>u</u> u <u>u</u> 7 <u>u</u> u <u>u</u> u <u>u</u> u | | | | |
| | 8 | | | | | u8 | | | | |
| | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 |
| pin 3 | 5AHH | 102A | 4A3F | 5AHH | 5AHH | 4U91 | 7499 | 5AHH | CHP5 | 0000 |
| pin 4 | 5AHH | 92FF | C665 | 5AHH | 5AHH | 31U5 | 4475 | 5AHH | P3PP | 0000 |
| pin 5 | 5AHH | 4FUC | 5526 | 5AHH | 5AHH | 739H | P7AH | 5AHH | H8HC | 0000 |
| pin 6 | 5AHH | 94F0 | C4A9 | 5AHH | 5AHH | 5724 | OUC4 | 5AHH | 84PU | 0000 |
| pin 10 | 5AHH | 102A | A73P | 5AHH | 5AHH | 4U91 | 1467 | 5AHH | 5UAU | 0000 |
| pin 11 | 5AHH | 92FF | PFP6 | 5AHH | 5AHH | 31U5 | U810 | 5AHH | U7A8 | 0000 |
| pin 12 | 5AHH | 4FUC | 163C | 5AHH | 5AHH | 739H | HA84 | 5AHH | A60U | 0000 |
| pin 13 | 5AHH | 94F0 | IAP8 | 5AHH | 5AHH | 5724 | C4HC | 5AHH | 56PA | 0000 |

Table 3-6. Front Panel Address Latches and Decoders
(A8U6 = P/N 5080-2160 REV A.00.00, A.00.01, A.00.02 and A.00.04 Inputs)

| Inputs: | | | | | |
|----------------------|---|---------------------|----------|----------------|----------|
| Node | Measurements | | | | |
| U14-26 | Toggling (unstable) | | | | |
| U14-35 | 37F8 | | | | |
| U14-38 | 1ABC | | | | |
| U15-9, U17-3,6 | Cycle power to unit--Lo to Hi after approx. 160 rns | | | | |
| U17-4,5 | Cycle power to unit--Hi to Lo after approx. 160 rns | | | | |
| Outputs: | | | | | |
| U13-1, U14-1, U15-3 | 969U | U14-5, U16-6 | F615 | U16-5, U17-12 | 9C3C |
| U13-2, U14-2, U15-4 | C7AA | U14-13 | Toggling | U16-12, U17-8 | 4056 |
| U13-3, U14-3, U15-5 | A372 | U14-14 | 5AHH | U16-13, U17-10 | Toggling |
| U13-4, U14-4, U17-11 | Toggling | U14-15 | HU9C | U17-1 | 37F8 |
| U13-5, U16-3 | 5C91 | U15-1, U17-2 | 6H15 | U17-2 | |
| U13-6, U14-6, U17-9 | 1ABC | U15-2 | +5V | | |
| U13-7 | 8U73 | U15-3 | | | |
| U13-9 | 5730 | U15-6, U16-2, U17-3 | FIP6 | | |
| U13-10 | PHFF | U15-8, U16-11 | P62F | | |
| U13-11 | 51U7 | U15-10, U16-1,4,10 | 9H84 | | |
| U13-12 | AH52 | | | | |
| U13-13 | 6F42 | | | | |
| U13-14 | 50A9 | | | | |
| U13-15 | F05U | | | | |

**Table 3-7. Front Panel RPG Latches and Input Port
(A8U6 = P/N 5080-2160 REV A.00.00, A.00.01 A.00.02, and A.00.04)**

| Inputs: | | | | | |
|---|--|-----------|----------------|----------|----------|
| Node | Measurement | | | | |
| U11-1 | 1ABC | | | | |
| U11-2 U12-4,10 | Toggling (unstable) | | | | |
| U16-10 | 9H84 | | | | |
| Procedure: | | | | | |
| Node | | | | | |
| S1 LCL | released | U11-13 Lo | U11-7, U16-9 | Lo | U16-8 Hi |
| S1 LCL | depressed | U11-13 Hi | U11-7, U16-8,9 | Toggling | |
| S2 OUTPUT ADJUST | released | U11-14 Lo | U11-7, U16-9 | Lo | U16-8 Hi |
| S2 OUTPUT ADJUST | depressed | U11-14 Hi | U11-7, U16-8,9 | Toggling | |
| S3 DISPLAY OVP | released | U11-3 Lo | U11-7, U16-9 | Lo | U16-8 Hi |
| S3 DISPLAY OVP | depressed | U11-3 Hi | U11-7, U16-8,9 | Toggling | |
| S4 DISPLAY SETTINGS | released | U11-4 Lo | U11-7, U16-9 | Lo | U16-8 Hi |
| S4 DISPLAY SETTINGS | depressed | U11-4 Hi | U11-7, U16-8,9 | Toggling | |
| S5 FOLDBACK | released | U11-5 Lo | U11-7, U16-9 | Lo | U16-8 Hi |
| S5 FOLDBACK | depressed | U11-5 Hi | U11-7, U16-8,9 | Toggling | |
| U12-5 | Node toggles when RPG is rotated clockwise | | | | |
| U12-9 | Node toggles when RPG is rotated in either direction | | | | |
| Set scope for dual trace operation, 2V/div, 10 ms/div, normal triggering, and positive edge on channel A. Connect channel A to U12-3 and channel B to U12-2. | | | | | |
| U12-3 | Rotate RPG CW | | | | |
| U12-2 | Rotate RPG CW | | | | |
| U12-3 | Rotate RPG CCW | | | | |
| U12-2 | Rotate RPG CCW | | | | |

Table 3-8. Secondary Processor Signature Table

| | | | | | | |
|--------|------|----------|-------|-------|--------|----------|
| DS(0) | P36U | U4-1 | U7-15 | U9-15 | U11-15 | |
| DS(1) | 2280 | U4-2 | U7-14 | U9-14 | U11-14 | |
| DS(2) | 4277 | U4-3 | U7-13 | U9-13 | U11-13 | |
| DS(3) | 720F | U4-4 | U7-12 | U9-12 | U11-12 | |
| DS(4) | 6A31 | U4-5 | U7-11 | U9-11 | U11-11 | |
| DS(5) | 662U | U4-6 | U7-10 | U9-10 | U11-10 | |
| DS(6) | 6020 | U4-7 | U7-9 | U9-9 | U11-9 | |
| DS(7) | 6327 | U4-8 | U7-8 | U9-8 | U11-8 | |
| DS(8) | 1377 | U4-39 | U7-7 | U9-7 | U11-7 | U2-16 |
| DS(9) | FF99 | U4-38 | U7-6 | U9-6 | U11-6 | U2-17 |
| DS(10) | 236P | U4-37 | U7-5 | U9-5 | U11-5 | U2-18 |
| DS(11) | H495 | U4-36 | U7-4 | U9-4 | U11-4 | U2-19 |
| WR* | 9FU7 | U4-12 | U7-17 | | | |
| WR* | 9FF7 | U4-13 | | U9-17 | | |
| WR* | 9FHU | U4-14 | | | U11-17 | |
| | F817 | U4-26 | | | | U20-1 |
| | 36U7 | U4-27 | | | | U20-16 |
| | 0562 | U4-28 | | | | U20-15 |
| ISTX | 9F97 | U4-11 | | | | U2-4, 14 |
| | 9FH6 | U4-17 | | | | U2-2 |
| | 9FH5 | U4-16 | | | | U2-11 |
| ALE | 0000 | U4-30 | | | | U2-1 |
| | AU68 | U4-35 | | | | |
| + 5V | 9FA8 | U4-33,34 | | | | |

Power Section Troubleshooting

Table 3-9 describes the signals at each of the control board test points. The test connector provided in service kit P/N 5060-2865 allows easy connection to each test point. The measurements given here include bias and reference voltages as well as power supply status signals. It provides conditions for these measurements and gives the components which are the sources of the signals. Tables 3-10 and 3-11 describe possible symptoms in the power section. Both give lists of circuit blocks or components which can cause the symptoms shown. The appropriate assembly is also given.

If the supply exhibits a symptom given in Table 3-10 or 3-11, go to the block which pertains to that symptom. If the exact symptom seen is not in the tables, start with the symptom that seems to be closest to the one observed. The blocks are given in the Power Section Blocks section starting on Page 50. Troubleshooting information for each block will include a brief description of the circuit. The columns provided are as follows:

NODE: This column lists the nodes where the measurements should be taken. In some cases this will be stated as NODE(+) and NODE(-) where the first is the test node and the second is the reference.

SETUP: If a certain setup is required for the measurement, it will be given in this column.

MEASUREMENT: This column indicates what the expected measurement is for the given node.

SOURCE: If applicable, the components which generate the signal will be provided in this column.

To troubleshoot the power supply the A4 power FET board and A2 control board can be raised out of the unit using extender boards and cables provided in service kit P/N 5060-2865.

Main Troubleshooting Setup

Figure 3-5 shows the troubleshooting setup for troubleshooting all of the unit except the front panel and initial no-output failures (see Page 49). The external power supply provides the unit's internal bus voltage. The ac mains connects directly to the unit's A1T3 bias transformer via the isolation transformer, thereby energizing the bias supplies, but it does not connect to the input rectifier and filter to create the bus voltage. With the external supply the unit operates as a dc-to-dc converter. The supply biases A4Q3, and A4Q4 PFETs with a low voltage rather than the 320Vdc bus voltage. This protects the PFETs from failure from excess power dissipation if the power-limit comparator or the off-pulse circuitry are defective. It also reduces the possibility of electrical shock to the troubleshooter.

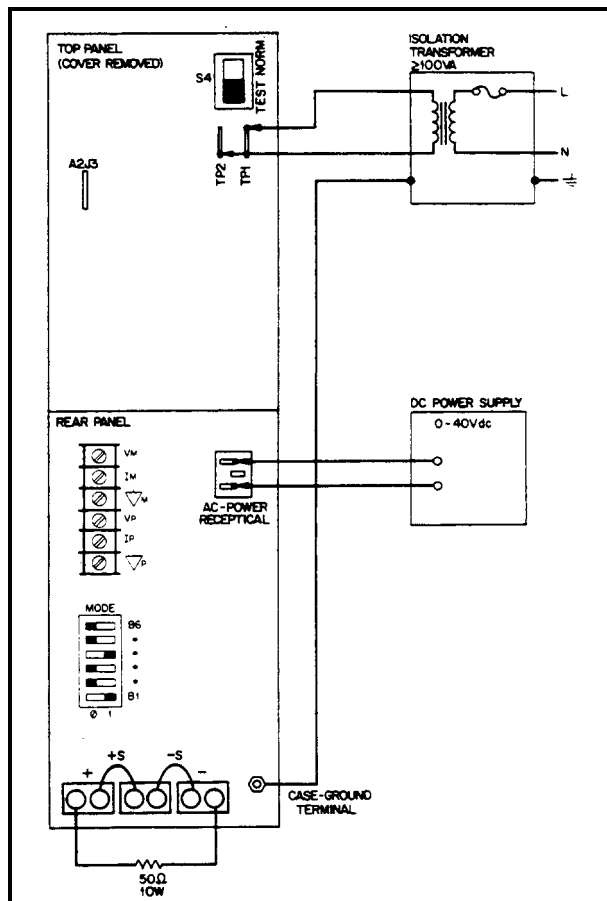


Figure 3 5. Main Troubleshooting Setup

WARNING

An isolation transformer provides ac voltage that is not referenced to earth ground, thereby reducing the possibility of accidentally touching two points having high ac potential between them. Failure to use an isolation transformer as shown in Figure 3-5 will cause the ac mains voltage to be connected directly to many components and circuits within the power supply, including the FET heatsinks, as well as to the terminals of the external dc power supply. Failure to use an isolation transformer is a definite personal-injury hazard.

The troubleshooting setup of Figure 3-5 connects high ac voltage to A1F1, A1S2, the fan, and other components and circuits along the left edge of the A1 main board.

As a convenience in implementing the troubleshooting setup, modify a spare mains cord set as shown in Figure 3-6. This facilitates connecting the unit's power receptacle to the external supply and connecting the bias transformer to the ac mains.

With the mains cord unplugged proceed as follows:

- a. Remove the top cover and the inside cover per Page 31. Set switch S4 (front-left corner of the A1 main board) in the TEST position.

WARNING

Failure to set switch S4 in the TEST position will result in damage to the power supply, damage to the external dc supply, and is an electrical shock hazard to you.

- a. Install control board test connector onto the A2J3 card-edge fingers.
- b. Connect a 50Ω 10-W load resistor to the unit's output terminals.
- c. With the LINE switch off, connect an external dc power supply to the outside prongs of the unit's power receptacle. Ignore polarity as the unit's input rectifying diodes steer the dc power to the correct nodes.
- d. Complete the setup of Figure 3-5 by attaching an ac mains cord to test points TP1 (L, black wire) and TP2 (N, white wire) and connect the green ground wire to the unit's case ground terminal or a suitably grounded cabinet screw. TP1 and TP2 are accessible through the cutout on the left side of the unit and are at the left edge of the A1 main board.

Troubleshooting No-Output Failures

No-output failures often include failure of the A4Q4 PFETs and their fuses A4F1 and A4F2. When either the off-pulses or the power-limit comparator fails, the PFETs can fail from excessive power dissipation. The strategy for localizing no-output failures is to check the voltages and waveforms at the control board test connector to predict if that circuit failure would cause the FETs to fail. This makes it possible to develop your troubleshooting approach without an extensive equipment setup. Proceed as follows:

- a. With the mains cord disconnected remove the A4 FET board per Page 32. Connect the mains cord and switch on power.
- b. Using Table 3-9 check the bias voltages, the PWM-OFF and PWM-ON Control signals and other signals of interest at the A2 control board test fingers, A2J3.
- c. Check for the presence of program voltages, VP and IP, at the rear panel.
- d. Check for presence of the 320Vdc rail voltage between the cathodes of diodes A1CR1 and A1CR2 and the anode of the diodes A1CR3 and A1CR4. If there is no rail voltage, check diodes A1CR1 through A1CR4.

WARNING

Diodes A1CR1 through A1CR4 connect to the ac mains voltage. Use a voltmeter with both input terminals floating to measure the rail voltage.

- a. Select the functional circuit for troubleshooting based on your measurements and Table 3-11, which provides direction based on the status of the PWM OFF and PWM ON signals.

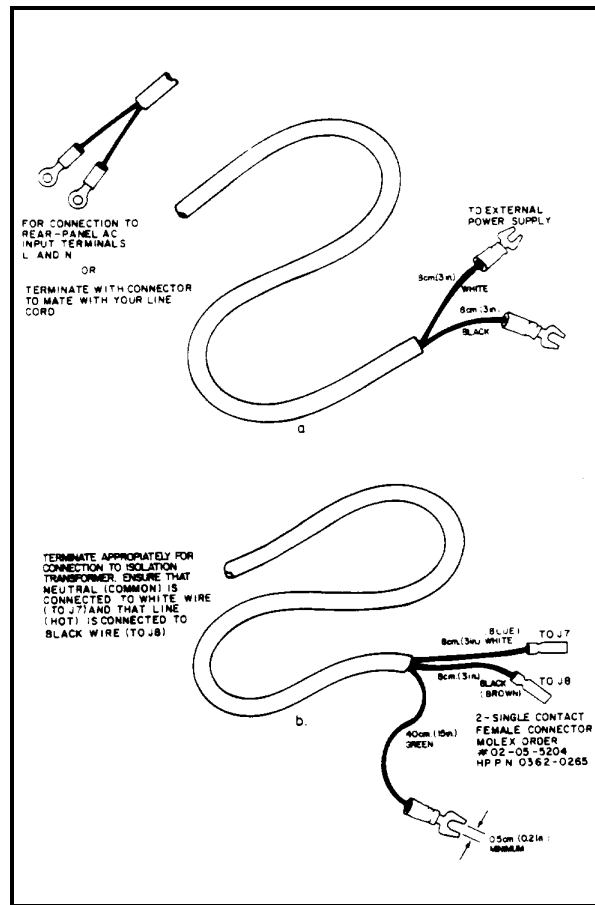


Figure 3-6. Modified Mains Cord Set For Troubleshooting

Power Section Blocks

This section contains the blocks referenced in Tables 3-10 and 3-11.

Table 3-9. Control Board Test Connector, A2J7

| PIN NO. | SIGNAL NAME | Vdc | WAVEFORM/CONDITIONS | SOURCE |
|---|---------------------------|---|---|----------------------|
| Digital-Circuits Bias & Reference Voltages | | | | |
| 1 | +5V | 5.0 | | A2Q3 (emitter) |
| 22 | + 20V(5V UNREG) | 20.0 | with 120Hz & 45KHz ripple | A1CR6, A1CR7 |
| 14 | 2.5V ref | 2.50 | | A2U9 (OUT) |
| 6 | 0.5V ref | 0.50 | | A2R79,A2R80 |
| Analog-Circuits Bias Voltages | | | | |
| 2 | +15V | 15.0 | | A2U12 (OUT) |
| 21 | -15V | -15.0 | | A2U4 (OUT) |
| Status Signals | | | | |
| 17 | \overline{CV} | TTL Lo | if in CV operation | A2Q6C-7 (collector) |
| 16 | \overline{CC} | TTL Lo | if in CC operation | A2Q6F-14 (collector) |
| 13 | \overline{OV} | TTL Hi | if not OVP shutdown | A2U11D-11 |
| 11 | $\overline{DROPOUT}$ | TTL Hi | if ac mains okay | A2U17D-11 |
| 12 | \overline{OT} | TTL Hi | if not overtemp shutdown | A2U11B-6 |
| Control Signals | | | | |
| 25 | PWM OFF | | 1.7 μ s TTL pulses, 20KHz | U1A-5 |
| 26 | PWM ON | | 1.7 μ s TTL pulses, 20KHz | U2B-6 |
| 18 | Ip MONITOR | | 1V pk, 1/2 sawtooth, 20KHz (at full power only) | A2CR26 (cathode) |
| 8 | $\overline{INHIBIT}$ | TTL Hi | if not remotely inhibited | A2R185C, U19A-2 |
| 15 | $\overline{DOWN PROGRAM}$ | 1.2-3.0 | while not down programming | A2CR21, A2CR27 |
| 7 | OVP PROGRAM | 1/10 OVP (6033A) 1/30 OVP (6038A) | e.g.: 2Vdc if OVP set to full voltage output | A3R6 (wiper) |
| 5 | $\overline{OV CLEAR}$ | +5V | inverted OV reset line | A8U4-35 |
| 19 | $\overline{PCLR2}$ | +5V | if +5V bias OK | A2Q60-9 |
| Commons & Current-Monitor | | | | |
| 4 | COMMON | 0.0 | common return for all bias voltages, status and control signals | A2C20(-), A2R50 |
| 9 | COMMON | 0.0 | common return for 2.5V ref and 0.5V ref | A2R83, A21-20 |
| 10 | I-TEST | \approx 0.005 (6033A). \approx 0.055 (6038A) | inboard-side monitoring res | A1R27 & A1R28, A1T2 |
| 3 | V-MON-BUF | V-OUT/12 | trimmed V-MON for readback | A8U25-6 |
| | | | | |

Table 3-10. Performance Failure Symptoms

| SYMPTOMS | DEFECTIVE BOARD | CHECK FUNCTIONAL CIRCUITS |
|---|------------------------|---|
| unexplained OVP shutdowns | A2 | OVP circuit, CV circuit |
| no current limit | A2 | CC circuit |
| max current < 10Adc (6038A) | A2 | CC Clamp, CC circuit |
| < 30Adc (6033A) | | |
| max power < specified | A2, A1 | Power Limit, 20KHz clock, transformer AIT1 |
| max voltage < 60Vdc (6038A) | A2, A1 | CV Circuit, diodes A1CR1-CR4 |
| < 20Vdc (6033A) | | |
| cycles on & off randomly | A2, A1 | AC-Surge-&-Dropout Detector, Mains Voltage Select switch A1S2 |
| CV overshoots | A2 | A2U10A, A2CR20, A2R94 |
| output noise (<1KHz) | A2,A1 | CV circuit, input filter |
| output noise (>1KHz) | A1, A4 | transformer AIT1, Output Filter, snubbers A4R7/R8/C5/CR5/, A4R13/ R14/C6/CR6, A4R33/C13 |
| CV regulation, transient response, programming time | A2, A1 | wrong sensing |
| CC regulation | A2 | low ac mains voltage, CV circuit |
| CV oscillates with capacitive loads | A2 | low ac mains voltage, CC circuit |
| CC oscillates with inductive loads | A2 | A2R10, A2C51, A2R95, A2R96, A2R86, A2C47, A2R71, A2C36 A2U10, A2R86, A2C47, A2C43, A2R77, A2U3D A2U3D, A2R30, A2C44, A2R76, A2R75, A2C42, A2C41, A2R1 |

**Table 3-11. No-Output Failures
(Bias supplies and AC turn-on circuit functioning)**

| Status of FET On/Off-Pulses | | DEFECTIVE BOARD | CHECK FUNCTIONAL CIRCUITS |
|------------------------------------|----------------------------|------------------------|--|
| PWM-ON A2J3-26 | PWM-OFF A2J3-25 | | |
| Lo | Lo | A2 | Control cks: CV & CC thru On- & Off-Pulse Oneshots * |
| Lo | Hi | A2&A4 | PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed |
| Hi | Lo | A2&A4 | PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed |
| Hi | Hi | A2&A4 | PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed |
| Lo | N | A2 | A2U17B, On-Pulse Oneshot and A2Q6A |
| N | Lo | A2&A4 | Off-Pulse Oneshot and DC-to-DC: A4Q3 and A4Q4 probably failed |
| Hi | N | A2&A4 | A2U17B, On-Pulse Oneshot & DC-to-DC: A4Q3 and A4Q4 probably failed |
| N | Hi | A2&A4 | Off-Pulse Oneshot and DC-to-DC: A4Q3 and A4Q4 probably failed |
| N | N | A2&A4 | Power-Limit Comparator and DC-to-DC: A4Q3 and A4Q4 probably failed |

Lo= TTL low Hi= TTL high N= normal 20KHz pulse train, TTL levels

* Decide which to troubleshoot--the CV circuit, the CC circuit, or the PWM and Off-Pulse & On-Pulse Oneshots-- by measuring the CV CONTROL (A2CR24, cathode) and the CC CONTROL (A2CR19 cathode) voltages. Troubleshoot whichever is negative, and if neither is negative, troubleshoot the PWM. Make these voltage measurements after you have implemented the Main Troubleshooting Setup.

Troubleshooting AC-Turn-On Circuits

Relay AIK1 closes at 1.0 seconds and $\overline{\text{DROPOUT}}$ goes high at 1.1 seconds after 20V (5V UNREG) reaches about 11Vdc. $\overline{\text{DROPOUT}}$ high enables the PWM if $\overline{\text{OVERVOLTAGE}}$, $\overline{\text{INHIBIT}}$, and $\overline{\text{OVERTEMP}}$ are also high.

Circuits Included. AC-Surge-&-Dropout Detector, Bias Voltage Detector, U11A, 1-Second Delay and Relay Driver--all on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer, and set the external supply to 0Vdc.

Inputs:

| NODE (+) * | SETUP | MEASUREMENT | SOURCE |
|-------------|---------|--------------------|--------------|
| A2J3-1 | wait 2s | 5.0Vdc | A2Q3 (emit.) |
| A2J3-22 | 20Vdc | A1CR6, A1CR7 | |
| A2U20-8, 10 | | f.w.rect, 1-2V pk | A1CR8,A1CR9 |
| A2U22-13 | | TTL sq wave, 20KHz | A2U22-6 |

Outputs:

| NODE | SETUP | MEASUREMENT |
|---------------------------------|-------------|----------------------------------|
| A2U20-5 | cycle power | transition 0 to 13.5Vdc |
| A2U20-2 | cycle power | transition 0 to 1.4Vdc |
| A2Q6-1 | cycle power | transition 0 to 5.0 to 0.3Vdc |
| A2Q6-9 | cycle power | transition 0 to 0.3 to 5.0Vdc |
| A2U20-6 | wait 2s | < 0.25Vdc |
| A2U20-1, 14 | wait 2s | Hi (5Vdc) |
| A2U11-3 | cycle power | transition Lo to Hi to Lo |
| A2U18-10 | cycle power | burst 1.25khz sq. wave, 1.1s |
| A2U18-13 | cycle power | five 100ms pulses then Hi |
| A2U18-12 | cycle power | two 200ms pulses then Hi |
| A2U18-15 | cycle power | transition Lo to Hi at 800ms |
| A2U17-8 | cycle power | transition Lo to Hi at 1.0s |
| A2U17-11 | cycle power | transition Lo to Hi at 1.1s |
| ($\overline{\text{DROPOUT}}$) | | |
| A2Q5 (col.) | cycle power | transition 5.0 to 0.3Vdc at 1.0s |
| (RELAY ENABLE) | | |

Troubleshooting DC-To-DC Converter

Parallel NOR gates A4U2A, A4U2B and A4U1A act as drivers and switch on PFETs A4Q3 and A4Q4 through pulse transformer A4T1. NOR gate A4U1B turns off the PFETs through pulse transformer A4T2 and transistors A4Q1 and A4Q2.

Circuits Included. On-Pulse Driver, Off-Pulse Driver, PFET Switches and Drivers on A4 power mesh board.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer, set the external supply to 40Vdc, and switch on the LINE switch. Set the unit's output voltage to 20Vdc and current to above 1Adc. Verify that the $\overline{\text{OVERRANGE}}$ LED lights. See Figure 3-7 for waveforms.

Inputs:

| NODE (+) | NODE (-) | MEASUREMENT | SOURCE |
|------------------|----------|-------------|---|
| A2J3-26(PWM-ON) | VM | waveform #1 | A2U17-6,A2P1-7, A4P1-24,C |
| A2J3-25(PWM-OFF) | VM | waveform #2 | A2U13-5,A2P1-13,A4P1-26,A |
| A4Q3-D | A4Q4-S | 39Vdc | A1C4 (+),A4P1-10,A,C A1C4 (-),A4P1-4,A,C |

Outputs:

| NODE (+) | NODE (-) | MEASUREMENT |
|----------|----------|-------------|
| A4Q3-G | A4Q3-S | waveform #3 |
| A4Q4-G | A4Q4-S | waveform #3 |
| A4Q3-D | A4Q3-S | waveform #4 |
| A4Q4-D | A4Q4-S | waveform #4 |
| A2J3-18 | A2J3-4 | waveform #5 |

Note: The Gate (G) and Source (S) leads of PFETs A4Q3 and A4Q4 can be accessed from the circuit side of the board and used as test points. The Drain (D) of A4Q3 can be picked up at its case or from the cathode of A4CR13. The Drain of A4Q4 can be picked up at its case or from the anode of A4CR14.

If all the INPUT measurements are correct but the OUTPUT Vgs waveform (3) is incorrect, the problem may be caused by weak PFETs. Two 6800pF capacitors (HP PN 0160-0159) can be substituted for the PFETs (G to S) to check waveform 3. If the waveform is still incorrect, the problem may be located in the drive components. If you replace the PFETs, replace both the PFETs and associated drive components as furnished in PFET Service Kit. HP Part No. 5060-2860.

CAUTION The PFETs are static sensitive and can be destroyed by relatively low levels of electrostatic voltage. Handle the A4 power mesh board and the PFETs only after you, your work surface and your equipment are properly grounded with appropriate resistive grounding straps. Avoid touching the PFET's gate and source pins.

Troubleshooting Bias Supplies

+5V On A2 Control Board. The PWM A2U6 includes a clock generator (45KHz set by A2R53 and A2C26), and a current limit (2Adc set by 0.15Vdc across A2R50). It turns off each output pulse using the difference between the voltage at voltage divider A2R46-A2R47 and the 2.5Vdc set by voltage regulator A2U5.

Circuit Included. +5Vdc bias supply circuitry from connector pins A2P1-15 through jumper A2W3 on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer, and set the external supply to 0Vdc.

Input:

| NODE | MEASUREMENT | SOURCE |
|---------|-------------|-------------|
| A2J3-22 | ≈ 20Vdc | A1CR6,A1CR7 |

Outputs:

| NODE | MEASUREMENT |
|------------|------------------------------|
| A2U6-6 | ≈2 to 4Vdc sawtooth, 45KHz |
| A2U6-12,13 | ≈ 19V pk, 15μs pulses, 45KHz |

| | |
|-----------------------|-----------------------------|
| A2Q3 (emit) | ≈ 20V pk, 5μs pulses, 45KHz |
| A2U5 (OUT) | 2.5 Vdc |
| A2R50, A2CR11 (anode) | ≈ 0 > V > 0.007Vdc |
| A2R46, A2R47 | 2.5 Vdc |

To check if load on + 5V is shorted, remove jumper A2W3

+15V On A2 Control Board. Voltage regulator A2U12 regulates the voltage across resistor A2R29 to be 1.25Vdc. That sets the current through zener diode A2VR1 at 7.5mA_{dc}. The output voltage is 1.25Vdc plus 11.7Vdc across A2VR1 plus the voltage across A2R34.

Circuit Included. +15Vdc bias supply circuitry from connector pin A2P1-27 through test point A2J3-2 on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the isolation transformer, and set the external supply to 0Vdc.

Input:

| NODE | MEASUREMENT | SOURCE |
|------------------------|-------------|----------------|
| A2U12(IN) A2C17 (+) | ≈ 24Vdc | A1U1, A1C1 (+) |

Outputs:

| NODE (+) | NODE (-) | MEASUREMENT |
|---------------|---------------|-------------|
| A2U12 (OUT) | A2U12 (ADJ) | 1.25Vdc |
| A2U12 (cath.) | A2U12 (anode) | 11.7Vdc |
| A2VR1 (anode) | A2R34, A2R33 | 2.05Vdc |
| A2LR3 (cath.) | A2VR3 (anode) | 6.2Vdc |

To check if load on +15V is shorted, remove jumper A2W1.

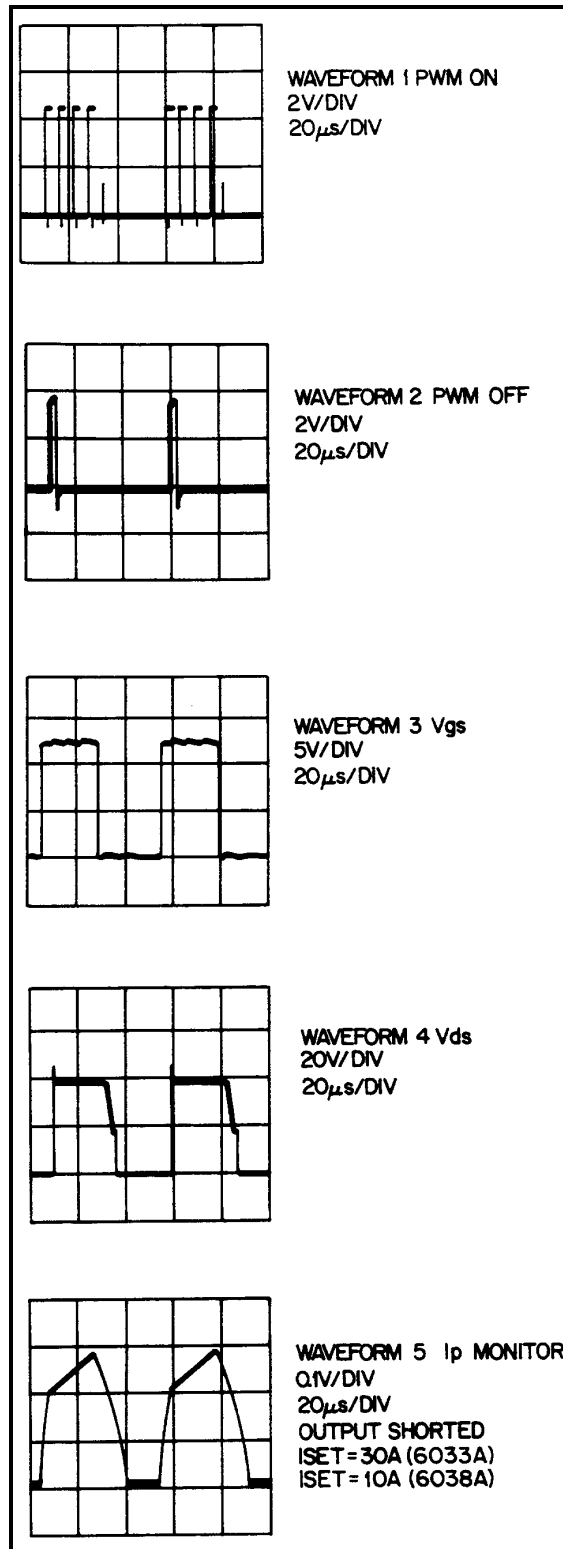


Figure 3-7. Waveforms

-15 V On A2 Control Board. Voltage regulator A2U4 regulates the voltage across resistor A2R32 to be 1.25Vdc.

Circuit Included. -15 Vdc bias supply circuitry from connector pin A2P1-30 through test point A2J3-21 on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer, and set the external supply to 0Vdc.

Input:

| NODE (+) | MEASUREMENT | SOURCE |
|---------------------|-------------|---------------|
| A2U4(IN), A2C16 (-) | ≈ - 24Vdc | A1U1, A1C1(+) |

Outputs:

| NODE (+) | NODE (-) | MEASUREMENT |
|---------------|---------------|-------------|
| A2U4 (ADJ) | A2U24 (OUT) | 1.25Vdc |
| A2VR2 (cath.) | A2VR2 (anode) | 11.7Vdc |
| A2R33, A2R34 | A2VR2 (cath.) | 2.05Vdc |

To check if load on -15V is shorted, remove jumper A2W3.

Refer to Down Programmer, for the + 8.9Vdc bias supply, and refer to OVP Circuit, for the + 2.5V bias supply.

Troubleshooting Down Programmer

The down programmer loads the output when either MASTER ENABLE is low or CV ERROR is more negative than about - 6Vdc. Comparator A4U3B triggers down programming when the voltage at A4U3B-5 is less than about 3Vdc. The collector-emitter current through transistor A4Q6 increases as the output voltage decreases because of feedback from voltage divider A4R24-A4R27 at A4U3A-2

Circuit Included. Down programmer and 8.9V bias supply on A4 power mesh board.

Setup. The Main Troubleshooting Setup, Page 48, except connect the external supply to the unit's + OUT (+) and - OUT (-) terminals. Apply the ac mains voltage to the bias transformer. Set the external supply (EXTERNAL) and adjust the unit's voltage setting (INTERNAL) as instructed below.

Outputs:

| NODE | Set Voltage (Vdc) | | Setup | Measurement |
|-------------|-------------------|----------|---------------|--------------------------------------|
| | External | Internal | | |
| A4U4 (OUT) | - | - | | 8.9Vdc |
| A4U3B-7 | 0 | 2 | unplug TS1 | 0Vdc |
| A4U3B-7 | 10 | 0 | reconnect TS1 | 0Vdc |
| A4U3B-7 | 0 | 2 | | 7.8Vdc |
| A4U3A-2 | 0 | 2 | unplug TS1 | 0.43Vdc |
| A4R26 | 0 | 2 | | ≈0.41Vdc (6038A) 0.2Vdc (6033A) |
| A4Q6 (base) | 20 | 2 | | 1.0Vdc |
| A4U3A-1 | 20 | 2 | | 4.0Vdc |
| A4R26 | 20 | 2 | | ≈0.34Vdc (6038A) ≈0.11Vdc (6033A) |

Troubleshooting CV Circuit

V-MON, the output of CV Monitor Amp A2U7 is the voltage between + S and - S. CV Error Amp A2U8 compares V-MON to CV PROGRAM. Innerloop Amp A2U10A stabilizes the CV loop with IVS input from A2U10C. The measurements below verify that the operational amplifier circuits provide expected positive and negative dc voltage excursion when the CV loop is open and the power mesh shut down.

Circuits Included. Constant Voltage (CV) Circuit and buffer amplifier A2U10C.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer, and disconnect the external supply. Remove the + S jumper and connect A2J3-2 (+15V) to + S. Set MODE switch settings B4, B5 and B6 all to 0. Set VP to 0Vdc by connecting to \downarrow P or set VP to + 5Vdc by connecting to A2J3-1 according to SETUP below.

Outputs:

| NODE | SETUP | MEASUREMENT |
|----------|--------|-------------|
| VM | | 3.75Vdc |
| A2U10C-8 | | 4.7Vdc |
| A2U8-6 | VP = 0 | -14Vdc |
| A2U10A-1 | VP = 0 | -14Vdc |
| A2U8-6 | VP = 5 | 4.7Vdc |
| A2U10A-1 | VP = 5 | 5.1Vdc |

If the failure symptoms include output voltage oscillation, check if the CV Error Amp circuit is at fault by shorting A2U8-6 to A2U8-2. If oscillations stop, the CV Error Amp circuit is probably at fault.

Troubleshooting CC Circuit

I-MON, the output of CC Monitor Amp A2U1, in volts is 1/6 the output current in amperes. CC Error Amp A2U2B compares I-MON to CC PROGRAM. Differentiator circuit A2U3D and A2U3C, stabilizes the CC loop. It differentiates IVS and has a voltage gain of 16. Its output is summed with CC PROGRAM at CC Error Amp A2U2B.

The measurements below verify that the operational amplifier circuits provide expected positive and negative dc voltage gain when the CC loop is open and the power mesh shut down.

Circuits Included. Constant Current (CC) Circuit on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48, except connect the external supply with polarity reversed to the unit's + OUT (-) and - OUT (+) terminals. Apply the ac mains voltage to the bias transformer. Set the external supply to 3.0Adc constant current with a voltage limit in the range 5 to 20Vdc. Set IP to 0Vdc by connecting to \downarrow P or set IP to +5Vdc by connecting to A2J3-1 according to the following SETUP.

Outputs:

| NODE | SETUP | MEASUREMENT |
|----------|-----------|-------------|
| IM | 0.50Vdc | |
| A2U2B-7 | IP=0 | -14Vdc |
| A2U2B-7 | IP=5 | 6.0Vdc |
| A2U3D-13 | +0.015Vdc | |
| A2U3C-9 | +0.015Vdc | |
| A2U3C-8 | +0.25Vdc | |

If the failure symptoms include output current oscillation, check if the differentiator circuit is at fault by removing resistor A2R16. If oscillations stop, the differentiator is probably at fault.

Troubleshooting OVP Circuit

Comparator A2U14D sets, and gate A2U17A resets flipflop A2U14B-A2U14C. TTL low at A2U14-1,8,13 inhibits the PWM.

Circuit included. OVP Circuit and 2.5V bias supply on A2 control board.

Setup. The Main Troubleshooting Setup, Page 48, except connect the external supply to the unit's + OUT (+) and - OUT (-) terminals. Apply the ac mains voltage to the bias transformer. Adjust the unit's OVP limit to 15Vdc. Set the external supply (EXTERNAL) as instructed below.

Outputs:

| NODE | SET VOLTAGE | | MEASUREMENT |
|------------|----------------|-------------|-------------|
| | EXTERNAL (Vdc) | SETUP | |
| A2U9 (OUT) | - | | 2.5Vdc |
| A2U14-10 | 10 | | 1.0Vdc |
| A2U14-11 | - | | 1.5Vdc |
| A2J3-13 | 10 | | Hi |
| A2J3-13 | 20 | | Lo |
| A2J3-13 | 10 | | Lo |
| A2J3-13 | 10 | cycle power | Hi |

Note: Connecting a test probe to either input of either comparator in the OV Flipflop (pins A2U14-1, 6, 7, 8, 9, 14 or A2U11-13) may cause the flipflop to change states and cause the probed input to be low.

Troubleshooting PWM & Clock

The inputs to Inhibit Gate A2U19A and PWM gate A2U19B are the keys to PWM troubleshooting. The 20KHz Clock starts each PWM output pulse, and the pulse stops when any of the inputs to A2U19A or A2U19B goes low. The PWM is inhibited and prevented from initiating output pulses as long as any of the eight inputs are low.

Circuit Included. Pulse Width Modulator (PWM), Inhibit Gate A2U19A, Off-Pulse Oneshot, On-Pulse Oneshot, A2U17B, 20KHz Clock.

Setup. The Main Troubleshooting Setup, Page 48. Apply the ac mains voltage to the bias transformer and switch on the LINE switch. Adjust the unit's current setting above 1.0 Adc. Set the external supply (EXTERNAL) and adjust the unit's voltage setting (INTERNAL) as instructed below.

Inputs:

| NODE | SETUP | MEASUREMENT | SOURCE |
|-------------|--------------------------|--------------------|----------------|
| A2J3-1 | | 5.0Vdc | A2Q3 (emitter) |
| A2U19-1 | | Hi | A2U17D-11 |
| A2U19-2 | | Hi | remote inhibit |
| A2U19-4 | | Hi | A2U14-1,8 |
| A2U19-5 | | Hi | A2U11B-6 |
| A2U19-10 | | Hi | A2U16-7 |
| A2U19-12 | POWER LIMIT fully CCW | Lo | A2U14-2 |
| A2U19-12 | POWER LIMIT fully CCW | Hi | A2U14-2 |

Outputs:

| NODE | SET VOLTAGE (Vdc) | | SETUP | MEASUREMENT |
|-------------|--------------------------|-------------|--------------------------|---------------------------------------|
| | EXT. | INT. | | |
| A2U21-7 | 0 | 0 | | TTL sq wave, 320KHz |
| A2U22-3 | 0 | 0 | | TTL sq wave, 160KHz |
| A2U22-6 | 0 | 0 | | TTL sq wave, 20KHz |
| A2U13-5 | 0 | 0 | | 23.5µs TTL pulses, 20KHz |
| A2U13-9 | 0 | 0 | | 23.5µs TTL pulses, 20KHz |
| A2U14-2 | 40 | 0 | POWER LIMIT fully CCW | Lo |
| A2U19-8 | 40 | 0 | | Lo |
| A2U13-9 | 40 | 0 | | Lo |
| A2U17-6 | 40 | 0 | | Lo |
| A2U13-13 | 40 | 0 | | Lo |
| A2U13-5 | 40 | 0 | | Lo |
| A2U17-6 | 40 | 0 | POWER LIMIT fully CCW | groups of 4 pulses, 1.7µs, TTL, 20KHz |
| A2U13-5 | 40 | 0 | | 1.7µs, TTL, 20KHz |
| +OUT | 40 | 15 | | ≈ 12.2Vdc (OVERRANGE); 6038A |
| +OUT | 40 | 2 | | 3.8Vdc (OVERRANGE); 6033A |
| +OUT | 40 | 2 | short A2J3-4 to A2J3-8 | 2.0Vdc (CV) |
| +OUT | 40 | 2 | | 0.0Vdc |

Principles of Operation

Introduction

This chapter contains block diagrams, simplified schematics, and related descriptions of the power supply. The instrument can be thought of as comprising two major sections: the HP-IB, microcomputer, and interface circuitry; and the power mesh and control circuits. Block diagrams represent the HP-IB board, the front panel board, and the power mesh and control board. The descriptions associated with these block diagrams explain the function of each block without describing how individual components within the circuit accomplish that function. Detailed descriptions are provided only for those individual circuits whose operation may not be obvious to the user.

The circuit names and layouts of the block diagrams are the same as used on the complete schematics; however, some items, such as bias supplies, are left off the block diagrams for clarity. In general, circuits are described as they appear on the diagrams from left to right. Signal names that appear on the drawings are printed in capitals in the descriptions, as are front-panel labels for indicators and controls. Signal names that describe an operating mode or condition are active when that condition exists. For example, OT is high and \overline{OT} is low if an overtemperature condition exists. Signal flow is from left to right and top to bottom, unless arrows indicate otherwise.

The following paragraphs describe the HP-IB and the front-panel board. These circuits provide the interface between the power mesh circuits and the controller and/or operator. The HP-IB and front-panel boards are referenced to earth common. Isolation is achieved by optical isolators on the HP-IB board. Data is sent between boards serially.

HP-IB Board

Circuits on the HP-IB board, see Figure 4-1, provide the interface between the power supply and the user, generate the fault/inhibit and relay controls signals (DFI/RI), and supply the analog control and reference signals for the power mesh and readback circuit. Two microprocessors (primary and secondary) control all data communication between the power supply and the user. Additional circuits on the HP-IB board include the serial interface ports, address switches, an EEPROM, and status registers.

Primary Microprocessor

The primary microprocessor controls the HP-IB/serial link interface, the front panel data communication, and the DFI/RI interface. It communicates with the secondary microprocessor through two serial link data lines that are optically coupled to provide the proper isolation of the user interface from the power mesh. The HP-IB board also has a ROM, which contains the operating firmware, and a RAM, which stores variables such as programmed voltage and current and readback values.

Address Switches

The primary microprocessor determines the HP-IB address by reading the address switch settings. Two of the address switches determine the power-on SRQ state and the DFI/RI port setting.

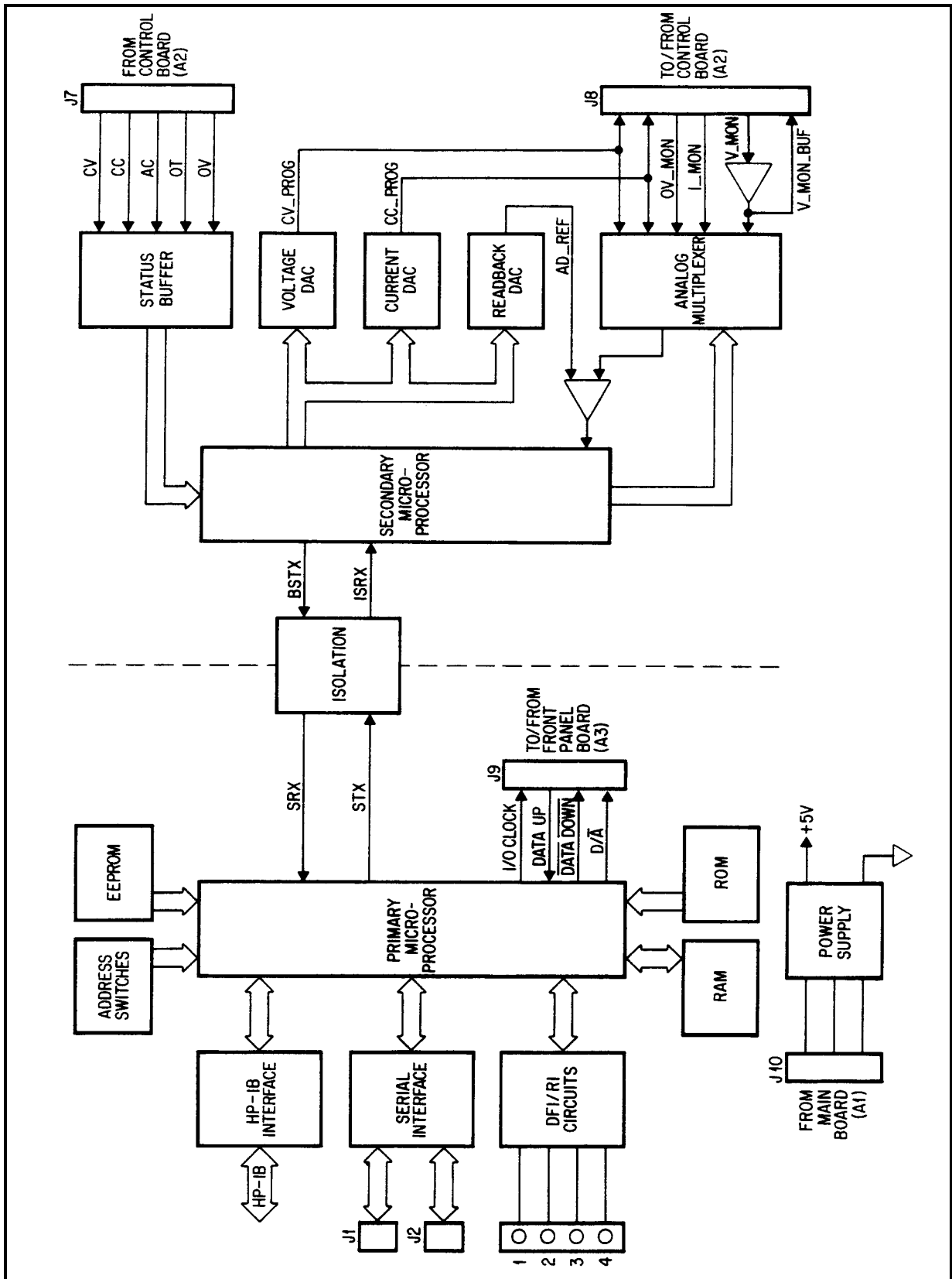


Figure 4-1. HP-IB Block Diagram

EEPROM

The primary microprocessor determines the power supply ID, start-up parameters, calibration constants and scale factors by reading the factory-initialized EEPROM.

Isolation

Two optical isolators transmit serial data between the primary and secondary microprocessors while maintaining electrical isolation between the controller/user-interface and the power mesh.

Secondary Microprocessor

The secondary microprocessor translates the serial data from the primary microprocessor into a parallel data bus and other control signals. Values are loaded into the voltage, current, and readback DAC via the data bus. The secondary microprocessor also controls the analog multiplexer, which is used when reading back the actual output.

Digital-to-Analog Converters

Output voltage and current are controlled by two 12-bit DACs whose digital inputs are directly connected to the secondary microprocessor. The microprocessor programs the DACs according to data received over the HP-IB or from the front panel rotary pulse generator. The DAC circuits also include buffers and compensation amplifiers.

The 12-bit readback DAC is connected to the input of a comparator where its output is compared to the unknown voltage output of the analog multiplexer. The secondary microprocessor programs the output of the readback DAC starting with the MSB and continuing down to the LSB. Each bit is programmed either on or off until the output of the DAC is closest to the unknown voltage output of the multiplexer. At this point, the microprocessor returns the programmed value of the readback DAC.

Analog Multiplexer

The analog multiplexer selects one of five input voltages to be compared to the readback DAC. This comparison allows the microprocessor to determine the value of the input voltage. The five inputs of the multiplexer are: CV_PROG and CC_PROG, which are only used during selftest, at power-on, or in response to the TEST? query when the supply is disabled; OV_MON, which represents the overvoltage trip setting; and I_MON and V_MON, which represent the measured values of output current and voltage.

Status Inputs

The status inputs from the main board provide the following status information to the secondary microprocessor. They are: CC, which is set when the supply is operating in constant current mode; CV, which is set when the supply is in constant voltage mode; AC_FAULT, which signals that ac power has dropped below the minimum operating voltage of the supply; OT, which indicates an overtemperature condition has occurred on the supply; and OV, which indicates an overvoltage has occurred on the supply.

Front Panel Board

The front-panel board, see Figure 4-2, contains the VOLTS and AMPS display circuits, the rotary pulse generator (RPG) and RPG decoders, five pushbutton switches, mode indicators, and the OVP ADJUST potentiometer. Data from the microprocessor is shifted to the display circuits via $\overline{\text{DATA DOWN}}$, and data from the front-panel controls circuits is shifted to the microprocessor via DATA UP. Circuits on the front-panel board operate from bias voltages supplied from the HP-IB board, and are referenced to the same common as the HP-IB board (earth ground). The OVP ADJUST potentiometer is part of the power mesh control circuitry (referenced to power supply negative output), and is not connected to any circuits on the front-panel board.

Address Latches and Decoders

DATA DOWN bits received while D / \overline{A} is low are latched and decoded in this circuit, which then steers clock pulses to the addressed circuit when D / \overline{A} goes high.

Volts and Amps Output Ports and Displays

These circuits display values sent by the microprocessor via DATA DOWN. Normally, these are the actual output voltage and current readings. Pressing the DISPLAY SETTINGS switch causes the microprocessor to send the voltage and current values that have been sent by the controller (remote) or RPG (local). If the unit is in CV mode, the voltage display should show the same reading for actual and set values; the current display will switch from the actual value to the current limit. In CC mode, the current readings will be the same and the voltage display will switch from actual value to the voltage limit. Pressing the DISPLAY OVP switch causes the voltage display to show the OVP trip voltage that has been set.

The microprocessor also uses the readout to display the HP-IB address switch settings, self-test error messages, and readback overrange conditions.

RPG and Latches

When rotated, the RPG produces two pulse trains that are 90 degrees phase shifted from each other, with the phase relationship determined by the direction of rotation. This circuit contains two flip-flops that monitor the RPG outputs. The output of one flip-flop goes low to indicate that the RPG has been rotated, and the output of the other goes low to indicate CW rotation or high to indicate CCW rotation. This data is loaded into an input port when D / \overline{A} is low, and the flip-flops are set back to their quiescent state by clock pulses from the address decoder when the input port is addressed.

Because the microprocessor reads the input approximately every millisecond, it can determine if the RPG is being turned rapidly (for a large change) or slowly (for fine adjustment), and the microprocessor varies the rate it changes the DAC inputs accordingly.

Front-Panel Switches and Input Port

Five front-panel pushbutton switches plus the two RPG flip-flop outputs are connected to this input port. Data is loaded when D / \overline{A} is low, and is shifted out by clock pulses from the address decoders. The microprocessor reads data in via DATA UP approximately every millisecond, and checks the switches every 10ms, thereby ensuring that even rapid switch operations will be captured.

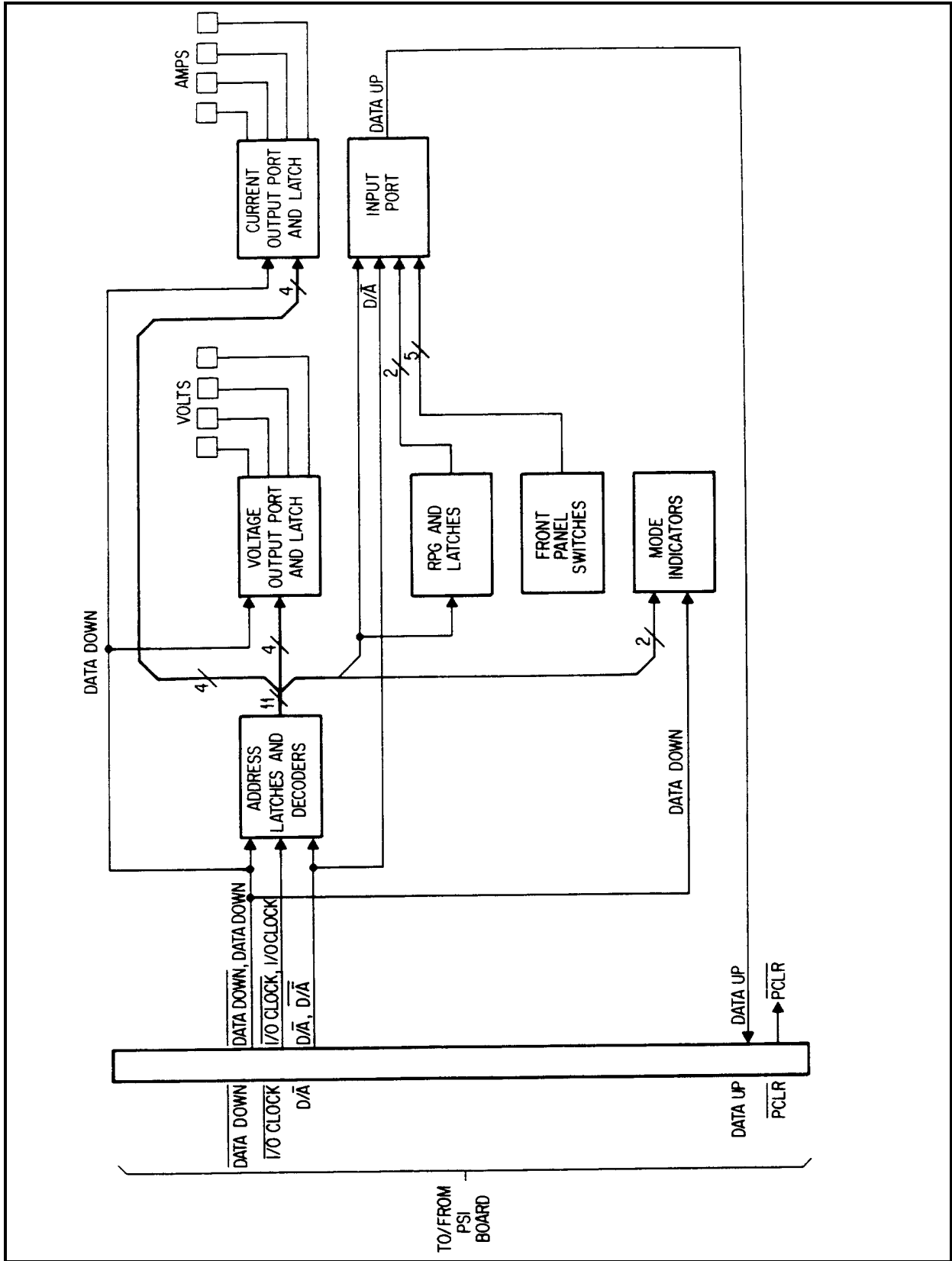


Figure 4-2. Front Panel Block Diagram

Mode Indicators

The front-panel mode indicators are controlled by the microprocessor via DATA DOWN and the mode indicator output ports and latches. DATA DOWN signals are shifted in by clock pulses from the address decoders.

OVP Adjust Control

The OVP ADJUST potentiometer sets the voltage level at which the overvoltage protection (OVP) circuit trips.

Power Clear

The power clear signal ($\overline{\text{PCLR}}$) from the HP-IB board goes low when the unit is turned on, and remains low until the bias power supplies have stabilized. This low level resets the display-circuit latches on the front panel board, causing all indicators and display segments to turn on and remain on until the microprocessor updates the display (approximately one second).

Power Mesh and Control Board

The basic operating concepts of the power mesh and control circuits are described in the following paragraphs. The beginning paragraphs describe the basic difference between an autoranging power supply and a conventional CV/CC power supply in terms of the available output, and provide an overview of the basic theory of operation. Later paragraphs describe the functions of the individual circuits on the power mesh and control board.

Overview

The basic difference between an autoranging power supply and conventional types of Constant Voltage/Constant Current (CV/CC) power supplies can be seen by comparing the maximum-output-power characteristics of each. A conventional CV/CC power supply can provide maximum output power at only one combination of output voltage and current, as shown in Figure 4-3a. The range of a power supply can be extended by designing an instrument with two or more switch-selectable voltage/current ranges within the maximum power-output capability, as shown in Figure 4-3b. An autoranging power supply provides maximum output power over a wide and continuous range of voltage and current combinations, as shown in Figure 4-3c, without the operator having to select the proper output range.

The unit is a flyback-type switching power supply, so-called from the flyback technique of generating high voltage in television receivers. Energy is stored in the magnetic field within a transformer while current flows in the primary, and is transferred to the secondary circuit when current flow in the primary is turned off. Current flow in the primary is controlled by FET switches which are turned on and off at a 20KHz rate by a pulse width modulator. Regulation is accomplished by controlling the on time of the FET switches. On pulses are initiated by a clock circuit. Off pulses are initiated when current flow in the primary has stored enough energy for the output circuit, which is determined as follows.

Sense voltages representing the actual output voltage and current are compared to reference voltages set either by front-panel controls or remote programming signals. These comparisons produce a control voltage, which represents the amount of power required by the output circuit. Current flow in the primary circuit produces a ramp voltage that represents the amount of energy being stored for transfer to the output circuit. An off pulse is generated when the ramp voltage exceeds the control voltage. It can be seen that the power available in the output circuit corresponds to the duty cycle of the FET switches.

Figure 4-4 shows the relationship of various signals associated with the FET on/off cycle.

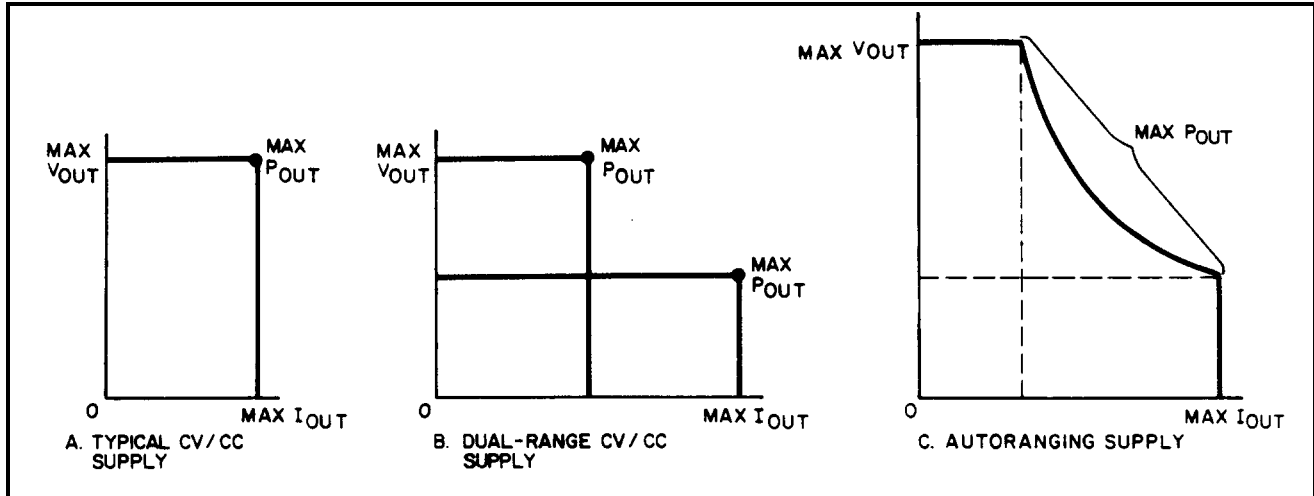


Figure 4-3. Output Characteristics; Typical, Dual Range, and Autoranging Supplies

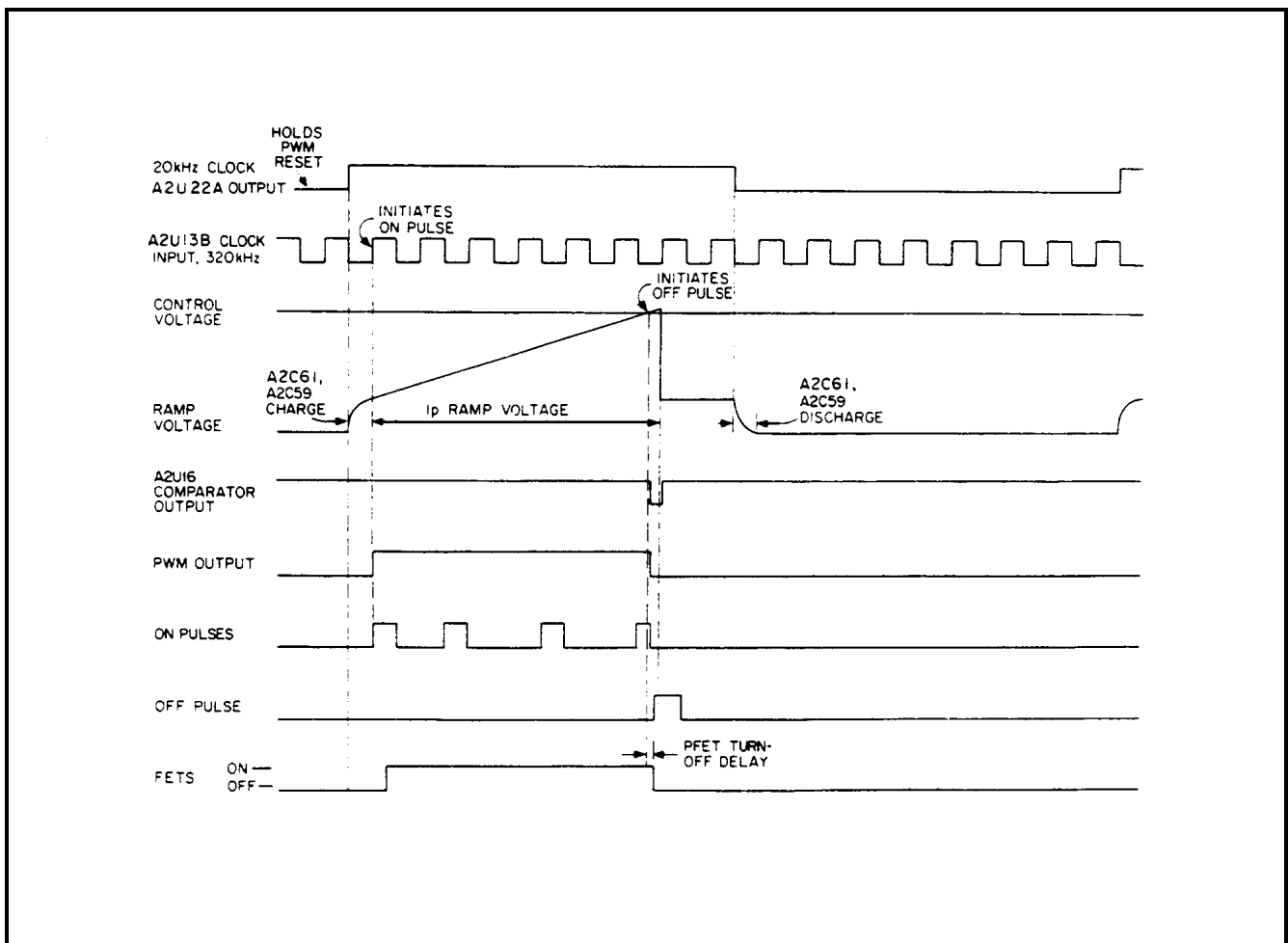


Figure 4-4. FET Control Signals Timing Diagram

Figure 4-5 is a block diagram of the power mesh. These circuits convert the ac input power to approximately 300Vdc, and convert this dc voltage to the proper dc output voltage.

AC Turn-On Circuits

Primary power comes to the input rectifier through a resistor which limits turn-on inrush current to the input filter. Jumper A1W5 connects the input rectifier and filter as a voltage doubler for 100/120Vac power lines. This jumper is not used for 220/240Vac; thus the input filter develops a dc bus voltage of about 300Vdc for either 100/120 or 220/240Vac power line voltages. Primary power also comes through line-voltage select switches to the bias power supplies, which provide the internal operating voltage for the power supply. The line-voltage select switches connect the primary winds of the bias-supplies transformer for operation at 100, 120, 220, or 240Vac.

The unit checks that the + 5Vdc bias voltage and the ac power line voltage are within acceptable limits as part of its turn-on sequence. When + 5Vdc comes up, the bias voltage detector resets the overvoltage protection circuit, enables the on-pulse driver for the PFET switches, and with the ac-surge-&-dropout detector starts the 1-second-delay circuit. After one second, relay A1K1 bypasses the inrush current-limiting resistor. After 0.1 seconds more, the 1-Second-Delay circuit enables the PWM through the DROPOUT signal. The power supply can then provide output power.

When the ac-surge-&-dropout detector detects high or low line voltage, the unit shuts down until an acceptable power-line voltage returns. Then it repeats the above turn-on sequence. This protects the unit from damage from power-line surges and brownouts.

DC-to-DC Converter

PFET switches A4Q3 and A4Q4 control current flow from the Input Filter through power transformer T1. The PWM creates on- and off-pulses for the PFETs. A train of on pulses comes through diodes A4CR4 and A4CR3 to the PFETs' gates to turn on the PFETs. The PFETs' input capacitances hold the PFETs on between on pulses. Off pulses turn on transistors A4Q1 and A4Q2 which then short the PFETs' input capacitances and turn off the PFETs.

The on-pulse one-shot A2U15B and off-pulse one-shot A2U15A generate the on and off pulses. A2U15A produces a train of 160 KHz on pulses during the PWM output pulse. Off pulse one-shot A2U15A triggers an off pulse at each trailing edge of the PWM output pulses. Figure 4-5 shows the timing. Driver circuits increase the current drive capability before applying the pulses to pulse transformers A4T1 and A4T2.

When the PFETs turn on, current flows through the primary of power transformer AIT1 and primary-current monitor transformer A4T3. The output rectifier A4CR7 is reverse biased and blocks current flow in the AIT1 secondary. Consequently, the AIT1 transformer stores energy. When the PFETs apply the dc bus voltage to the primary, the primary current ramps up, storing more and more energy. The A4T3 transformer senses the AIT1 primary current, and the secondary of A4T3 develops the Ip-RAMP VOLTAGE across resistor A2R108. This linearity increasing voltage predicts the correction in the supply's output voltage or current which will occur when the PFETs are turned off. Comparators monitoring the Ip-RAMP VOLTAGE signal the PWM to turn off the PFETs when Ip-RAMP VOLTAGE exceeds either the CP CONTROL-PORT voltage or the POWER-LIMIT reference voltage.

When the PFETs turn off, the collapsing magnetic field reverses the polarity of the voltages across the AIT1 primary and secondary, and current flows from the AIT2 secondary through output rectifier A4CR7 to charge output capacitor A1C8, A1C9 and A1C10. When the PFETs turn off, the leakage inductance of T1 forces the current to continue to flow in the primary. Flyback Diodes A4CR13 and A4CR14 protect the PFETs from excess reverse voltage by conducting this current around the PFETs and back to the input filter.

Down Programmer

This circuit allows the output voltage to be lowered rapidly when required. In order to lower the output voltage it is necessary to discharge the output filter capacitors (typically, through the load). In situations that require the output voltage to drop more rapidly than can be accomplished through the load, the Down Programmer discharges the capacitors and pulls the output line low. Five conditions can trigger down programming: programming of a lower output voltage, overvoltage, overtemperature, remote disable, or primary power failure. The Down Programmer turns on when either MASTER ENABLE is low or the CV ERROR VOLTAGE is more negative than about -6Vdc.

The + 8.9Vdc bias supply for the Down Programmer stores enough energy in its input capacitor to operate the Down Programmer after loss of primary power. This ensures that the Down Programmer will be able to discharge the output circuit completely when primary power is turned off.

Bleeder Circuit (6038A only)

This circuit enables the output capacitor to discharge faster by providing ample bleed current at various output levels, (thereby improving Down Programming times). The path for the bleed current is provided by one of two transistors, A1Q1 or A1Q2. At output voltages below 13 to 15.5Vdc, transistor A1Q2 is turned on to supply milliamperes of bleed current. When the output voltage is above 13 to 15.5Vdc, transistor A1Q1 is turned on, turning off A1Q2.

Fuse A1F3 provides protection to internal components should A1Q2 short and draw excessive current. Down programming response time at no load will be considerably longer if components malfunction in the bleeder circuit or if fuse A1F3 is blown.

Constant-Voltage (CV) Circuit

The constant-voltage circuit compares the output voltage to the user-set CV PROGRAM VOLTAGE to produce CV CONTROL VOLTAGE. Two comparison amplifier loops accomplish the comparison. In the outerloop, CV error amplifier A2U8 compares V-MON, a buffered fraction of the sensed output voltage OVS, to the programming voltage from the HP-IB board, to create the CV ERROR VOLTAGE. Then in the innerloop, amplifier A2U10A compares this error voltage to IVS, a buffered fraction of the innerloop output voltage, to produce the CV CONTROL VOLTAGE. The CV ERROR VOLTAGE is also diode-OR connected through diode A2CR21 as an input to the down programmer.

V-MON also connects through protective circuitry to rear-panel terminal VM for remote monitoring of the output voltage. As output varies from zero to full scale, V-MON varies from 0 to + 5 volts.

Settings of the CV programming switches--the B6, B5 and B4 MODE switch settings--allow the CV PROGRAM VOLTAGE to come from the HP-IB board, from an external voltage applied between rear-panel terminals VP and \downarrow P, or from an external resistor between VP and \downarrow P. When using an external resistor, current from the CV constant-current source flows through the applicable resistance to develop the CV PROGRAM VOLTAGE.

In CV mode the CV CONTROL VOLTAGE varies between about - 0.5Vdc and about + 1.0Vdc. It is most negative when the load is drawing no power. As the load draws more power, the voltage becomes more positive. The CV CONTROL VOLTAGE is at the cathode of diode A2CR24, part of the diode-OR input to the control-voltage comparator. Diode A2CR20 prevents voltage overshoots during transient load changes and program changes.

Constant-Current (CC) Circuit

The constant-current circuit compares the output current user-set CC PROGRAM VOLTAGE to produce CC CONTROL VOLTAGE. As with the CV Circuit, two comparison amplifier loops accomplish the comparison. OCS is the voltage across current-monitoring resistors A1R27 and A1R28, and it senses the output current for the outerloop. To compensate for the fraction of the output current which flows through the unit's output-voltage sensing resistors, CC monitor amplifier A2U1 adds a fraction of VMON to OCS. It amplifies both to produce the outerloop current-sense voltage, I-MON.

I-MON also connects through protective circuitry to rear-panel terminal IM for remote monitoring of the output current. As output varies from zero to full scale, I-MON varies from 0 to + 5 volts.

Differentiation of IVS develops a current proportional voltage which senses the interloop current flowing into the capacitive output filter. CC error amplifier A2U2B sums this differentiated innerloop voltage with I-MON and compares the sum to the CC PROGRAM VOLTAGE to produce CC CONTROL VOLTAGE. In CC mode the CC CONTROL VOLTAGE varies between about -0.5 Vdc and about +1.0Vdc at the cathode of diode A2CR19. CC clamp A2U2A limits CC PROGRAM VOLTAGE to about 5.6 peak volts.

Settings of the rear-panel CC programming switches--the B3, B2 and B1 MODE switch settings--allow the CC PROGRAM VOLTAGE to come from the HP-IB board, from an external voltage applied between terminals IP and ∇ P, or from an external resistor between IP and ∇ P. When using an external resistor, current from the CC constant-current source flows through the resistance to develop CC PROGRAM VOLTAGE.

Overvoltage Protection (OVP) Circuit

The OVP circuit monitors the power supply output voltage and compares it to a preset limit determined by a front-panel OVP ADJUST potentiometer. If the output voltage exceeds the limit, the OVP Circuit initiates a PWM OFF pulse, which also triggers the Down Programmer. The OVP Circuit latches itself until it receives OV CLEAR or ac power is turned off. The bias voltage detector resets the OVP at turn-on of the unit.

Power-Limit Comparator

Two comparisons with Ip-RAMP VOLTAGE provide POWER LIMIT and CONTROL V LIMIT, two of the four inputs for the PWM. Power Limit is the output of the Power Limit Comparator A2U14A. The comparator compares Ip-RAMP VOLTAGE with the power-limit reference voltage of about 1.0Vdc. The reference is adjustable with the POWER LIMIT calibration trim pot A2R25. POWER LIMIT sets the maximum primary current in power transformer A1T1 by going low and turning off the PWM when Ip-RAMP VOLTAGE exceeds the reference.

Primary current is approximately proportional to output power, and POWER LIMIT turns off the PWM when the CONTROL V LIMIT would otherwise allow the unit to deliver more than about 200 watts. This occurs during transient load increases, step increases in CV PROGRAM VOLTAGE and when the combination of the CV PROGRAM VOLTAGE and the CC PROGRAM VOLTAGE calls for more than 200 watts. The power-limit comparator produces the power-limited portion of the unit's output characteristic curve in Figure 4-3 and is the essence of the unit's autoranging characteristic.

Control-Voltage Comparator

The control-voltage comparator A2U16 produces the CONTROL V LIMIT input to the PWM by comparing Ip-RAMP VOLTAGE to CP CONTROL-VOLTAGE. In CV or CC operation CP is one diode-drop more than the lower of the CV and CC CONTROL VOLTAGE. CONTROL V LIMIT goes low and turns off the PWM when Ip-RAMP VOLTAGE exceeds CP. The A2R113-A2R114 voltage divider steers control of CP by its connection at the anodes of series diodes A2CR19 and A2CR24. The A2R113-A2R114 voltage divider sets the maximum CP voltage to + 1.5Vdc. As an illustration of CV-CC selection, suppose the unit is in CV operation and diode A2CR24 is forward biased by a low CV CONTROL VOLTAGE:

then CV sets CP to less than + 1.5Vdc. CV keeps diodes A2CR19 reverse biased and prevents CC control until the CC CONTROL VOLTAGE is even lower.

The lower of the control voltages varies between about - 0.5Vdc and + 1.0Vdc regulating the unit's output. The higher control voltage has no effect on the output and increases in response to the error voltage in its circuit. When higher, the CC CONTROL VOLTAGE limits at about 6Vdc. When higher, the CV CONTROL VOLTAGE increases only slightly. In CV or CC mode CP remains one diode drop more than the lower control voltage and varies from about 0.0 to + 1.5Vdc. In UNREGULATED mode CP is + 1.0Vdc.

Initial-Ramp Circuit

The control voltage and ramp voltage waveforms in Figure 4-4 show that there is a time delay between when the control voltage is exceeded and when the PFETS turn off. This cumulative circuit delay causes the PFETS to deliver power even when no power is requested by the control circuits. To eliminate the delay, the initial-ramp circuit adds a ramp voltage to Ip-RAM VOLTAGE at the input to the control voltage comparator. The added ramp voltage starts with the 20KHz clock pulse and causes the combined-ramp voltage to exceed the control voltage earlier, thereby essentially eliminated the PFET turn-off delay. A two-state RC integrating network consisting of resistors A2R116 and A2R117 and capacitors A2C59 and A2C61 creates the initial ramp by shaping the 20KHz clock pulses.

Pulse-Width Modulator (PWM)

The PWM generates 20 KHz repetition-rate pulses which vary in length according to the unit's output requirements. The pulses start 1.5 μ s after each 20KHz clock pulse and turn off when any of these four inputs go low: The output of the control-voltage comparator (CONTROL V LIMIT), the output of the power-limit comparator (POWER LIMIT), the 20 KHz clock pulse (50% duty cycle limit), or the output of the inhibit gate A2U19A (MASTER ENABLE). As discussed on Page 68, the PFETs turn on during and turn off at the trailing edges, respectively, of PWM output pulses.

The PWM generates pulses as follows: a 20KHz dock pulse holds the 1.5 μ s-delay flip-flop A2U13B reset; 1.5 μ s after the trailing edge of the 20KHz pulse, the next pulse from the 320 KHz clock oscillator clocks the output of A2U13B high, and this initiates the PWM pulse from PWM flip-flop A2U13A. When one of the above four inputs to AND-gate A2U19B goes low, A2U19B resets A2U13A, and the PWM pulse turns off.

Bias Voltage Detector

The bias voltage detector prevents spurious operation, which might occur at turn-on, of the unit if circuits tried to operate before the + 5Vdc bias voltage is at the clock, PWM, and logic circuits. After turn-on, as the output of the + 5Vdc bias supply rises from 0Vdc through 1Vdc, three transistor switches in the Bias Voltage Detector turn on. They inhibit the Relay Driver and the On-Pulse Driver, and they create the power clear signal, $\overline{\text{PCLR2}}$. The transistors inhibit the circuits and hold $\overline{\text{PCLR2}}$ low until the unregulated input to the + 5Vdc bias supply is greater than about 11Vdc, an input voltage sufficient to assure + 5Vdc bias output. PCLR2 resets the OVP at turn-on.

AC-Surge-&-Dropout Detector

The ac-surge-&-dropout detector protects the unit from damage from power line voltage surges and dropouts by shutting down the unit when there is either a 40% overvoltage or a 20ms voltage interruption in the ac power line voltage. The detector shuts down the unit by inhibiting the PWM through the DROPOUT signal from the 1-Second Delay circuit. Line Detect signal, which is fullwave-rectified ac from the + 5Vdc secondary of the bias-supplies transformer, senses the power line voltage.

The dropout detector, including comparators A2U20A and A2U20D, operates by enabling a capacitor timing ramp when UNE DETECT ceases. Comparator A2U20C monitors the amplitude of UNE DETECT to provide highline voltage detection.

1-Second-Delay Circuit

The 1-second-delay circuit is the heart of the unit's controlled turn on. It causes relay A1K1 to bypass inrush current-limiting resistor A1R1 one second after turn on, and it enables the PWM 0.1 second later. When either the output of the ac-surge-&-dropout detector or $\overline{\text{PCLR2}}$ is low NAND gate A2U11A holds the circuit reset. The circuit starts counting at 1/16 the clock frequency (1.25 KHz) when both inputs to A2U11A are high and causes RELAY ENABLE to go high in 1.0 seconds and $\overline{\text{DROPOUT}}$ to go high in 1.1 seconds. When $\overline{\text{DROPOUT}}$ goes high, it stops the count, and it enables the PWM.

Replaceable Parts

Introduction

This chapter contains information for ordering replacement parts. Table 5-3 lists parts in alpha-numeric order by reference designators and provides the following information:

- a. Reference Designators. Refer to Table 5-1.
- b. Hewlett-Packard model in which the particular part is used.
- c. Hewlett-Packard Part Number.
- d. Description. Refer to Table 5-2 for abbreviations.

Parts not identified by reference designator are listed at the end of Table 5-4 under Mechanical and/or Miscellaneous.

Table 5-1. Reference Designators

| | |
|----|---------------------------------|
| A | Assembly |
| B | Blower |
| C | Capacitor |
| CR | Diode |
| DS | Signaling Device (light) |
| F | Fuse |
| FL | Filter |
| G | Pulse Generator |
| J | Jack |
| K | Relay |
| L | Inductor |
| Q | Transistor |
| RT | Thermistor Disc |
| S | Switch |
| T | Transformer |
| TB | Terminal Block |
| TS | Thermal Switch |
| U | Integrated Circuit |
| VR | Voltage Regulator (Zener diode) |
| W | Wire (Jumper) |
| X | Socket* |
| Y | Oscillator |

* Reference designator following "X" (e.g. XA2) indicates assembly or device mounted in socket.

Ordering Information

To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office. Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 5-3, give a complete description of the part, its function, and its location.

Table 5-2. Description Abbreviations

| | |
|-----------------|---------------------------------------|
| ADDR | Addressable |
| ASSY | Assembly |
| AWG | American Wire Gauge |
| BUFF | Buffer |
| CER | Ceramic |
| COMP | Carbon Film Composition |
| CONV | Converter |
| DECODER/DEMULTI | Decoder/Demultiplexer |
| ELECT | Electrolytic |
| EPROM | Erasable Programable Read-Only Memory |
| FET | Field Effect Transistor |
| FF | Flip-Flop |
| FXD | Fixed |
| IC | Integrated Circuit |
| INP | Input |
| LED | Light Emitting Diode |
| MET | Metalized |
| MOS | Metal-Oxide Silicon |
| OP AMP | Operational Amplifier |
| OPTO | Optical |
| OVP | Over Voltage Protection |
| PCB | Printed Circuit Board |
| PORC | Porcelain |
| POS | Positive |
| PRIOR | Priority |
| ROM | Read-Only Memory |
| RAM | Random Access Memory |
| RECT | Rectifier |
| REGIS | Register |
| RES | Resistor |
| TBAX | Tube Axial |
| TRIG | Triggered |
| UNI | Universal |
| VAR | Variable |
| VLTG REG | Voltage Regulator |
| WW | Wire Wound |

Table 5-3. Replaceable Parts List

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|--|
| A1 | 6033A | 06023-60021 | Main Board Assembly |
| | 6038A | 06038-60021 | Main Board Assembly |
| C1 | both | 0160-7606 | cap 1 μ F +10% 50Vac |
| C2,3 | both | 0180-3426 | cap 590 μ F +50-10% 400V |
| C4 | both | 0180-3427 | cap 300 μ F +50-10% 200V |
| C5 | both | 0160-7606 | cap 1 μ F +20% 250V |
| C6,7 | both | 0160-5933 | cap 0.022 μ F 10% 1500V |
| C8-10 | 6033A | 0180-3425 | cap 5500 μ F 10V |
| | 6038A | 0180-3548 | cap 1700 μ F 75V |
| C11,12 | 6033A | 0160-5377 | cap 2.2 μ F 100V |
| | 6038A | 0160-6167 | cap 2.2 μ F 63V |
| C13,14 | both | 0160-7731 | cap 0.22 μ F 10% 1500V |
| C15,16 | both | 0160-4355 | cap 0.01 μ F +10% 250V |
| C17 | 6033A | 0160-5422 | cap 0.047 μ F +20% 100V |
| | 6038A | 0160-4834 | cap 0.047 μ F +20% 50V |
| C20,21 | both | 0180-3428 | cap 1000 μ F 50V |
| C22,23 | both | 0160-4439 | cap 4700pF +20% 250V |
| C24,25 | both | 0160-4281 | cap 2200pF 20% 250V |
| C26 | both | 0160-4323 | cap 0.047 μ F 20% 250V |
| CR1-4 | both | 1901-1199 | diode-power rectifier 600V 3A |
| CR6,7 | both | 1901-0731 | diode-power rectifier 400V 1A |
| CR8,9 | both | 1901-0050 | diode-switching 80V 200mA |
| CR13-15 | both | 1901-0731 | diode-power rectifier 400V 1A |
| F2 | both | 2110-0007 | fuse 1A 250V |
| F3 | 6038A | 2110-0763 | fuse, 1/4A 125V |
| J1 | both | 1251-5927 | connector, 26-contact |
| J2 | both | 1251-5384 | connector, 3-contact |
| J3 | both | 1251-8676 | connector, 5-contact |
| K1 | both | 0490-1417 | relay, DPST |
| L1 | both | 06024-80094 | choke, RFI, 3A (magnetic core 9170-0721) |
| L3 | 6033A | 5080-1981 | choke 0.5 μ H |
| | 6038A | 9140-0987 | choke 3 μ H |
| Q1 | 6038A | 1854-0087 | transistor, NPN SI |
| Q2 | 6038A | 1854-0799 | transistor, NPN SI TIP41C |
| R1 | both | 0811-3667 | res 20 5% 7W |
| R2 | 6033A | 0811-1856 | res 250 1% 5W |
| | 6038A | 0811-1865 | res 2K 1% 5W |
| R3 | 6033A | 5080-2007 | res 0.0005 (current sense) |
| R4 | both | 0683-1025 | res 1K 5% 1/4W |
| R5 | 6033A | 8151-0013 | wire, tinned copper, AWG 22 |
| | 6038A | 7175-0057 | wire, tinned copper, AWG 22 |
| R6 | both | 0683-1025 | res 1K 5% 1/4W |
| R7 | 6038A | 0699-1210 | res 80K 0.1% 0.1W |
| R8 | 6033A | 8151-0013 | wire, tinned copper, AWG 22 |
| | 6038A | 0699-0118 | res 20K 0.1% 0.1W |
| R9 | 6033A | 8151-0013 | wire, tinned copper, AWG 22 |
| | 6038A | 7175-0057 | wire, tinned copper, AWG 22 |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|---|
| R10 | 6033A | 8151-0013 | wire, tinned copper, AWG 22 |
| | 6038A | 0698-6359 | res 80K 0.1% 1/8W |
| R11 | both | 0698-6322 | res 4K 0.1% 1/8W |
| R12 | both | 0698-8695 | res 36K 0.1% 1/8W |
| R14 | 6033A | 0698-3572 | res 60.4 1% 1/8W |
| R15 | 6033A | 8151-0013 | wire, tinned copper, AWG 22 |
| | 6038A | 0757-0270 | res 249K 1% 1/4W |
| R17,18 | both | 0683-1005 | res 10 5% 1/4W |
| R19 | both | 0683-1055 | res 1M 5% 1/4W |
| R20,21 | both | 0811-1867 | res 15K 5% 5W |
| R22,23 | both | 0686-1065 | res 10M 5% 1/2W |
| R24,25 | both | 0686-1035 | res 10K 5% 1/2W |
| R26 | both | 0683-3315 | res 330 5% 1/4W |
| R27A,28B | 6038A | 0811-3823 | res 0.1 5% 20W (current sense) |
| R29 | both | 0686-3335 | res 33K 5% 1/2W |
| R30 | 6038A | 0811-1865 | res 2K 1% 5W |
| R31 | 6038A | 0812-0098 | res 135 5% 5W |
| R32 | 6038A | 0683-1035 | res 10K 5% 1/4W |
| R33 | 6038A | 0683-4745 | res 470 5% 1/4W |
| R34 | 6038A | 0683-2035 | res 20K 5% 1/4W |
| S2 | both | 3101-1914 | switch 2-DPDT, slide |
| S4 | both | 3101-2046 | switch DPDT, slide |
| T1 | 6033A | 5080-1978 | transformer, power |
| | 6038A | 06038-80090 | transformer, power |
| T2 | both | 9170-1264 | core, magnetic (used with primary wire 06023-80004) |
| T3 | both | 9100-4864 | transformer, bias |
| T4 | both | 5080-1984 | choke, line 2mH |
| TP1,2 | both | 1251-5613 | connector, single contact |
| U1 | both | 1906 0006 | rectifier bridge 400V 1A |
| VR1,2 | 6038A | 1902-1377 | diode-zener 6.19V 2% |
| W1,2 | both | 06023-80003 | jumper, output 10 AWG |
| XA2P1 | both | 1251-8665 | connector, 30-contact |
| XA2P2 | both | 1251-8667 | connector, 20-contact |
| XA4P1,2 | both | 1251-8806 | connector, DIN 32-contact |
| | | A1 Mechanical | |
| | both | 1480-0552 | pin, escutcheon (L1) |
| | both | 0380-1489 | snap-in spacer |
| | both | 2110-0726 | fuseholder, clip type (F2) |
| | both | 0360-2190 | jumper, local sensing (2) |
| | 6038A | 0360-1833 | barrier block, 6-position |
| | 6033A | 0360-2192 | barrier block, 2-position |
| | 6033A | 06023 00007 | bus bar, negative |
| | 6033A | 06023-00008 | bus bar, positive |
| A2 | 6033A | 06023-60023 | Control Board Assembly |
| | 6038A | 06038 60023 | Control Board Assembly |
| C1 | both | 0160-5469 | cap 1 μ F 10% 50V |
| C2 | both | 0160-5422 | cap 0.047 μ F 20% 50V |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|-------------|----------|----------------|------------------------|
| C3 | 6033A | 0160-4801 | cap 100pF 5% 100V |
| | 6038A | 0160-4812 | cap 220pF 5% |
| C7 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C8 | both | 0160-4812 | cap 220pF 5% 100V |
| C9 | both | 0160-5377 | cap 2.2μF 10% 63V |
| C10,11 | both | 0160-5469 | cap 1μF 10% 50V |
| C12,13 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C14 | both | 0180-0291 | cap 1μF 10% 35V |
| C15 | both | 0180-1731 | cap 4.7μF 10% 50V |
| C16,17 | both | 0180-0230 | cap 1μF 20% 50V |
| C18,19 | both | 0180-0291 | cap 1μF 10% 35V |
| C20 | both | 0180-2624 | cap 2000μF +75-25% 10V |
| C21 | both | 0160-5098 | cap 0.22μF 10% 50V |
| C22 | both | 0160-4832 | cap 0.01μF 10% 100V |
| C23 | both | 0180-3407 | cap 2200μF +50-10% 35V |
| C24 | both | 0160-5098 | cap 0.22μF 10% 50V |
| C25 | both | 0160-4833 | cap 0.022μF 10% 100V |
| C26 | both | 0160-0154 | cap 2200pF 10% 200V |
| C27,28 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C29 | 6033A | 0160-4808 | cap 470pF 5% 100V |
| | 6038A | 0160-4812 | cap 220pF 5% 100V |
| C30 | both | 0160-4830 | cap 2200pF 10% 100V |
| C31 | 6033A | 0160-4808 | cap 470pF 5% 100V |
| | 6038A | 0160-4801 | cap 100pF 5% 100V |
| C32 | both | 0160-4801 | cap 100pF 5% 100V |
| C33-35 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C36 | 6033A | 0160-5422 | cap 0.047μF 20% 50V |
| | 6038A | 0160-4833 | cap 0.022μF 10% 100V |
| C37 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C38 | 6033A | 0160-4801 | cap 100pF 5% 100V |
| | 6038A | 0160-4803 | cap 68pF 5% 100V |
| C39,40 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C41 | both | 0160-4835 | cap 0.1μF 10% 50V |
| C42 | both | 0160-4805 | cap 47pF 5% 100V |
| C43 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C44 | both | 0160-4805 | cap 47pF 5% 100V |
| C45 | 6033A | 0160-4808 | cap 470pF 5% 100V |
| | 6038A | 0160-4810 | cap 330pF 5% 100V |
| C46 | both | 0160-4807 | cap 33pF 5% 100V |
| C47 | both | 0160-4822 | cap 1000pF 5% 100V |
| C48 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C49 | 6033A | 0160-5644 | cap 0.033μF 10% 100V |
| | 6038A | 0160-4833 | cap 0.022μF 10% 100V |
| C50 | 6033A | 0160-0167 | cap 0.082μF 10% 200V |
| | 6038A | 0160-0168 | cap 0.1μF 10% 200V |
| C51 | both | 0160-4801 | cap 100pF 5% 100V |
| C52,53 | both | 0160-4831 | cap 4700pF 10% 100V |
| C54 | both | 0160-5422 | cap 0.047μF 20% 50V |
| C55,56 | both | 0160-4801 | cap 100pF 5% 100V |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|-------------|----------|----------------|---------------------------------|
| C57,58 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C59 | both | 0160-4812 | cap 220pF 5% 100V |
| C60 | both | 0160-5422 | cap 0.047pF 20% 50V |
| C61 | both | 0160-4812 | cap 220pF 5% 100V |
| C62 | both | 0160-5422 | cap 0.047pF 20% 50V |
| C63 | both | 0180-0116 | cap 6.8 μ F 10% 35V |
| C64,65 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C66 | both | 0180-0376 | cap 0.47 μ F 10% 35V |
| C67,68 | both | 0160-4812 | cap 220pF 5% 100V |
| C69 | both | 0160-4832 | cap 0.01 μ F 10% 100V |
| C70 | both | 0180-1980 | cap 1 μ F 5% 35V |
| C71 | both | 0160-5422 | cap 0.047pF 20% 50V |
| C72 | 6038A | 0160-5422 | cap 0.047pF 20% 50V |
| CR1,2 | both | 1901-0033 | diode-gen purp 180V 200mA |
| CR3 | both | 1901-0050 | diode-switching 80V 200mA |
| CR5-7 | both | 1901-0033 | diode-gen purp 180V 200mA |
| CR8-10 | both | 1901-0050 | diode-switching 80V 200mA |
| CR11 | both | 1901-0992 | diode-power rectifier 40V 3A |
| CR12-16 | both | 1901-0033 | diode-gen purp 180V 200mA |
| CR18 | both | 1901-0033 | diode-gen purp 180V 200mA |
| CR19 | both | 1901-0050 | diode-switching 80V 200mA |
| CR20 | both | 1901-0033 | diode-gen purp 180V 200mA |
| CR21-30 | both | 1901-0050 | diode-switching 80V 200mA |
| J1,2 | both | 1251-8417 | connector, 16-contact |
| L1 | both | 06023-80090 | choke, bias, 820 μ H |
| P1 | both | 1251-8664 | connector, 30-contact |
| P2 | both | 1251-8666 | connector, 20-contact |
| Q1,2 | both | 1855-0413 | transistor, J-FET P-chan 2N5116 |
| Q3 | both | 1854-0635 | transistor, NPN SI D44H5 |
| Q4 | both | 1853-0012 | transistor, PNP SI 2N2904A |
| Q5 | both | 1854-0823 | transistor, NPN SI |
| Q6 | both | 1858-0023 | transistor array CA3081E |
| Q7 | 6038A | 1854-0087 | transistor, NPN SI |
| R1 | both | 0683-5125 | res 5.1K 1/2W |
| R2 | 6033A | 0757-4715 | res 470 1% 1/8W |
| | 6038A | 0757-0419 | res 681 1% 1/8W |
| R3 | 6033A | 0698-6329 | res 845 1% 1/8W |
| | 6038A | 0698-6393 | res 585 1% 1/8W |
| R4 | both | 0683-1035 | res 10K 5% 1/4W |
| R5 | 6033A | 0699-7880 | res 28.7K 1% 1/8W |
| | 6038A | 0699-0774 | res 6.65K 1% 1/8W |
| R6 | both | 0683-5125 | res 5.1k 5% 1/4W |
| R7 | both | 0683-4745 | res 470K 5% 1/4W |
| R8 | both | 2100-3353 | trimmer 20K side adjust |
| R9 | 6033A | 2100-3350 | trimmer 200 side adjust |
| | 6038A | 2100-3993 | trimmer 200 side adjust |
| R10 | 6033A | 0757-5625 | res 5.6K 1% 1/8W |
| | 6038A | 0757-0427 | res 1.5K 1% 1/8W |
| R11 | 6033A | 0698-3136 | res 17.8K 1% |
| | 6038A | 0683-1025 | res 1K 5% 1/4W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|-------------------------|
| R12 | both | 0683-1025 | res 1K 5% 1/4W |
| R13 | both | 0683-2735 | res 27K 5% 1/4W |
| R14 | both | 0686-5125 | res 5.1K 1/2W |
| R15 | both | 0683-2015 | res 200 5% 1/4W |
| R16 | 6033A | 0683-3355 | res 3.3M 5% 1/4W |
| | 6038A | 0683-2255 | res 2.2M 5% 1/4W |
| R17 | 6033A | 0683-6835 | res 68k 5% 1/8W |
| | 6038A | 0757-0289 | res 13.3K 1% 1/8W |
| R18 | 6033A | 0683-3035 | res 30K 5% 1/4W |
| | 6038A | 0757-0449 | res 20K 1% 1/8W |
| R19 | 6033A | 0683-4735 | res 47K 5% 1/4W |
| | 6038A | 0757-0449 | res 20K 1% 1/8W |
| R20 | both | 0683-1035 | res 10K 5% 1/4W |
| R21 | 6033A | 2100-3350 | trimmer 200 side adjust |
| | 6038A | 2100-3273 | trimmer 2K side adjust |
| R22 | both | 2100-3353 | trimmer 20k side adjust |
| R23 | both | 2100-3273 | trimmer 2K side adjust |
| R24 | both | 2100-3350 | trimmer 200 side adjust |
| R25 | both | 2100-3207 | trimmer 5K side adjust |
| R26 | both | 0683-1045 | res 100K 5% 1/4W |
| R27 | both | 0698-6322 | res 4K 0.1% 1/8W |
| R28 | both | 0683-1045 | res 100K 5% 1/4W |
| R29 | both | 0698-4416 | res 169 1% 1/8W |
| R30 | both | 0683-7545 | res 750K 5% 1/4W |
| R31 | both | 0698-6322 | res 4K 0.1% 1/8W |
| R32 | both | 0698-4416 | res 169 1% 1/8W |
| R33 | both | 0698-4447 | res 280 1% 1/8W |
| R34 | both | 0757-0404 | res 130 1% 1/8W |
| R35 | both | 0698-4608 | res 806 1% 1/8W |
| R36 | both | 0757-0438 | res 5.11K 1% 1/8W |
| R37,38 | both | 0683-1035 | res 10K 5% 1/4W |
| R39 | both | 0686-2005 | res 20 5% 1/2W |
| R40 | both | 0683-1005 | res 10 5% 1/4W |
| R41,42 | both | 0686-6215 | res 620 5% 1/2W |
| R43 | both | 0683-1515 | res 150 5% 1/4W |
| R44 | both | 0757-0434 | res 3.65K 1% 1/8W |
| R45 | both | 0757-0442 | res 10k 1% 1/8W |
| R46,47 | both | 0757-0283 | res 2K 1% 1/8W |
| R48,49 | both | 0686-1315 | res 130 5% 1/2W |
| R50 | both | 0811-3174 | res 0.07 5% 5W |
| R51 | both | 0698-6076 | res 39K 1% 1/8W |
| R52 | both | 0757-0280 | res 1K 1% 1/8W |
| R53 | both | 0698-4121 | res 11.3K 1% 1/8W |
| R54 | both | 0683-2015 | res 200 5% 1/4W |
| R55 | 6033A | 0683-5655 | res 5.6M 5% 1/4W |
| | 6038A | 0683-1055 | res 1M 5% 1/4W |
| R56 | 6033A | 0757-0408 | res 243 1/4W |
| | 6038A | 0757-0269 | res 270 1/4W |
| R57 | 6033A | 0683-1325 | res 1.3K 5% 1/4W |
| | 6038A | 0683-2015 | res 200 5% 1/4W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|-----------------------------|
| R58 | both | 0683-1045 | res 100K 5% 1/4W |
| R59 | both | 0698-8816 | res 2.15 1% 1/8W |
| R60 | both | 0757-0199 | res 21.5K 1% 1/8W |
| R61 | 6033A | 0699-0059 | res 5K 0.1% 1/8W |
| | 6038A | 0698-6360 | res 10K 0.1% 1/8W |
| R62 | 6033A | 0698-3432 | res 26.1 1% 1/8 W |
| | 6038A | 8159-0005 | wire, tinned copper, AWG 22 |
| R63 | 6033A | 0699-0059 | res 5K 0.1% 1/8W |
| | 6038A | 0698-6360 | res 10K 0.1% 1/8W |
| R64 | both | 0683-5125 | res 5.1K 5% 1/4W |
| R65 | 6033A | 0699-0118 | res 20K 0.1% 0.1W |
| | 6038A | 0699-1210 | res 80K 0.1% 0.1W |
| R66 | 6033A | 0699-0118 | res 20K 0.1% 0.1W |
| | 6038A | 0699-1211 | res 95K 0.1% 0.1W |
| R67,68 | both | 0686-5125 | res 5.1K 5% 1/2W |
| R69 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R70 | both | 0683-2015 | res 200 5% 1/4W |
| R71 | 6033A | 0683-2735 | res 27K 1% 1/8W |
| | 6038A | 0698-5089 | res 33K 1% 1/8W |
| R72 | 6033A | 0757-0465 | res 100K 1% 1/8W |
| | 6038A | 0757-0470 | res 162K 1% 1/8W |
| R73,74 | 6033A | 0683-2035 | res 20K 1% 1/8W |
| | 6038A | 0757-0452 | res 27.4K 1% 1/8W |
| R75 | both | 0683-7545 | res 750K 5% 1/4W |
| R76 | 6033A | 0683-4735 | res 47K 1% 1/8W |
| | 6038A | 0757-0446 | res 15K 1% 1/8W |
| R77 | 6033A | 0683-7545 | res 750K 1% 1/8W |
| | 6038A | 0757-0469 | res 150K 1% 1/8W |
| R78 | 6033A | 0757-0415 | res 475 1% 1/8W |
| | 6038A | 0698-4014 | res 787 1% 1/8W |
| R79 | both | 0698-6983 | res 20.4K 0.1% 1/8W |
| R80 | both | 0698-6320 | res 5K 0.1% 1/8W |
| R81 | both | 0757-0459 | res 56.2K 1% 1/8W |
| R82 | both | 0683-3325 | res 3.3K 5% 1/4W |
| R83 | both | 0757-0270 | res 249K 1% 1/8W |
| R84 | 6033A | 0683-5125 | res 5.1K 1% 1/8W |
| | 6038A | 0757-0442 | res 10K 1% 1/8W |
| R85 | both | 0698-3450 | res 42.2K 1% 1/8W |
| R86 | both | 0757-0452 | res 27.4K 1% 1/8W |
| R87 | both | 0683-2715 | res 270 5% 1/8W |
| R88,89 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R90 | both | 0683-2715 | res 270 5% 1/4W |
| R91 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R92 | both | 0683-2015 | res 200 5% 1/4W |
| R93 | both | 0683-5125 | res 5.1K 5% 1/4W |
| R94 | both | 0683-1035 | res 10K 5% 1/4W |
| R95 | both | 0757-0472 | res 200K 1% 1/8W |
| R96 | 6033A | 0698-3572 | res 60.4K 1% 1/8W |
| | 6038A | 0757-0455 | res 36.5K 1% 1/8W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|---------------------|
| R97 | both | 0683-5125 | res 5.1K 5% 1/4W |
| R98 | both | 0683-2735 | res 27K 5% 1/4W |
| R99 | both | 0683-1035 | res 10K 5% 1/4W |
| R100,101 | both | 1810-0365 | network sip 2.2K X5 |
| R102,103 | both | 0757-0449 | res 20K 1% 1/8W |
| R104 | both | 0757-0280 | res 1K 1% 1/8W |
| R105 | both | 0698-3430 | res 21.5K 1% 1/8W |
| R106 | both | 0698-3449 | res 28.7K 1% 1/8W |
| R107 | both | 0698-3153 | res 3.38K 1% 1/8W |
| R108 | both | 0683-2035 | res 20K 5% 1/4W |
| R109 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R110 | both | 0683-4725 | res 4.7K 5% 1/4W |
| R111 | both | 0683-2025 | res 2K 5% 1/4W |
| R112 | both | 0683-1125 | res 1.1K 5% 1/4W |
| R113 | both | 0757-0442 | res 10K 1% 1/8W |
| R114 | both | 0757-0424 | res 1.1K 1% 1/8W |
| R115 | both | 0683-1015 | res 100 5% 1/4W |
| R116 | both | 0698-3498 | res 8.66K 1% 1/8W |
| R117 | both | 0757-0438 | res 5.11K 1% 1/8W |
| R118 | both | 1810-0365 | network sip 2.2K X5 |
| R119 | both | 0757-0288 | res 9.09 1% 1/8W |
| R120 | both | 0683-1005 | res 10 5% 1/4W |
| R121 | both | 0757-0442 | res 10K 1% 1/8W |
| R122 | both | 0683-5135 | res 51K 5% 1/4W |
| R123-126 | both | 0683-4725 | res 4.7K 5% 1/4W |
| R127 | both | 0683-1855 | res 1.8M 5% 1/4W |
| R128 | both | 0683-6835 | res 68K 5% 1/4W |
| R129 | both | 0757-0439 | res 6.8K 1% 1/8W |
| R130 | both | 0683-1055 | res 1M 5% 1/4W |
| R131 | both | 0683-3335 | res 33K 5% 1/4W |
| R132 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R133 | both | 0683-2735 | res 27K 5% 1/4W |
| R134 | both | 0757-0466 | res 110K 1% 1/8W |
| R135,136 | both | 0757-0442 | res 10K 1% 1/8W |
| R137 | both | 0698-3455 | res 261K 1% 1/8W |
| R138 | both | 0683-2045 | res 200K 5% 1/8W |
| R139 | both | 0757-0442 | res 10K 1% 1/8W |
| R140 | both | 0698-3160 | res 31.6K 1% 1/8W |
| R141 | both | 0683-1025 | res 1K 5% 1/4W |
| R142 | both | 0683-2225 | res 2.2K 5% 1/4W |
| R143 | both | 0683-1045 | res 100K 5% 1/4W |
| R144 | both | 0683-4725 | res 4.7K 5% 1/4W |
| R145 | both | 0683-4715 | res 470 5% 1/4W |
| R146,147 | both | 0683-1125 | res 1.1K 5% 1/4W |
| R148 | both | 0683-3925 | res 3.9K 5% 1/4W |
| R149 | both | 1810-0365 | network sip 2.2K X5 |
| R150,151 | both | 0683-1815 | res 180 5% 1/4W |
| R152 | both | 0683-1025 | res 1K 5% 1/4W |
| R153 | 6038A | 0683-1035 | res 10K 5% 1/4W |
| R155 | 6038A | 0683-1005 | res 10 5% 1/4W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|----------------------------------|
| R156-158 | 6038A | 0683-1005 | res 10 5% 1/4W |
| S1 | both | 3101-2097 | switch 6-1A slide |
| U1 | both | 1826-0493 | IC op amp Lo-bias Hi-impedance |
| U2 | both | 1826-0346 | IC op amp dual general purpose |
| U3 | both | 1826-0161 | IC op amp quad general purpose |
| U4 | both | 1826-0527 | IC voltage regulator 1.2/37V |
| U5 | both | 1826-0544 | IC voltage reference 2.5V |
| U6 | both | 1826-0428 | IC voltage regulator 1/40V |
| U7,8 | both | 1826-0493 | IC op amp Lo-bias Hi-impedance |
| U9 | both | 1826-0544 | IC voltage reference 2.5V |
| U10 | both | 1826-0161 | IC op amp quad |
| U11 | both | 1820-1209 | IC buffer quad NAND |
| U12 | both | 1826-0393 | IC voltage regulator 1.2/37V |
| U13 | both | 1820-1112 | IC flip-flop D-type |
| U14 | both | 1826-0138 | IC comparator quad |
| U15 | both | 1820-1437 | IC multivibrator monostable dual |
| U16 | both | 1826-0065 | IC comparator precision |
| U17 | both | 1820-1246 | IC gate quad AND |
| U18 | both | 1820-0935 | IC counter binary CMOS |
| U19 | both | 1820-1205 | IC gate dual AND |
| U20 | both | 1826-0138 | IC comparator quad |
| U21 | both | 1826-0065 | IC comparator precision |
| U22 | both | 1820-2096 | IC counter binary dual |
| VR1,2 | both | 1902-0018 | diode-zener 11.7V 5% |
| VR3 | both | 1902-0777 | diode-zener 6.2V 5% |
| VR4 | both | 1902-3110 | diode-zener 5.9V 2% |
| VR5 | both | 1902-0575 | diode-zener 6.5V 2% |
| W1-3 | both | 7175-0057 | jumper wire, AWG 22 |
| Y1 | both | 0960-0586 | resonator 320KHz |
| | both | A2 Mechanical | |
| | both | 5060-2942 | heatsink (Q2, U15,16) |
| | both | 1200-0181 | insulator (Q4) |
| | both | 1200-0485 | socket (S1) |
| | both | 0360-2195 | terminal block, 6-position |
| | both | 1531-0309 | clevis, tapped |
| | both | A3 | Front Panel Board |
| C1,2 | both | 06033-60020 | cap 10 μ F 10% 20V |
| C3-14 | both | 0180-0374 | cap 0.047 μ F 20% 50V |
| DS1-8 | both | 0160-5422 | numeric display, 8-character |
| DS9, 10 | both | 1990-0985 | LED |
| DS11-16 | both | 1990-0835 | LED |
| DS17-23 | both | 1990-0831 | LED |
| G1 | both | 1990-0835 | LED |
| J1 | both | 06033-60008 | pulse generator |
| J2,3 | both | 1251-8417 | connector, 16-contact |
| L1 | both | 1251-8675 | connector, 5-contact |
| R1-58 | both | 9100-1618 | inductor 5.6 μ H 10% |
| | both | 0683-4715 | res 470 5% 1/4W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|-------------|----------|----------------------|--------------------------------|
| R59 | both | 2100-1775 | trimmer 5K top adjust |
| R60 | both | 0683-1015 | res 100 5% 1/4W |
| R61,62 | both | 1810-0272 | network sip 330 X9 |
| R63 | both | 1810-1231 | network smd 100 X8 |
| S2-5 | both | 5060-9436 | switch, pushbutton |
| U1-10 | both | 1820-1433 | IC shift register, 8-bit |
| U11 | both | 1820-1975 | IC shift register, 8-bit |
| U12 | both | 1820-1112 | IC flip flop, D-type |
| U13,14 | both | 1820-1216 | IC decoder, 3-to-8 line |
| U15 | both | 1820-1433 | IC shift register, 8-bit |
| U16 | both | 1820-1197 | IC gate quad NAND |
| U17 | both | 1820-1199 | IC inverter, HEX |
| | | A3 Mechanical | |
| | both | 4040-1615 | standoff, LED (DS9-23) |
| A4 | 6033A | 06023-60022 | Power Mesh Board |
| | 6038A | 06038-60022 | Power Mesh Board |
| C1 | both | 0160-5891 | cap 0.47 μ F 10% 800Vdc |
| C2 | both | 0160-5422 | cap 0.047 μ F 20% 50Vdc |
| C5,6 | both | 0160-4960 | cap 2200pF 10% 1.6KV |
| C7 | both | 0180-0155 | cap 2.2 μ F 20% 20V |
| C8 | both | 0160-0127 | cap 1 μ F 20% 25V |
| C9 | both | 0180-2780 | cap 470 μ F 10% 16V |
| C10 | both | 0160-4834 | cap 0.047 μ F 10% 100V |
| C11,12 | both | 0160-4835 | cap 0.1 μ F 10% 50V |
| C13 | 6033A | 0160-0161 | cap 0.01 μ F 10% 200V |
| | 6038A | 0160-5022 | cap 2200pF 10% 600Vac |
| CR1-4 | both | 1901-0050 | diode-switching 80V 200mA |
| CR5,6 | both | 1901-1065 | diode-power rectifier 400V 1A |
| CR7 | 6033A | 1901-1127 | diode-power rectifier 150V 70A |
| | 6038A | 1901-0887 | diode-power rectifier 300V 50A |
| CR10,11 | both | 1901-0050 | diode-switching 80V 200mA |
| CR13,14 | both | 1901-1087 | diode-power rectifier 600V 3A |
| F1,2 | both | 2110-0671 | fuse, 1/8A 125V |
| F3 | 6033A | 2110-0546 | fuse, 5A 125V |
| | 6038A | 2110-0688 | fuse, 3A |
| L3 | both | 06024-80096 | inductor, 3A |
| L4 | 6033A | 06023-80005 | core, ferrite 5 μ H |
| | 6038A | 06024-80097 | inductor, 12A |
| P1,2 | both | 1251-8807 | connector DIN 32-contact |
| Q1,2 | both | 1854-0477 | transistor, NPN SI 2N222A |
| Q3,4 | both | 1855-0916 | transistor, MOSFET N-channel |
| Q6 | 6033A | 1854-0264 | transistor, NPN SI |
| | 6038A | 1854-1017 | transistor, NPN SI |
| Q7 | both | 1855-0549 | transistor, PFET |
| R1,2 | both | 0686-0275 | res 2.7 5% 1/2W |
| R3 | both | 0683-3915 | res 390 5% 1/4W |
| R4 | both | 0683-1015 | res 100 5% 1/4W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|--------------------------------|
| R5 | both | 0683-4705 | res 47 5% 1/4W |
| R6 | both | 0683-1045 | res 100K 5% 1/4W |
| R7 | both | 0811-1857 | res 400 5% 5W |
| R8 | both | 0698-3601 | res 10 5% 2W |
| R9 | both | 0683-3915 | res 390 5% 1/4W |
| R10 | both | 0683-1015 | res 100 5% 1/4W |
| R11 | both | 0683-4705 | res 47 5% 1/4W |
| R12 | both | 0683-1045 | res 100K 5% 1/4W |
| R13 | both | 0811-1857 | res 400 5% 5W |
| R14 | both | 0698-3601 | res 10 5% 2W |
| R15 | both | 0757-0403 | res 121 1% 1/8W |
| R16 | both | 0683-3305 | res 33 5% 1/4W |
| R17 | both | 0683-1025 | res 1K 5% 1/4W |
| R18 | both | 0683-0475 | res 4.7 5% 1/4W |
| R19 | both | 0683-2025 | res 2K 5% 1/4W |
| R20 | both | 0683-0275 | res 2.7 5% 1/4W |
| R21,22 | both | 0683-0475 | res 4.7 5% 1/4W |
| R23 | both | 0683-2725 | res 2.7K 5% 1/4W |
| R24 | 6033A | 0757-0464 | res 90.9K 1% 1/8W |
| | 6038A | 0757-0476 | res 301K 1% 1/8W |
| R25 | 6033A | 0686-1005 | res 10 5% 1/2W |
| | 6038A | 0686-3005 | res 30 5% 1/2W |
| R26 | 6033A | 0811-2490 | res 0.1 3% 5W |
| | 6038A | 0811-2994 | res 0.27 3% 5W |
| R27 | both | 0698-3225 | res 1.43K 1% 1/8W |
| R28 | both | 0757-0279 | res 3.16K 1% 1/8W |
| R29 | both | 0698-3159 | res 26.1K 1% 1/8W |
| R30 | both | 0698-3202 | res 1.74K 1% 1/8W |
| R31 | both | 0698-4046 | res 732 1% |
| R32 | both | 0757-0442 | res 10K 1% 1/8W |
| R33 | 6033A | 0698-3601 | res 10 5% 2W |
| | 6038A | 0698-3628 | res 220 5% 2W |
| R34 | both | 0698-4484 | res 19.1K 1% 1/8W |
| R35,36 | both | 0683-3305 | res 33 5% 1/4W |
| R37 | both | 0683-3325 | res 3.3K 5% 1/4W |
| R38 | 6038A | 0757-0465 | res 100K 1% 1/8W |
| R39 | both | 0683-1055 | res 1M 5% 1/4W |
| T1,2 | both | 5080-1983 | transformer, FET driver |
| T3 | both | 1900-4350 | transformer, current |
| TS1 | both | 3103-0116 | thermal switch +100 C |
| TP14 | both | 1251-0646 | connector, contact |
| U1,2 | both | 1820-1050 | IC driver dual NOR |
| U3 | both | 1826-0346 | IC op amp dual general purpose |
| U4 | both | 1826-0393 | IC voltage regulator 1.2/37V |
| VR2 | both | 1902-3002 | diode-zener 2.37V 5% |
| VR3 | both | 1902-0057 | diode-zener 6.49V 5% |
| VR4 | both | 1902-0575 | diode-zener 6.50V 2% |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|-------------|----------|----------------------|---------------------------|
| | | A4 Mechanical | |
| | both | 1205-0919 | heatsink (Q3,4) |
| | both | 5060-2942 | heatsink (Q7) |
| | both | 06023-20001 | heatsink (CR7) |
| | both | 1531-0309 | clevis, tapped |
| A8 | both | 5063-3463 | HP-IB/PSI Board |
| C1 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C2,3 | both | 0160-4807 | cap 33pF 5% 100V |
| C4 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C5 | both | 0160-4822 | cap 1000pF 100V |
| C6 | both | 0180-0197 | cap 2.2 μ F 10% 20V |
| C7,8 | both | 0160-4807 | cap 33pF 5% 100V |
| C9 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C10 | both | 0160-4801 | cap 100pF 5% 100V |
| C11,12 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C13 | both | 0160-4801 | cap 100pF 5% 100V |
| C14 | both | 0160-4832 | cap 0.01 μ F 10% 50V |
| C15 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C16 | both | 0160-4801 | cap 100pF 5% 100V |
| C22 | both | 0180-3798 | cap 4700 μ F 25V |
| C23 | both | 0180-4136 | cap 10 μ F 10% 20V |
| C24 | both | 0180-0393 | cap 39 μ F 10% 10V |
| C25,26 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C27 | both | 0180-0374 | cap 10 μ .F 10% 20V |
| C28-31 | both | 0160-5469 | cap 1 μ F 10% 50V |
| C32-37 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C38 | both | 0180-0116 | cap 6.8 μ F 10% 35V |
| C39,40 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C41,42 | both | 0160-4820 | cap 1800pF 5% 100V |
| C43-47 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C48 | both | 0180-0116 | cap 6.8 μ F 10% 35V |
| C49-51 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C52 | both | 0160-4822 | cap 1000pF 100V |
| C53-58 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C59,60 | both | 0160-4822 | cap 1000pF 100V |
| C61 | both | 0160-4830 | cap 2200pF 10% 250V |
| C62,63 | both | 0160-4807 | cap 33pF 5% 100V |
| C64 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C65 | both | 0180-0393 | cap 39 μ F 10% 10V |
| C66 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| C67-70 | both | 0160-4832 | cap 0.01 μ F 10% 50V |
| C71,73 | both | 0160-4830 | cap 2200pF 10% 250V |
| C142 | both | 0160-4801 | cap 100pF 5% 100V |
| C143,144 | both | 0160-5422 | cap 0.047 μ F 20% 50V |
| D8,9 | both | 1901-0731 | diode-power rectifier |
| D13-17 | both | 1901-1098 | diode-switching |
| D20,21 | both | 1901-1080 | diode-1N5817 |
| D22 | both | 1901-1098 | diode-switching |
| F1,2 | both | 2110-0712 | fuse, 4A 125V |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|--------------------------|
| J1,2 | both | 1251-7330 | telephone jacks |
| J3 | both | 1200-0485 | right angle socket |
| J4 | both | 1252-0268 | HP-IB connector |
| J5 | both | 1251-4926 | connector 8-contact |
| J6 | both | 1251-4927 | connector 16-contact |
| J7,8 | both | 1251-8417 | connector 16-contact |
| J9 | both | 12514927 | connector 16-contact |
| J10 | both | 1251-5384 | connector 3-contact |
| L1 | both | 9170-1680 | choke |
| L2-4 | both | 9170-1454 | core-shield bead |
| Q1, 4 | both | 1853-0089 | transistor 2N4917 |
| R1 | both | 0757-0457 | res 47.5 1% 1/8W |
| R2 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R3 | both | 0757-0442 | res 10K 1% 1/8W |
| R4 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R5 | both | 0683-1065 | res 10M 5% 1/4W |
| R6 | both | 0698-4037 | res 46.4 1% 1/8W |
| R7 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R8-11 | both | 0757-0401 | res 100 1% 1/8W |
| R12 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R14 | both | 0698-0082 | res 464 1% 1/8W |
| R15-17 | both | 0698-4037 | res 46.4 1% 1/8W |
| R18 | both | 0757-0280 | res 1K 1% 1/8W |
| R19 | both | 0698-8827 | res 1M 1% 1/8W |
| R20-22 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R23 | both | 0698-0082 | res 464 1% 1/8W |
| R24,26 | both | 0698-3156 | res 14.7K 1% 1/8W |
| R28 | both | 0699-0059 | res 5K 0.1% 1/10W |
| R29 | both | 2100-3353 | trimmer 20K, side adjust |
| R30 | both | 0699-0642 | res 10K 0.1% 1/10W |
| R32 | both | 0757-0457 | res 47.5K 1% 1/8W |
| R33 | both | 0698-6360 | res 10K 0.1% 1/8W |
| R34 | both | 0757-0401 | res 100 1% 1/8W |
| R35 | both | 0699-0059 | res 5K 0.1% 1/10W |
| R36 | both | 0757-0316 | res 42.2 1% 1/8W |
| R37 | both | 0699-0642 | res 10K 0.1% 1/10W |
| R39 | both | 0757-0270 | res 249K 1% 1/8W |
| R40 | both | 2100-3353 | trimmer 20K, side adjust |
| R41 | both | 0757-0401 | res 100 1% 1/8W |
| R42 | both | 0757-0411 | res 332 1% 1/8W |
| R43 | both | 0699-0059 | res 5K 0.1% 1/10W |
| R44 | both | 0757-0316 | res 42.2 1% 1/8W |
| R45 | both | 0699-0642 | res 10K 0.1% 1/10W |
| R46 | both | 0757-0411 | res 332 1% 1/8W |
| R48 | both | 0757-0457 | res 47.5K 1% 1/8W |
| R49 | both | 0698-6360 | res 10K 0.1% 1/8W |
| R50 | both | 0757-0401 | res 100 1% 1/8 |
| R51 | both | 2100-3353 | trimmer 20K, side adjust |
| R52 | both | 0698-3156 | res 14.7K 1% 1/8W |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|---------------------------------|
| R55,58 | both | 2100-3732 | trimmer 500, top adjust |
| R59,60 | both | 0698-3558 | res 4.02K 1% 1/8W |
| R61 | both | 2100-3732 | trimmer 500, top adjust |
| R62-64 | both | 0698-3558 | res 4.02K 1% 1/8W |
| R65 | both | 0757-0280 | res 1K 1% 1/8W |
| R66 | both | 0698-3558 | res 4.02K 1% 1/8W |
| R67 | both | 0698-6320 | res 5K 0.1% 1/8W |
| R68 | both | 0757-0400 | res 90.9 1% 1/8W |
| R69 | both | 0698-6320 | res 5K 0.1% 1/8W |
| R70 | both | 0757-0400 | res 90.9 1% 1/8W |
| R71 | both | 0698-6320 | res 5K 0.1% 1/8W |
| R72 | both | 0757-0400 | res 90.9 1% 1/8W |
| R73 | both | 0757-0451 | res 24.3k 1% 1/8W |
| R74 | both | 0757-0199 | res 21.5K 1% 1/8W |
| R75 | both | 2100-3273 | trimmer 2K, side adjust |
| R76 | both | 0698-3455 | res 261K 1% 1/8W |
| R78 | both | 0698-3156 | res 14.7K 1% 1/8W |
| R79,80 | both | 8159-0005 | res 0 ohm |
| R82 | both | 0698-0082 | res 464 1% 1/8W |
| R83-88 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R89 | both | 0757-0280 | res 1K 1% 1/8W |
| R90,98,99 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R101 | both | 0698-6360 | res 10K 0.1% 1/8W |
| R102 | both | 0698-3558 | res 4.02K 1% 1/8W |
| R103 | both | 0698-3455 | res 261K 1% 1/8W |
| R106 | both | 1810-0206 | network, sip 10K X7 |
| R109,110 | both | 0698-3155 | res 4.64K 1% 1/8W |
| R111 | both | 0757-0316 | res 42.2 1% 1/8W |
| R112 | both | 1810-0305 | network, sip |
| S1 | both | 3101-1973 | HP-IB switch |
| TB1 | both | 0360-2312 | terminal block 4-contact |
| U1 | both | 1826-0468 | IC MC3423P1 0V-level detect |
| U2 | both | 5080-2157 | IC GAL programmed |
| U4 | both | 1820-8773 | IC 80C51 microprocessor |
| U5 | both | 1826-1369 | IC LT1021 voltage regulator 10V |
| U6 | both | 5080-2624 | IC EPROM AM27512 |
| U7 | both | 1826-2187 | IC converter PM-7545 |
| U8 | both | 1818-4134 | IC RAM MCM6164C55 |
| U9 | both | 1826-2187 | IC converter PM-7545 |
| U11 | both | 1826-2187 | IC converter PM-7545 |
| U12 | both | 1820-3210 | IC UART MC68B50P |
| U13 | both | 1990-0543 | IC opto-isolator |
| U14 | both | 1821-1479 | IC 80C196 microprocessor |
| U16 | both | 1820-2724 | IC latch 74ALS573 |
| U19 | both | 1826-0161 | IC LM324N quad op amp |
| U20 | both | 1826-0609 | IC 8-input multiplexer |
| U24 | both | 1826-1475 | IC LT1011 comparator |
| U25 | both | 1826-1896 | IC LT1001 op amp |
| U28 | both | 1990-1387 | IC opto-isolator |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|---------------------------|-----------------------------------|
| U31 | both | 1820-6789 | IC 75176B RS485 driver |
| U32 | both | 1990-1387 | IC opto-isolator |
| U33 | both | 1826-0536 | IC LM340AK-5 voltage regulator 5V |
| U35 | both | 5080-2625 | IC GAL programmed |
| U36 | both | 5080-2158 | IC GAL programmed |
| U37 | both | 1820-4185 | IC DS3658N interface |
| U64-69 | both | 1826-1896 | IC LT1001 op amp |
| U70 | both | 1818-4932 | IC EEPROM NMC9346 |
| U115 | both | 1820-6045 | IC SN75ALS61610 |
| U116 | both | 1820-6170 | IC SN75ALS6160 |
| U117 | all | 1821-1740 | IC 9914 talker/listener |
| VR2 | both | 1902-3172 | diode-zener 11V |
| VR3,4 | both | 1902-0049 | diode-zener 6.19V |
| VR6,7,8 | both | 1902-0766 | diode-zener 18.2V |
| Y1,2 | both | 0410-2109 | oscillator 12MHz |
| | | A8 Mechanical | |
| | both | 1205-0564 | heat sink (U33) |
| | both | 5001-6732 | HP-IB mounting plate |
| | | Chassis Electrical | |
| B1 | both | 3160-0343 | fan |
| S1 | both | 3101-0402 | switch, DPST (on/off) |
| FL1 | both | 9135-0223 | ac line filter |
| F1 | both | 2110-0383 | fuse, 8A 250V |
| W1 | both | 8120-4355 | cable, ribbon (A3 to A8) |
| W2 | both | 8120-4352 | cable, 3-pin (A1 to A8) |
| W3 | both | 8120-4351 | cable, 5-pin (A1 to A3) |
| W5,6 | both | 8120-4356 | cable, ribbon (A2 to A8) |
| | | Chassis Mechanical | |
| | both | 06023-00016 | chassis |
| | both | 5021-8417 | front frame casting |
| | both | 06033-00010 | front sub-panel |
| 6033A | | 06033-00013 | front panel, screened |
| 6038A | | 06038-00015 | front panel, screened |
| | both | 06023-00024 | rear panel |
| | both | 1510-0044 | binding post (rear panel ground) |
| | both | 2110-0564 | fuseholder body |
| | both | 2110-0565 | fuseholder cap |
| | both | 2110-0569 | fuseholder nut |
| | both | 3160-0309 | finger guard (fan) |
| | both | 06023-00023 | bracket, upper (lettered) |
| | both | 0403-0282 | bumper feet (on upper bracket) |
| | both | 06033-00002 | bracket, lower (A8 board) |
| | both | 5041-8803 | top trim strip |
| | both | 5001-0540 | side trim strip (2) |
| | both | 01650-47401 | knob (RPG adjust) |

Table 5-3. Replaceable Parts List (continued)

| Ref. Desig. | HP Model | HP Part Number | Description |
|--------------------|-----------------|-----------------------|------------------------|
| | both | 5041-0309 | plain key cap (4) |
| | both | 5041-2089 | lettered key cap (LCL) |
| | both | 7120-1254 | LOGO |
| | both | 4040-1954 | display window |
| | both | 06023-00020 | cover, top |
| | both | 06023-00022 | cover, bottom |
| | both | 06023-00009 | cover, terminal block |
| | 6033A | 0360-2191 | cover, dc output |
| | 6038A | 1540-1626 | cover, dc output |
| | both | 5062-3703 | strap handle |
| | both | 5041-8819 | handle retainer, front |
| | both | 5041-8820 | handle retainer, back |
| | both | 5041-8801 | foot (4) |

Component Location and Circuit Diagrams

This chapter contains component location diagrams, schematics, and other drawings useful for maintenance of the power supply. Included in this section are:

- Component location illustrations (Figures 6-1 through 6-6), showing the physical location and reference designators of almost all electrical parts. (Components located on the rear panel are easily identified.)
- Notes (Table 6-1) that apply to all schematic diagrams.
- Schematic diagrams (Figures 6-7 through 6-9).

WARNING

AC line voltage is present on the A1 Main Board Assembly whenever the power cord is connected to an ac power source.

Table 6-1. Schematic Diagram Notes

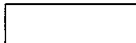
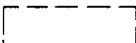
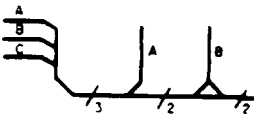


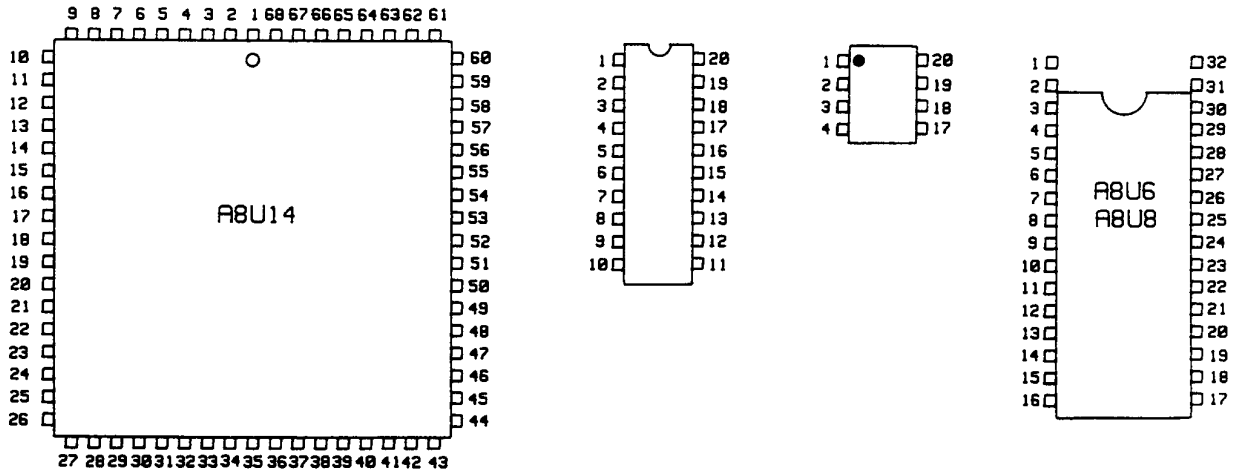
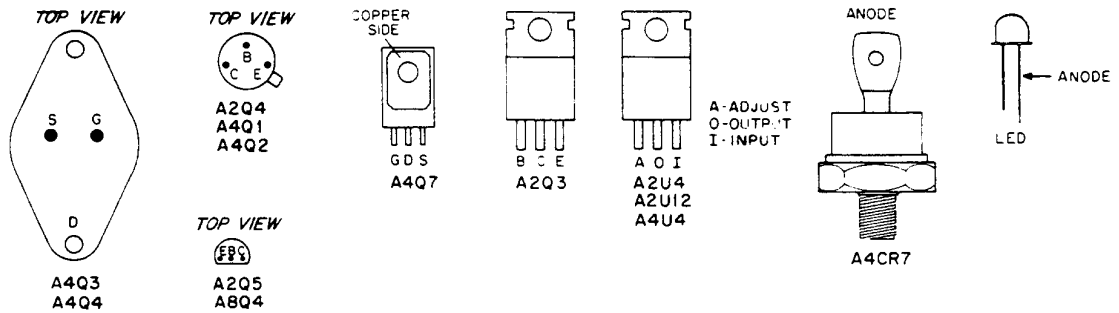
-  denotes front-panel marking.
-  denotes rear-panel marking.
- Complete reference designator consists of component reference designator prefixed with assembly number (e.g.: A2R14).
- Resistor values are in ohms. Unless otherwise noted, resistors are either 1/4W, 5% or 1/8W, 1%. Parts list provides power rating and tolerance for all resistors.
- Unless otherwise noted, capacitor values are in microfarads.
- Square p.c. pads indicate one of the following:
 - pin 1 of an integrated circuit.
 - the cathode of a diode or emitter of a transistor.
 - the positive end of a polarized capacitor.
- Schematic components marked with an asterisk (*) indicate that different values are used in each model. Refer to the parts list for the applicable values.
-  indicates multiple paths represented by only one line. Reference designators with pin numbers indicate destination, or signal names identify individual paths. Numbers indicate number of paths represented by the line.
- Inter-board commons have letter identifications (e.g.: ); commons existing on a single assembly have number identifications (e.g.: ).

Table 6-1. Schematic Diagram Notes (continued)

10. For single in-line resistor packages, pin 1 is marked with a dot. For integrated circuit packages, pin 1 is either marked with a dot, or pin 1 is to the left (as viewed from top) of indentation on the integrated circuit package (except for A8U6 and A8U8).



Pin locations for other semiconductors are as follows:



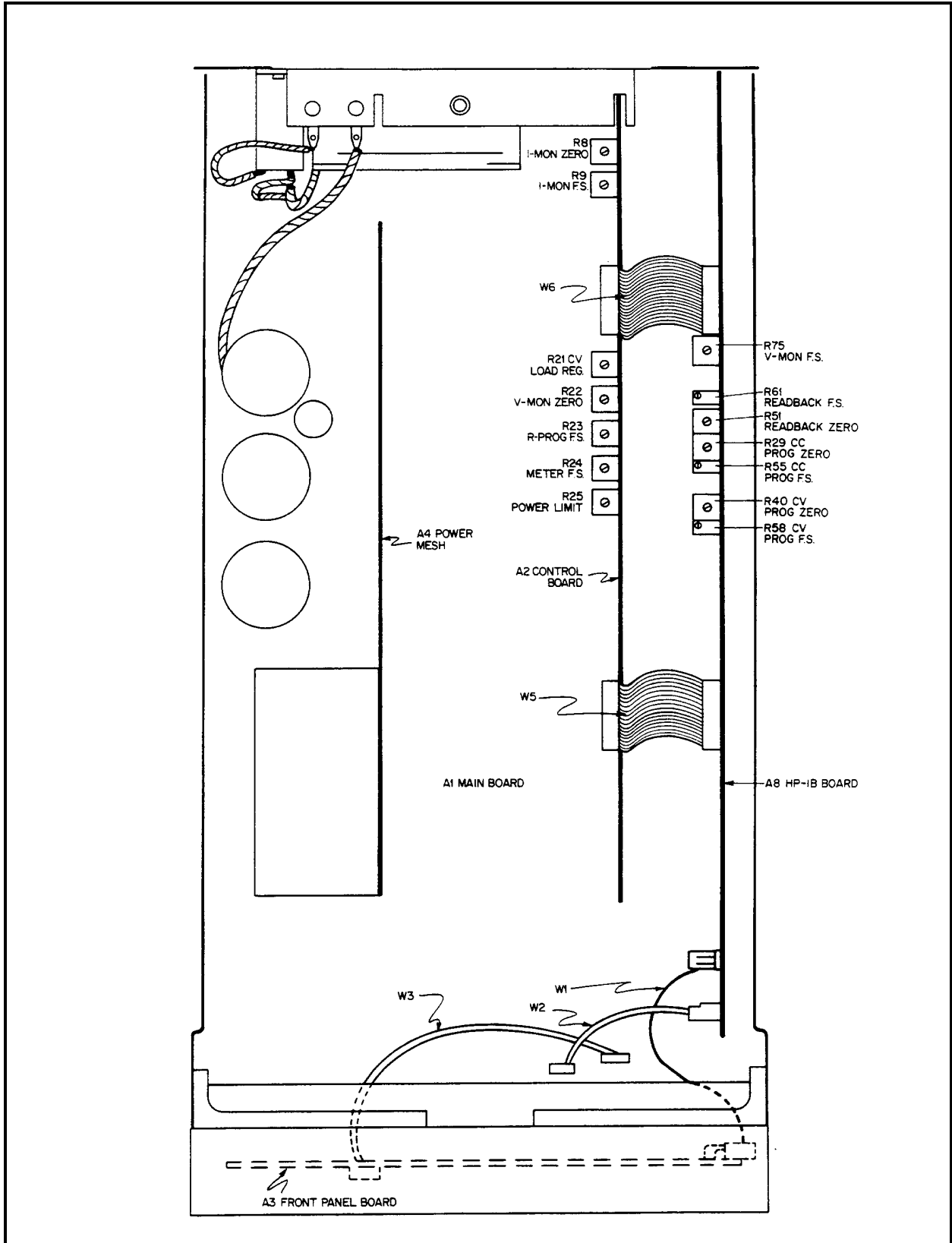


Figure 6-1. Top View, Top Covers Removed

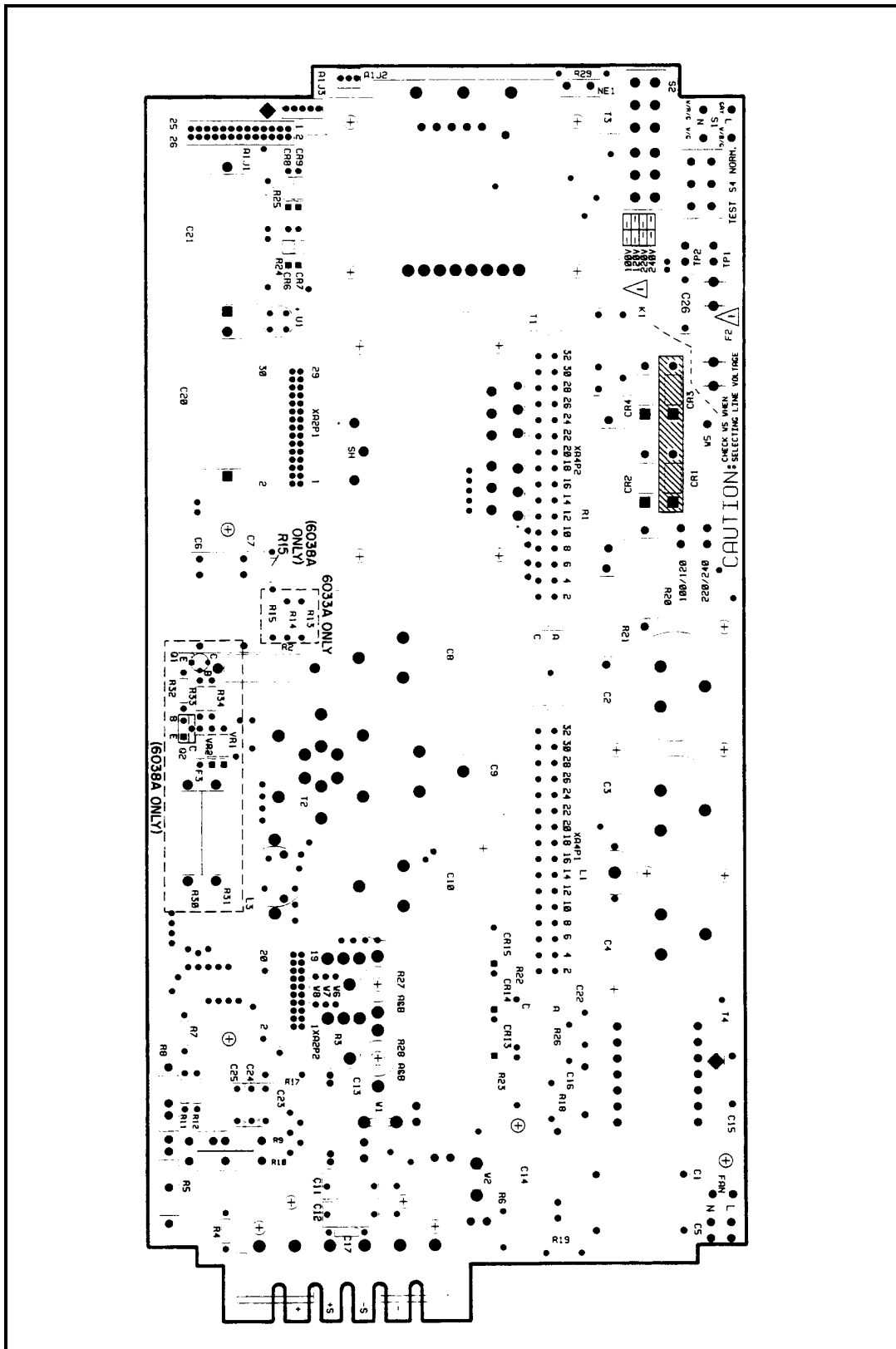


Figure 6-2. Main Board (A1) Component Location

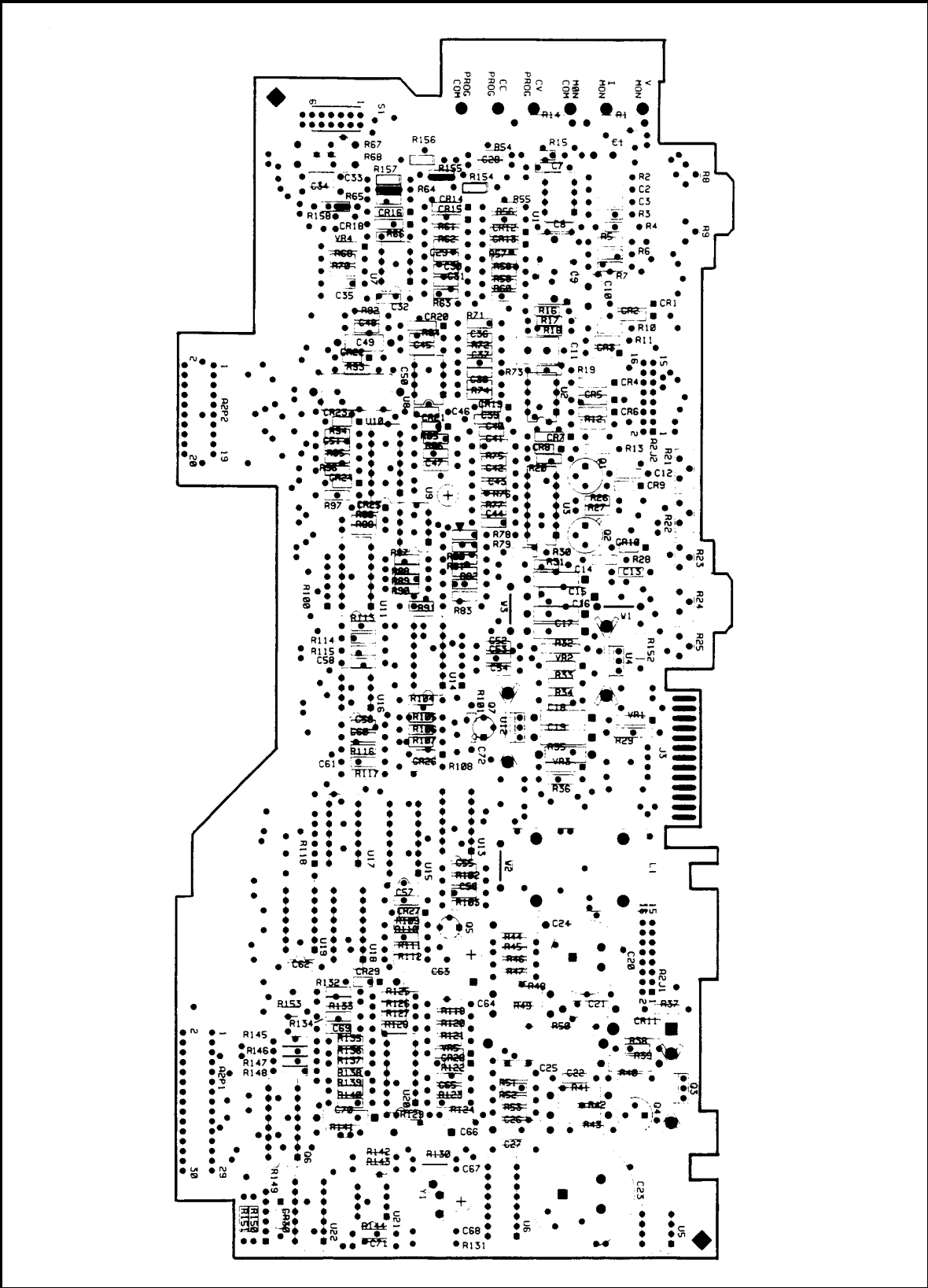


Figure 6-3. Control Board (A2) Component Location

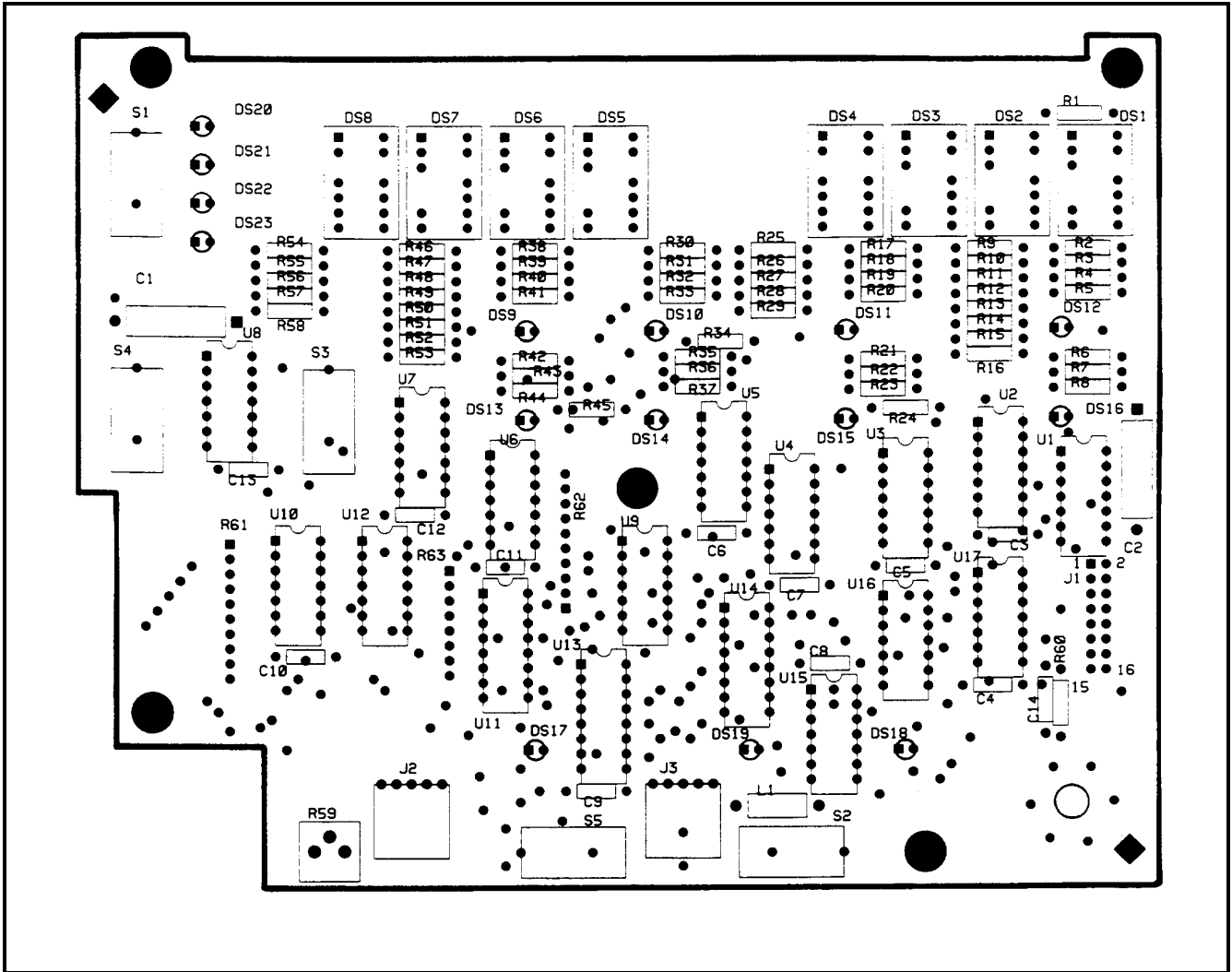


Figure 6-4. Front Panel Board (A3) Component Location

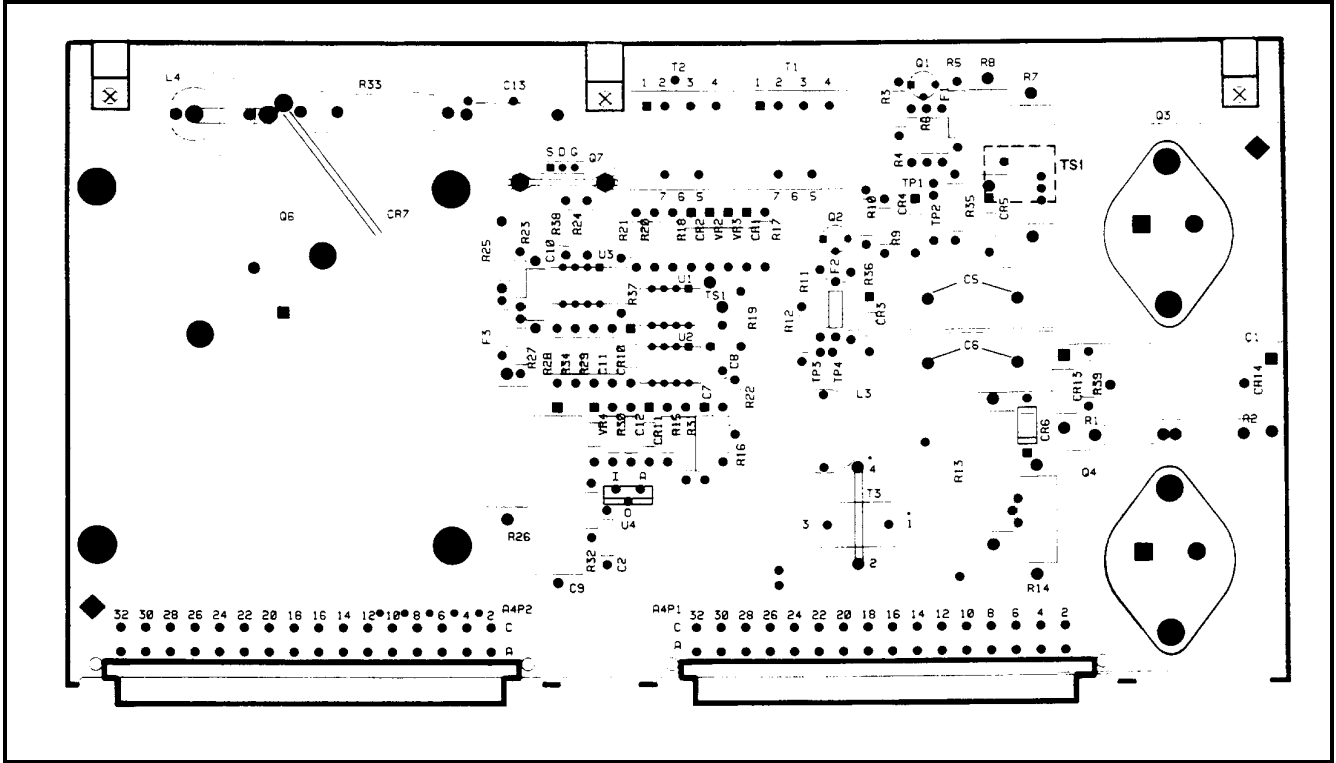


Figure 6-5. Power Mesh Board (A4) Component Location

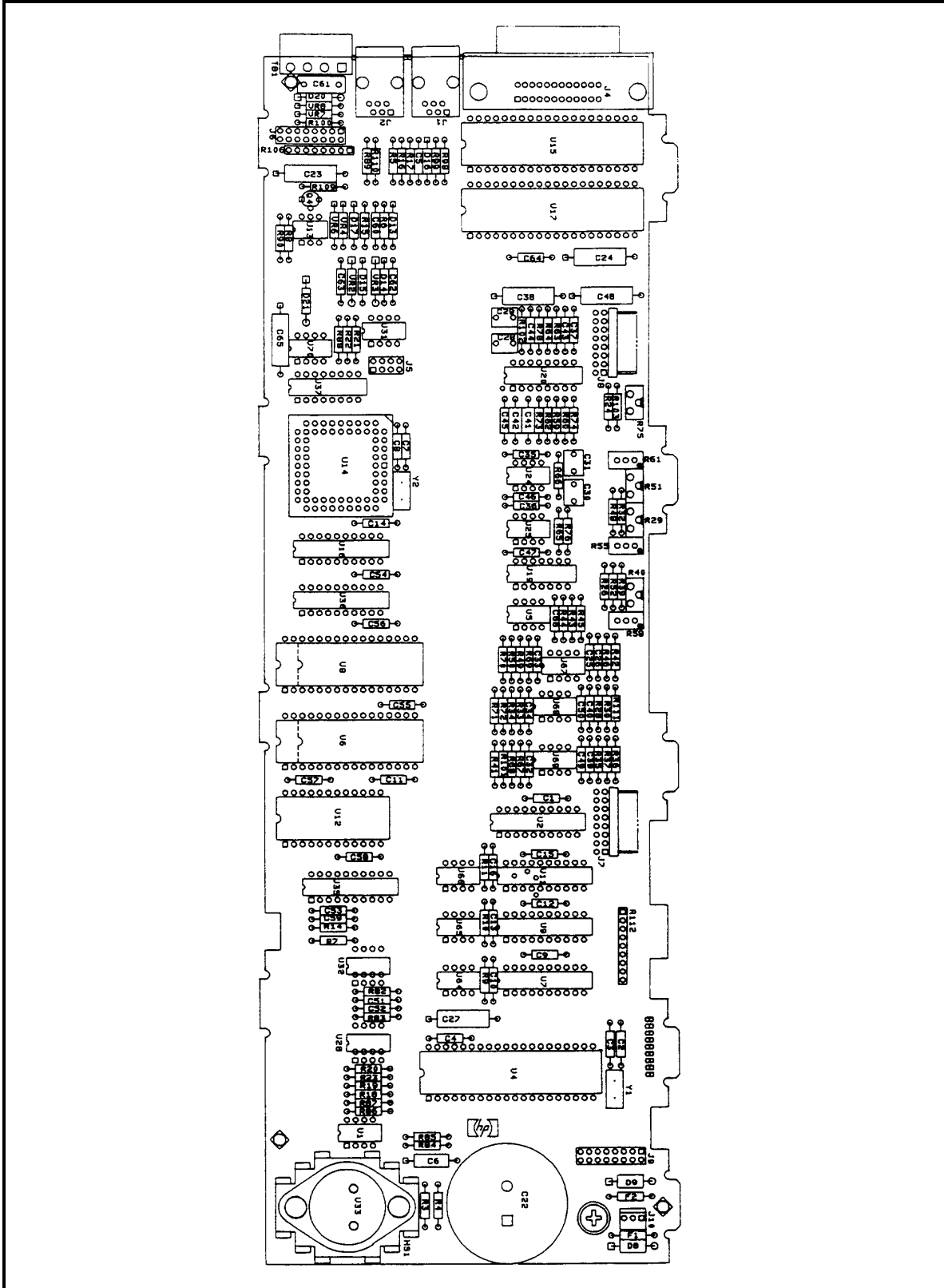


Figure 6-6. HP-IB Board (A8) Component Location

100 Vac Input Power Option 100

General Information

Description

Option 100 is a modification of HP 6033A/6038A power supplies that involves changing a resistor in the A2 OVP circuit, recalibrating the supply, and changing the Front Panel. These changes allow the units to operate at a lower line voltage of 87 to 106 Vac, while operating on the same line frequency of 48 to 63 Hz. The reduced input voltage limits the output power to 150W and the output voltage from 0 to 17V for the HP6033A, and from 0 to 50V for the HP6038A, while retaining the standard's unit output current rating. Other specifications that change due to Option 100 include Programming Response Time, Overvoltage Protection and Remote Analog Programming.

Scope of Appendix A

This appendix contains all the information necessary to support HP 6033A/6038A power supplies that are equipped with Option 100. The appendix describes only the changes pertaining to Option 100 and how they affect the other portions of this manual. Unless otherwise specified in Appendix A, all other portions of the manual apply to both the standard unit and the Option 100 unit.

Suggestions for Using Appendix A

The Option 100 changes are listed sequentially, starting with Chapter 1 in the main body of the manual and working back through Chapter 6. It is recommended that the user mark all the necessary changes directly into his manual. This will update the manual for Option 100 and eliminate the need for constant referrals back to Appendix A.

Chapter 1 Manual Changes

On Page 9, in Scope change the output power from 200 to 150 watts.

Chapter 2 Manual Changes

On Page 16, in Constant Voltage Full Scale Calibration, step b, change VSET 20 to VSET (6033A).

On Page 17, in Constant Voltage Full Scale Calibration, step d,
change 20.0025V to 17.0025V \pm 600 μ V (6033A).
change 60.0075 to 50.0175V \pm 1.52mV (6038A).

On Page 17, in Voltage Monitor and Remote Readback Full Scale Calibration step b, change VSET 60 to VSET 50 (6038A).

On Page 17, in Voltage Monitor and Remote Readback Full Scale Calibration step c,
change 5.000625V to 4.250625V \pm 100 μ V (6033A).
change 5.000625V to 4.168125V \pm 80 μ V (6038A).

On Page 17, in Voltage Monitor and Remote Readback Full Scale Calibration step f,
change 20V and 20.005V to 17.000 and 17.005V (6033A).
change 60V and 60.015V to 50.025V and 50.01V (6038A).

On Page 19, in Power Limit Calibration step d, change 10A to 9.2A (6033A)

On Page 19, in Power Limit Calibration step e,
change ISET 30.5 to ISET 27.5 (6033A).
change VSET 23 to VSET 21 (6038A).

On Page 21 in Voltage Programming and Readback Accuracy step g,
change VSET 20 to VSET17 (6033A).
change VSET 60 to VSET 50 (6038A).

On Page 22, in Voltage Programming and Readback Accuracy step h,
change 19.984 and 20.016 to 16.988 and 17.012 (6033A).
change 59.939 and 60.061 to 49.9375 and 50.0525 (6038A).

On Page 22 in Voltage Programming and Readback Accuracy step I,
change 0.02 to 0.018V (6033A).

On Page 22, in Load Effect (Load Regulation) step c,
change 7.0V to 6.25V (6033A).
change 20.0V to 15.0V (6038A).

On Page 22 in Load Effect (Load Regulation) step d,
change 29A to 25A (6033A).

On Page 22 in Load Effect (Load Regulation) step h,
change 0.0027V to 0.0026V (6033A).

On Page 23, in Source Effect (Line Regulation) step d,
change 20V to 17V (6033A).
change 60V to 50V (6038A).

On Page 23, in Source Effect (Line Regulation) step e,
change 10A to 9A (6033A).

On Page 23, in Source Effect (Line Regulation) step i,
change 0.003 to 0.0027 (6033A).
change 0.08 to 0.007 (6038A).

On Pages 23, 25, in RMS Measurement Procedure and Peak Measurement step c,
change 7.0 to 6.25V (6033A).

On Pages 23, 25, in RMS Measurement Procedure and Peak Measurement step d,
change 29A to 25A (6033A).

On Page 25, in Load Transient Recovery Time and step c
change 6.7V to 5.0V (6033A).

On Page 26, in Current Programming and Readback Accuracy steps c and g,
change 20V to 17V (6033A).
change 60V to 50V (6038A).

On Page 27 in Load Effect (Load Regulation) steps c,
change 10A to 9A (6033A).

On Page 27 in Load Effect (Load Regulation) steps d,
change 20V to 17V (6033A).
change 60V to 50V (6038A).

On Page 27, in Source Effect (Line Regulation) step d,
change 30A to 25A (6033A).

On Page 27, in Source Effect (Line Regulation) step e,
change 7.0 to 6.25V (6033A).
change 20.0 to 15.0V (6038A).

On Page 27, in Source Effect (Line Regulation) step i,
change 90 μ V to 85 μ V (6033A).

On Page 28, in PARD Ripple and Noise step c,
change 29A to 25A (6033A).

On Page 28, Initialization, change step 2 as follows:

2. Turn the power on, and depending on your unit's model number, send the following strings:

```
"EEINIT 6033  
"EEPROM 10,4,17.500"  
or  
"EEINIT 6038  
"EEPROM 10,4,51.495"
```

Chapter 3 Manual Changes:

On Page 41, in Readback Multiplexer (U20), change Node U20-9,
from + 5V to + 4.25V (6033A).
from + 5V to + 4.167V (6038A).

On Page 48 in Main Troubleshooting and on Page 49 in Troubleshooting No-Out Failures step d, change 320Vdc to 250Vdc.

In Table 3-10 (page 52) under Symptoms,
change max voltage <20 to max voltage <17 (6033A).
change max voltage <60 to max voltage <50 (6038A).

On Page 54 in Troubleshooting AC-Turn-On Circuits, setup,
change 20V to 17V (6033A).

Chapter 4 Manual Changes:

On Page 65, change 5V to 4.25V (6033A); change 5V to 4.167V (6038A).

On page 68, change 200W to 150W.

Chapter 5 and 6 Manual Changes

On Page 76,
change A2 board from 06023-60023 to 06023-60123 (6033A).
change A2 board from 06038-60023 to 06038-60024 (6038A).

On Page 80,
change R78 from 475 to 1.43K, HP P/N 0698-3225 (6033A).
change R78 from 787 to 1.96K, HP P/N 0698-0083 (6038A).
Make these same changes on the schematic diagram, Figure 6-7.

On Page 82, add Option 100 label (A2 board) 9320-5540.

On Page 88,
change front panel from 06033-00013 to 06033-00012 (6033A).
change front panel from 06038-00015 to 06038-00014 (6038A).

On Page 89,
add line voltage label (rear panel) 06033-81004 (6033A).
add line voltage label (rear panel) 06023-81004 (6038A).

Blank Front Panel Option 001

Introduction

This appendix describes the blank front panel option (Option 001) for the power supply. Option 001 is designed for applications in which front panel operation and monitoring are unnecessary. It has no front-panel controls and indicators except for the LINE switch and OVP ADJUST control found on the standard unit, and a pilot light to indicate when ac input power is turned on. All other characteristics of the standard are retained.

Except for references to front-panel controls and indicators, most of the information in the manual applies to Option 001 units. No attempt has been made in this appendix to change every reference to front-panel controls and indicators. In general, information in this appendix replaces only those procedures whose modification may not be obvious to the user. When reading the manual, the user can usually skip over references to front-panel controls and indicators other than the LINE switch and OVP ADJUST control.

Troubleshooting

The major difference between troubleshooting an Option 001 unit and a standard power supply is that the front panel is not available to help you isolate the problem to a specific section in the power supply. If you know which section of the supply is defective, simply go to that section in the troubleshooting procedure and troubleshoot as described in Chapter 3.

To help you isolate the problem to a specific area of the supply, use the flowchart provided in this section.

If you cannot isolate the problem using the flowchart, you could replace the blank front panel of your supply with a standard front panel and then troubleshoot the unit. Part numbers for front panel assemblies are provided in Chapter 5.

Chapter 2 Manual Changes:

On Page 19, Power Limit Calibration, change step f to read: Connect a DVM to control board test connector A2J3 pin 16 (CC). Observe the DVM while adjusting A2R25 (POWER LIMIT) clockwise. Stop adjusting as soon as test point A2J3-16 goes from high to low.

Note: You can also send an STS? query (or SCPI equivalent) in a looping program and monitor when the power supply status changes to CC mode.

Under the Performance Tests section, any references to front panel control will have to be accomplished using HP-IB commands. Use the following guidelines:

1. To set the voltage and current to specific values, use the VSET and ISET (or SCPI equivalent) commands.
2. If the procedure says to check the CC or CV LED's, use an STS? query (or SCPI equivalent). A returned value of 1 indicates CV mode; a value of 2 indicates CC mode.

Chapter 3 Manual Changes:

Replace Figure 3-1 with the figure on the next page. SA Tables 3-5 through 3-7 do not apply to Option 001 units.

Chapter 5 and 6 Manual Changes:

On Page 83 under A3 Front Panel Board, the only part that applies to the Option 001 unit is R59, the OVP-adjust potentiometer. Change R59 from 2100-1775 to 2100-4060.

On Page 86 under Chassis Electrical, add Neon Pilot Light, P/N 1450-0647. Also add OVP Cable (R59), P/N 06032-60004. Under Chassis Mechanical, change screened front panel to:

06033-00011 (6033A)

06038-00013 (6038A)

On Figure 6-7, add the neon pilot light in series with R29, 33K, across pins 4 and 5 of transformer T3.

On Figure 6-9, the only part that applies to the Option 001 unit is R59, the OVP-adjust potentiometer.

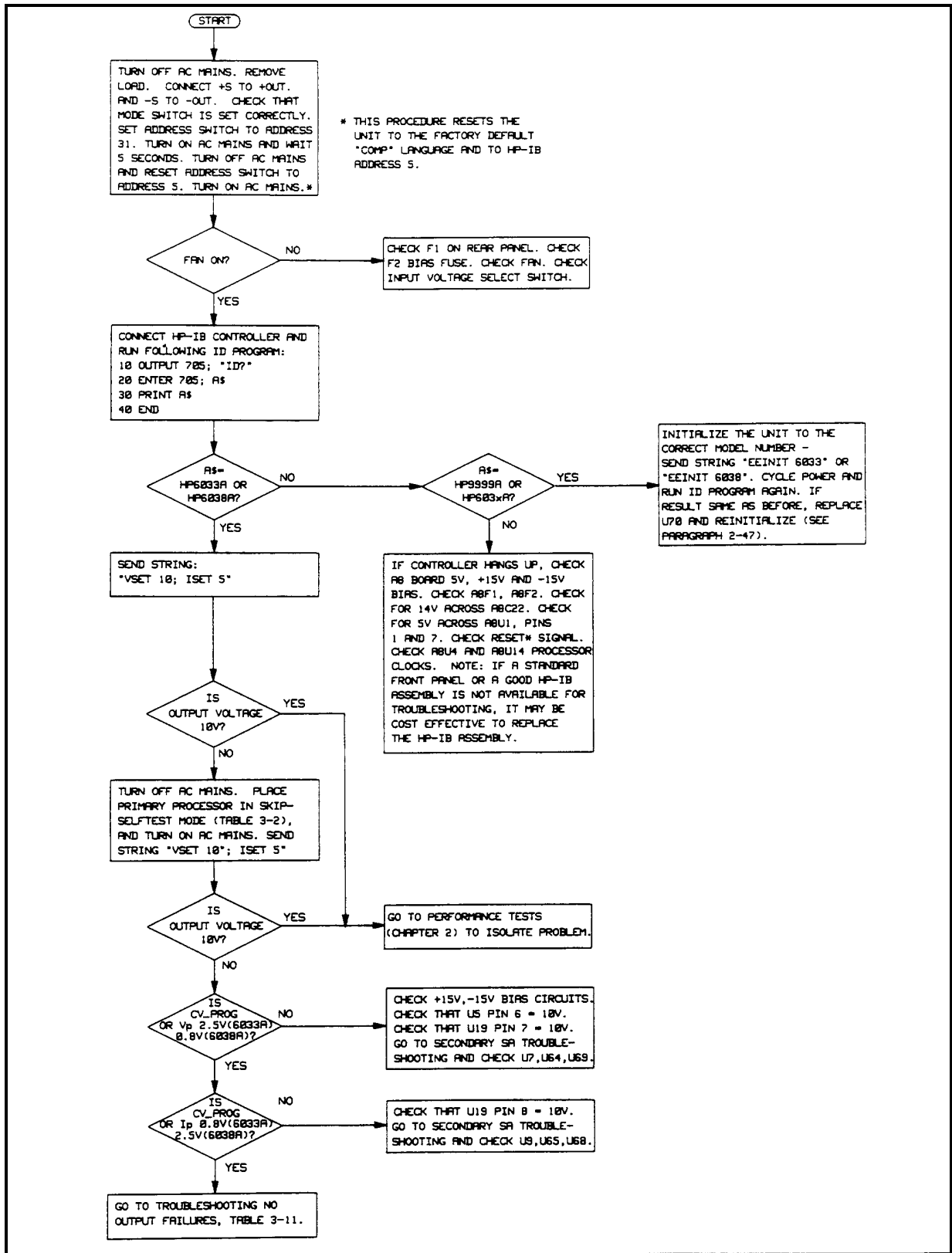


Figure 3-1. Troubleshooting Isolation (option 001)

HP 6033A Test Record

Performance Test Record - HP 6033A POWER SUPPLY (Page 1 of 2)

Test Facility:

Report No. _____

Date _____

Customer _____

Tested By _____

Model **HP 6033A**

Serial No. _____

Options _____

Firmware Revision _____

Ambient Temperature _____ °C

Relative Humidity _____ %

Nominal Line Frequency _____ Hz (nominal)

Special Notes:

| Test Equipment Used | | | |
|---------------------|---------------------------|-----------|---------------|
| Description | Model No. | Trace No. | Cal. Due Date |
| 1. AC Source | _____ | _____ | _____ |
| 2. DC Voltmeter | HP 3458A | _____ | _____ |
| 3. RMS Voltmeter | HP 3400A | _____ | _____ |
| 4. Oscilloscope | HP 54504A | _____ | _____ |
| 5. Electronic Load | HP 6060A and HP 60502A | _____ | _____ |
| 6. Current Probe | _____ | _____ | _____ |
| 7. Current Shunt | Guildline 9230/100 | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

Performance Test Record - HP 6033A POWER SUPPLY (Page 2 of 2)

| | | |
|-----------------------|------------------|------------|
| MODEL HP 6033A | Report No. _____ | Date _____ |
|-----------------------|------------------|------------|

| Page No. | Test Description | Minimum Spec. | Results * | Maximum Spec. | Measurement Uncertainty |
|-------------------------------|---|---------------------------|-----------|---------------------------|-------------------------|
| Constant Voltage Tests | | | | | |
| 21 | Voltage Programming and Readback | | | | |
| | Low Voltage (0.100V) | 0.091 | _____ V | 0.109 | 3μV |
| | Front Panel Display | V _{OUT} - 0.011 | _____ V | V _{OUT} + 0.011 | 3μV |
| | HP-IB Readback | V _{OUT} - 0.006 | _____ V | V _{OUT} + 0.006 | 3μV |
| | High Voltage (20.00V) | 19.984 | _____ V | 20.016 | 300μV |
| | Front Panel Display | V _{OUT} - 0.025 | _____ V | V _{OUT} + 0.025 | 300μV |
| | HP-IB Readback | V _{OUT} - 0.020 | _____ V | V _{OUT} + 0.020 | 300μV |
| 22 | Load Effect (7.0V) | V _{OUT} - 0.0027 | _____ mV | V _{OUT} + 0.0027 | 20μV |
| 22 | Source Effect (20.00V) | V _{OUT} - 0.003 | _____ mV | V _{OUT} + 0.003 | 20μV |
| | PARD (Ripple and Noise) | | | | |
| 23 | RMS | 0 | _____ mV | 0.003 | 450μV |
| 23 | Peak-to-Peak | 0 | _____ mV | 0.030 | 900μV |
| 25 | Transient Recovery (90% to 100% Full Load) | 0 | _____ mV | 0.050 | 6mV |
| Constant Current Tests | | | | | |
| 26 | Current Programming and Readback | | | | |
| | Low Current (1.000A) | 0.9785 | _____ A | 1.0210 | 400μA |
| | Front Panel Display | I _{OUT} - 0.023 | _____ A | I _{OUT} + 0.023 | 400μA |
| | HP-IB Readback | I _{OUT} - 0.028 | _____ A | I _{OUT} + 0.028 | 400μA |
| | High Current (30.00A) | 29.935 | _____ A | 30.065 | 12mA |
| | Front Panel Display | I _{OUT} - 0.155 | _____ A | I _{OUT} + 0.155 | 12mA |
| | HP-IB Readback | I _{OUT} - 0.115 | _____ A | I _{OUT} + 0.115 | 12mA |
| 27 | Load Effect (10.0A) | I _{OUT} - 0.010 | _____ mA | I _{OUT} + 0.010 | 19μA |
| 27 | Source Effect (30.0A) | I _{OUT} - 0.009 | _____ mA | I _{OUT} + 0.009 | 19μA |
| 27 | PARD (Ripple and Noise) | 0 | _____ mA | 0.015 | 2μA |

HP 6038A Test Record

Performance Test Record - HP 6038A POWER SUPPLY (Page 1 of 2)

Test Facility:

Report No. _____

Date _____

Customer _____

Tested By _____

Model **HP 6038A**

Serial No. _____

Options _____

Firmware Revision _____

Ambient Temperature _____ °C

Relative Humidity _____ %

Nominal Line Frequency _____ Hz (nominal)

Special Notes:

| Test Equipment Used | | | |
|---------------------|---------------------------|-----------|---------------|
| Description | Model No. | Trace No. | Cal. Due Date |
| 1. AC Source | _____ | _____ | _____ |
| 2. DC Voltmeter | HP 3458A | _____ | _____ |
| 3. RMS Voltmeter | HP 3400A | _____ | _____ |
| 4. Oscilloscope | HP 54504A | _____ | _____ |
| 5. Electronic Load | HP 6060A and HP 60502A | _____ | _____ |
| 6. Current Probe | _____ | _____ | _____ |
| 7. Current Shunt | Guildline 9230/15 | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

Performance Test Record - HP 6038A POWER SUPPLY (Page 2 of 2)

| | | |
|-----------------------|------------------|------------|
| MODEL HP 6038A | Report No. _____ | Date _____ |
|-----------------------|------------------|------------|

| Page No. | Test Description | Minimum Spec. | Results * | Maximum Spec. | Measurement Uncertainty |
|-------------------------------|---|---------------------------|-----------|---------------------------|-------------------------|
| Constant Voltage Tests | | | | | |
| 21 | Voltage Programming and Readback | | | | |
| | Low Voltage (0.090V) | 0.050 | _____ V | 0.130 | 3μV |
| | Front Panel Display | V _{OUT} - 0.050 | _____ V | V _{OUT} + 0.050 | 3μV |
| | HP-IB Readback | V _{OUT} - 0.050 | _____ V | V _{OUT} + 0.050 | 3μV |
| | High Voltage (60.0V) | 59.939 | _____ V | 60.061 | 845μV |
| | Front Panel Display | V _{OUT} - 0.092 | _____ V | V _{OUT} + 0.092 | 845μV |
| | HP-IB Readback | V _{OUT} - 0.092 | _____ V | V _{OUT} + 0.092 | 845μV |
| 22 | Load Effect (20.00V) | V _{OUT} - 0.005 | _____ mV | V _{OUT} + 0.005 | 20μV |
| 22 | Source Effect (60.0V) | V _{OUT} - 0.008 | _____ mV | V _{OUT} + 0.008 | 40μV |
| | PARD (Ripple and Noise) | | | | |
| 23 | RMS | 0 | _____ mV | 0.003 | 450μV |
| 23 | Peak-to-Peak | 0 | _____ mV | 0.030 | 900μV |
| 25 | Transient Recovery (90% to 100% Full Load) | 0 | _____ mV | 0.075 | 9mV |
| Constant Current Tests | | | | | |
| 26 | Current Programming and Readback | | | | |
| | Low Current (0.500A) | 0.4896 | _____ A | 0.5104 | 221μA |
| | Front Panel Display | I _{OUT} - 0.012 | _____ A | I _{OUT} + 0.012 | 221μA |
| | HP-IB Readback | I _{OUT} - 0.012 | _____ A | I _{OUT} + 0.012 | 221μA |
| | High Current (10.00A) | 9.9815 | _____ A | 10.0185 | 4.1mA |
| | Front Panel Display | I _{OUT} - 0.031 | _____ A | I _{OUT} + 0.031 | 4.1mA |
| | HP-IB Readback | I _{OUT} - 0.031 | _____ A | I _{OUT} + 0.031 | 4.1mA |
| 27 | Load Effect (3.30A) | I _{OUT} - 0.0053 | _____ mA | I _{OUT} + 0.0053 | 2μA |
| 27 | Source Effect (10.0A) | I _{OUT} - 0.003 | _____ mA | I _{OUT} + 0.003 | 4μA |
| 27 | PARD (Ripple and Noise) | 0 | _____ mA | 0.005 | 750μA |

Manual Backdating

This section describes changes that must be made to the manual so that it applies to instruments with serial numbers lower than those listed on the title page. Look in the following table for the serial number of your instrument, and make only those changes listed for your instrument. Note that for some changes you may be instructed to update the instrument if certain components are being replaced during repair.

| Prefix | Serial Number | Make Changes |
|--------------|---------------|--------------|
| <u>6033A</u> | | |
| 3004A | 05092-05096 | 1-10 |
| 3024A | 05272-06111 | 1-10 |
| 3124A | 06112-06591 | 1-10 |
| 3211A | 06592-06691 | 1-10 |
| 3223A | 06692-07051 | 1-9 |
| 3251A | 07052-07091 | 1-8 |
| 3303A | 07092-07171 | 1-7 |
| 3313A | 07172-07251 | 1-6 |
| 3329A | 07252-07691 | 1-5 |
| 3430A | 07692-07831 | 1-4 |
| 3442A | 07832-07951 | 1-3 |
| 3506A | 07952-08561 | 1, 2 |
| 3649A | 08562-08881 | 1 |
| US3649 | 0101-0230 | 1 |
| <u>6038A</u> | | |
| 2933A | 08856-08860 | 1-10 |
| 3025A | 09316-11135 | 1-10 |
| 3122A | 10396-06591 | 1-10 |
| 3212A | 11136-11255 | 1-10 |
| 3221A | 11256-11655 | 1-9 |
| 3250A | 11656-11695 | 1-8 |
| 3304A | 11696-11815 | 1-7 |
| 3309A | 11816-12075 | 1-6 |
| 3329A | 12076-12545 | 1-5 |
| 3431A | 12546-12655 | 1-4 |
| 3440A | 12656-12855 | 1-3 |
| 3511A | 12856-13825 | 1, 2 |
| 3651A | 13826-14195 | 1 |
| US3831 | 0101-0400 | 1 |

CHANGE 1:

Under A8 HP-IB Board.

Add: R100 p/n 0698-4037.

U17 p/n 1820-2549

Delete: C67-70 0.01uF 10%, p/n 0160-4832, qty 4.

C71,73 2200pF 10%, p/n 0160-4830, qty 2.

L1 choke, p/n 9170-1680.

L2-4 core-shield bead, p/n 9170-1454, qty 3.

Q1 transistor 2N4917, p/n 1853-0089.

R1 47.5K 1%, p/n 0757-0457.

CHANGE 1 (continued)

Delete: R2,12 4.64K 1%, p/n 0698-3155, qty 2.

R79,80 0 ohm, p/n 8159-0005, qty 2.

U117 IC-9914 talker/listener, p/n 1821-1740.

Change: A8, HP-IB board to p/n 5060-3551.

C14 to 0.047uF, p/n 0160-5422.

C23 to 39uF, p/n 0180-0393.

C61 to p/n 0160-4281.

U6 to p/n 5080-2160.

U36 to p/n 5080-2158.

CHANGE 2:

Under A4 Power Mesh board, change Q3,4 to transistor PFET, p/n 1855-0547.

CHANGE 3:

Under A8 HP-IB Board, change U33 to p/n 1820-0430.

CHANGE 4:

Under A8 HP-IB Board, change U14 to p/n 1820-6721.

CHANGE 5:

Under A8 HP-IB Board:

Add: U15, p/n 1LH4-0001.

Delete: U115, SN75ALS61610, p/n 1820-6045.

U116, SN75ALS6160, p/n 1820-6170.

C142 100pF, p/n 0160-4801.

C143-144 .047uF, p/n 0160-5422.

Change: A8, HP-IB board to p/n 5060-3305.

CHANGE 6:

Under A1 Main Board Assembly, Change CR1,3 to p/n 1901-1087. Change CR2,4 to p/n 0901-0759.

CHANGE 7:

Under A3 Front Panel, change G1 to p/n 06033-60007.

Under Chassis Mechanical, change Knob to p/n 0370-1303.

CHANGE 8:

Under A1 Main Board Assembly, change C13, 14 to 0.022uF, p/n 0160-5933.

CHANGE 9:

Under A8 HP-IB Board, change U8 to p/n 1818-4111.

CHANGE 10:

Under A8 HP-IB Board, delete D22.