



**DUAL OUTPUT  
POWER SUPPLY  
MODEL 6234A**

**OPERATING AND SERVICE MANUAL  
FOR SERIALS 1822A-00101 AND ABOVE**

**\*For Serials above 1822A-00101,  
a change page may be included.**

HP Part No. 06234-90001  
Microfiche Part No. 06234-90002

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### CERTIFICATION

*Hewlett-Packard Company certifies that this instrument met its published specifications at the time of shipment from the factory. Hewlett-Packard Company 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.*

### WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship for a period of one year from the date of shipment [except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period]. Hewlett-Packard will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard, and provided the preventive maintenance procedures in this manual are followed. Repairs necessitated by misuse of the product are not covered by this warranty. **NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. HEWLETT-PACKARD IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.**

Service contracts or customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

## SECTION I GENERAL INFORMATION

### 1-1 DESCRIPTION

1-2 The Model 6234A Dual Output Power Supply is a compact, constant voltage/current limiting supply that delivers two isolated 0\* to 25V outputs rated at 0.2A. It is an ideal power supply for design and breadboard work where single or dual voltages are required. Each output voltage is continuously variable throughout its range and separate fixed current limit circuits protect each output against overload or short circuit damage.

1-3 Connections to the outputs are made to binding post type terminals on the front panel. The outputs can be used individually or in combination to satisfy any number of output demands. The positive or negative terminal of each output can be grounded or each output can be left floating. A chassis ground terminal is located on the rear of the supply.

1-4 The front panel also contains a line switch, output voltage controls, a combination voltmeter/ammeter, and two meter select pushbutton switches. One meter pushbutton selects either voltage or current monitoring while the other selects which output is monitored. The supply is furnished with a permanently attached 5-foot, 3-wire grounding type line cord. The ac line fuse is an extractor type fuseholder on the rear heat sink.

### 1-5 SPECIFICATIONS

1-6 Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested.

### 1-7 OPTIONS

1-8 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available with this instrument.

<u>OPTION NO.</u>	<u>DESCRIPTION</u>
028	Input power: 208-250Vac, 47-63Hz, single phase.
910	One additional operating and service manual shipped with the power supply.

1-9 Before the supply is shipped from the factory, the proper internal jumpers are connected and the correct fuse installed for the line voltage specified on the order. A label on the rear heatsink identifies this line voltage option. The user can

\*Each output has a minimum operating voltage of  $\leq 20mV$ .

convert an instrument from one line voltage option to the other by following the instructions in paragraph 3-13.

### 1-10 SAFETY CONSIDERATIONS

1-11 This product is a Safety Class 1 instrument (provided with a protective earth terminal). The instrument and manual should be reviewed for safety markings and instructions before operation.

### 1-12 ACCESSORIES

1-13 The accessory listed below may be ordered from your local Hewlett-Packard field sales office either with the power supply or separately. (Refer to the list at the rear of the manual for addresses.)

#### HP PART NO.

#### DESCRIPTION

14522A Rack Mounting Tray for mounting one or two 6234A supplies in a standard 19" relay rack.

### 1-14 INSTRUMENT AND MANUAL IDENTIFICATION

1-15 Hewlett-Packard power supplies are identified by a two part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits indicate the year (10 = 1970, 11 = 1971, etc.) the second two digits indicate the week, and the letter "A" designates the U.S.A. as the country of manufacture. The second part is the power supply serial number. A different sequential number is assigned to each power supply, starting with 00101.

1-16 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes define the difference between your instrument and the instrument described by this manual.

### 1-17 ORDERING ADDITIONAL MANUALS

1-18 One manual is shipped with each power supply. (Option 910 is ordered for each extra manual, see paragraph 1-9.) Additional manuals may also be purchased separately from your local Hewlett-Packard field office (see the list at the rear of this manual for addresses). Specify the model number, serial prefix, and the HP Part Number provided on the title page.

**Table 1-1. Specifications**

<p><b>DC Output:</b> Voltage span over which output may be varied using front panel controls.</p> <p>Output V1*: 0 to 25V at 0.2A Output V2*: 0 to 25V at 0.2A</p> <p>*Minimum operating voltage for each output is <math>\leq 20</math> millivolts. Short circuit output current is 0.275A <math>\pm 10\%</math> for each output.</p> <p><b>Load Effect (Load Regulation):</b> Less than 0.01% + 1mV for a load current change equal to the current rating of the supply.</p> <p><b>Source Effect (Line Regulation):</b> Less than 0.01% + 1mV for any input voltage change within rating.</p> <p><b>PARD (Ripple and Noise):</b> 200<math>\mu</math>V rms/1mV p-p.</p> <p><b>Load Transient Recovery Time:</b> Less than 50<math>\mu</math>sec for output recovery to within 15mV of nominal output voltage following a load change from a full load to half load (or vice versa).</p> <p><b>Temperature Ratings:</b> Operating: 0 to +40°C ambient. From 40°C to 55°C, output current is derated linearly to 50% at 55°. Storage: -40°C to +75°C.</p>	<p><b>Temperature Coefficient:</b> Less than 0.04% + 1mV voltage change per degree Celsius over the operating range from 0 to 40°C after 30 minutes warm-up.</p> <p><b>Drift (Stability):</b> Less than 0.1% + 5mV (dc to 20Hz) during 8 hours at constant line, load, and ambient after an initial warm-up time of 30 minutes.</p> <p><b>Input Power:</b> Standard: 104-127Vac (120Vac nominal), 47-63Hz, single phase. (240Vac line voltage option available, see paragraph 1-8).</p> <p><b>Meter Ranges:</b> 0 to 30V, 0 to 0.25A.</p> <p><b>Meter Accuracy:</b> Voltmeter: <math>\pm 4\%</math> of full scale. Ammeter: <math>\pm 4\%</math> of full scale.</p> <p><b>Weight:</b> Net: 5 lb (2.3 kg) Shipping: 7 lb (3.2 kg)</p>
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## SECTION II INSTALLATION

### 2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, file claim with carrier immediately. The Hewlett-Packard Sales and Service office should be notified as soon as possible.

### 2-3 Mechanical Check

2-4 This check should confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or cracked.

### 2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

### 2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. Before applying power to the instrument, see the CAUTION notice in paragraph 3-11.

### 2-9 Location

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the rear of the instrument when it is in operation. It should be used in an area where the ambient temperature does not exceed 40°C (up to 55°C with derating).

### 2-11 Outline Diagram

2-12 Figure 2-1 illustrates the outline shape and dimensions of this supply.

### 2-13 Rack Mounting

2-14 One or two 6234A's may be mounted in a standard 19-inch rack panel using rack mounting tray HP Part No. 14522A. Installation consists of bolting the rack mounting tray to the 19-inch rack and sliding the power supply(s) into the slot(s) provided in the tray. The power supply's rubber feet are seated in holes in the bottom of the tray.

### 2-15 Input Power Requirements

2-16 The supply may be operated continuously from a nominal 120V or 240V (47-63Hz) single phase power source. The supply is shipped from the factory ready to be operated from one of these power sources. A label on the rear heatsink identifies the line voltage option of your supply. The input voltage range and input current required for each of the nominal inputs are listed below. The maximum input power (high line, full load conditions) required for either input is 30 watts.

Option	Line Voltage Range	Maximum Input Current
Standard (120Vac) 028 (240Vac)	104-127Vac 208-250Vac	0.26A 0.12A

2-17 If desired, the user can convert the unit from one option to another by following the instructions in paragraph 3-13.

### 2-18 Power Cable

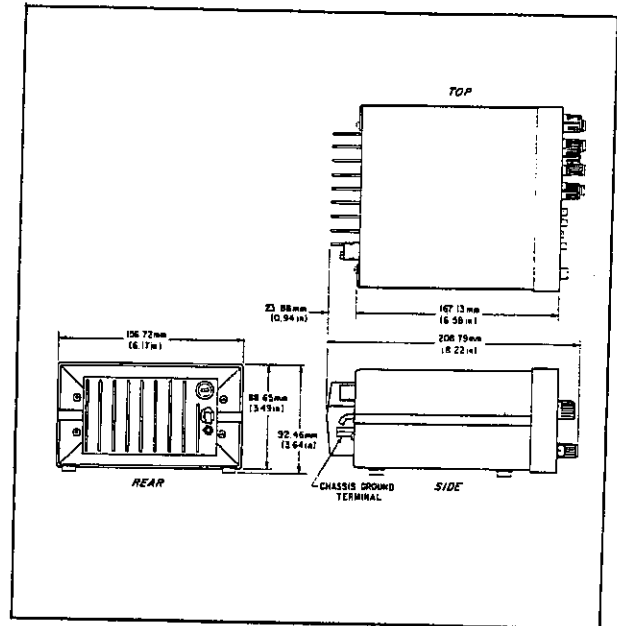


Figure 2-1. Outline Diagram

2-19 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection. In no event shall this instrument be operated without an adequate cabinet ground connection.

2-20 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter (if permitted by local regulations) and connect the green lead on the adapter to ground.

2-21 Model 6234A is equipped at the factory with a power cord plug appropriate for the user's location. Figure 2-2 illustrates the standard configuration of power cord plugs used by HP. Below each drawing is the HP Part Number for a replacement power cord equipped with a plug of that configuration. Notify the nearest HP Sales Office if you require a different power cord.

## 2-22 REPACKAGING FOR SHIPMENT

2-23 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped and provide the Authorized Return label necessary to expedite the handling of your instrument return. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

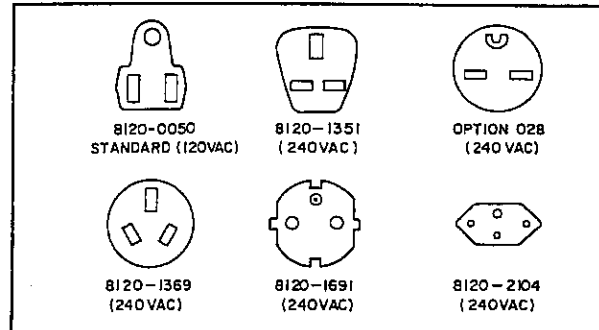


Figure 2-2. Power Cord Plug Configurations.

## SECTION III OPERATING INSTRUCTIONS

### 3-1 INTRODUCTION

3-2 This section describes the operating controls and indicators, turn-on checkout procedures, and other operating considerations for the Model 6234A Dual Output Power Supply.

#### WARNING

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

*Only fuses with the required rated current and specified type should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.*

### 3-3 CONTROLS AND INDICATORS

#### 3-4 Line Switch

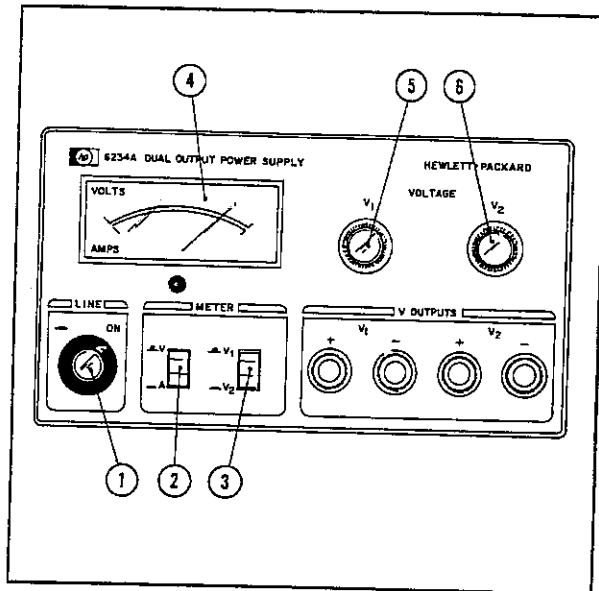


Figure 3-1. Controls and Indicators

3-5 The LINE pushbutton switch (item ①, Figure 3-1) is pushed-in to turn the supply ON and released (out position) to turn the supply OFF. A simulated (non-electrical) ON indicator (within the pushbutton) "lights" when the button is pushed-in whether or not power is applied to the unit.

#### 3-6 Voltage and Current Metering

3-7 Two meter select pushbutton switches (items ② and ③) permit the output voltage or current of either output (V1 or V2) to be monitored on the VOLT/AMPS meter ④. The V/A pushbutton ② selects either voltage (out position) or current (in position). The V1 and V2 output select pushbuttons ③ connect the desired output to the metering circuit when the applicable button is pushed in. The voltmeter range is from 0 to 30V while the ammeter range is from 0 to 0.25A.

#### 3-8 Voltage Controls

3-9 The V1 and V2 VOLTAGE controls (items ⑤ and ⑥) set the voltage level of the corresponding output. The voltage controls are 3 3/4 turn, cermet potentiometers with infinite resolution; thus, the resolution obtained depends only upon the user's care in setting the controls. Each control has a self-contained clutch (ball-bearing mechanism) that allows the control to be rotated continuously in either direction. When the clutch becomes engaged at either end point (CW or CCW), further rotation in that direction will not change the potentiometer's electrical setting. A slight resistance is encountered when rotating a control with the clutch mechanism engaged.

#### NOTE

*Greater accuracy in setting the controls can be achieved if a DVM is used to monitor the outputs.*

### 3-10 TURN-ON CHECKOUT PROCEDURES

3-11 The following steps describe the use of the Model 6234A front panel controls and indicators illustrated in Figure 3-1 and serve as a brief check that the supply is operational. Follow this checkout procedure or the more detailed performance test of paragraph 5-6 when the instrument is received and before it is connected to any load equipment. Proceed to the more detailed performance test beginning in paragraph 5-15 if any difficulties are encountered.

## CAUTION

*Before the supply is switched on, check the label on the heat sink to make certain that the supply's line voltage option agrees with the line voltage to be used. The supply will be damaged if it is wired for a 120Vac input and 240Vac input power is applied.*

- a. Connect line cord to power source and push LINE switch ① in.
- b. Set meter select switches ② , ③ to monitor supply's V<sub>1</sub> output voltage. With no load connected, vary the V<sub>1</sub> voltage control ⑤ over its range and check that the voltmeter ④ responds to the control setting.
- c. Monitor the supply's V<sub>2</sub> output voltage. With no load connected, vary the V<sub>2</sub> voltage control ⑥ over its range and check that voltmeter responds to the control setting.
- d. Turn the V<sub>1</sub> and V<sub>2</sub> VOLTAGE controls fully CW. Connect ammeter (e. g., Simpson Multimeter Model 269) in turn, between the + and - terminals of each output. The internal resistance of the meter is low enough to overload the supply so that the output will current limit. Verify that the current limit circuit in each supply (V<sub>1</sub> and V<sub>2</sub>) is limiting the output current to 0.275A to  $\pm 10\%$  @25°C.
- e. Remove ammeter and connect loads to the output terminals (see paragraph 3-21).

3-12 If this brief checkout procedure or later use of the supply reveals a possible malfunction, see Section V of this manual for detailed test, troubleshooting and adjustment procedures.

### 3-13 LINE VOLTAGE OPTION CONVERSION

3-14 To convert the supply from one line voltage option to the other, proceed as follows:

1. Disconnect line cord from the power source.
2. Remove top cover from supply by removing 2 screws in rear of supply and sliding cover to the rear. The line voltage jumpers are located behind line switch S1. (See component locations diagram in Section VII.)
3. Refer to component locations diagram and install jumper(s) for 120Vac or 240Vac input as follows:

<u>Input</u>	<u>Jumpers</u>
120Vac	J1 and J2 in, J3 out
240Vac	J3 in, J1 and J2 out

4. Check the rating of the installed fuse and replace it with correct value, if necessary. For 120Vac input, use a 0.4A slo-blow fuse (HP Part No. 2110-0340). For 240Vac input, use a 0.2A slo-blow fuse (HP Part No. 2110-0235).
5. Install proper line cord and plug (see paragraph 2-19).
6. Replace cover and mark the supply clearly with a tag or label indicating the correct line voltage to be used.

### 3-15 OPERATION

3-16 The dual outputs of the 6234A can be used individually, in series, or in parallel. Each output can be floated (up to 300 volts off ground) or, the + or - terminal of either output can be grounded to the chassis ground terminal which is located on the supply's rear heat sink.

### 3-17 Overcurrent Protection

3-18 The outputs are individually protected against overload or short circuit damage by separate current limiting circuits. The circuits are factory adjusted to limit the output current to  $0.275A \pm 10\%$ . The current limits are set by adjusting R2 in the V<sub>1</sub> supply and R12 in the V<sub>2</sub> supply (see paragraph 5-47 ). No deterioration of the supply's performance occurs if the output current remains below the current limit setting.

### 3-19 Operation Beyond Rated Output

3-20 The 6234A can provide voltages and currents greater than its rated maximum outputs if the line voltage is at or above its nominal value. The V<sub>1</sub> and V<sub>2</sub> supplies can be operated above their ratings (e. g., up to 30V), but performance specifications cannot be guaranteed above the rated output of 0 to 25V at 0.2A.

### 3-21 Connecting Loads

3-22 Connect each load to the power supply output terminals using separate pairs of connecting wires. This minimizes mutual coupling between loads and takes full advantage of the low output impedance of the supply. Load wires must be of adequately heavy gauge to maintain satisfactory regulation at the load. Make each pair of connecting wires as short as possible and twist or shield them to reduce noise pick-up. If shielded wire is used, connect one end of the shield to the power supply ground terminal and leave the other end unconnected.

3-23 If load considerations require locating output power distribution terminals at a distance from the power supply, then the power supply output terminals should be connected to the remote distribution terminals by a pair of twisted or shielded wires and each load should be connected to the remote distribution terminals separately.

### 3-24 Series Operation

3-25 The two outputs (V<sub>1</sub> and V<sub>2</sub>) can be connected in series to obtain a higher voltage (up to 50V) than is available from a single output. Each output control (V<sub>1</sub> and V<sub>2</sub>) must be adjusted in order to obtain the total output voltage. Diodes connected internally across each output protect the supply's output filter capacitors against reverse voltages. This could occur if the supplies are connected in series and the output is shorted.

### 3-26 Parallel Operation



**3-27** The  $V_1$  and  $V_2$  supplies can be connected in parallel to obtain a total output current greater than that available from one supply. The total output current is the sum of the output currents of the individual supplies. The output voltage controls of one power supply should be set to the desired output voltage, and the other supply set for a slightly larger output voltage. The supply set to the lower output voltage will act as a constant voltage source, while the supply set to the higher output will act as a current-limited source, dropping its output voltage until it equals that of the other supply. The constant voltage source will deliver only that fraction of its rated output current necessary to fulfill the total current demand.

### **3-28 Special Operating Considerations**

**3-29 Pulse Loading.** The power supply will automatically cross over from constant-voltage to current-limit operation in response to an increase in the output current over the preset limit. Although the preset limit may be set higher than the average output current, high peak currents as occur in pulse loading may exceed the preset current limit and cause crossover to occur and degrade performance.

**3-30 Output Capacitance.** An internal capacitor across the output terminals of the power supply helps to supply high-

current pulses of short duration during constant-voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the load protection provided by the current limiting circuit. A high-current output pulse may damage load components before the average output current is large enough to cause the current limiting circuit to operate.

**3-31 Reverse Current Loading.** An active load connected to the power supply may actually deliver a reverse current to the supply during a portion of its operating cycle. Internal diodes protect the series regulator transistors in the 6234A supply by preventing reverse current from flowing through them.

**3-32 Reverse Voltage Protection.** Internal diodes connected with reverse polarity across the output terminals protect the output electrolytic capacitors and the driver transistors from the effects of a reverse voltage applied across a supply output.

**3-33 Output Voltage Overshoot.** During turn-on or turn-off of ac power, output plus overshoot will not exceed 1V if the output is set for less than 1V. If the control is set for 1V or higher, there is no overshoot.

## SECTION IV PRINCIPLES OF OPERATION

### 4-1 OVERALL DESCRIPTION

4-2 This section presents the principles of operation for the Model 6234A Dual Output Power Supply. Throughout this section, refer to the schematic of Figure 7-1.

4-3 The 6234A contains two independent power supplies (designated V<sub>1</sub> and V<sub>2</sub>), a common input power circuit, and a meter circuit that can monitor the output voltage or current of either supply.

4-4 The two primary windings of the power transformer are connected for either a 120Vac (nom.) or a 240Vac (nom.) input by installing the applicable jumper(s). The transformer secondaries provide reduced ac voltages to two full-wave bridge rectifier circuits in each supply (V<sub>1</sub> and V<sub>2</sub>). One circuit provides raw dc for a 0-25V regulator circuit while the other provides raw dc for a reference and bias supply.

4-5 By comparing its output to a high-stability reference, the V<sub>1</sub> supply's 0 to 25V regulator holds its output voltage at the value determined by the V<sub>1</sub> VOLTAGE front panel control. Any error in the actual output as compared to the desired output is amplified by an operational amplifier and applied as feedback to control the conduction of a series regulator transistor. As a result, the voltage across the series transistor varies so as to hold the output voltage constant at the desired level. The high gain of the voltage comparison amplifier and the stability of the reference ensure that input voltage or load current variations have little effect on the output voltage.

4-6 The V<sub>1</sub> output is protected by a fixed current limit circuit. When the output current increases to 0.275A, this circuit will take control of the regulator output voltage and reduce it as necessary to keep the output current from exceeding 0.275A.

4-7 The V<sub>1</sub> reference and bias supply provides the bias voltages and a reference current source for the V<sub>1</sub> 0-25V regulator.

4-8 The V<sub>2</sub> supply contains a 0-25V regulator and its own reference and bias supply and is identical to the V<sub>1</sub> supply.

4-9 Two pushbutton switches select which supply (V<sub>1</sub> or V<sub>2</sub>) has its output voltage or current indicated on the combination voltmeter/ammeter.

### 4-10 CIRCUIT DESCRIPTION

4-11 Since the V<sub>1</sub> and V<sub>2</sub> supplies are identical, only the V<sub>1</sub> circuits are discussed.

### 4-12 0 to +25V Regulated Supply

4-13 **Voltage Comparison Amplifier.** The voltage comparison amplifier controls the conduction of series regulator Q1 so that the voltages at the two inputs of the amplifier remain equal. Its inverting input (U3-6) monitors the output voltage. Its non-inverting input (U3-5) monitors a stable reference voltage which is produced by a constant reference current (I<sub>REF</sub>, 3mA nominal) flowing through the V<sub>1</sub> VOLTAGE control (R1). The reference voltage level is proportional to the resistance setting of R1, thus the output voltage of the supply is proportional to the resistance setting of R1. At the output of the comparison amplifier (U3-7), a negative change corresponds to a decrease in the conduction of Q1.

4-14 CR7 and CR8 protect the amplifier against excessive input voltage, C6 and R7 form a low pass filter to smooth any noise generated across the VOLTAGE control R1. C5 stabilizes the supply's high frequency characteristics.

4-15 **Driver and Series Regulator.** The +12V<sub>A</sub> output of the bias supply provides the turn-on bias for series regulator transistor Q1. Its complete current path includes U4, R4, and Q1. The voltage comparison amplifier (U3) or the current limit sense transistor Q4 controls the conduction of driver Q2 which regulates the flow of turn-off bias for Q1. The algebraic sum of the nearly constant turn-on bias through R4 and the variable turn-off bias through Q2 controls the conduction of series regulator transistor Q1.

4-16 Resistors R28 and R29 provide an alternate path for leakage current when the supply is turned-off. Ferrite bead L1 suppresses high frequency oscillations.

4-17 **Current Limit Circuit.** Current limiting occurs when the current limit sense transistor Q4 conducts. This is determined by the voltage drop across current sampling resistor R10 and the adjustment of current limiting potentiometer R2. When the output current reaches the limit value (0.275A ± 10%), the voltage at the Q4 base becomes positive enough to turn Q4 on. For this condition, driver transistor Q2 is turned on harder diverting base drive away from the series regulator transistor. Consequently, the regulator's output voltage is reduced as necessary to keep the output current from exceeding the limit value.

4-18 **Circuit Protection Components.** Diodes CR1 and CR2 each protect the V<sub>1</sub> supply from specific hazards. Series regulator diode CR1 prevents a reverse current from flowing through Q1 should an external source try to push current back through the supply. Output diode CR2 protects the supply's components if a reverse voltage is applied to the output ter-

minals. Diodes CR4 and CR6 are included to protect against overshoot for low output voltages at turn-off. Diode CR5 prevents the voltage comparison amplifier from sourcing current when the regulator is in the current limit mode, thus preventing instability in the current limit operating mode.

#### 4-19 Reference and Bias Supply

4-20 The reference and bias supply powers the operational amplifiers, provides bias voltages for the series regulator and driver transistors, and produces the constant reference current required by the 0-25V regulator circuit.

4-21 The  $V_1$  reference and bias supply consists of full-wave bridge rectifier IC (U1), +12V regulator IC (U4), and a reference current source comprised of operational amplifier (P/O U3) and transistors Q3 and Q5. The transistors are con-

nected in a Darlington configuration to achieve a nearly ideal current source. The operational amplifier compares the voltage at the junction of R22 and R41 with a highly stable zener reference and furnishes the proper base drive current required to keep the reference current ( $I_{REF}$ ) constant.

#### 4-22 Meter Circuit

4-23 The output voltage or output current of either supply can be measured on voltmeter/ammeter (M1). The volts/amps (V/A) pushbutton selects either voltage or current and the  $V_1/V_2$  pushbutton connects the desired output to the metering circuit. R24 is a voltage scaling resistor. When measuring output current, the meter, in series with resistor R25 and ammeter adjust potentiometer (R26), is connected across the applicable current sampling resistor R10 ( $V_1$  supply) or R20 ( $V_2$  supply).

## SECTION V MAINTENANCE

### 5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance test of paragraph 5-6 can be made. This test is suitable for incoming inspection. Section III contains a quick but less comprehensive checkout procedure that can be used in lieu of the performance test if desired.

5-3 If a fault is detected in the power supply while making the performance test or during normal operation, proceed to the troubleshooting procedure in paragraph 5-32. After troubleshooting and repair, repeat the performance test to ensure that the fault has been properly corrected and that no other faults exist. Before performing any maintenance checks, turn on the power supply and allow a half-hour warm-up.

### 5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

### 5-6 PERFORMANCE TEST

5-7 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated to check the operation of the instrument after repairs. If the correct result is not obtained for a particular check, proceed to the troubleshooting procedures of paragraph 5-32.

#### CAUTION

*Before applying power to the supply, check the label on the heat sink to make certain that the supply's line voltage option agrees with the line voltage to be used. The supply will be damaged if its internal jumpers are connected for a 120Vac input and 240Vac input power is applied.*

### 5-8 General Measurement Techniques

5-9 **Connecting Measuring Devices.** To achieve valid results when measuring the load effect, PARD (ripple and noise), and transient recovery time of the supply, measuring devices must be connected as close to the output terminals as possible. A measurement made across the load includes the impedance of the leads to the load. The impedance of the load leads can easily be several orders of magnitude greater than the supply impedance and thus invalidate the measurement. To avoid mutual coupling effects, each measuring device must be connected directly to the output terminals by separate pairs of leads.

5-10 When measurements are made at the front panel terminals, the monitoring leads must be connected at point A, as shown in Figure 5-1, and not at point B. Connecting the measuring device at point B would result in a measurement that includes the resistance of the leads between the output terminals and the point of connection.

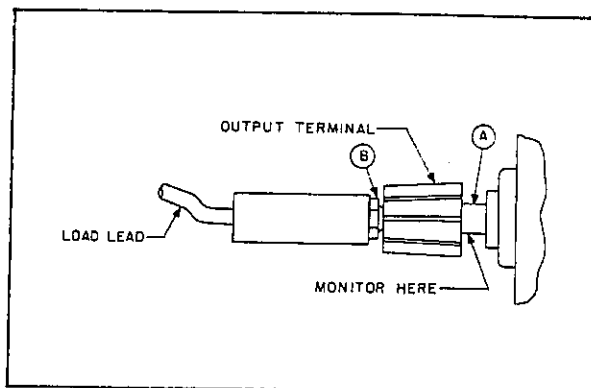


Figure 5-1. Front Panel Terminal Connections

5-11 **Selecting Load Resistors.** Power supply specifications are checked with a full load resistance connected across the supply output. The resistance and wattage of the load resistor, therefore, must permit operation of the supply at its rated output voltage and current. For example, a supply rated at 25 volts and 0.2 amperes would require a load resistance of 125 ohms at the rated output. The wattage rating of this resistor would have to be at least 5 watts.

5-12 Either a fixed or variable resistor (rheostat) can be used as the load resistance. Using a rheostat (alone or in series with a fixed resistor) is often more convenient than using fixed resistors as loads because the latter may be more difficult to obtain in the exact resistance required.

5-13 **Output Current Measurements.** For accurate output current measurements, a current sampling resistor should be inserted between the load resistor and the output of the supply. An accurate voltmeter is then placed across the sampling resistor and the output current calculated by dividing the voltage across the sampling resistor by its ohmic value. The total resistance of the series combination should be equal to the full load resistance as determined in the preceding paragraphs.

5-14 Figure 5-2 shows a four terminal meter shunt. The load current through a shunt must be fed to the extremes of the wire leading to the resistor while the sampling connections are made as close as possible to the resistance portion itself.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Digital Voltmeter	Sensitivity: 100mV full scale (min.). Input impedance: 10 megohms (min.).	Measure dc voltages: calibration procedures	HP 3490A.
Variable Voltage Transformer	Range: 90-130Vac Equipped with voltmeter accurate within 1 volt	Vary ac input	-----
Oscilloscope	Sensitivity: 100 $\mu$ V/cm. Differential input.	Display transient response and ripple and noise waveforms.	HP 180C with 1821A, and 1801A or 1803A plug-ins.
Repetitive Load Sw.	Rate: 60Hz, 2 $\mu$ s rise and fall time	Measure transient response.	See Figure 5-5
Resistive Loads	See paragraph 5-15	Power supply load resistors.	-----
Current Sampling Resistor (Shunt)	See paragraph 5-15	Measure output current.	-----

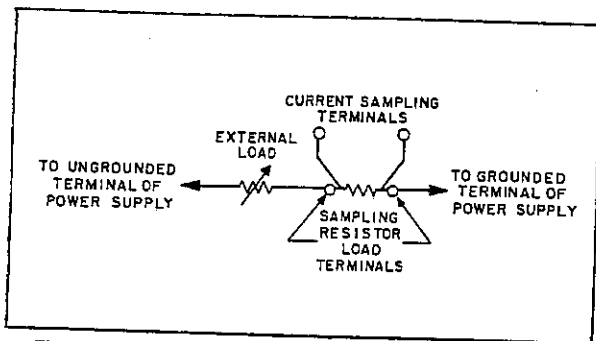


Figure 5-2. Current Sampling Resistor Connections

NOTE

The  $V_1$  and  $V_2$  VOLTAGE controls are 3/4-turn, cermet potentiometers. Each control has a self-contained clutch (ball-bearing mechanism) that allows the control to be rotated continuously in either direction. When the clutch becomes engaged at either end point in the CW or CCW direction, further rotation in the same direction will not change the control's electrical setting. A slight resistance is felt when the control is rotated with the clutch mechanism engaged.

5-15 Rated Output, Meter Accuracy, and Current Limit

5-16 To check that all supplies will furnish their maximum rated output voltage and current, that the front panel voltmeter/ammeter is accurate, and that the current limit circuits function, proceed as follows:

**Rated Output Voltage and Voltmeter Accuracy**

- Connect a 125 $\Omega$ , 5W,  $\pm 5\%$  across the + and - output terminals of the  $V_1$  supply.
- Connect a DVM between the  $V_1$  + and - output terminals. Connect meter common to the - terminal.

- Rotate the  $V_1$  VOLTAGE control fully CCW until clutch mechanism engages. Check that the DVM indication is  $\leq 20$  millivolts.
- Set meter select switches to monitor the  $V_1$  supply's output voltage.
- Rotate  $V_1$  VOLTAGE control CW until front panel voltmeter indicates exactly 25 volts.
- DVM should indicate 25 volts  $\pm 4\%$ .
- Repeat steps a through f for  $V_2$  supply.

**Rated Output Current and Ammeter Accuracy**

- Connect the test setup shown in Figure 5-3 to the  $V_1$  supply's + and - output terminals.

- b. Set meter select switch to monitor the  $V_1$  supply's output current.
- c. Close the switch and adjust  $V_1$  VOLTAGE control until front panel ammeter indicates exactly 0.20A.
- d. DVM should indicate  $1.2V \pm 0.048V$ .
- e. Open the load switch and repeat steps a through d above for the  $V_2$  supply.

#### Current Limit

- a. Disconnect all loads from supply.
- b. Connect test setup shown in Figure 5-3 to the  $V_1$  supply's + and - output terminals. Substitute a short for  $R_L$  and leave load switch open.
- c. Rotate  $V_1$  VOLTAGE control fully CW until the clutch mechanism engages.
- d. Close load switch and determine the current flow through the current flow through the current sampling resistor  $R_S$  by measuring its voltage drop with DVM. DVM should read  $1.65V \pm 10\%$ .
- e. Open the load switch and repeat steps a through d above for the  $V_2$  supply.

#### 5-17 Load Effect (Load Regulation):

Definition: The change,  $\Delta E_{out}$ , in the static value of dc output voltage resulting from a change in load resistance from open circuit to the value that yields maximum rated output current (or vice versa).

5-18 To check the load effect:

- a. Connect a full load resistance ( $125\Omega$ ) and a digital voltmeter across the output of the  $V_1$  supply.
- b. Turn on the supply and adjust its voltage to its maximum rated value (25V).
- c. Record the voltage indicated on the DVM.
- d. Disconnect the load resistance and recheck the DVM indication. It should be within 3.5mV of the reading in step (c).
- e. Repeat steps (a) through (d) for the  $V_2$  supply.

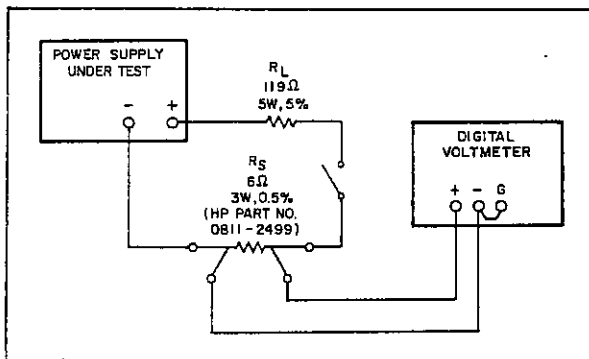


Figure 5-3. Output Current, Test Setup

#### 5-19 Source Effect (Line Regulation)

Definition: The change,  $\Delta E_{out}$ , in the static value of dc output voltage resulting from a change in ac input voltage over the specified range from low line (typically 104Vac) to high line (typically 127Vac), or from high line to low line.

5-20 To test the source effect:

- a. Connect a variable autotransformer between the input power source and the power supply line plug.
- b. Connect a full load resistance and a digital voltmeter across the output of the  $V_1$  supply.
- c. Adjust the autotransformer for a low line input.
- d. Turn on the power, adjust the output of the supply to its maximum rated voltage, and record the DVM indication.
- e. Adjust the autotransformer for a high line input and recheck the DVM indication. It should be within 3.5mV of the reading in step (d).
- f. Repeat steps (b) through (e) for the  $V_2$  supply.

#### 5-21 PARD (Ripple and Noise)

Definition: The residual ac voltage that is superimposed on the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its rms or peak-to-peak value.

5-22 Measurement Techniques. Figure 5-4A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential  $E_g$  between the two ground points causes an IR drop that is in series with the scope input. This IR drop, normally having 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply and can completely invalidate the measurement.

5-23 The same ground current and pickup problems can exist if an rms voltmeter is substituted in place of the oscilloscope in Figure 5-4. However, the oscilloscope display, unlike the true rms meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an HP supply is 120Hz (due to full-wave rectification), an oscilloscope display showing a 120Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple.

5-24 Figure 5-4B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply output. To ensure that no potential difference exists between the supply and the oscilloscope, it is recommended that they both be plugged into the same ac power bus. If the same bus cannot be used, both ac grounds must be at earth ground potential.

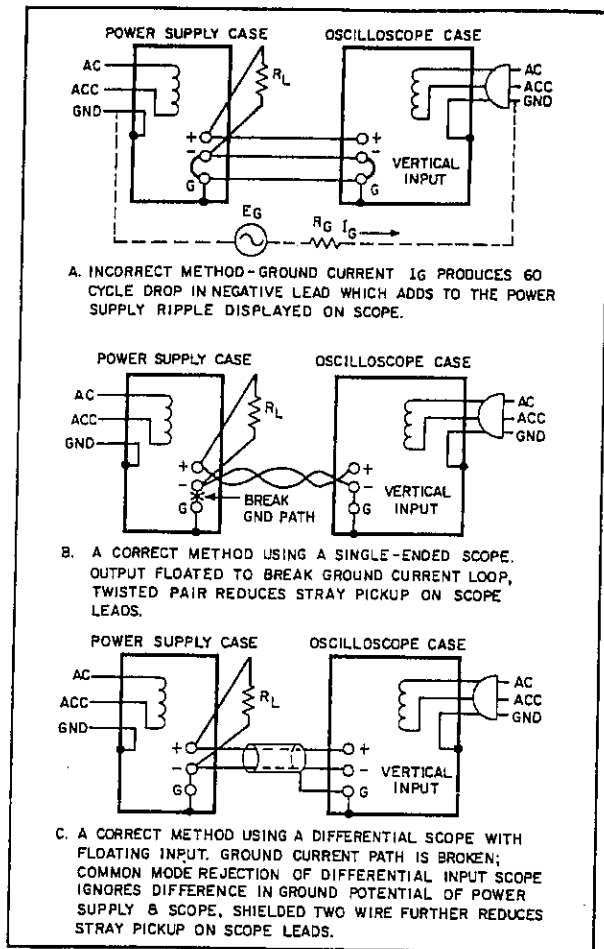


Figure 5-4. Ripple and Noise, Test Setup

5-25 Either a twisted pair or, preferably, a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be taken that one of the two wires is connected to the grounded input terminal of the oscilloscope to ensure that the supply output is safely grounded. When using shielded two-wire, it is essential for the shield to be connected to ground at one end only to prevent ground current flowing through this shield from inducing a signal in the shielded leads.

5-26 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (-) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-27 In most cases, the single-ended scope method of Figure 5-4B will be adequate to eliminate extraneous ripple so that a satisfactory measurement may be obtained. However, in more stubborn cases (or if high frequency noise up to 20MHz must be measured), it may be necessary to use a dif-

ferential scope with floating input as shown in Figure 5-4C. If desired, two single-conductor shielded cables may be substituted in place of the shielded two-wire cable with equal success. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal produced by the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, then the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-28 **Measurement Procedure.** To measure the ripple and noise on each supply output, follow the steps below. If a high frequency noise measurement is desired, an oscilloscope with sufficient bandwidth (20MHz) must be used. Ripple and noise measurements can be made at any input ac line voltage combined with any dc output voltage and load current within rating.

a. Connect an oscilloscope or rms voltmeter across an output of the supply as shown in Figures 5-4B or 5-4C.

b. Energize the supply and observe the oscilloscope or meter indication. The ripple and noise should not be greater than 0.2mV rms or 1.0mV peak-to-peak.

c. Repeat for the other supply output.

### 5-29 Load Transient Recovery Time

**Definition:** The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current, where: "Y" equals 15mV, and "Z" is the specified load current change, equal to half of the current rating of the supply. The nominal output voltage is defined as the dc level halfway between the static output voltage before and after the imposed load change.

5-30 **Measurement Techniques.** Care must be taken in switching the load resistance on and off. A hand-operated switch in series with the load is not adequate since the resulting one-shot displays are difficult to observe on most oscilloscopes and the arc energy occurring during switching completely masks the display with a noise burst. Transistor load switching devices are expensive if reasonably rapid load current changes are to be achieved. Instead, a mercury-wetted relay should be used for loading and unloading the supply. Connect it in the load switching circuit shown in Figure 5-5. When this load switch is connected to a 60Hz ac input, the mercury-wetted relay will open and close 60 times per second. The 25K control adjusts the duty cycle of the load current switching to reduce jitter in the oscilloscope display. This relay may also be used with a 50Hz ac input.

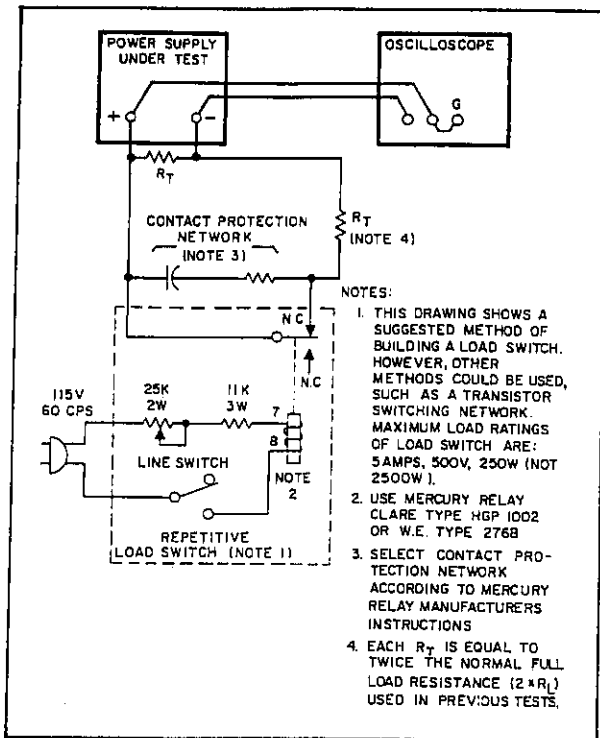


Figure 5-5. Load Transient Recovery Time, Test Setup

**5-31 Measurement Procedure.** To measure the load transient recovery time, follow the steps below for each supply output. Transient recovery time may be measured at any input line voltage and any output voltage within rating. For this supply the specified load change is between half load and full load.

- Connect the test setup shown in Figure 5-5. Both load resistors ( $R_T$ ) are twice the normal value of a full load resistance.
- Turn on the supply and close the line switch on the repetitive load switch.
- Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.
- Set the vertical input of the oscilloscope for ac coupling so that small dc level changes in the output voltage of the power supply will not cause the display to shift.
- Adjust the horizontal positioning control so that the trace starts at a point coincident with a major graticule division. This point then represents time zero.
- Adjust the vertical centering of the scope so that the tail ends of the no-load and full-load waveforms are symmetrically displaced about the horizontal center line of the oscilloscope. This center line now represents the nominal output voltage defined in the specification.
- Increase the sweep rate so that a single transient spike can be examined in detail.
- Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.

i. Starting from the major graticule division representing time zero, count to the right  $50\mu s$  and vertically  $15mV$ . Recovery should be within these tolerances, as illustrated in Figure 5-6.

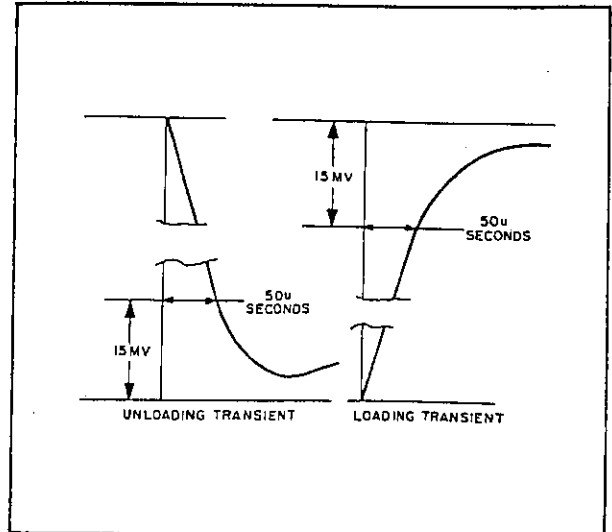


Figure 5-6. Load Transient Recovery Time Waveforms

## 5-32 TROUBLESHOOTING

**5-33** Before attempting to troubleshoot this instrument, ensure that the fault is in the instrument itself and not in an associated piece of equipment. You can determine this without removing the covers from the instrument by using the appropriate portions of the performance test of paragraph 5-6.

**5-34** A good understanding of the principles of operation is a helpful aid in troubleshooting, and the reader is advised to review Section IV of the manual before beginning detailed troubleshooting. Once the principles of operation are understood, proceed to the troubleshooting procedures in paragraph 5-35.

### WARNING

*Hazardous voltage is present on the circuit board in the area of the LINE switch S1, fuse, and the ac input jumpers. Exercise care when troubleshooting this unit with protective covers removed.*

## 5-35 Troubleshooting Procedure

- 5-36** If a malfunction is found, follow the steps below:
- Disconnect input power from the supply, remove all loads from the output, and remove covers from supply.
  - Table 5-2 lists the symptoms and probable causes of several possible troubles. If the symptom is one of those listed, make the recommended checks.
  - If none of the symptoms of Table 5-2 apply, proceed to the troubleshooting procedures in Table 5-3.



5-37 The numbered test points referred to in the troubleshooting procedures are identified on the circuit schematic and on the component location diagram at the rear of the manual.

### 5-38 Open Fuse Troubleshooting

5-39 Although transients or fatigue can cause a fuse to blow, it is a good idea to inspect the unit for obvious shorts such as damaged wiring, charred components, or extraneous metal parts or wire clippings in contact with circuit board conductors before replacing the fuse. The rating of the correct replacement fuse depends on the line voltage option of the instrument: for 120Vac line voltage, use a slo-blow 0.4 amp fuse (HP Part No. 2110-0340); for 240Vac line voltage, use a slo-blow 0.2 amp fuse (HP Part No. 2110-0235).

## 5-40 REPAIR AND REPLACEMENT

### 5-41 Series Regulator Replacement

5-42 To remove and replace a series regulator transistor:

- Remove the top and bottom covers from the instrument.
- Remove the collector screws and unsolder the base and emitter leads from the board to remove the transistor.
- To replace the transistor, follow the below reassembly order, as viewed from the bottom of the heat sink: collector screws, P. C. board, heat sink, two insulating bushings (in collector screw holes in heatsink), heat sink compound (HP 6040-0415), mica insulator, another coating of silicon grease, transistor, lock-washers, and hex-nuts.
- Resolder the emitter and base pins to the circuit board.

### 5-43 Semiconductor Replacement

5-44 Table 6-4 contains replacement data for the semiconductors used in this power supply. When replacing a semiconductor, use the listed Hewlett-Packard or exact commercial replacement if these are available. If neither of these are immediately available and a part is needed without delay for operation or troubleshooting verification, the parts designated Note 1, Alternate Part Number can be tried with a high probability of success.

5-45 Notice that both the commercial and alternate replacements listed in Table 6-4 apply only to the HP power supplies covered by this manual and their use in any other Hewlett-Packard instrument is not necessarily recommended because of inclusion in this table.

## 5-46 ADJUSTMENT AND CALIBRATION

### WARNING

*Hazardous voltage is present on line switch, fuse, and ac input jumpers. Exercise care when making the following adjustments with protective covers removed from power supply.*

## 5-47 Current Limit Adjustment

5-48 Perform the following steps to adjust the current limit circuit in the V<sub>1</sub> or V<sub>2</sub> supply. Potentiometer R2 sets the V<sub>1</sub> and R12 the V<sub>2</sub> current limit. (See component location diagram in Section VII.)

- Turn the current limit adjustment pot (R2 or R12) to center (approx.) position.
- Connect the test circuit of Figure 5-3 to the output of the supply to be adjusted. Substitute a short for R<sub>L</sub> and leave load circuit switch open.
- Turn on the supply and set the VOLTAGE control for maximum output (fully clockwise).
- Close load switch and adjust the current limit pot (R2 or R12) until the DVM indicates a voltage drop across the shunt of 1.65V  $\pm$  10%.

## 5-49 Meter Calibration

5-50 **Meter Zero.** The meter pointer must rest on the zero calibration mark on the meter scale when the instrument is at normal operating temperature, resting in its normal operating position, and turned off. To zero set the voltmeter/ammeter, proceed as follows:

- Turn on the instrument and allow it to come up to normal operating temperature (in about 30 minutes).
- Turn off instrument and allow 30 seconds for all capacitors to discharge.
- Insert small screwdriver into the small hole directly below meter face.
- Rotate zero adjust screw clockwise until meter reads zero, then rotate counterclockwise slightly in order to free adjustment screw from meter suspension. Pointer should not move during latter part of adjustment. If pointer moves, repeat the adjustment.

5-51 **Ammeter.** Check and calibrate the front panel ammeter by following the steps below.

- Set meter switches to monitor the V<sub>1</sub> supply's output current.
- Connect the test setup of Figure 5-3 to the V<sub>1</sub> supply's + and - output terminals.
- Close the switch and set the V<sub>1</sub> VOLTAGE control so that the DVM reads 1.2V.
- Check that the front panel ammeter reads 0.2A. If necessary adjust potentiometer R26 for 0.2A indication on front panel ammeter.

5-52 **Voltmeter.** Check the accuracy of the front panel voltmeter by performing the voltmeter accuracy test in paragraph 5-15. The accuracy specification is  $\pm$  4% for the V<sub>1</sub> and V<sub>2</sub> ranges. If the voltmeter ranges are not within specification, check the value of R24 in the meter circuit.

**Table 5-2. Miscellaneous Troubles**

SYMPTOM	CHECK — PROBABLE CAUSE
High Ripple	a. Check operating setup for ground loops (see paragraph 5-22). b. Defective C1, C3, C7 (V <sub>1</sub> supply) or C10, C13, C17 (V <sub>2</sub> supply). c. Open C2, C5, C6 (V <sub>1</sub> supply) or C12, C15, C16 (V <sub>2</sub> supply) d. Shorted R27 or R37. e. Defective U4, VR1 (V <sub>1</sub> supply) or U14, VR10 (V <sub>2</sub> supply).
Will not current limit	a. Shorted C8, R10 (V <sub>1</sub> supply) or C18, R20 (V <sub>2</sub> supply). b. Defective Q4 or Q14. c. Open R2, R23 (V <sub>1</sub> supply) or R12, R33 (V <sub>2</sub> supply).
Poor load regulation	a. Check load connections. b. Check current limit adjustment in paragraph 5-47. c. Defective U4, VR2 (V <sub>1</sub> supply) or U14, VR12 (V <sub>2</sub> supply). d. Defective C5, Q3, Q5 (V <sub>1</sub> supply) or C15, Q13, Q15 (V <sub>2</sub> supply).
Poor line regulation	a. Check main rectifiers and filters. b. Defective U4, VR2 (V <sub>1</sub> supply) or U14, VR12 (V <sub>2</sub> supply). c. Shorted R27 or R37.
Poor transient response	a. Defective C5, C8, R9 (V <sub>1</sub> supply) or C15, C18, R19 (V <sub>2</sub> supply). b. Shorted R21 or R31.
Turn on/off overshoot	a. Shorted CR4, R27 (V <sub>1</sub> supply) or CR14, R37 (V <sub>2</sub> supply). b. Open CR6, R28, R29 (V <sub>1</sub> supply) or CR16, R38, R39 (V <sub>2</sub> supply). c. Defective Q1 or Q11.

**Table 5-3. Troubleshooting Procedures**

SYMPTOM	STEP — ACTION	RESPONSE — PROBABLE CAUSE
No outputs (V <sub>1</sub> and V <sub>2</sub> outputs measure OV on front panel meter) with controls turned CW.	1. Check for obvious troubles such as improper ac input connection or input power failure.  2. Remove power and check fuse F1.  3. Apply power and measure voltage between the V <sub>1</sub> supply's + and - terminals on front panel with DVM.	a. If blown, check the following components for short circuits: C1, C3, C11, C13, U1, U2, U11, U12.  b. If fuse is not blown, proceed to step 3.  a. If DVM measures >25V, meter M1 or switch S2 defective.  b. If voltage is OV, check S1 and T1.

Table 5-3. Troubleshooting Procedures (Continued)

SYMPTOM	STEP – ACTION	RESPONSE – PROBABLE CAUSE
<p>NOTE: If the output is normal unloaded but falls when loaded, check the current limit adjustment (paragraph 5-47).</p> <p>One output (V<sub>1</sub> or V<sub>2</sub>) is lower than rating</p>	<p>1. Check unregulated 28V (nom) and 44V (nom) input voltages of applicable supply (see schematic).</p> <p>2. Check +12V bias voltage of applicable supply: TP1 for V<sub>1</sub> supply or TP11 for V<sub>2</sub> supply. Connect meter common to applicable + output terminal.</p> <p>3. Check -5.6V bias voltage of applicable supply: TP2 for V<sub>1</sub> supply or TP12 for V<sub>2</sub> supply. Connect meter common to applicable + output terminal.</p> <p>4. Check the following components in defective supply for open circuit: V<sub>1</sub> supply: Q1, Q3, Q5, CR1, CR4, or V<sub>2</sub> supply: Q11, Q13, Q15, CR11, CR14.</p> <p>5. Check the following components in defective supply for short circuit: V<sub>1</sub> supply: Q2, Q4, CR6, CR7, CR8. or V<sub>2</sub> supply: Q12, Q14, CR16, CR17, CR18.</p>	<p>a. If both correct, proceed to step 2.</p> <p>b. If both incorrect, transformer T1 secondary winding or lead open,</p> <p>c. If one incorrect, check applicable full wave bridge rectifier (U1, U2, U11, or U12).</p> <p>a. If voltage is normal (approx. +12V), proceed to step 3.</p> <p>b. If voltage is not normal, check applicable +12V reg. (U4 or U14).</p> <p>a. If voltage is normal (approx. 5.6V), proceed to step 4.</p> <p>b. If voltage is not normal, check applicable zener diode (VR1 or VR10).</p> <p>a. Replace open circuited component.</p> <p>b. If none opened, proceed to step 5.</p> <p>a. Replace shorted component.</p> <p>b. If none shorted, check applicable op amp (U3 or U13) and VOLTAGE control (R1 or R11).</p>
<p>One output (V<sub>1</sub> or V<sub>2</sub>) is latched high (no control).</p>	<p>1. Check the following components in the defective supply for open circuit: V<sub>1</sub> supply: Q2, CR5, CR7, CR8, R1, R9 or V<sub>2</sub> supply: Q12, CR15, CR17, CR18, R11, R19.</p> <p>2. Check the following components in the defective supply for short circuit.</p> <p>V<sub>1</sub> supply: Q1, VR1 or V<sub>2</sub> supply: Q11, VR11.</p>	<p>a. Replace open circuited component.</p> <p>b. If none opened, proceed to step 2.</p> <p>a. Replace shorted component.</p> <p>b. If none shorted replace applicable op amp (U3 or U13)</p>

## SECTION VI REPLACEABLE PARTS

### 6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alpha-numeric order by reference designators and provides the following information:

- a. Reference Designators. Refer to Table 6-1.
- b. Description. Refer to Table 6-2 for abbreviations.
- c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.
- d. Manufacturer's Part Number or Type.
- e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.
- f. Hewlett-Packard Part Number.
- g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.
- h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

### 6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). 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 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A = assembly	E = miscellaneous
B = blower (fan)	electronic part
C = capacitor	F = fuse
CB = circuit breaker	J = jack, jumper
CR = diode	K = relay
DS = device, signaling (lamp)	L = inductor
	M = meter

Table 6-1. Reference Designators (Continued)

P = plug	V = vacuum tube, neon bulb, photocell, etc.
Q = transistor	VR = zener diode
R = resistor	X = socket
S = switch	U = integrated cir- cuit or network
T = transformer	
TB = terminal block	
TS = thermal switch	

Table 6-2. Description Abbreviations

A = ampere	mod. = modular or modified
ac = alternating current	mtg = mounting
assy. = assembly	n = nano = $10^{-9}$
bd = board	NC = normally closed
bkt = bracket	NO = normally open
$^{\circ}$ C = degree Centigrade	NP = nickel-plated
cd = card	$\Omega$ = ohm
coef = coefficient	obd = order by description
comp = composition	OD = outside diameter
CRT = cathode-ray tube	p = pico = $10^{-12}$
CT = center-tapped	P.C. = printed circuit
dc = direct current	pot. = potentiometer
DPDT = double pole, double throw	p-p = peak-to-peak
DPST = double pole, single throw	ppm = parts per million
elect = electrolytic	pvr = peak reverse voltage
encap = encapsulated	rect = rectifier
F = farad	rms = root mean square
$^{\circ}$ F = degree Fahrenheit	Si = silicon
fxd = fixed	SPDT = single pole, double throw
Ge = germanium	SPST = single pole, single throw
H = Henry	SS = small signal
Hz = Hertz	T = slow-blow
IC = integrated circuit	tan. = tantalum
ID = inside diameter	Ti = titanium
incnd = incandescent	V = volt
k = kilo = $10^3$	var = variable
m = milli = $10^{-3}$	ww = wirewound
M = mega = $10^6$	W = Watt
$\mu$ = micro = $10^{-6}$	
met. = metal	
mfr = manufacturer	

Table 6-3. Code List of Manufacturers

Code	Manufacturer	Address
01121	Allen Bradley Co.	Milwaukee, WI
01686	RCL Electronics, Inc.	Manchester, NH
03508	G. E. Semiconductor Prod. Dept.	Syracuse, NY
04713	Motorola Inc. Semiconductor Prod. Div.	Phoenix, AZ
06001	General Electric Co., Electronic Capacitor and Battery Prod. Dept.	Irmo, SC
24546	Corning Glass Works, Electronic Components Div.	Bradford, PA
25140	TRW Electronic Components Div.	Dayton, OH
27014	National Semiconductor Corp.	Santa Clara, CA
28480	Hewlett-Packard Co.	Palo Alto, CA
56289	Sprague Electric Co.	North Adams, MA
73138	Beckman Instruments, Inc., Helipot Div.	Fullerton, CA
75042	TRW Electronic Components, IRC Philadelphia Div.	Philadelphia, PA
75915	Littelfuse, Inc.	Des Plaines, IL

Table 6-4. Replaceable Parts

Ref. Desig.	Description	TQ	Mfr. Part No.	Mfr. Code	HP Part No.	RS
	<b>Printed Circuit Board Assy.</b>					
C1, 11	fxd, elect 220 $\mu$ F 50V	4		28480	0180-2628	1
C2, C12	fxd, cer. 0.1 $\mu$ F 50V	2		28480	0150-0121	1
C3, 13	fxd, elect 850 $\mu$ F 75V	2	68D44592-DFP	56289	0180-1915	1
C4, 14	fxd, cer. 0.02 $\mu$ F 500V	2		28480	0160-0468	1
C5, 15	fxd, mica 100pF 300V	2		28480	0160-3070	1
C6, 16	fxd, elect. 1 $\mu$ F 50V	2	150D105X0050A2	56289	0180-0230	1
C7, 17	fxd, elect. 220 $\mu$ F 50V	2		28480	0180-2628	1
C8, 18	fxd, poly. 2200pF 200V	2	AE12C222KT	06001	0160-0154	1
CR1, 2, 11, 12	diode, power rectifier	4	1N5059	28480	1901-0327	2
CR4-8, 14-18	diode, general purpose	10	1N485B	28480	1901-0033	5
L1, 11	inductor, ferrite bead	2		28480	9170-0894	1
Q2, 12	SS PNP Si	2	S21297 (NOTE 1)	04713	1853-0041	2
Q3, 13	SS PNP Si.	4	2N2907A	28480	1853-0281	4
Q4, 14	SS NPN Si.	2	SPS3611 (NOTE 1)	04713	1854-0215	2
Q5, 15	SS PNP Si.		2N2907A	28480	1853-0281	
R2, 12	var. cer. 1k 10%	2	72-105-0	73138	2100-3211	1
R3, 13	fxd, comp. 15k 5% 1/2W	2	EB-1535	01121	0686-1535	1
R4, 14	fxd, film 1.33k 1% 1/4W	2	C5-1/4-TO-1331-F	24546	0698-3134	1
R5, 15	fxd, comp. 620 5% 1/4W	2	CB-6215	01121	0683-6215	1
R6, 16	fxd, comp. 33 5% 1/2W	2	EB-3305	01121	0686-3305	1
R7, 17	fxd, film 10k 1% 1/4W	2	C5-1/4-TO-1002-F	24546	0757-0340	1
R8, 9, 18, 19	fxd, film 5.11k 1% 1/8W	4	C4-1/8-TO-5111-F	24546	0757-0438	1
R10, 20	fxd, ww 6 0.5% 3W	2	T2B-70	01686	0811-2499	1
R21, 31	fxd, ww 0.62 5% 2W	2	BWH2-62/100-J	75042	0811-1759	1
R22, 32	fxd, film 2.3k 1% 1/8W	2	NE55	24546	0698-6387	
R23, 33	fxd, film 243 1% 1/8W	2	C4-1/8-TO-243R-F	24546	0757-0408	1
R24	fxd, film 15k 1% 1/4W	1	C5-1/4-TO-1502-F	24546	0757-0757	1
R25	fxd, film 619 1% 1/8W	1	C4-1/8-TO-619R-F	24546	0757-0418	1
R26	var. cer. 200 10%	1	72-103-0	73138	2100-3212	1
R27, 37	fxd, film 1.62k 1% 1/4W	2	C5-1/4-TO-1621-F	24546	0757-0737	1
R28, 38	fxd, comp. 10k 5% 1/2W	2	EB-1035	01121	0686-1035	1
R29, 39	fxd, comp. 1k 5% 1/4W	2	CB-1025	01121	0683-1025	1
R30, 40	fxd, comp. 12k 5% 1/4W	2	CB-1235	01121	0683-1235	1
R41, 51	fxd, comp. 30k 5% 1/4W	2	CB-3035	01121	0683-3035	1
S1	switch, line	1		28480	3101-2287	1
S2	switch assembly, meter switch and power supply select	1		28480	3101-2349	1
U1, 2, 11, 12	diode, fullwave bridge rect.	4		28480	1906-0006	4
U3, 13	operational amp. IC	2	LM358AN	27014	1826-0346	2
U4, 14	voltage reg. IC	2	MC78L12ACP	04713	1826-0275	2
VR1, 11	diode, zener 5.62V 5%	2	SZ10939-110	04713	1902-3104	2
VR2, 12	zener reference IC, 6.9V	2	LM329DZ	27014	1826-0585	2

Note 1: Alternate part number, see paragraph 5-43.

Table 6-4. Replaceable Parts

Ref. Desig.	Description	TQ	Mfr. Part No.	Mfr. Code	HP Part No.	RS
M1 R1, 11	Front Panel Electrical meter, VOLTS/AMPS var. cermet 10k 5% (4 turn) (V1 and V2 VOLTAGE controls)	1		28480	1120-1391	1
		2		28480	2100-3775	1
F1	Rear Heatsink Electrical fuse 0.4A 250V slo-blow (120Vac operation)	1	313.400 2N3055	75915	2110-0340	1
Q1, 11	power NPN Si.	2		28480	1854-0563	2
T1	power transformer	1		28480	06234-80090	1
	<b>Mechanical</b>					
	binding post, red	4		28480	1510-0091	
	binding post, chassis ground	1		28480	1510-0044	
	knob, control (R1, 11)	2		28480	0370-1091	
	knob, pushbutton (S2)	2		28480	0370-2486	
	fuseholder, body	1		28480	2110-0564	
	fuseholder, nut	1		28480	2110-0569	
	cover, top	1		28480	5000-3137	
	cover, bottom	1		28480	5000-3138	
	frame, front	1		28480	5000-3139	
	front panel	1		28480	06234-00001	
	heat sink	1		28480	5020-2579	
	foot, rubber	4		28480	0403-0266	
	clip, cable	1		28480	1400-0911	
	bracket, meter	1		28480	06234-00002	
	bushing, transistor insulator	4		28480	0340-0168	
	transistor insulator, mica	2		28480	0340-0174	
	bushing, insulator	2		28480	0340-0415	
	<b>Miscellaneous</b>					
	line cord			28480	see para. 2-21	
	line cord strain relief			28480	0400-0013	
	packing carton			28480	9211-2812	
	float pad	4		28480	9220-2854	
	filler pad	2		28480	9220-2853	
	fuse 0.2A slo-blow (240Vac operation)	1	313.200	75915	2110-0235	

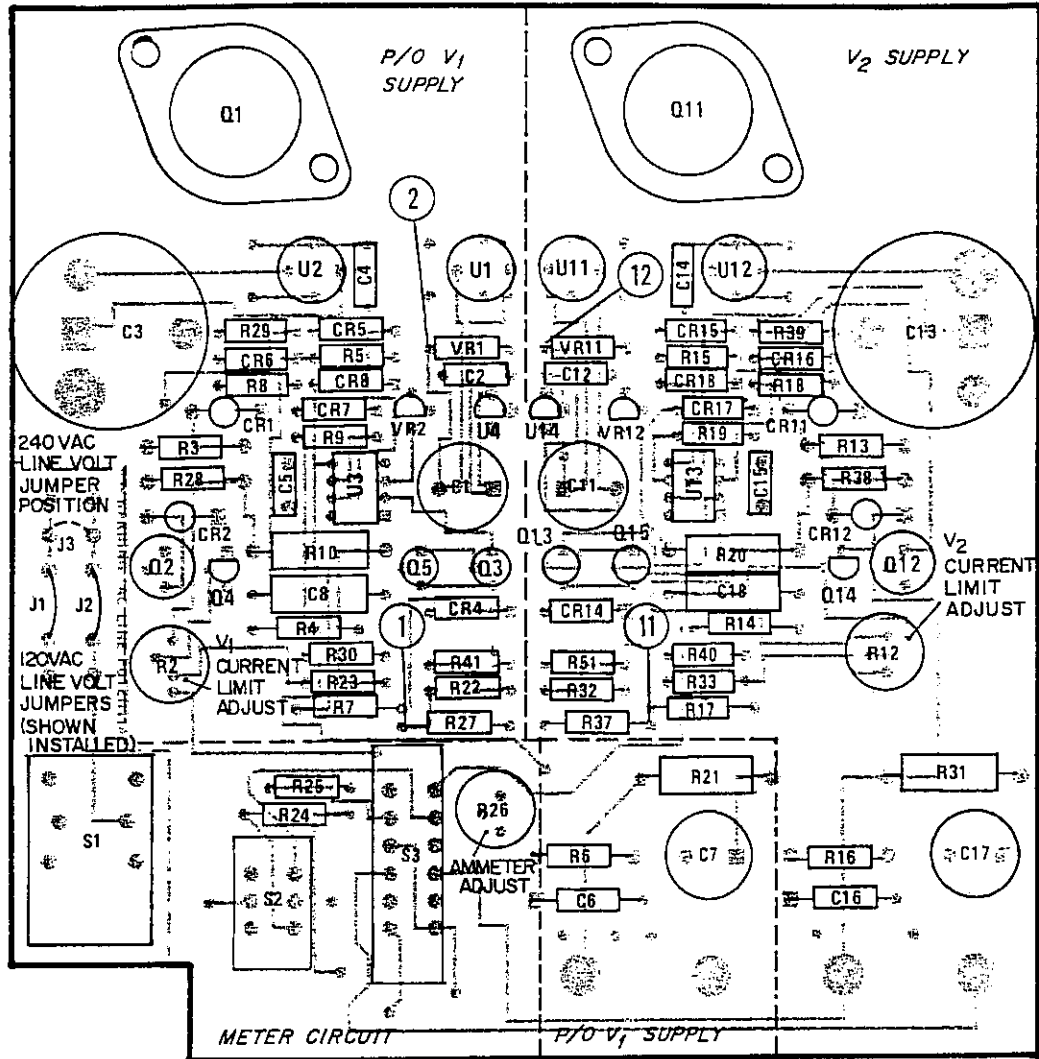
## SECTION VII CIRCUIT DIAGRAMS

### 7-1 COMPONENT LOCATION DIAGRAM

7-2 The component location diagram for power supply Model 6234A is given below. The illustration shows the physical locations and reference designations of parts mounted on the printed circuit card.

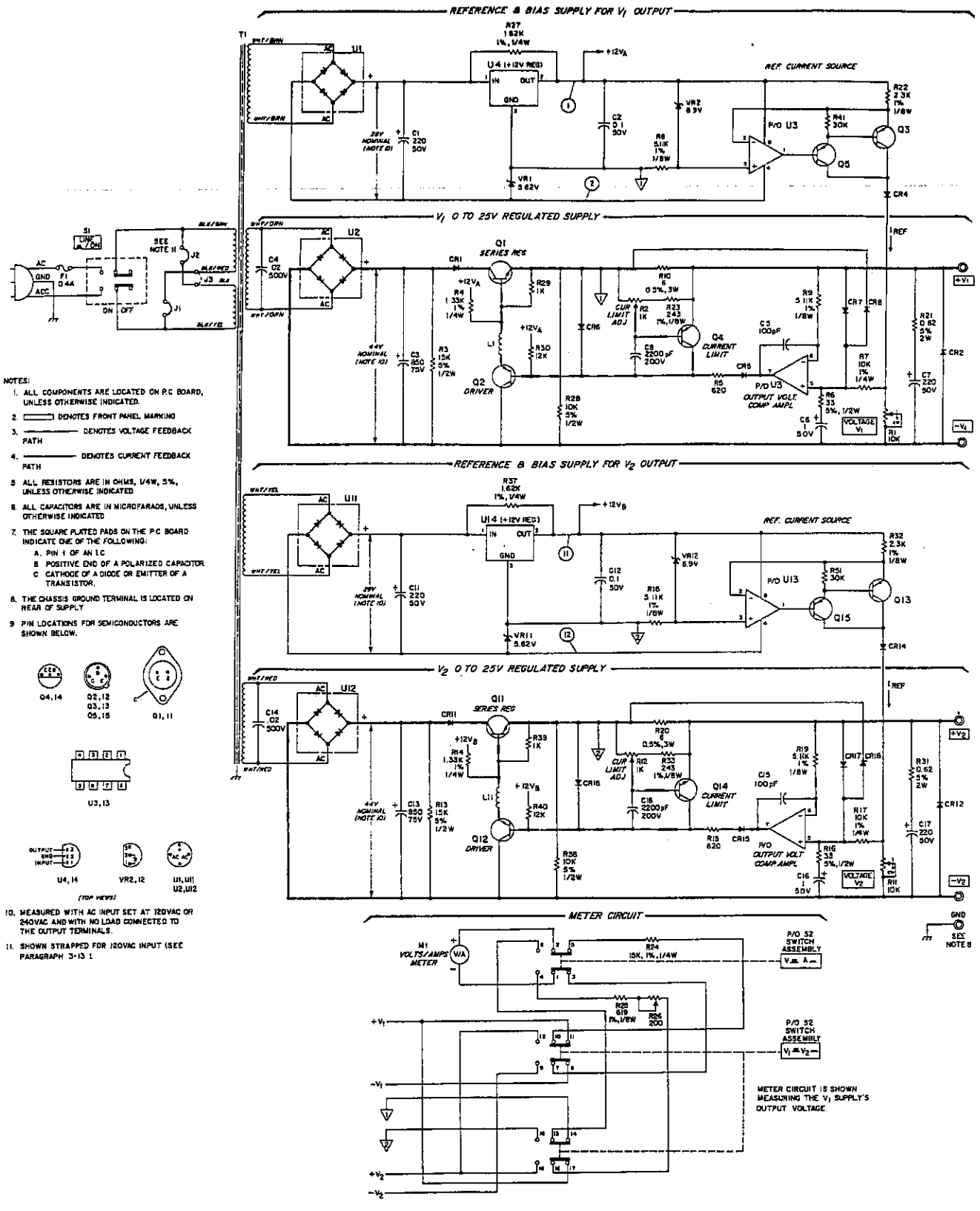
### 7-3 SCHEMATIC DIAGRAM

7-4 Figure 7-1 is a schematic diagram of the 6234A. The test points (circled numbers) shown on the schematic correspond to those on the component location diagram and in the troubleshooting procedure in Section V.



Model 6234A, Component Locations





- NOTES:**
- ALL COMPONENTS ARE LOCATED ON P.C BOARD, UNLESS OTHERWISE INDICATED.
  - DENOTES FRONT PANEL MARKING
  - DENOTES VOLTAGE FEEDBACK PATH
  - DENOTES CURRENT FEEDBACK PATH
  - ALL RESISTORS ARE IN OHMS, 1/4W, 5%, UNLESS OTHERWISE INDICATED
  - ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED
  - THE SQUARE PLATED PADS ON THE P.C BOARD INDICATE ONE OF THE FOLLOWING:
    - PIN 1 OF AN I.C
    - POSITIVE END OF A POLARIZED CAPACITOR
    - CATHODE OF A DIODE OR EMITTER OF A TRANSISTOR
  - THE GROUND TERMINAL IS LOCATED ON REAR OF SUPPLY
  - PIN LOCATIONS FOR SEMICONDUCTORS ARE SHOWN BELOW.
- TOP VIEWS:**
- 04, 14
  - 02, 12
  - 03, 13
  - 05, 15
  - 01, 11
  - U3, 13
  - U4, 14
  - VR2, 12
  - U1, U11
  - U2, U12

- MEASURED WITH AC INPUT SET AT 120VAC OR 240VAC AND WITH NO LOAD CONNECTED TO THE OUTPUT TERMINALS.
- SHOWN STRAPPED FOR 120VAC INPUT (SEE PARAGRAPH 3-13.1)

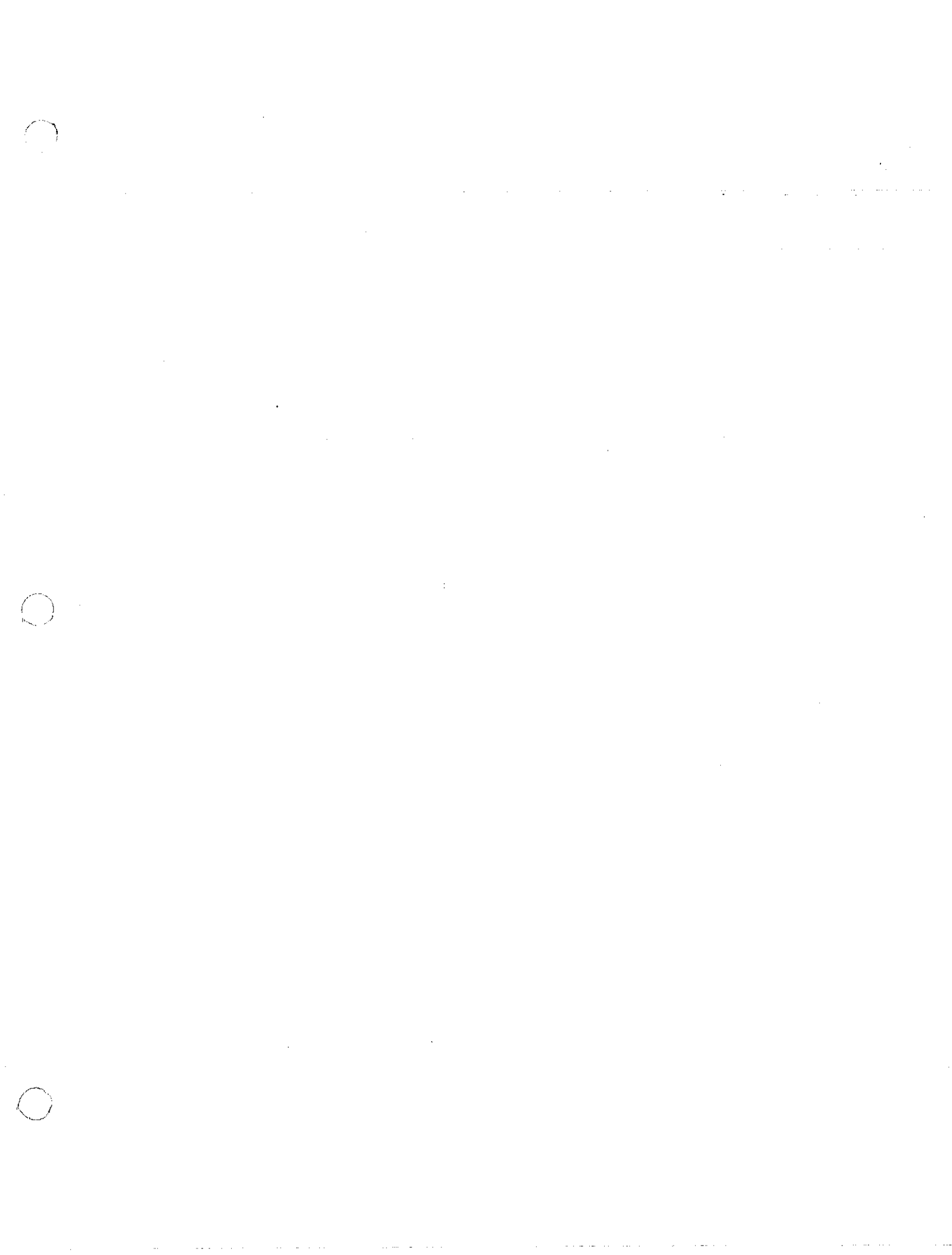
Figure 7-1. Model 6234A, Schematic Diagram



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