**POWER SUPPLIES**

**Autoring Power Supplies**
Models 6010A, 6011A, 6012B, 6023A, and 6024A

- Complete front panel control/display
- Constant voltage/constant current operation
- Remote programming and sensing

**HP Model 6024A**

As an autoring dc power supply, the HP 6024A can provide 200 watts over a wide and continuous range of voltage and current combinations, with maximums of 60 volts and 10 amperes. This provides greater flexibility than traditional power supplies that have only one maximum power point. Ten-turn potentiometers provide precise control of the output voltage and current. The output levels can be observed on the separate front panel voltage and current meters. Terminals are available on both the front and rear panel for load connections. The built-in OVP is adjustable from the front panel. Other protective features include over-temperature and high ac line detection.

The HP 6024A has many system-oriented features. It can be remotely programmed with 0-5 volt or 0-2500 ohm analog signals. The output current can be easily monitored without an external shunt with the proportional 0-5 volt buffered analog output. Remote sensing can be used to eliminate the effects of voltage drops in the load leads, and either terminal may be biased up to ±240 volts from chassis ground. Several units can be combined in auto-series, auto-parallel, and auto-system configurations, further increasing the HP 6024A's flexibility.

For more system features, see Option 002.

**General Specifications**

- **Dimensions:**
  - 6010A, 6011A, and 6012B: 132.6 mm H x 425.5 mm W x 156.4 mm D (5.2 in. x 16 7/8 in. x 6.13 in.)
  - 6023A: 177.0 mm H x 213.2 mm W x 443.6 mm D (6.95 in. x 8.36 in. x 17.5 in.)
  - 6024A: 133.4 mm H x 212.3 mm W x 413.3 mm D (5.25 in. x 8.36 in. x 16.3 in.)

**Ordering Information**

Price: $348.00

**Option Specifications**

- OVP: Provides remote programming and monitoring capabilities for system use. A card inserted into the power supply is accessible through a 37-pin connector on the rear panel. It provides easy access to the control and monitor signals available on standard units, as well as three additional features:
  - OVP trim and reset
  - power supply inhibit
  - status bit indicating off state, off state, and remote programming via an 0-2.5 VDC current link

**General**

- **Models:**
  - HP 6010A, 6011A, 6012B, and 6013B
  - HP 6023A and 6024A

- **Price:**
  - HP 6010A: $63.00
  - HP 6023A: $55.00
  - HP 6024A: $60.00

- **Notes:**
  - No rack-mount kit for single unit. A Rack Mount Kit supplied is ordered for half rack width units.
  - HP 6010A, 6011A, 6012B, 6023A, and 6024A provide all ten features standard, but HP 6024A-only provides a scaled 0-5 volt output to represent the output current, not the output voltage.
  - Programmable remote/local for use when programming with a current sink.

---

**Specifications**

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Current Range</th>
<th>Load Effect</th>
<th>Source Effect</th>
<th>DC Charge Transfer Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10V</td>
<td>50mA</td>
<td>0.01%</td>
<td>0.01%</td>
<td>100%</td>
</tr>
<tr>
<td>0.25V</td>
<td>200mA</td>
<td>0.02%</td>
<td>0.02%</td>
<td>99%</td>
</tr>
<tr>
<td>0.50V</td>
<td>500mA</td>
<td>0.04%</td>
<td>0.04%</td>
<td>98%</td>
</tr>
<tr>
<td>0.75V</td>
<td>750mA</td>
<td>0.06%</td>
<td>0.06%</td>
<td>97%</td>
</tr>
<tr>
<td>1.00V</td>
<td>1.00A</td>
<td>0.10%</td>
<td>0.10%</td>
<td>96%</td>
</tr>
<tr>
<td>1.50V</td>
<td>1.50A</td>
<td>0.15%</td>
<td>0.15%</td>
<td>94%</td>
</tr>
<tr>
<td>2.00V</td>
<td>2.00A</td>
<td>0.20%</td>
<td>0.20%</td>
<td>92%</td>
</tr>
<tr>
<td>2.50V</td>
<td>2.50A</td>
<td>0.25%</td>
<td>0.25%</td>
<td>90%</td>
</tr>
<tr>
<td>3.00V</td>
<td>3.00A</td>
<td>0.30%</td>
<td>0.30%</td>
<td>88%</td>
</tr>
<tr>
<td>3.50V</td>
<td>3.50A</td>
<td>0.35%</td>
<td>0.35%</td>
<td>86%</td>
</tr>
<tr>
<td>4.00V</td>
<td>4.00A</td>
<td>0.40%</td>
<td>0.40%</td>
<td>84%</td>
</tr>
<tr>
<td>4.50V</td>
<td>4.50A</td>
<td>0.45%</td>
<td>0.45%</td>
<td>82%</td>
</tr>
<tr>
<td>5.00V</td>
<td>5.00A</td>
<td>0.50%</td>
<td>0.50%</td>
<td>80%</td>
</tr>
</tbody>
</table>

*Note: The power supply is provided with Basic Option 050, see page 442 for more details.
SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Model 6024A is an autoranging 200-watt power supply providing laboratory-grade performance with the high efficiency of switching regulation techniques. Autoranging allows the supply to furnish 200 watts output power over a wide range of output voltage and current combinations without the user having to select the proper output range. The output is adjustable through the entire operating range of 0 to 60 volts and 0 to 10 amperes by 10-turn front-panel controls.

1-3 The supply is of the Constant Voltage/Constant Current (CV/CC) type with front-panel LEDs to indicate whether the unit is operating in CV or CC mode. Output voltage and current are continuously indicated on individual front-panel meters. A red LED indicates an overvoltage condition. The overvoltage protection (OVP) circuit protects the user's load by quickly and automatically interrupting energy transfer if a preset trip voltage is exceeded. A screwdriver control on the front panel sets the overvoltage trip point between 2V and 64V.

1-4 Connections to the output are made either to front-panel binding posts or rear-panel screw-on terminals. Either the positive or negative output terminal may be grounded, or the output may be floated at up to 240 volts DC from ground.

1-5 Remote programming, remote sensing, and several methods of operating multiple supply combinations are possible by making connections to rear-panel terminals. These capabilities are more fully described in Section III.

1-6 The unit is fan cooled and is packaged in an Hewlett-Packard System II-compatible modular enclosure, which is sturdy, attractive, and provides easy access for servicing.

1-7 SAFETY CONSIDERATIONS

1-8 This product is a Safety Class I instrument (provided with a protective earth terminal). The instrument and this manual should be reviewed for safety markings and instructions before operation.

1-9 SPECIFICATIONS

1-10 Detailed specifications for the power supply are given in Table 1-1.

1-11 INSTRUMENT AND MANUAL IDENTIFICATION

1-12 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 of the prefix indicate the year (19 = 1979, 20 = 1980, etc), the second two digits indicate the week, and the letter “A” designates the USA as the country of manufacture. The second part of the serial number is a different sequential number assigned to each power supply, starting with 00101.

1-13 If the serial number on your instrument does not agree with those on the title page of this manual, a yellow Manual Changes sheet supplied with the manual defines the difference between your instrument and the instrument described by this manual.

1-14 OPTIONS

1-15 Options are standard factory modifications that are requested by the customer. The following options are available with this instrument. Option 002 is described in Appendix A.

OPTION NO. DESCRIPTION

002 Systems Option: allows the supply to operate automatically in system applications. Provides resistance, voltage, and current programming of voltage and current; six isolated status lines; three isolated control lines; ±5V and ±15V bias voltages. This option is mounted on a single additional printed-circuit board, which includes a rear-panel connector.
<table>
<thead>
<tr>
<th>OPTION NO.</th>
<th>DESCRIPTION</th>
<th>PART NO.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>Input Power: 191 to 233 Vac, 48 to 63 Hz, single phase.</td>
<td>5061-0057</td>
<td>Rack mounting adapter kit for 5-1/4 inch high cabinets, includes one rack flange and one half-module width extension adapter.</td>
</tr>
<tr>
<td>240</td>
<td>Input Power: 208 to 260 Vac, 48 to 63 Hz, single phase.</td>
<td>5061-0071</td>
<td>Rack mounting adapter kit for center mounting one 5-1/4 inch high cabinet, includes one rack flange and one quarter-module width extension adapter; two kits required.</td>
</tr>
<tr>
<td>910</td>
<td>One additional operating and service manual shipped with the power supply.</td>
<td>5061-0097</td>
<td>Support shelf for mounting 5-1/4 inch high cabinets of different depths.</td>
</tr>
</tbody>
</table>

### 1-16 ACCESSORIES

1-17 The System II cabinet accessories listed below may be ordered with the power supply or separately from your local Hewlett-Packard Sales and Service office (see list of addresses at the rear of this manual).

<table>
<thead>
<tr>
<th>HP Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5061-0089</td>
<td>Front handle kit for 5-1/4 inch high cabinets.</td>
</tr>
<tr>
<td>5061-2002</td>
<td>Bail handle kit for 5-1/4 inch high, half-module width cabinets.</td>
</tr>
<tr>
<td>1460-1345</td>
<td>Tilt stand snaps into standard foot supplied with unit, must be used in pairs.</td>
</tr>
<tr>
<td>5061-0077</td>
<td>Rack flange kit for 5-1/4 inch high cabinets (must be used with another half-module width instrument of same depth and with lock-together kit #5061-0094).</td>
</tr>
<tr>
<td>5061-0083</td>
<td>Rack flange and front handle combination kit for 5-1/4 inch high cabinets (must be used with another half-module width instrument of same depth and with lock-together kit #5091-0094).</td>
</tr>
<tr>
<td>5061-0094</td>
<td>Lock-together kit for cabinets of equal depth, enough links for three side-by-side joints (over-under connections are not possible).</td>
</tr>
</tbody>
</table>

### 1-18 ORDERING ADDITIONAL MANUALS

1-19 One manual is shipped with each power supply. Additional manuals may be purchased directly from your local Hewlett-Packard Sales office. Specify the model number, instrument serial number prefix, and the manual part number provided on the title page. (When ordered at the same time as the power supply, additional manuals may be purchased by adding Option 910 to the order and specifying the number of additional manuals desired.)
Table 1-1. Specifications, Model 6024A

All performance specifications are at rear terminals with a resistive load.

INPUT POWER:
Two internal switches and one internal jumper permit operation from 120, 220, or 240Vac (−13%, +6%);
48.63Hz; 320W maximum. Maximum input current is 5.3A rms for 120Vac, 2.8A rms for 220Vac, and 2.7A rms for 240Vac. A three-wire detachable line cord is supplied.

INPUT PROTECTION:
The ac input is protected by a rear-panel mounted fuse; 6A for 120Vac, 4A for 220Vac and 240Vac.

PEAK INRUSH CURRENT:
(typical values)
@25°C ambient, 25A
30 seconds after turn-off, 30A
@55°C ambient, 50A
30 seconds after turn-off, 60A

DC OUTPUT:
Adjustable from 0 to 60V and 0 to 10A. Maximum output power is 200W at extremes of voltage and current; increases to approximately 230W at mid-range. (This power is available at load with up to 0.5V drop in each load lead.) See graph:

LOAD EFFECT (LOAD REGULATION):

Constant Voltage - Less than 0.01% of output voltage plus 3mV for a load change equal to the maximum available current rating of the supply at the set voltage.
Constant Current - Less than 0.01% of output current plus 3mA for a load change equal to the maximum available voltage rating of the supply at the set current.

SOURCE EFFECT (LINE REGULATION):
Constant Voltage - Less than 0.01% of output voltage plus 2mV for any line voltage change within rating.
Constant Current - Less than 0.01% of output current plus 2mA for any line voltage change within rating.

PARD (Ripple and Noise), 20Hz to 20MHz:
Constant Voltage - Less than 3mV rms and 30mV p-p.
Constant Current - Less than 5mA rms.

TEMPERATURE COEFFICIENT:
Constant Voltage - Less than 0.01% plus 1mV change in output per degree Celsius change in ambient after 30-minute warmup.
Constant Current - Less than 0.03% plus 1mA change in output per degree Celsius change in ambient after 30-minute warmup.

DRIFT (Stability):
(Change in output over an 8-hour interval under constant line, load, and ambient temperature after 30-minute warmup).
Constant Voltage - Less than 0.03% of output plus 3mV.
Constant Current - Less than 0.03% of output plus 3mA.

LOAD TRANSIENT RECOVERY TIME:
Less than 1ms is required for output voltage recovery (in constant voltage operation) to within 75mV of the nominal output following a change in output current from 90% to 100% or 100% to 90% of maximum current rating.

RESOLUTION:
(Minimum output voltage or current change that can be obtained using the 10-turn front-panel controls)
Constant Voltage - 20mV
Constant Current - 5mA
Table 1-1. Specifications, Model 6024A (continued)

**OUTPUT IMPEDANCE (Typical):**

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Impedance (mΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>10000</td>
<td>100</td>
</tr>
<tr>
<td>100000</td>
<td>10</td>
</tr>
<tr>
<td>1000000</td>
<td>10</td>
</tr>
</tbody>
</table>

**DC OUTPUT ISOLATION:**
Either output terminal may be floated up to ±240Vdc (including output voltage) from earth ground.

**OVERVOLTAGE PROTECTION:**
Trip voltage adjustable from 2V to 64V. Minimum setting above output voltage to avoid false tripping is 1.5V.

**REVERSE VOLTAGE PROTECTION:**
(Maximum permissible reverse current caused by reverse voltage impressed across output terminals) 10A continuous.

**REMOTE SENSING:**
Maintains nominal voltage at load by correcting for load lead voltage drop of up to 0.5V per lead.

**REMOTE PROGRAMMING:**
Resistance Programming - 0 to 2.5K provides zero to maximum rated voltage or current output.
- Accuracy: CV, 0.8% + 2mV CC, 2.5% + 1mA

Voltage Programming - 0 to 5V provides zero to maximum rated voltage or current output.
- Accuracy: CV, 0.2% + 2mV CC, 1.0% + 2mA

Current Programming - 2mA to 0mA current sink provides zero to maximum rated voltage or current output (with user-provided 2.5k resistor).
- Accuracy: CV, 0.2% + 0.36V + accuracy of resistor CC, 1.0% + 0.15A + accuracy of resistor

**PROGRAMMING RESPONSE TIME:**
Maximum time for output voltage to change from 0V to 60V or 60V to 2V and settle within 60mV band (0.1% of maximum rated output).
- **Up:** Full Load (18Ω) 200mS
- No Load 200mS
- **Down:** Full Load (18Ω) 300mS
- No Load 600mS

**Typical response time, for excursions other than full-scale**

**Down:** On graph, read difference in time between initial output voltage and final output voltage; add settling time

**CURRENT MONITORING OUTPUT:**
0 to 5V output from rear-panel terminal indicates zero to maximum rated current output; accuracy, 0.9% + 7mV output impedance, 10kΩ
<table>
<thead>
<tr>
<th>METERS AND INDICATORS:</th>
<th>TEMPERATURE RATINGS:</th>
</tr>
</thead>
</table>
| **Voltmeter** - Continuously reading 70V scale with secondary scale indicating amperes available; accuracy, ±3% of full scale. | **Operating:** 0 to +55°C  
**Storage:** -40 to +75°C  
Unit is fan cooled. A thermostat turns off unit if temperature rises above a critical level; resets automatically. |
| **Ammeter** - Continuously reading 12A scale with secondary scale indicating volts available; accuracy, ±3% of full scale. | |
| **VOLTAGE Indicator** - Green LED indicates Constant Voltage operation. | |
| **CURRENT Indicator** - Green LED indicates Constant Current operation. | |
| **OUTPUT UNREGULATED Indicator** - Red LED indicates that output is unregulated because of any of the following conditions: overrange operation, overvoltage, over temperature, or low-input-power shutdown. | |
| **OVP Indicator** - Red LED indicates shutdown caused by voltage at output terminals exceeding preset limit. | |

<table>
<thead>
<tr>
<th>MULTIPLE UNIT OPERATION:</th>
<th>OPTIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auto-Parallel</strong> - Up to eight units may be connected in parallel to increase total output current capability while maintaining control from a single unit.</td>
<td><strong>Option 002 (System Interface) specifications are listed in Appendix A.</strong></td>
</tr>
<tr>
<td><strong>Auto-Series</strong> - Up to four units (eight if center-tapped to ground) may be connected in series to increase total output voltage to 240Vdc (480Vdc if center-tapped to ground) while maintaining control from a single unit.</td>
<td></td>
</tr>
<tr>
<td><strong>Auto-Tracking</strong> - Any number of units may have either one of their output terminals connected to a common bus so that all outputs track, at some fraction, the output of a single, controlled, unit.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CERTIFICATION:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit complies with these requirements:</td>
<td></td>
</tr>
<tr>
<td>IEC 348 - Safety Requirements for Electronic Measuring Apparatus,</td>
<td></td>
</tr>
<tr>
<td>CSA Electrical Bulletin 556B - Electronic Instruments and Scientific Apparatus for Special Use and Applications.</td>
<td></td>
</tr>
<tr>
<td>VDE 0871/6.78 Level A - RFI Suppression of Radio Frequency Equipment for Industrial, Scientific, and Medical (ISM) and Similar Purposes.</td>
<td></td>
</tr>
<tr>
<td>VDE 0411 - Electronic Measuring Instruments and Automatic Controls.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIMENSIONS:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>See Figure 2-1.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WEIGHT:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net: 5.4kg (12 lb)</td>
<td></td>
</tr>
<tr>
<td>Shipping: 7.3kg (16 lb)</td>
<td></td>
</tr>
</tbody>
</table>
SECTION III
OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-2 This section describes the operating controls and indicators, turn-on check-out procedures, and operating procedures and considerations for the Model 6024A.

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 current rating and specified type should be used. Do not use repaired fuses or short circuit fuses. To do so could cause a shock or fire hazard.

3-4 TURN-ON CHECKOUT PROCEDURE

3-5 The following checkout procedure describes the use of the front panel controls and indicators (see Figure 3-1) and ensures that the supply is operational. This check should be performed when the unit is first received. If the supply fails to perform properly, proceed to the troubleshooting procedures in Section V.

a. Ensure that rear terminal board straps are connected as shown in Figure 3-2, but do not connect load. Check that rear-panel label indicates unit is set for line voltage to be used. If it is not, refer to paragraph 2-23. If unit is equipped with System Option 002 ensure that option cable is disconnected from rear panel option connector before proceeding.

b. Ensure that CURRENT control ⑤ is rotated clockwise at least two turns and OVP ADJUST potentiometer ⑧ is fully clockwise.

c. Press pushbutton LINE switch ① to ON (pushbutton in) and observe that reflective indicator shows in the LINE switch and that fan operates.

d. Turn VOLTAGE control ② through output voltage range of unit as indicated on volmeter ④.

e. Check out overvoltage circuit by turning OVP ADJUST control ⑧ (screwdriver adjust) counterclockwise until unit shuts down. Output voltage should drop to −0.5 to 0 volts and OVP ⑨ and UNREGULATED ⑩ indicators should light.

f. Reset overvoltage circuit by returning OVP control to maximum clockwise position and turning supply off for at least one second and then back on. Output voltage should return to value set in step d.

g. To check constant current circuit, turn off supply and connect short (AWG #18 or larger) across + and — output terminals ① and ⑩ on front panel or + and — on rear panel. Ensure that VOLTAGE control is rotated at least two turns clockwise.

h. Turn supply back on and rotate CURRENT control ⑤ through output current range of unit as indicated on ammeter ⑪. CURRENT light ⑥ should be on across entire range indicating that supply is in constant current mode.

i. Turn off supply, remove short from output, and read remainder of operating instructions before connecting actual load to supply.

Figure 3-1. Front Panel Controls and Indicators
3-6 OPERATING MODES

3-7 This power supply is designed so that its mode of operation can be selected by making strapping connections on its rear panel. Normal operating mode for this power supply uses local programming of the output voltage and current via the front panel VOLTAGE and CURRENT controls, and local sensing of the output voltage. Alternate operating modes allow use of remote programming, remote sensing, and multiple power supply combinations.

3-8 The following paragraphs first describe operating considerations with the normal operating mode, using the strapping pattern as it is connected at the factory. Later paragraphs cover alternate operating modes. The operating considerations described with normal mode, such as constant voltage/constant current crossover, overrange, constant voltage and constant current operation, overvoltage protection, protective circuits, and load connections, apply to the alternate modes as well as to normal mode. More theoretical descriptions regarding the operational features of power supplies in general are given in the DC Power Supply Handbook, Application Note 506 (available at no charge from your local Hewlett-Packard Sales Office).

3-9 NORMAL OPERATING MODE

3-10 The power supply was shipped with the proper rear panel strapping connections made for constant voltage/constant current operation with local sensing and local programming. This strapping pattern is illustrated in Figure 3-2. By means of the front panel voltage and current controls, the operator selects either a constant voltage or a constant current output as described in paragraphs 3-17 or 3-19. Whether the supply functions in the constant voltage or constant current mode depends on the settings of the VOLTAGE and CURRENT controls and on the value of the load resistance.

3-11 Figure 3-3 shows the overall output range of the supply, with three sample operating loci. Locus 1 is established with a VOLTAGE setting of 20V and a CURRENT setting of 3A. For any values of load resistance greater than the crossover value of 6.7 ohms, the supply operates in constant voltage mode. For values of load resistance less than the crossover value, the supply operates in constant current mode. The transition occurs smoothly and automatically; no switches need be operated or connections changed. The front panel VOLTAGE and CURRENT lights indicate which mode is operating.

3-12 Locus 2 is established with a VOLTAGE setting of 35V and a CURRENT setting of 6.5A. Its crossover load resistance is 5.4 ohms, and lies on the rated-output-power boundary.

3-13 A rectangular operating locus will be established for all voltage and current settings within the rated-output-power boundary. However, if the VOLTAGE and CURRENT controls are set so that the boundary can be exceeded, as in locus 3, the supply will go into overrange if the load resistance falls within a critical band (refer to next paragraph).
3-14 Overrange. The supply will be driven into overrange (shaded area of Figure 3-3) if the VOLTAGE and CURRENT controls are set above the output power rating and the load resistance falls within a critical band. For example, assume that the operator sets the VOLTAGE control at 50V and the CURRENT control at 8.5A, as in locus 3 on Figure 3-3. For all load resistances above 11.9 ohms (which is the critical value) the supply would operate normally in the constant voltage mode. If the load resistance were to fall much below 11.9 ohms, however, the supply would be forced into overrange. If the load resistance continued to decrease to a 2.9 ohm value, the supply would automatically come out of overrange and into the constant current mode at the 8.5A, 25V point. (The supply will probably go out of regulation while operating in the overrange region, refer to paragraph 3-16.)

3-15 Anytime the supply operates in overrange, the VOLTAGE and CURRENT indicators turn off and the UNREGULATED indicator lights. The VOLTS and AMPERES meters indicate the voltage and current being supplied to the output. (The product of the two readings will exceed 200 watts.) Paragraph 3-30 identifies conditions other than overrange which cause the UNREGULATED indicator to light.

3-16 The supply can operate in the overrange region (beyond the rated-output-power boundary) for sustained periods without being damaged. However, the supply is not guaranteed to meet specifications in overrange. Output ripple increases substantially and regulation is seriously degraded. As an operator aid, the maximum available load current for each constant voltage setting is indicated on a secondary scale of the voltmeter. Similarly, the maximum available load voltage for each current setting is indicated on the ammeter.

NOTE

Under certain conditions of line and load, it is possible for the supply to provide more than rated output power and still maintain regulation. If this occurs, the unit will operate normally and the UNREGULATED indicator will be off. However, the slightest change in either line or load may cause the unit to go out of regulation. Operation of the unit beyond the rated-output-power boundary is not recommended under any circumstances.

3-17 Constant Voltage Operation

3-18 To adjust the supply for constant voltage operation:

a. Turn on supply and, with output terminals open, adjust the VOLTAGE control for the desired output voltage. Then turn power off.

b. Connect a short across the front or rear panel + and - output terminals, turn the power on, and adjust the CURRENT control for the desired maximum output current. Then turn power off and remove the short. If a load change causes this current limit to be exceeded, the supply automatically crosses over to constant current operation at this preset current limit and the output voltage drops proportionately. In setting the current limit, make an adequate allowance for high peak currents that could cause unwanted crossover.

3-19 Constant Current Operation

3-20 To adjust the supply for constant current operation, with supply turned off:

a. Connect a short across the front or rear panel + and - output terminals, turn the power on, and adjust the CURRENT control for the desired output current.

b. Open the output terminals and adjust the VOLTAGE control for the desired maximum output voltage. If a load change causes this voltage limit to be exceeded, the supply automatically crosses over to constant voltage operation at this preset voltage limit and the output current drops proportionately. In setting the voltage limit, make an adequate allowance for high peak voltages that could cause unwanted crossover.

3-21 Overvoltage Protection

3-22 Adjustment. The overvoltage trip point is adjusted with the OVP ADJUST screwdriver control on the front panel. The approximate trip voltage range for this unit is from two volts to 64V. When the overvoltage protection (OVP) circuit trips, the supply is inhibited and delivers no output power; the OVP and UNREGULATED indicators on the front panel light. Rotating the control clockwise sets the trip voltage higher. (It is set to maximum at the factory.)

3-23 When adjusting the OVP trip point, the possibility of false tripping must be considered. If the trip voltage is set too close to the supply’s operating voltage, a transient in the output would falsely trip the OVP. For this reason it is recommended that the OVP trip voltage be set higher than the output voltage by at
least 1.5 volts. To adjust the OVP trip voltage, proceed as follows:

a. With OVP ADJUST potentiometer fully CW, no load connected; turn on supply.
b. Set output VOLTAGE control to desired trip voltage.
c. Turn OVP ADJUST pot CCW until OVP circuit fires; red OVP indicator lights and output voltage falls to zero.
d. Turn off supply and turn down output voltage.
e. Turn supply back on and set desired output voltage.

3-24 Resetting the OVP Circuit. If the OVP circuit trips during normal operation, the ac LINE switch must be turned off for at least one second and then back on to reset the circuit. If the OVP circuit trips continuously check the load and/or the trip point setting. If the supply does not operate properly after the OVP circuit is reset, proceed to troubleshooting in Section V.

3-25 CONNECTING THE LOAD

3-26 To satisfy the requirements of safety, the wires to the load should be at least heavy enough not to overheat while carrying the power supply current that would flow if the load were shorted. Stranded AWG #16 wire is rated for 12.7A at 105°C conductor temperature (45°C rise above 60°C ambient temperature). Stranded AWG #14 wire is rated for 14.8A at 80°C conductor temperature (20°C rise above 60°C ambient temperature). These ratings are based on use of a twisted pair to connect the load to the supply. Generally, heavier wire is required to obtain good regulation at the load. If the load is critical, use remote voltage sensing. (Refer to paragraph 3-34).

3-27 If multiple loads are connected to one supply, each load should be connected to the supply's output terminals using separate pairs of connecting wires. This minimizes mutual coupling effects between loads and takes full advantage of the supply's low output impedance. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup.

3-28 If load considerations require the use of output distribution terminals that are located remotely from the 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 separately connected to the remote distribution terminals. Remote voltage sensing is required under these circumstances (paragraph 3-34).

3-29 Either positive or negative voltages can be obtained from this supply by grounding one of the output terminals or one end of the load. Always use two wires to connect the load to the supply regardless of where or how the system is grounded. Never ground the system at more than one point. This supply can be operated with either output terminal up to ±240 volts dc from ground.

3-30 PROTECTIVE CIRCUITS

3-31 Protective circuits within the instrument may limit or turn off the output in case of abnormal conditions. The cause for the protective action can be determined by observing the front panel indicators (lights and meters). An overrange condition is indicated by the UNREGULATED indicator on, the VOLTS and AMPERES meters reading relatively high, and the VOLTAGE, CURRENT, and OVP indicators off. An overvoltage condition is indicated by both the OVP and UNREGULATED indicators on, the meters reading near zero, and the VOLTAGE and CURRENT indicators off. An overtemperature condition is indicated by the UNREGULATED indicator on, the VOLTAGE, CURRENT, and OVP indicators off, and the meters dropping toward zero from the readings that existed when the overtemperature condition occurred. If the primary power voltage drops below approximately 70% of nominal, the level detector will shut down the instrument. In this case, the UNREGULATED indicator is on, the VOLTAGE, CURRENT, and OVP indicators are off, and the meters read zero immediately.

3-32 ALTERNATE OPERATING MODES

3-33 The alternate operating modes discussed in the following paragraphs include: remote voltage sensing, remote programming, auto-parallel operation, auto-series operation, and auto-tracking operation. By changing the rear panel strapping pattern according to the instructions which follow, the supply can be operated in any of the modes listed above.

**WARNING**

Disconnect input ac power before changing any rear panel connections and make certain all wires and straps are properly connected and terminal strip screws are securely tightened before reapplying power.

3-34 Remote Voltage Sensing

3-35 Because of the unavoidable voltage drop developed in the load leads, the normal strapping pattern shown in Figure 3-2 will not provide the best possible voltage regulation at the load. The remote sensing connections shown in Figure 3-4 improve the voltage regulation at the load by monitoring the voltage there instead of...
at the supply's output terminals. (The advantages of remote sensing apply only during constant voltage operation.) When using remote sensing, turn off the power supply before changing the rear panel straps, sense leads, or load leads. The following paragraphs discuss some precautions that should be observed when making a remote sensing installation.

Figure 3-4. Remote Sensing

3-36 The load leads should be of the heaviest practicable wire gauge, at least heavy enough to limit the voltage drop in each lead to 0.5 volts. The power supply has been designed to minimize the effects of long load lead inductance, but best results will be obtained by using the shortest load lead practical.

NOTE

Because the OVP circuit monitors voltage at the rear terminals and there is an unavoidable voltage drop in the load leads, it may be necessary to readjust the OVP trip point in remote sensing mode.

3-37 Since the sensing leads carry only a few milliamperes, the wires used for sensing can be much lighter than the load leads (AWG#22 is generally adequate), but they should be a shielded, twisted pair to minimize the pickup of external noise. Any noise picked up on the sensing leads will appear at the supply's output, and CV load regulation may be adversely affected. The shield should be grounded at one end only and should not be used as one of the sensing conductors. The sensing leads should be connected as close to the load as possible.

3-38 The sensing leads are part of the supply's programming circuit, so they should be connected in such a way as to make it unlikely that they might inadvertently become open circuited. It is recommended that no switch, relay, or connector contacts be included in the remote sensing path.

NOTE

If the + output lead opens, the load voltage (+ sense to – output) will remain regulated at the set value, but the output voltage of the supply will rise to some high value dependent on the control settings and the load. If this voltage exceeds the OVP voltage, the OVP trips and down-grades the output voltage to zero volts. Whether or not the OVP trips, neither the supply nor the load will be damaged by excessive voltage.

If the – output lead opens, the load voltage (+ output to – sense) will drop to some low value and the output voltage of the supply operates at some value between zero and seven volts, both depending on the control settings and the load.

3-39 Remote Programming

3-40 The output voltage and/or current of the power supply can be remotely controlled by external resistance, voltage, or current sink. Programming can be accomplished via the standard rear-panel screw-on terminals or via the option connector on units equipped with System Option 002. Standard programming is described in this section; programming with System Option 002 is described in Appendix A.

3-41 For resistance programming, a variable resistor can control the output over its entire range. Or, a variable resistor connected in series and/or parallel with a fixed resistor can have its control restricted to a limited portion of the output range. Alternately, a switch can be used to select fixed values of programming resistance to obtain a set of discrete voltages or currents. (The switching configuration used may require make-before-break contacts to avoid producing the output voltage transients caused by momentarily opening the programming terminals.) To maintain the temperature and stability specifications of the supply, any resistors used for programming must be stable, low-noise resistors with a temperature coefficient of less than 25ppm per °C and a power rating at least 30 times what they will actually dissipate.

3-42 Both voltage and current outputs can also be controlled by a voltage source. A voltage source of 0 to 5 volts programs the output from zero to full scale.
Voltage sources of more than 5 volts can be scaled down to the proper range.

3-43 Current programming of both voltage and current outputs is possible also. With current programming, the supply's own constant current sources are used to provide current through an external resistance. A controllable current sink, such as a DAC, in parallel with the external resistor sinks a controllable percentage of the current around the resistance. The remaining current flows through the external resistance and develops a voltage that programs the power supply.

3-44 Connecting a supply for remote voltage or current programming disables the corresponding front-panel controls.

3-45 The following paragraphs discuss in greater detail the methods of remotely programming the output voltage or current using either a resistance, voltage, or current input. Whichever method is used, the wires connecting the programming terminals of the supply to the remote programming device must be shielded to reduce noise pickup. The outer shield of the cable should not be used as a conductor, and should be connected to ground at one end only.

3-46 Although the following connection drawings (Figures 3-5 through 3-12) show the supply strapped for local sensing, remote programming and remote voltage sensing do not interact and may be used simultaneously.

3-47 Constant Voltage Output, Resistance Control. The rear panel connections shown in Figure 3-5 allow the output voltage to be varied by using an external resistor to program the supply. A programming resistor variable from 0 to 2500 ohms produces a proportional output voltage from zero to full scale. Note that fixed resistors may be connected in series and/or in parallel with the variable programming resistor to set lower and/or upper output voltage limits. The resultant programming resistance is the sum of the series/parallel resistor combination, and must be between 0 and 2500 ohms. For example, a 1250 ohm resistor connected in series with the variable programming resistor will set the lower limit for output voltage at one-half full scale, i.e., 30 volts.

NOTE
If the programming terminals (A2 to -S) become open circuited during resistance programming, the output voltage will tend to rise above rating. The supply will not be damaged if this occurs, but the overvoltage trip point should be properly adjusted to protect the user’s load.

3-48 Constant Voltage Output, Voltage Control. The rear panel connections shown in Figure 3-6 allow the output voltage to be varied by using an external voltage source to program the supply. A voltage source variable from 0 to +5 volts produces a proportional output voltage from zero to full scale. The load on the programming voltage source is less than 6μA.

3-49 Constant Voltage Output, Scaled Voltage Control. The rear panel connections shown in Figure 3-7 allow the output voltage to be varied by using an external voltage source of more than 5 volts to program the supply. The ratio of the resistance values in the voltage divider must be selected so that the voltage at the center tap of the divider, A2, varies from 0 to 5 volts as the programming voltage source varies from zero to maximum.
3-50 The total resistance of the voltage divider should be as small as practical without excessively loading the external voltage source. This minimizes degrading the programming speed, offset, and drift specifications. For example, a total resistance of 7.5K will approximately double the up-programming time. A total resistance of less than 5K will make the degradation unnoticeable in most applications.

3-51 Constant Voltage Output, Current Control.
The rear panel connections shown in Figure 3-8 allow the output voltage to be varied by using an external current sink to program the supply. In this configuration the supply's own constant current source is used to develop a voltage across a resistor. A current sink, such as a DAC, connected in parallel with the resistor sinks part or all of the current, and thereby determines the voltage developed across the resistor. A current sink variable from 2 mA to 0 mA produces an inversely proportional output voltage from zero to full scale. Many DACs include a sign-change bit, so that a zero digital input to the DAC will produce a 0 volt output from the power supply, and a maximum digital input to the DAC will produce a full scale output from the power supply. Note that the VOLTAGE control potentiometer can be used in place of the external resistor by connecting A1 to A2 in addition to the connections shown in Figure 3-8.

CAUTION

If the DAC is turned off or the programming leads open, the output voltage will tend to rise above rating. The supply will not be damaged if this occurs, but the over voltage trip point should be properly adjusted to protect the user's load.

3-52 Constant Current Output, Resistance Control.
The rear panel connections shown in Figure 3-9 allow the output current to be varied by using an external resistor to program the supply. The discussion in paragraph 3-47 for constant voltage operation also applies for constant current operation.

3-53 Constant Current Output, Voltage Control.
The rear panel connections shown in Figure 3-10 allow the output current to be varied by using an external voltage source to program the supply. The discussion in paragraph 3-48 for constant voltage operation also applies for constant current operation.

Figure 3-8. Current Programming of Output Voltage

Figure 3-9. Resistance Programming of Output Current
3-54 Constant Current Output, Scaled Voltage Control.
The rear panel connections shown in Figure 3-11 allow the output current to be varied by using an external voltage source of more than 5 volts to program the supply. The discussion in paragraphs 3-49 and 3-50 for constant voltage operation also applies for constant current operation.

Figure 3-10. Voltage Programming of Output Current

3-55 Constant Current Output, Current Control.
The rear panel connections shown in Figure 3-12 allow the output current to be varied by using an external current sink to program the supply. The discussion in paragraph 3-51 for constant voltage operation also applies for constant current operation, except that the CURRENT control can be used in place of the external resistor by connecting A6 to A7 in addition to the connections shown in Figure 3-12.

CAUTION

If the DAC is turned off or the program leads open, the output current will tend to rise above rating. The supply will not be damaged if this occurs, but the VOLTAGE control should be adjusted such that the supply will switch to CV mode once the output current reaches the highest level the load can absorb and/or the OVP ADJUST should be set to shut down the supply.

Figure 3-11. Scaled Voltage Programming of Output Current

3-56 Auto-Parallel Operation

3-57 Figure 3-13 shows the rear panel interconnection required to auto-parallel two or more units. This mode of operation provides a greater current capability than can be obtained from a single supply, while ensuring that each supply will share the load proportionally to its own total power capability under all load conditions. For example, if a 200W supply and a 1000W supply were auto-paralleled, the 200W supply would provide 1/6 the total current and the 1000W supply would provide 5/6 the total current. The 6024 can be auto-paralleled only with other autoranging units, or with units that have current-monitoring output signals that are internally referenced to the output and equal to 5V at maximum rated current output. Up to eight supplies may be connected in auto-parallel.

Figure 3-12. Current Programming of Output Current

NOTE

Use wires of equal length and gauge to connect each auto-paralleled supply to the load. Load sharing will not be equal unless the leads connecting each supply to the load are equal in resistance. If it is impractical to run leads from each supply to the load because of distance between the supplies and the load, leads of equal length should be run from each supply to common distribution terminals, with a single pair of leads run from the distribution terminals to the load.
3-58 Setting the Voltage and Current Controls.
The auto-parallel combination of supplies behaves as
it were a single constant voltage/constant current
supply controlled by the voltage and current controls
of the master supply. The current controls of the slaves
are disabled. The voltage controls of the slaves should
be set above the desired output voltage to avoid interfer-
ence with the master.

NOTE
The voltage controls of the slave supplies
can be disabled by disconnecting the straps
between the A1 and A2 terminals and
connecting a resistor between A2 and –S
on each slave. The resistor value should
be chosen to program a voltage higher
than the desired output voltage. (See
paragraph 3-47.)

3-59 Overvoltage Protection in Auto-Parallel.
Adjust the OVP trip point at the master supply. The
slave supply OVP control(s) may be set to the same
level or to maximum (fully clockwise) to disable them.
If the master supply OVP trips, the master will program
the slaves to zero output. If a slave OVP trips, it
shuts down only that slave; the other units supply more
current until the master switches to CC mode.

3-60 Auto-Parallel with Remote Sensing.
To combine auto-parallel operation with remote sensing,
connect the supplies as described above but remove
the +S and –S jumpers from the master supply and
connect the +S and –S terminals directly to the + and
− ends of the load. Observe the precautions outlined
under paragraph 3-34.

3-61 Auto-Parallel with Remote Programming.
The output voltage and/or current of an auto-parallel
combination can be remotely programmed. Remote
programming connections are made to the master
supply. Observe all precautions outlined in the remote
programming paragraphs. Simultaneous use of remote
sensing and remote programming is also possible during
auto-parallel operation.

NOTE
Because only the master can down-program
the output of an auto-parallel combination,
down-programming speed will be reduced
under no-load conditions.

3-62 Auto-Series Operation

3-63 Figures 3-14 and 3-15 show the rear-panel
interconnections required to operate two or more
supplies in auto-series. This mode of operation provides
a greater voltage capability than can be obtained from
a single supply. As many as four supplies can be
connected in auto-series in the configuration shown in Figure 3-14, and as many as eight supplies can be connected if the power supply combination and load are center-tapped as in Figure 3-15 (with no more than four supplies on each side of the center tap). Either configuration allows all the supplies to be programmed simultaneously by the voltage and current controls of the master supply. The master supply must always be the one at the positive end of the series combination Any point of the output can be grounded if desired, as long as no other point in the output is more than 240 volts from ground.

Figure 3-15. Auto-Series Operation, Positive and Negative Outputs

3-64 The output voltage of each slave supply varies in direct proportion to that of the master. The ratio of each slave’s output voltage to the master’s is established by the ratio of the resistors in the voltage divider connected between the + Sense of the master and the −Sense of the slave.

3-65 Any power supply capable of auto-series operation can be used in the auto-series combination. The supply with the lowest current rating limits the maximum output current of the combination. Any well-regulated, variable-output supply can be used as the master.

3-66 In applications in which coordinated positive and negative voltages are required, center tapping the supply combination and load as shown in Figure 3-15 allows simultaneous proportional control of both supply voltages.

CAUTION

If more than four supplies are connected together in an auto-series combination, be certain that neither the more positive end nor the more negative end of the auto-series combination is more than 240 volts from ground.

3-67 Setting the Voltage and Current Controls.
The auto-series combination of supplies behaves as if it were a single constant voltage/constant current supply controlled by the voltage and current controls of the master supply. The voltage controls of the slaves are disabled. The current controls of the slaves should be set above the desired output current to avoid having a slave switch to CC mode.

NOTE

The current controls of the slave supplies can be disabled by disconnecting the straps between the A6 and A7 terminals and connecting a resistor between A7 and A5 on each slave. The resistor value should be chosen to program a current greater than the desired output current. (See paragraph 3-52.)

3-68 Resistor Values. As shown, each slave has an external voltage divider, \( R_X \) and \( R_Y \), that determines its programming voltage. The ratio of \( R_Y \) to \( R_X \) determines the ratio of the slave output voltage to the master output voltage. To determine the values of \( R_Y \) and \( R_X \), first choose the ratio of the slave output voltage to the master output voltage \( \frac{V_{MS}}{V_{VS}} \), select a value for \( R_Y \), and then determine the value for \( R_X \) by solving this equation: \( R_X = 12 \left( \frac{R_Y}{1 + \frac{V_{MS}}{V_{VS}}} \right) - R_Y \). For example, assume a two-supply combination that is to provide 80 volts, 50 volts from the master and 40 volts from the slave. If we select a value of 1k for \( R_Y \), the equation becomes:

\[
R_X = 12 \left( \frac{1000}{1 + \frac{50}{40}} \right) - 1000 \\
R_X = 12,000 \left( \frac{2.25}{2.25} \right) - 1000 \\
R_X = 26,000
\]

3-69 Note that the slave output voltage may be lower than, equal to, or higher than the master output voltage.
3-70 Two factors must be considered when selecting the resistance value of $R_Y$; the effect on programming specifications, particularly speed, and the power that the resistor will have to dissipate. In the previous example, with a total resistance of 27k across an output of 80 volts, $R_Y$ will have to dissipate 290 milliwatts and $R_Y$ will have to dissipate slightly more than 11 milliwatts. Lower resistance values of $R_X$ and $R_Y$ will increase programming speed while increasing the amount of power that $R_X$ and $R_Y$ will have to dissipate.

3-71 To maintain the temperature coefficient and stability specifications of the supplies, $R_X$ and $R_Y$ must be stable, low-noise resistors with temperature coefficients of less than 25 ppm per °C and power ratings of at least 30 times what they will actually dissipate.

3-72 The front-panel VOLTAGE control of the slave can be used in place of $R_Y$ by connecting a strap from A2 of the slave to A1 of the slave. This enables the user to vary the percentage of the total voltage contributed by the slave. For calculation purposes, use a resistance value of 2.7k for the VOLTAGE control when it is set to maximum.

3-73 Overvoltage Protection in Auto-Series. Set the OVP in each supply so that it trips at a level higher than the voltage that supply will contribute. If the master supply OVP trips, the master will program the slaves to zero output. If a slave OVP trips, that slave and all slaves between it and the negative end of the series will go to zero output; all units more positive than the tripped slave (which includes the master) will continue to supply their set output voltage. Therefore, the total output voltage of the auto-series combination will be the sum of the outputs from the master plus any slaves between the master and the tripped slave.

3-74 Auto-Series with Remote Sensing. To combine auto-series operation with remote sensing, connect the supplies as described above but remove the +S jumper from the master supply and the −S jumper from the most negative supply, and connect the +S and the −S terminals directly to the + and − ends of the load.

3-75 The output voltage and/or current of an auto-series combination can be remotely programmed. Remote programming connections are made to the master supply. The percentage of the total voltage contributed by a slave can also be remotely programmed by connecting a variable resistor to the slave in place of $R_Y$. Observe all precautions outlined in the remote programming paragraphs. Simultaneous use of remote sensing and remote programming is also possible during auto-series operation.

3-76 Auto-Tracking Operation

3-77 Figure 3-16 shows the interconnections required to operate two or more units in auto-tracking mode. This mode of operation allows multiple supplies that share a common negative (or positive) output bus to power separate loads and have their output voltages simultaneously programmed by the voltage and current controls of the master supply. The output voltage of each slave supply varies in direct proportion to that of the master. The ratio of each slave's output voltage to the master's is established by the ratio of the resistors in the voltage divider connected between the +S of the master and the −S of the slave.

![Auto-Tracking Operation](image)

3-78 Figure 3-17 shows the interconnections required to provide both positive and negative outputs from an auto-tracking combination. As can be seen, the only difference from standard auto-tracking operation is that the + Out terminal of slave #2 instead of the − Out terminal is connected to the common bus. There is no limit to the number of supplies that can be operated in either auto-tracking configuration.
and $R_Y$ for the slaves providing positive outputs, and the equation in Paragraph 3-68 is used to determine the values of $R_X$ and $R_Y$ for the slaves providing negative outputs.

3-84 To maintain the temperature coefficient and stability specifications of the supplies, $R_X$ and $R_Y$ must be stable, low-noise resistors with temperature coefficients of less than 25 ppm per °C and power ratings at least 30 times what they will actually dissipate.

3-85 The front panel VOLTAGE control of the slave can be used in place of $R_Y$ by connecting a strap from A2 of the slave to A1 of the slave. This enables the user to vary the ratio of the slave output voltage to the master output voltage. For calculation purposes, use a resistance value of 2.7k for the VOLTAGE control when it is set to maximum.

3-86 Setting the Current Controls. The current controls of all supplies in an auto-tracking combination are independently operative and can be used to set current limits for each individual load. If the master supply goes into the constant current mode, the output voltages of the slaves continue to track that of the master. If a slave supply goes into constant current mode, however, no other supply is affected.

3-87 Overvoltage Protection in Auto-Tracking

Set the OVP of each supply as appropriate for the load connected to that supply. If the master supply OVP trips, the master will program the slaves to zero output. If a slave OVP trips, only that slave and its load will be affected.

3-88 Auto-Tracking with Remote Sensing. To combine auto-tracking operation with remote sensing, connect the supplies as described above but remove the +S and -S jumpers from each supply and connect the +S and -S terminals directly to the + and - ends of its load.

3-89 Auto-Tracking with Remote Programming.

The output voltages of an auto-tracking combination can be remotely programmed by programming connections made to the master supply. In addition, the ratio of each slave's output to the master's output can be remotely programmed by connecting a variable resistor to the slave in place of $R_Y$. The output currents of the individual supplies can also be remotely programmed. Observe all precautions outlined in the remote programming paragraphs. Simultaneous use of remote sensing and remote programming is also possible during auto-tracking operation.
3-90 I-MONITOR OUTPUT SIGNAL

3-91 An amplified and buffered output signal from the current-monitoring resistance (RM) is available between terminals A4 and A5 on the rear panel. This signal can be connected to a remote voltmeter to indicate the amount of output current. The signal varies from 0 to 5 volts to indicate a zero to full scale (10A) current output. The + terminal of the voltmeter should be connected to terminal A5. Output impedance at terminal A4 is 10k; a load of 1 megohm will maintain 1% reading accuracy.
Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed changes(s) in the manual.

<table>
<thead>
<tr>
<th>SERIAL</th>
<th>MAKE CHANGES</th>
</tr>
</thead>
<tbody>
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<td>Number</td>
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<tr>
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</tr>
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<td>2129A</td>
<td>00661-01390</td>
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<td>01391-02290</td>
</tr>
<tr>
<td>2332A</td>
<td>02291-up</td>
</tr>
</tbody>
</table>

**ERRATA:**

In Table 1-1, under **REMOTE PROGRAMMING**, **Accuracy specifications should be:**

- **Resistance Programming**
  - CV: 0.8% + 12 mV CC; 2.5% + 2mA
- **Voltage Programming**
  - CV: 0.2% +2 mV CC; 1.0% +2mA
- **Current Programming**
  - CV: 0.2% +0.36 V + accuracy of resistor CC; 1.0% + 0.15 A + accuracy of resistor

On Figure 5-3 and 5-4, the power supply - and -S terminals should be connected to the power supply frame ground terminal ( ).

Paragraph 5-44 step (a.) should be: Connect test setup shown in Figure 5-7. Set RL to minimum resistance initially. Paragraph 5-44 step (f.) should begin: Increase resistance of RL until DVM reads exactly 20 V (maximum rated power output). Ensure that power supply remains in constant-current mode.

Paragraph 5-81 step (c.) should be: Adjust A2R65 less than +/-2mV on DVM. Paragraph 5-87 step (d.) should be: Adjust A2R91 for less than +/-0.2 mV on DVM (less than 2 mA through shunt). Paragraph 5-89 step e should be: Adjust A2R92 for 0.1 V +/-0.2 mV on DVM (10 A +/-20 mA output).

In Table A-1, under **REMOTE PROGRAMMING**, **Accuracy specifications should be:**

- CV: 0.8% + 30mV CC; 2.5% + 10mA.

In the replaceable parts list for A2 Control Board Assembly, add: C22, HP P/N 0140-0203, 30pF 50 500 V MICA; R63, HP P/N 0683-1055, 10 M 5% .25 W F; R64, HP P/N 0698-5094, 5.1 M 5% .25 W F.

**CHANGE 1:**

In the replaceable parts list, page 6-8 Delete Support Spacers HP P/N 1390-0481 and Add NUT EXPANSION HP P/N 0590-1422.

**CHANGE 2:**

In the replaceable parts list, page 6-5 change C23 to 2.2 uF Polyester, HP P/N 0160-5377 and C28 to Fixed electrolytic 390 uF, 20 Vdc HP P/N 0160-3056.

**CHANGE 3:**

On page 6-3 change Q1,2 to HP P/N 5080-2017.

Delete inductors L4,5 HP P/N 9140-0179 from the replaceable parts list and the schematic diagram. Replace L4,5 with R67, R68, 62 ohm, 1/8 W, HP P/N 0698-4132. R67,68 should have asterisks marked next to them when added to the parts list.

On page 6-4 change T3,4 to HP P/N 5080-2018. Also, T3, 4 should have asterisks marked next to them.