HEWLETT PACKARD

AUTORANGING DC POWER SUPPLY
HP MODEL 6023A

OPERATING AND SERVICE MANUAL
FOR INSTRUMENTS WITH SERIAL NUMBERS
2407A-00101 AND ABOVE

For instruments with Serial Numbers above 2407A-00101, a change page may be included.

HP Part No. 06023-90001

Printed: January, 1984

SAFETY SUMMARY

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

BEFORE APPLYING POWER.

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

GROUND THE INSTRUMENT.

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

INPUT POWER MUST BE SWITCH CONNECTED.

For instruments without a built-in line switch, the input power lines must contain a switch or another adequate means for disconnecting the instrument from the ac power lines (supply mains).

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

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

KEEP AWAY FROM LIVE CIRCUITS.

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

DO NOT SERVICE OR ADJUST ALONE.

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

DO NOT EXCEED INPUT RATINGS.

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

SAFETY SYMBOLS.

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

Indicates hazardous voltages.

or Indicate earth (ground) terminal.

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

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

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

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

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

page 1-2 change the HP part numbers of e following accessories;

	Accessories	New HP P/N
	Slide Kit	1494-0065
.	Rack Mounting Adapter Kit (center mounting)	5061-9661
.	Rack Mounting Adapter Kit (side Mounting)	5061-9660
.	Rack Flange and Front Handle kit	5061-9678
.	Rack Mounting Flange Kit	5061-9684
.	Front Handle Kit	5061-9690
'.	Lock-together Kit	5061-9694
3.	Support Shelf	5061-9698
).	Bail Handle Kit	5061-9703
10.	Front Filler Cap	5061-9727

On page 5-12, under the second CAUTION delete sentences a. d. e. and f.

CHANGE 4:

In the replaceable parts list, under A2 Control Board add A2R152, 1K, 1/4W, TQ 1, HP P/N 0683-1025, and A2R155,158, 0 ohm, TQ 2, HP P/N 8159-0005. On the schematic, Figure 7-8, add the following components; A2R152, 1K, is connected between J2-14, V-MON 1 and J3-3, A2R155, 0 ohm, is connected between A2R73 and the junction of A2CR1 and CV PROGRAM, and A2R158 is connected between switch B4 (ref. Mode Switch S1) and the junction of A2R58 and CV PROGRAM.

On page 7-6, Figure 7-3, add the following components to the A2 Control Board; A2R155 is located directly above A2R64 near the terminal block, add A2R158 directly below A2CR34, near Mode Switch S1, and add A2R152 between A2U4 and A2R25, near the J3 edge connector.

CHANGE 5:

In the replaceable parts list for Appendix A, page A-14 add resistor R57, 6.49K, 1%, 1/8W, HP P/N 0698-3226 and on page A-15 under Mechanical add solder pin HP P/N 0360-1300, qty 2. On the schematic Figure A-16, add R57 between C8 negative and VR11 anode. On figure A-15 add R57 vertically between CR30 and CR15.

ERRATA:

In the replaceable parts list, change the part number for F003 on the 06023-60122 assembly from HP P/N 2110-0546 to HP P/N 2110-0699.

CHANGE 6:

In the replaceable parts list, change the following parts: (Note that some parts are listed with options in the manual).

	Qty	From:	To:
Cover-Top	1	06023-00002	06023-00020
Cover-Bottom	1	06023-00003	06023-00022
Trim-Top	1	5040-7203	5041-8803
Trim-Sides	2	5001-0440	5001-0540
Front Frame	1	5021-5817	5021-8417
Feet	4	5040-7201	5041-8801
Strap Handle Assy	1	5060-9803	5062-3703
Strap-Retainer Rear	1	5041-6820	5041-8820
Strap-Retainer Front	1	5041-6819	5041-8819
Front Panel SCR	1	06023-00015	06023-00021
OPTION 908	1	5061-9660	5062-3960
OPTION 800	1	5061-9678	5062-3978

MANUAL CHANGES
Model 6023A DC Power Supply
Manual HP P/N 06023-90001

11/28/88

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 in the manual.

SERIAL		MAKE
PREFIX	NUMBER	CHANGES
ALL		ERRATA
2420A	00124-00138	1
2428A	00139-00183	1,2
2508A	00184-00363	1-3
2541A	00364-00618	1-4
2704A	00619-01068	1-5
2845A	01069-up	1-6

ERRATA:

On page 3-11, paragraph 3-87, in the second sentance, change Figure 3-13 to 3-14. In paragraph 3-88, change the formula for the ratio of Rx to Ry to Rx/Ry= K(Vm/Vs)-1. In paragraph 3-89, change the formula for Rx to Rx=40(Vm/Vs)-10kohm, 1/2 watt. On page 5-9, Table 5-3, under Code to Calibration, delete in step 3, Fullscale (F/S).

On page 7-10, Front Panel Board Schematic Diagram, make the following changes. In the shaded area labeled, Voltage Range Switching Circuit, change R77 to 51.1k. Label R87 to have values of 80k, 1%, 1/8W. Change R68 (located near U7D) to 1k. In shaded areas, Voltage Display and Current Display, relabel the pinouts for DS2-4 and DS6-8 as follows;

Segment "a" corresponds to pinout "1"
"f" "13"
"d" "10"
"c" "8"
"b" "7"
"e" "2"
"g" "11"

At right of page, change LED segments, DS4, DS8 to DS1, DS5 and change DS1-3, DS5-7 to DS2-4, DS6-8.

CHANGE 1:

In the replaceable parts list, page 6-13, change panel, sub from HP P/N 06023-00006 to 06023-00014. Change front panel, HP P/N 06023-00012 to 06023-00015.

ERRATA:

On page 1-3, in the specifications table, under TEMPERATURE COEFFICIENT, change the voltage spec to;
Voltage: 100ppm + 1mv.
On page 1-4, under PROGRAMMING RESOLUTION change the specification for current from 10mv to 10ma.

CHANGE 2:

In the replaceable parts list, page 6-9, change DS1 through DS8 to Display Kit HP P/N 1990-0985, Qty. 1.

ERRATA:

In Section 5, Maintenance, the mode switches are incorrect in Figures 5-2, 5-3, 5-4, 5-7, and 5-9. Refer to Figure 3-2 for correct positioning of mode switches.

In the replaceable parts list, page 6-9, change the description of R4,5 to see Chassis Electrical. On page 6-11, under Chassis Electrical add R4,5, var. 5k (ref. front panel), HP P/N 2100-4060, qty. 2. In the replaceable parts list, page 6-3, add an asterisk to R20-23 since these resistors are also part of the output filter. On page 6-14, delete R20-23 from the parts list. In the Specifications Table 1-1, page 1-4, PROGRAMMING RESOLUTION for current is 10mA. In the repalceable parts list, page 6-13, add cover, terminal block, HP P/N 1990-0521, qty. 2.

CHANGE 3:

In the replaceable parts list, page 6-12 and 6-13 under Chassis Mechanical change retainer, strap handles to HP P/N 5041-6819 and 5041-6820, chassis to HP P/N 06023-00016, rear panel, screened to HP P/N 06023-00019, frame, front to HP P/N 5021-5817, and add sub panel, front, HP P/N 06023-00018, Qty 1.

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Section I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The 6023A is a 200 watt, 20 volt, 30 ampere, CV/CC Autoranging power supply. Autoranging allows the 6023A to be light weight and compact, yet to deliver 200 watts from 6.7 Vdc at 30 Adc to 20 Vdc at 10 Adc. That's a range of output voltage-current combinations which otherwise would require the use of more than one supply or a higher rated-power supply. The Autoranging power circuit includes a pulse-width modulated, 20 kHz switching power converter using power field effect transistors (PFETs) as the power switches. The output voltage is adjustable from 0 to 20 Vdc and the output current is adjustable from 0 to 30 Adc by 10-turn, front-panel controls or by remote programming with external 0-5 Vdc voltages or 0-4 kΩ resistances.

1-3 The front panel includes a digital multimeter for the supply. Two 3½ digit displays accurately show the output voltage and current. Push-button switches allow the displays to alternately show the programmed values of voltage and current or the shut-down limit voltage for overvoltage protection. LED indicators show the unit's operating mode—CV, CC, or unregulated (power limited)—and the status of the overvoltage protection.

1-4 All connections are to rear-panel screw terminals. Either the positive or negative output terminal can be grounded, or both terminals can be floated above ground. A rear-panel DIP 6-pole MODE switch makes easy work of changing from front-panel control to remote-voltage or remote-resistance programming. Please see Section III for a full description of remote programming, remote sensing, and several methods of multiple-supply operation.

1-5 The 6023A is mechanically rugged. A quiet fan provides cooling for operation up to 55°C. A thermostat shuts the supply off if an overtemperature condition occurs and resets automatically. The supply's HP System-II-compatible case allows options for easy rack mounting and the addition of handles for portability. The supply's modular, functionally partioned construction facilitates servicing.

1-6 SAFETY CONSIDERATIONS

1-7 The unit is a Safety Class I instrument, that is, it is provided with a protective earth terminal. Please study your 6023A and this manual for safety markings and instructions before attempting to operate.

1-8 SPECIFICATIONS

1-9 Table 1-1 gives detailed performance and safety specifications. Figure 2-1 gives outline dimensions and identifies rear-panel switches and screw terminals. Figure 3-1 identifies the front-panel controls and meters.

1-10 INSTRUMENT AND MANUAL IDENTIFICATION

1-11 A two-part serial number identifies your unit. The serial-number prefix encodes the date of the latest significant design change and the country of manufacture. As an illustration, a serial number beginning with the prefix 2345A denotes a unit built to a 1983 (23 = 1983, 24 = 1984, etc.), 45th week design in the USA (A). The second part of the serial number is a unique, six-digit number assigned sequentially starting with 000101 to each unit.

1-12 Loose, yellow MANUAL CHANGES sheets may be included with your manual to provide errata changes which update all manuals and design changes which update manuals for designated blocks of serial numbers. If the serial-number prefix on your unit is not the same as the prefix on the title page of this manual, please refer to the MANUAL CHANGES sheets. They explain the differences between your unit and the units covered by this manual.

1-13 ACCESSORIES

HP PART NO.	DESCRIPTION
06023-60024	Control-board extender for servicing the A3 Control Board
06023-60025	Powermesh-board extender for servicing the A4 Powermesh Board
06033-60003	Service Kit: 06023-60024 and 06023-60025 boards and 1251-6016 test connector.
1251-6016	Control-board test connector for 6023A calibration.
1460-1345	Tilt stand, snaps into standard foot on unit (two required).
1494-0041	Slide kit for support shelf.
5061-0060	Rack-mounting adapter kit for side-mounting one 7-inch high cabinet, includes one rack flange and one half-module width extension adapter.

HP PART NO.	DESCRIPTION
5061-0061	Rack-mounting adapter kit for center-mounting one 7-inch high cabinet, includes one rack-flange and one quarter-module width extension adapter (two required).
5061-0078	Rack-flange kit for 7-inch high cabinet, includes two rack flanges (used with lock-together kit and other instrument(s) to expand assembly to full-module width for mounting).
5061-0084	Rack-flange and front-handle kit for 7-inch cabinet, includes two rack flanges and two handles (other accessories required to expand assembly to full-module width for mounting).
5061-0090	Front-handle kit for 7-inch high cabinets, includes two handles.
5061-0094	Lock-together kit for cabinets of equal depth, mounts up to three cabinets side by side.
5061-0098	Support shelf for mounting 7-inch high cabinets of different depths.
5061-2003	Bail-handle kit for carrying 7-inch high, half-module width cabinets.
5061-2027	Front filler panel for 7-inch high, half-module width cabinet on support shelf.
5060-2860	PFET service kit, includes components replaced when PFETs are replaced.
06023-90001	6023A Operating and Service Manual (this manual).

1-14 Ordering Accessories

1-15 Extra manuals and some of the System-II cabinet accessories may be ordered with your 6023A as options. Please refer to the HP general catalog for a full description of cabinet accessories. You can order any accessory from your HP Sales and Service office. A list of addresses is at the back of this manual.

Table 1-1. Specifications and Supplemental Characteristics

All performance specifications are at rear terminals with a resistive load. All specifications apply over the full operating temperature range unless otherwise specified.

AC INPUT

Two internal switches and one internal jumper permit operation from 120, 220 or 240 Vac (− 13%, +6%, 48-63 Hz).

INPUT CURRENT

120 Vac: 6.5 A
220 Vac: 3.8 A
240 Vac: 3.6 A

850 VA Maximum
375 W Maximum, 200 W Output

INPUT FUSE RATINGS

The AC input is protected by a rear panel mounted fuse; 8 A for 120 Vac, 4 A for 220 Vac and 240 Vac.

PEAK INRUSH CURRENT

20 A maximum at any line or temperature.

DC OUTPUT

Voltage and current can be programmed via, front panel control or remote analog control over the following ranges:

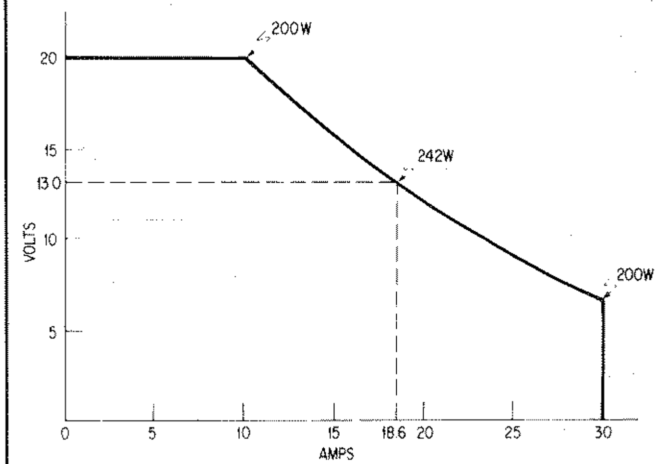
Voltage: 0 to 20 V
Current: 0 to 30 A

See graph and table for maximum output power.

OUTPUT BOUNDARY SPECIFICATION

Voltage (V)	Current (A)	Power (W)
6.7	30.0	200
7.0	29.0	203
8.0	27.0	216
9.0	25.0	225
10.0	23.3	233
11.0	21.6	238
12.0	20.0	240
13.0	18.6	242
14.0	17.2	241
15.0	15.9	239
16.0	14.6	234
17.0	13.5	230
18.0	12.4	223
19.0	11.3	215
20.0	10.0	200

Current (A)	Voltage (V)	Power (W)
10	20.0	200
12	18.4	221
14	16.6	232
16	14.9	238
18	13.5	243
20	12.0	240
22	10.8	238
24	9.6	230
26	8.5	221
28	7.5	210
30	6.7	200



LOAD EFFECT

For a load change equal to the maximum available current rating of the supply at the set voltage (CV) or maximum available voltage rating at the set current (CC):

Voltage: 0.01% +2 mV
Current: 0.01% +9 mA

SOURCE EFFECT

For a line change within rating:

Voltage: 0.01% +1 mV
Current: 0.01% +6 mA

PARD (Ripple and Noise)

RMS/pk-pk 20Hz-20 MHz:

Voltage: 3 mV/30 mV
Current: 15 mA
Common mode current: 1 mA/40 mA typical

TEMPERATURE COEFFICIENT

Change in output per °C after a 30-minute warmup.

Voltage: 70 ppm +0.6 mV
Current: 100 ppm +2.0 mA

DRIFT (Stability)

Change in output over an 8-hr interval under constant line, load and ambient temperature after 30-minute warm-up.

Voltage: 0.02% +1 mV
Current: 0.02% +10 mA

Table 1-1. Specifications and Supplemental Characteristics (continued)

LOAD TRANSIENT RECOVERY TIME

The time required for the output voltage to recover within a band around the nominal voltage following a 10% or 50% change in load current.

10% load current change: 1 ms to within 50 mV
50% load current change: 2 ms to within 150 mV

The typical deviation of the output voltage is 20 mV per amp of load current change.

PROGRAMMING RESOLUTION

Voltage: 5.0 mV
Current: 10 mV

PROGRAMMING RESPONSE TIME

Maximum time for output voltage to change from 0 to 20 V or 20 V to 2 V and settle within 5 mV of final value.

		Full load (2 ohms)	Light load (50 ohms)	No load
Up:	0 - 20 V	100 ms	100 ms	100 ms
Down:	20 - 2 V	200 ms	500 ms	1500 ms

Typical programming response time data for changes other than full-scale excursions:

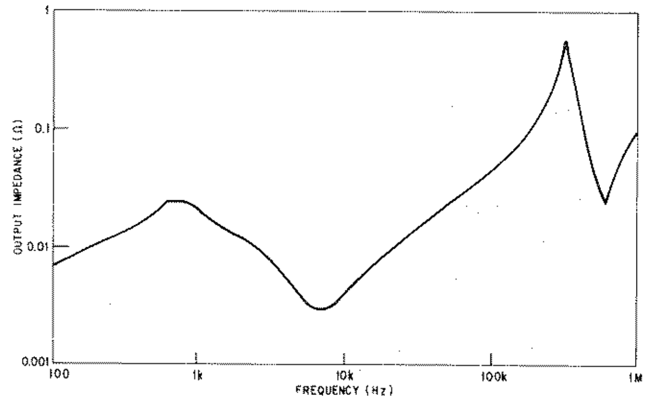
		Full load (2 ohms)	Light load (50 ohms)	No load
Up:	0 - 20 V	75 ms	60 ms	60 ms
	0 - 10 V	55 ms	50 ms	50 ms
	10 - 20 V	60 ms	50 ms	50 ms
Down:	20 - 2 V	110 ms	180 ms	1000 ms
	20 - 5 V	100 ms	180 ms	255 ms
	20 - 10 V	85 ms	170 ms	190 ms

Typical output voltage overshoot:

Final value	Overshoot
<2 V	1 V
>2 V	15 mV

OUTPUT IMPEDANCE (Typical)

See graph:



FRONT PANEL METERS (25 ±5 °C)

VOLTAGE

Range	Resolution	Accuracy
20 V	10 mV	0.6% +20 mV
200 V	100 mV	0.6% +200 mV

TC: 75 ppm +0.25 mV

CURRENT

Range	Resolution	Accuracy
200 A	100 mA	0.6% +200 mA

TC: 100 ppm +1.5 mA

OVP

Range: 200 V
Resolution: 100 mV
Accuracy: 2.5% +250 mV
TC: 200 ppm + 1 mV

OVERVOLTAGE PROTECTION

Trip voltage adjustable via front panel control.

Range: 0-23 V
Resolution: 100 mV
Accuracy: 2.5% +250 mV (Set using DISPLAY OVP function)
TC: 200 ppm +1.0 mV/°C

Minimum setting above output voltage to avoid nuisance tripping is 1 V.

Table 1-1. Specifications and Supplemental Characteristics (continued)

REMOTE ANALOG PROGRAMMING (25 ±5 °C)

Resistance programming:

0 to 4 k provides zero to maximum rated output voltage or current. The resulting scale factor is 200 ohms/volt and 133 ohms/amp

Voltage
Accuracy: 0.50% +12 mV
TC: 70 ppm +0.6 mV

Current
Accuracy: 1.0% +110 mA
TC: 100 ppm +1.5 mA

Voltage programming:

0 to 5 V provides zero to maximum rated output voltage or current.

Voltage
Accuracy: 0.25% +12 mV
TC: 10 ppm +0.6 mV

Current
Accuracy: 0.30% +110 mA
TC: 70 ppm +1.5 mA

The programming inputs are protected against input voltages up to ±40 V.

VOLTAGE AND CURRENT MONITOR OUTPUTS (25 ±5°C)

0 to 5 V output indicates zero to maximum rated output. All accuracy specifications are referred to the output of the supply.

Voltage

Accuracy: 0.25% +2 mV
TC: 10 ppm +0.2 mV/°C

Current

Accuracy: 0.30 +15 mA
TC: 70 ppm +1.5 mA/°C
Output Impedance: 10.2 k ohm ±5%

DC ISOLATION

±240 Vdc maximum between either output terminal and earth ground including the output voltage. Cabinet is at earth ground.

REMOTE SENSING

Meets load-effect specification at load by correcting for load-lead drop of up to 0.5 V per lead with sense wire resistance of less than 0.2 ohms per sense lead and lead lengths of less than 5 metres.

Operation with up to 2 V drop per load lead is possible; load-effect specification depends on sense-wire resistance. Refer to Section III.

REVERSE VOLTAGE PROTECTION

Maximum permissible current caused by reverse voltage impressed across output terminals:

30 A with AC power on
15 A with AC power off

TEMPERATURE RATINGS

Operating: 0 to +55°C
Storage: −40 to +75°C

CERTIFICATION

Unit complies with the following requirements:

IEC 348-Safety Requirements for Electronic Measuring Apparatus.

CSA 556B-Electronic Instruments and Scientific Apparatus for Special Use and Applications.

VDE 0411-Electronic Measuring Instruments and Automatic Controls.

VDE 0871/6.78 level B- RFI Suppression

DIMENSIONS

See Figure 2-1

WEIGHT

Net: 8.6 kg (19 lb)
Shipping: 10.5 kg (23 lb)

Section II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 After unpacking the unit, inspect for any damage that may have occurred in transit. Save all packing material until the inspection is complete. If you find damage, file a claim with the carrier and notify your HP Sales and Service office.

2-3 Mechanical Check

2-4 Confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches and that the unit does not rattle.

2-5 Electrical Check

2-6 Perform the TURN-ON CHECKOUT PROCEDURE in Section III to confirm that the unit is operational. Alternately, check the unit more fully using the FUNCTIONAL TEST PROCEDURE in Section V. Please refer to the inside front cover for Certification and Warranty statements.

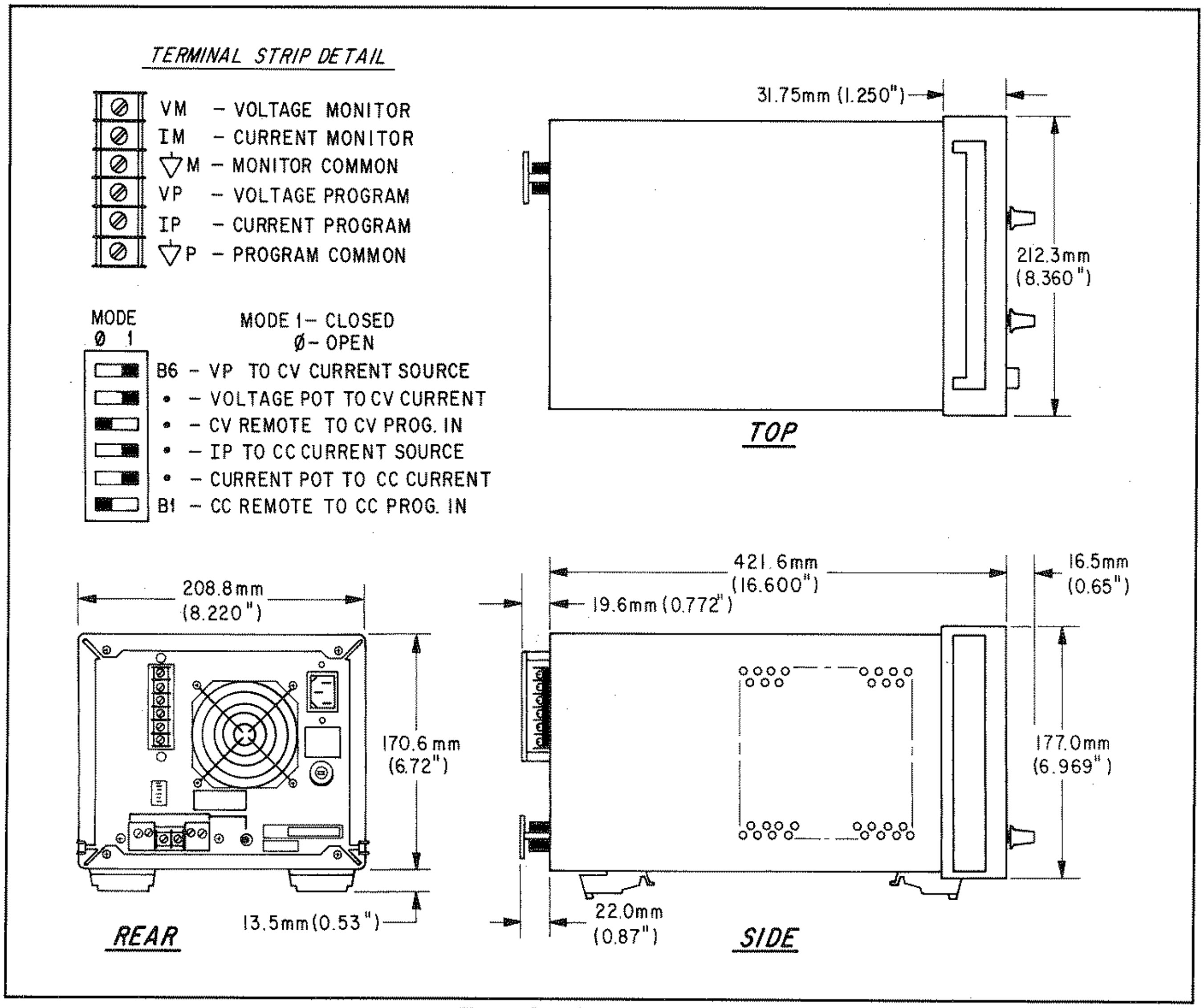


Figure 2-1. Outline Diagram

2-7 REPACKING FOR SHIPMENT

2-8 If returning the unit, please use the original packaging materials. If they are not available, contact your local HP Sales and Service office to obtain them. The office can also furnish the address to ship your unit for service. Before packing attach a tag or label to the unit giving the return address, model number, serial number and service required.

2-9 INSTALLATION DATA

2-10 The unit is shipped ready for bench operation at one of three ac mains voltage ranges. Before applying power, please read paragraph 2-18.

2-11 Location and Cooling

2-12 The unit is fan cooled and designed to operate in room ambients up to 55°C. To asure reliable operation and to prevent overtemperature shutdowns, install the unit with provision for cooling air to flow in the rear and out the sides. One side or the other may be restricted to have as little as about ¼ inch (6 mm) of space as for rack mounting with another half-module width instrument.

2-13 Outline Drawing

2-14 Figure 2-1 shows the unit's outline dimensions and identifies rear-panel terminals.

2-15 Rack Mounting

2-16 If desired, rack mount the unit in a standard 19-inch rack panel either by itself or alongside another instrument. Please see ACCESSORIES in Section I for available rack mounting accessories. Each rack-mounting kit includes complete installation instructions.

2-17 Input Power Requirements

2-18 The unit can operate from nominal ac mains voltages of 120, 220 or 240 Vac (48-63 Hz). The table below lists the minimum and maximum acceptable mains voltages and the required mains currents for full output power. A label on the rear panel shows the nominal mains voltage set for the unit at the factory. You can convert the unit to another nominal mains voltage by following the instructions in paragraph 2-23.

Nominal Mains Voltage	Mains Voltage Range	Maximum Input Current
120 Vac	104-127	6.5 A rms
220 Vac	191-233	3.8 A rms
240 Vac	208-250	3.6 A rms

2-19 Mains Cord

2-20 The unit is shipped with a mains cord intended for your location. Figure 2-2 illustrates the power plugs on standard HP mains cords.

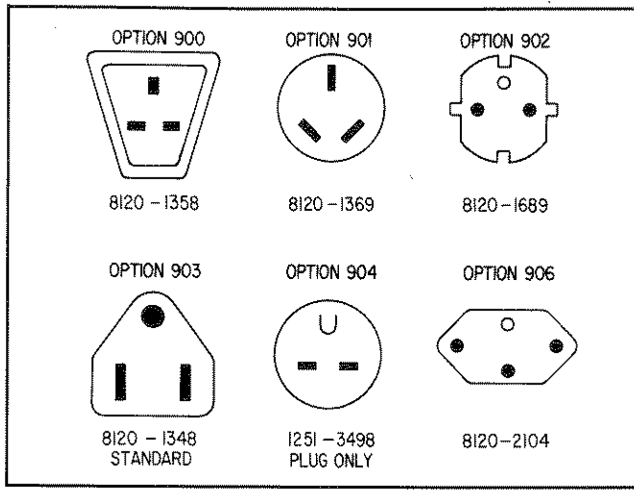


Figure 2-2. Power Plugs for Optional Mains Cords

2-21 Properly ground the cabinet to protect yourself and others from possible hazardous fault voltage between the unit's cabinet and earth ground. This is done for you when you plug the mains cord into a grounded outlet. The mains cord includes a third-wire ground. Use it!

2-22 Preserve the integrity of the earth-ground connection through the mains cord if you use a 3-prong-to-2-prong plug adapter. The offset pin in the 3-prong plug is the ground connection. Connect the green lead of the adapter or the cabinet of the unit to earth ground when connecting the unit to power from a 2-contact outlet.

2-23 MAINS VOLTAGE CONVERSION

2-24 Change the required mains voltage by adjusting three components inside the unit: the two-section mains-select switch A1S2, mains-voltage jumper A1W5, and rear-panel mains fuse F1. These appear in Figure 2-3.

2-25 Unplug the mains cord, and remove the top cover by removing three screws—the rear handle screw and the two top-rear-corner screws—and sliding the cover to the rear. Do not remove the front handle screw as the sheet-metal retaining nut will fall into the unit.

2-26 Set the two sections of switch A1S2 with a small, flatblade screw driver. A1S2 is at the left-front corner of the main board. Select the new switch positions from the diagram on the main board or the duplicate diagram in Figure 2-3. (Figure 2-3 shows A1S2 set for 120 Vac. If both white slots were near the center, it would be set for 220 Vac.)

2-27 Grasp the crimped portion of the connector on jumper A1W1 with needle-nose pliers by reaching through the cutout in the left side of the unit. Unplug the connector, and plug it onto the prong labeled "100/120" or the prong labeled "220/240" according to the mains voltage desired. A1W1 is behind A1S1 at the left edge of the main board.

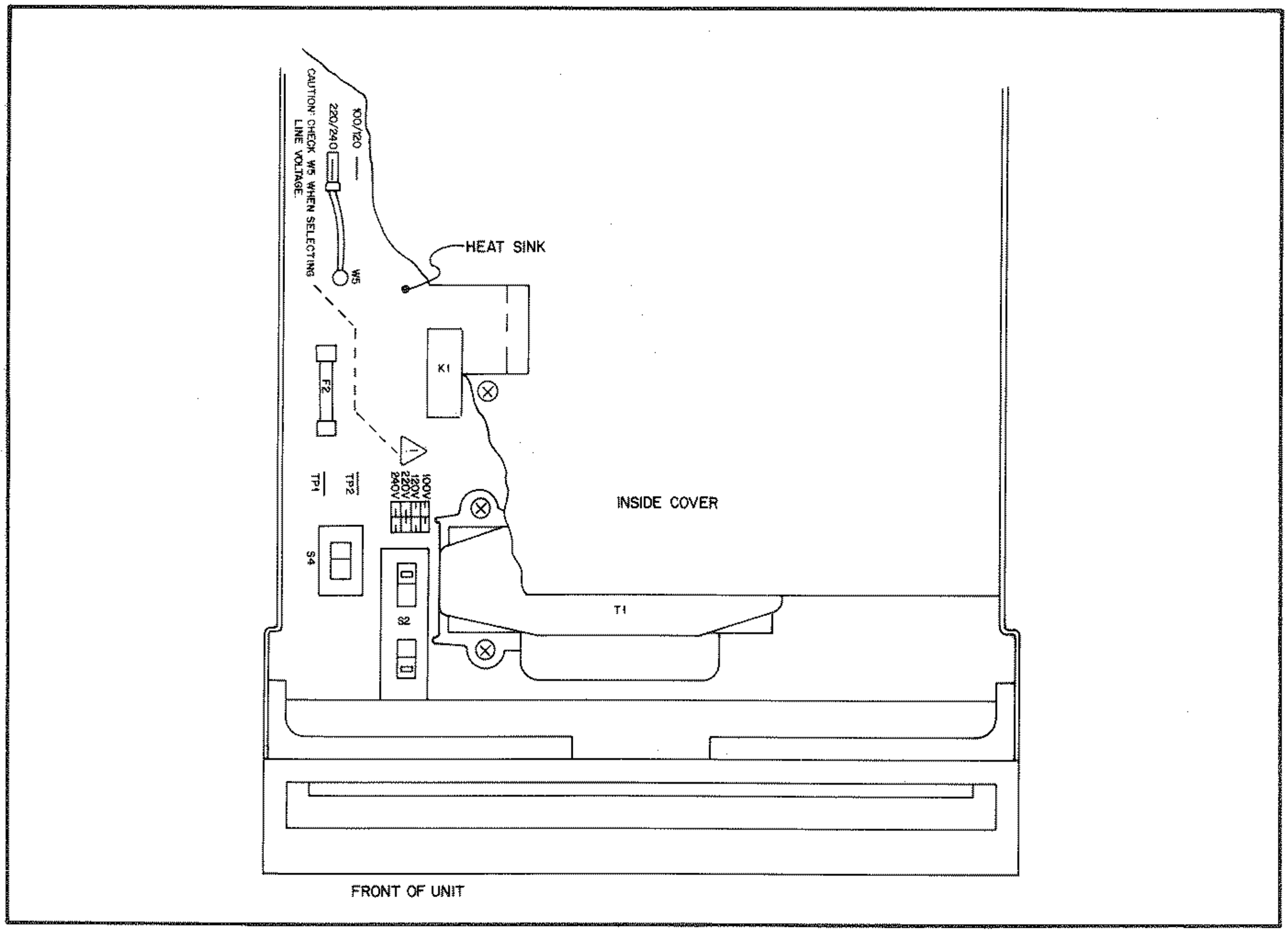


Figure 2-3. Mains Voltage Select Switch A1S2 and Mains Voltage Jumper A1W5

2-28 Check the rating of fuse F1 in the rear-panel fuse holder. For 120 Vac operation install an 8 A, 250 V fast-blow fuse (HP Part Number 2110-0383); for 220/240 Vac operation install a 4 A, 250 V fast-blow fuse (HP Part Number 2110-0055).

2-29 Replace top cover and mains cord. Mark the unit with a prominent tag or label specifying the new mains voltage required. Your unit can be damaged by connection to 220/240 Vac when configured for 120 Vac operation.

Section III
OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-2 This section explains the operating controls and indicators and provides information on many operating modes possible with your unit. WARNINGs give information for your safety. CAUTIONs give information to protect the unit or other equipment. NOTEs highlight important operating information.

WARNING

If the unit is operated without connection to earth ground through its mains cord and a grounded power outlet, a hazardous fault voltage can exsist on the unit's cabinet. The fault voltage can be a shock hazard and can cause personal injury. Before operating verify that the unit has a solid connection to earth ground not compromised by extension cord, auto transformer, or other device connected with it. Defective fuses can cause a shock or fire hazard. Replace fuses only with 250 V fuses of the required current rating. Do not use slow-blow fuses.

3-3 CONTROLS AND INDICATORS

3-4 The numbers below are for front-panel controls and indicators, and they refer to Figure 3-1.

(1) **LINE Switch:** Pressing at top of switch applies ac mains voltage to unit's bias and power circuits. Unit is operational 1.1 seconds after power on.

(2) **VOLTAGE Control:** Clockwise rotation increases output voltage, 0 to 20 Vdc range.

(3) **CURRENT Control:** Clockwise rotation increases output current, 0 to 30 Adc range.

(4) **OVP ADJUST Screwdriver Control:** Clockwise rotation with a small, flat-blade screwdriver increases setting for overvoltage shutdown, 0 to 23 Vdc range.

(5) **VOLTS Display:** Digital display of actual output voltage, output-voltage setting, or OVP shutdown setting. Output-voltage display changes from LO to HI range at 19.99 and back to LO at about 18.0.

(6) **AMPS Display:** Digital display of actual output current or output-current setting.

(7) **DISPLAY SETTINGS Switch:** Pressing causes VOLTS Display to show programmed output voltage and causes the AMPS Display to show programmed output current. Programmed values are front-panel settings or settings from remote voltage or resistance programming.

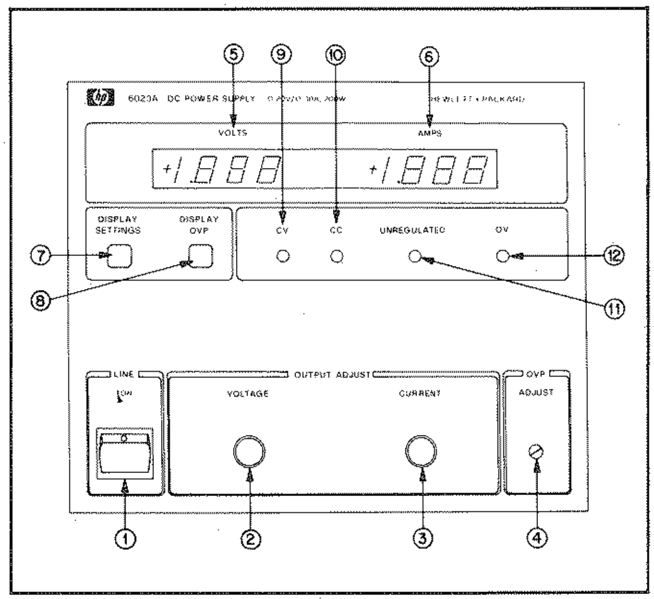


Figure 3-1. Front-Panel Controls and Indicators

(8) **DISPLAY OVP Switch:** Pressing causes VOLTS Display to show voltage setting for overvoltage shutdown.

(9) **CV LED Indicator:** Shows output voltage is regulated when lighted.

(10) **CC LED Indicator:** Shows output current is regulated when lighted. (Both CV and CC LEDs light when the unit is crossing over from constant voltage to constant current or the reverse.)

(11) **UNREGULATED LED Indicator:** Shows that neither output voltage nor current are regulated when lighted. This occurs when output is power limited or shut down by a protective circuit.

(12) **OV LED Indicator:** Shows that output is shutdown by occurance of overvoltage. Removing the cause of overvoltage and switching the power off and then on resets the unit.

3-5 TURN-ON CHECKOUT PROCEDURE

3-6 This procedure checks that the unit provides constant-voltage operation and is set up for front panel control. It acquaints you with the operating controls and switches. Use the FUNCTIONAL TEST PROCEDURE of Section V for a full checkout when the unit is first received.

a. Check that the rear-panel MODE switch settings are as shown in Figure 3-2.

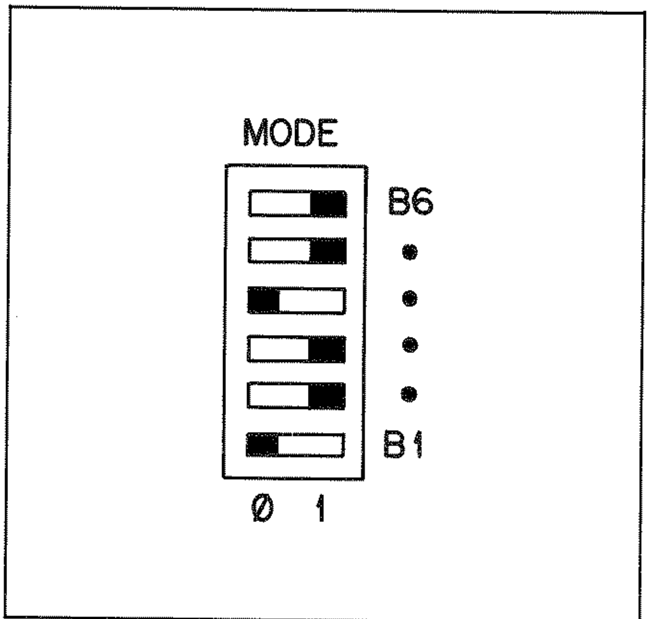


Figure 3-2. MODE-Switch Settings for Front-Panel Control

b. Check that the +OUT terminal is jumpered to the +S terminal, and the −OUT terminal is jumpered to the −S terminal.

c. Check that the rear-panel label indicates that the unit is set for the mains voltage to be used. (If not, refer to MAINS VOLTAGE CONVERSION in Section II.)

d. Plug the unit into an appropriate ac power outlet, turn the VOLTAGE control all the way down, and turn the CURRENT control up very slightly—to assure CV operation.

e. Switch on power; turn up output voltage slightly, and verify that the VOLTS display, the AMPS display and the CV LED are lighted.

f. Press the DISPLAY OVP switch, and verify that the OVP shutdown is set above 20.0 Vdc. If not, turn up OVP ADJUST with a small flat-blade screwdriver.

g. Turn up the output voltage; verify that the VOLTS display can increase to 20.0 Vdc. The CC LED should light while voltage is adjusted quickly.

h. Verify that the VOLTS display does not change when DISPLAY SETTINGS is pressed.

i. With DISPLAY SETTINGS depressed turn the CURRENT control up, and verify that the AMPS display can increase to 30.0.

3-7 OPERATING MODES

3-8 Settings of the rear-panel MODE switch determine the operating modes of the unit. The Normal operating mode is with the unit set up for sensing of output voltage directly at the output terminals—local sensing—and set up for operation using the front-panel controls—local programming. 3-2 shows the MODE switch settings for the normal operating mode. Othe operating modes covered in this section are remote voltage sensing, remote programming of output voltage and current using external voltages or resistances, and multiple supply operation in auto-parallel, auto-series, and auto-tracking operating modes.

3-9 Even if you plan to use one of the unit's other modes of operation, read the NORMAL OPERATING MODE section below first. The operating considerations described apply to the other modes as well. If you desire a more thorough explanation of power-supply operating modes and application possibilities, ask your local HP Sales office for a free copy of the DC Power Supply Handbook, Application Note AN90B.

3-10 NORMAL OPERATING MODE

3-11 The unit is shipped from the factory configured in the normal operating mode—local sensing and programming. Besides jumpers between output and sense terminals, normal operating mode requires the MODE switch settings shown in Figure 3-2.

3-12 The unit provides constant-voltage (CV) or constant-current (CC) output. For CV operation set the output voltage with the VOLTAGE control, and set a current limit by setting the CURRENT control to a value of current higher than the load current at the selected voltage. For CC operation set the output current with the CURRENT control, and set a voltage limit by setting the VOLTAGE control to a voltage higher than the load voltage with the selected output current flowing through the load.

3-13 The settings of the VOLTAGE and CURRENT controls and the load resistance jointly determine whether the unit supplies constant voltage, constant current, or unregulated (power-limited) output. For all rated combinations of output voltage and current the unit is in CV or CC operation: CV if the selected voltage can be applied to the load with less than the selected current, and CC if the selected current can flow with less than the selected voltage across the load.

3-14 Rated output voltage-current combinations are those enclosed by the Output-Boundary curve shown in Table 1-1. Combinations outside the curve cannot be delivered. The VOLTAGE control sets 20 Vdc maximum; the CURRENT control sets 30 Adc maximum, and power-limit circuitry sets a maximum rated power limit—the curved portion of the Output-Boundary curve.

3-15 The output of the unit is unregulated when both the output-voltage setting and the output-current setting require more than rated power to the load. When the output is unregulated, neither the set voltage nor the set current is delivered to the load. As an illustration, consider a unit set to 15 Vdc and 25 Adc with a 0.60Ω load. As seen in Figure 3-3 a 0.60 Ω load line intersects the power-limited portion of the Output-Boundary curve at 12 Vdc and 20 Adc. 12 Vdc and 20 Adc are the highest rated voltage and current that can be delivered to a 0.60 Ω load. The actual load voltage will be between 12 and 15 Vdc, and the actual load current will be between 20 and 25 Adc; neither will be well regulated, and both will be only approixmately predictable.

3-16 The load resistance connected to the output terminals determines the ratio of the output voltage to the output current (Ohm's law). The unit is in CV mode when the ratio of the voltage setting to the current setting is greater than the load resistance, and the unit is in CC mode when the ratio of the settings is less than the load resistance. For the 0.60Ω load example, all possible combinations of output voltage and current are on the load line in Figure 3-3 extending from the origin (0 Vdc, 0 Adc) to the intercept with the Output Boundary (12 Vdc, 20 Adc). Voltage-current settings combinations above the load line result in CV operation; below the line, CC operation.

3-17 When the settings ratio or load resistance is changing, crossover from CV to CC or CC to CV occurs smoothly and automatically at the point the settings ratio equals the load resistance. For a 0.60Ω load, if settings are changed from 15 Vdc and 15 Adc (a 1.0Ω ratio) to 7.5 Vdc and 15 Adc (a 0.5Ω ratio), the unit will crossover from CV to CC operation as the VOLTAGE control is adjusted through 9.0 Vdc (a 0.60Ω ratio).

3-18 Constant-Voltage Operation

3-19 This procedure sets up the unit to supply a selected, constant voltage to the load.

a. With power off connect the load to the rear-panel output terminals.
b. With the VOLTAGE control all the way down switch on the power.
c. With DISPLAY SETTINGS depressed adjust CURRENT control for the desired current limit.
d. Turn up the VOLTAGE control to the desired output voltage. Verify that the CV LED is lighted. (If the CC LED is lighted, choose a higher current limit. A current setting greater than the voltage setting divided by the load resistance in ohms is required for CV operation. If the UNREGULATED LED is lighted, the voltage cannot be supplied to your load within the unit's rated power. Consider Auto-Series operation if two units are available.)

3-20 Constant-Current Operation

3-21 This procedure sets up the unit to supply a selected, constant current through the load.

a. With power off connect the load to the rear-panel output terminals.
b. With the VOLTAGE control all the way down switch on the power.
c. With DISPLAY SETTINGS depressed adjust CURRENT control for the desired output current.
d. Turn up the VOLTAGE control to the desired voltage limit. Verify that the CC LED is lighted. (If the CV LED is lighted, choose a higher voltage limit. A voltage setting more than the current setting times the load resistance in ohms is required for CC operation. If the UNREGULATED LED is lighted, the current cannot be supplied to your load within the unit's rated power. Consider Auto-Parallel operation if two units are available.)

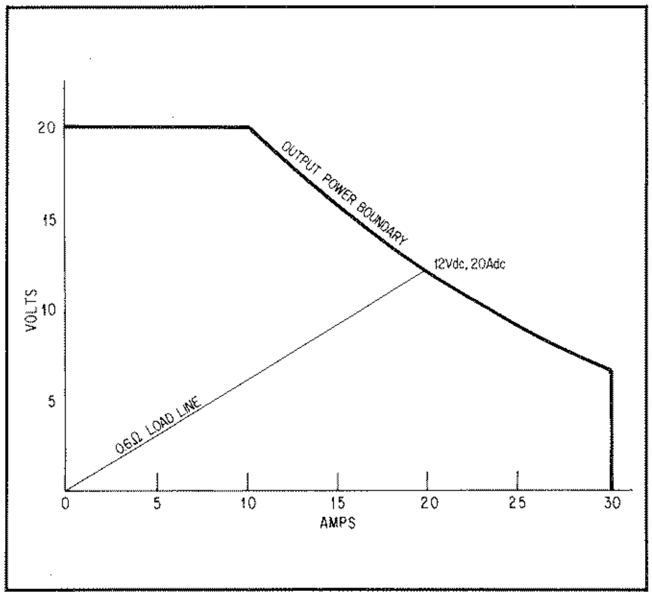


Figure 3-3. Output Voltage-Current Combinations for 0.60Ω load—All combinations are on Load Line 0 Vdc, 0 Adc to 12 Vdc, 20 Adc.

3-22 OVERVOLTAGE PROTECTION (OVP)

3-23 When the voltage at the output terminals increases (or is increased by an external source) to the OVP shutdown voltage set by the the OVP ADJUST control, the unit's OVP circuit inhibits the output, and the output voltage and current drop to zero. During OVP shutdown the OV and UNREGULATED LEDs light.

3-24 False OVP shutdowns may occur if you set the OVP shutdown too close to the unit's operating voltage. Set the OVP shutdown voltage 1.0 V or more above the output voltage to avoid false shutdowns from load-incudced transients.

3-25 Adjusting OVP. Follow this procedure to adjust the OVP shutdown voltage.

a. With the VOLTAGE control all the way down, switch on the power.
b. Depress DISPLAY OVP, and adjust the OVP ADJUST control to the desired OVP shutdown using a small, flat-blade screwdriver.
c. Follow the procedure for CV or CC operation to set the output voltage and current.

3-26 Resetting OVP. If OVP shutdown occurs, reset the unit by switching power off. Wait one or more seconds, and switch power on again. If OVP shutdowns continue to occur, check the connections to the load and sense termianls, and check the OVP limit setting.

3-27 CONNECTING THE LOAD

3-28 Use load leads of adequate wire gauge to safely handle short-circuit current and also have acceptable voltage drop at the normal load current. The American Wire Gauges (AWG) for solid or stranded copper wires capable of safely handling 30 Adc are shown below. The maximum lengths listed allow a 0.5 Vdc drop with 30 Adc flowing.

AWG	METRIC EQUIVALENT mm^2	MAXIMUM LENGTH (m)	(ft.)
10	4	3.6	12.0
8	6	4.9	17.0
6	10	8.5	27.0

3-29 The table below gives suggested maximum currents for smaller gauge wires. To use these wire gauges set the output current to less than the maximum current listed. A length of about 3 meters (10 feet) produces a 0.5 Vdc drop at the listed maximum current. Use larger wire routinely if feasible to avoid wasting output power. At the maximum current listed the power in watts wasted in a 6-meter round trip to and from the load is the same as the current in amperes (e.g., 15.6 Adc flowing in 6 m of 14 AWG wire wastes 15.6 W of output power).

AWG	METRIC EQUIVALENT mm^2	MAXIMUM CURRENT Adc
18	0.823	7.7
16	1.308	9.7
14	2.082	15.6
12	3.308	24.7

3-30 Use short load leads and twisted pairs or shielding to reduce noise pickup. In temporary setups where twisting the load leads is a nuisance, route the leads close together to reduce the size of the noise pickup loop. If you connect more than one load to to the unit, use separate pairs of load leads from each load to the output terminals. This reduces coupling of transients between loads and provides a lower source impedance to each load.

3-31 If you cannot use separate pairs of leads for multiple loads and you use remote output-distribution terminals instead, connect +OUT and -OUT to the distribution terminals with a pair of twisted or shielded wires. Use remote voltage sensing as described in paragraph 3-39 to assure a low source impedance to the loads connected to the distribution terminals.

3-32 Set up the output ground connections to the unit as follows to assure quiet, well-regulated output voltage to the load: Connect either output to ground as desired to obtain a positive or negative output voltage. If you connect an output terminal to ground, make the connection at a single point, at the output terminal or at the load. Do not rely on ground as the return-current path for the supply. Use two load leads directly to the load.

3-33 PROTECTIVE SHUTDOWN

3-34 The unit includes protection circuits which inhibit the output when required to protect the unit or the load. The output shuts down when any of four conditions occurs: an overvoltage at the output, an overtemperature inside the unit, a low ac mains input voltage or a high ac mains input voltage. Reset the unit after eliminating the cause of shutdown by switching the power off for one second and then back on.

3-35 Front-panel LEDs indicate that a protective shutdown has occurred. During an overvoltage shutdown CV and CC LEDs are out and the OV and UNREGULATED LEDs light. During overtemperature or ac mains shutdowns only the UNREGULATED LED lights.

3-36 OTHER OPERATING MODES

3-37 Other operating modes discussed below are remote voltage sensing, remote voltage programming and remote resistance programming. You can set up the unit for remote sensing by removing the straps between output and sense terminals, and you can set up the unit for the other modes by changing the settings of the rear-panel MODE switch. Procedures follows.

CAUTION

Switch off ac power while making changes to MODE switch settings or rear-panel connections. This avoids the possibility of damage to the load and OVP shutdown from unintended output from the unit.

3-38 Remote Voltage Sensing

3-39 Remote voltage sensing of the output voltage at the load allows the unit to automatically increase the output voltage and compensate for the voltage drops in the load leads. This improves the voltage regulation at the load, and is especially useful for CV operation with loads that vary and have significant load-lead resistance.

3-40 Remote sensing has no effect during CC operation. Connect the unit for remote voltage sensing by connecting load leads from +OUT and −OUT terminals to the load and sense leads from the +S and −S terminals to the load as shown in Figure 3-4.

3-41 To achieve specified CV load regulation, use large enough wire for load leads to assure no more than 0.5 Vdc drop in each load lead, and use large enough wire for sense-leads to assure no more than 0.2 ohms lead resistance in each sense lead. Select the load-lead wire gauge from paragraph 3-29 or 3-30, and select the sense-lead wire gauge from the table on the next page.

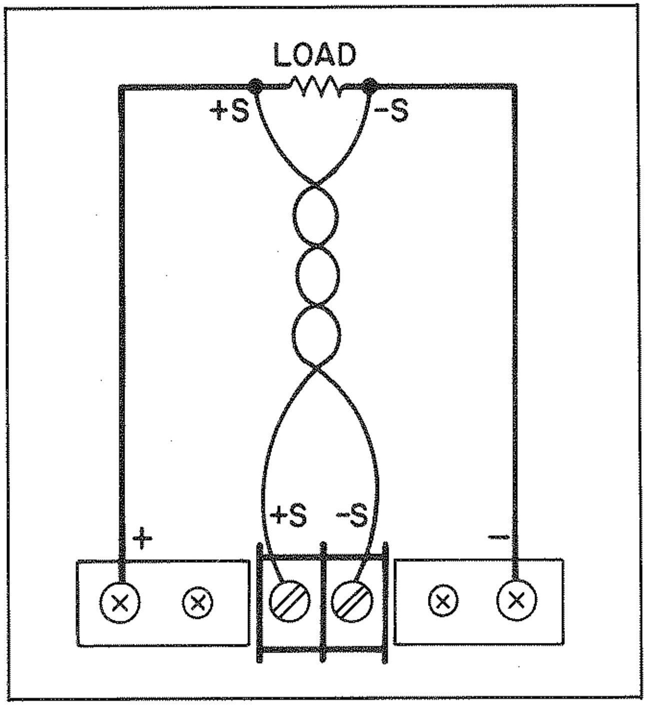


Figure 3-4. Remote Voltage Sensing (Load leads shown untwisted for clarity)

AWG	METRIC EQUIVALENT mm^2	MAX. LENGTH (m)	(ft.)
24	0.204	2.1	7
22	0.324	2.8	9
20	0.518	4.4	15
18	0.823	9.4	30

3-42 With slightly degraded CV load regulation performance, the unit will provide remote voltage sensing with up to 2 Vdc in each load lead and with more than 0.2 Ω in each sense-lead. As the voltage drop in the load leads increases, the load voltage error due to the sense-lead resistance increases as (2Rs +0.5)Vd/1000, where Rs is the resistance in ohms of each sense lead and Vd is the voltage drop in each load lead. For example, if the voltage drop in each load lead is 2 Vdc and the resistance in each sense lead is 1 Ω, the load voltage will differ by [2(1)+0.5]2/1000=5 mV from that with no sense-lead resistance.

NOTE

During remote sensing the load-lead voltage drops cause the voltage at the output terminals to increase beyond the set value. Readjust the OVP shutdown voltage as required to avoid nuisance OVP shutdowns.

3-43 Any noise picked up on the sense leads will appear on the unit's output voltage and may degrade voltage regulation. To reduce noise pick up use a twisted pair or shielded pair with the shield grounded at one end only. Connect the sense leads as close to the load as possible.

3-44 Accidental open-connections of sense or load leads during remote-sensing operation have various unwanted effects. Provide secure, permanent connections—especially for the sense leads. The sense leads are part of the unit's programming feedback control loop.

NOTE

The 6023A includes protection resistors which reduce the effect of open sense leads during remote-sensing operation. If the + S sense lead opens, the output voltage increases about 4% and is sensed between the + OUT terminal and the negative side of the load. If the − S sense lead opens the output voltage increases about 1% and is sensed between the positive side of the load and − OUT. If both sense leads open, the output voltage increases about 4.8% and is sensed locally.

3-45 Remote Programming

3-46 This section describes programming the output voltage or output current from zero to full output using either 0-5 Vdc voltages or 0-4 kΩ resistances. Remote programming requires changing settings of the MODE switch and connecting voltages or resistors to screw terminals VP, IP and ∇P on the rear-panel barrier strip.

3-47 The stabilty of the external voltages or resistances directly affects the stability of the output. Low noise, 1/2 watt resistors with a temperature coefficient of 25 ppm/°C are suitable. If external switches are used to interchange resistors for different fixed outputs, use make-before-break contacts to avoid output transients during program switching.

3-48 A 1.0 Vdc change in the remote programming voltage produces a 4 Vdc change in output voltage or a 6 Adc change in output current. During remote resistance programming, internal CV and CC current sources apply 1.25 mA current through the remote programming resistors to create programming voltages for the unit. The 1.25 mA current allow a 1 kΩ change in remote programming resistance to produce a 5 Vdc change in output voltage or a 7.5 Adc change in output current.

CAUTION

The unit includes clamp circuits to prevent it from supplying more than about 120% of rated output voltage or current when the remote programming voltage is greater than 5 Vdc or remote programming resistance is greater than 4 kΩ. Do not intentionally operate the unit above 100% rated output. Limit your programming voltage to 5 Vdc and programming resistance to 4 kΩ to assure reliable operation.

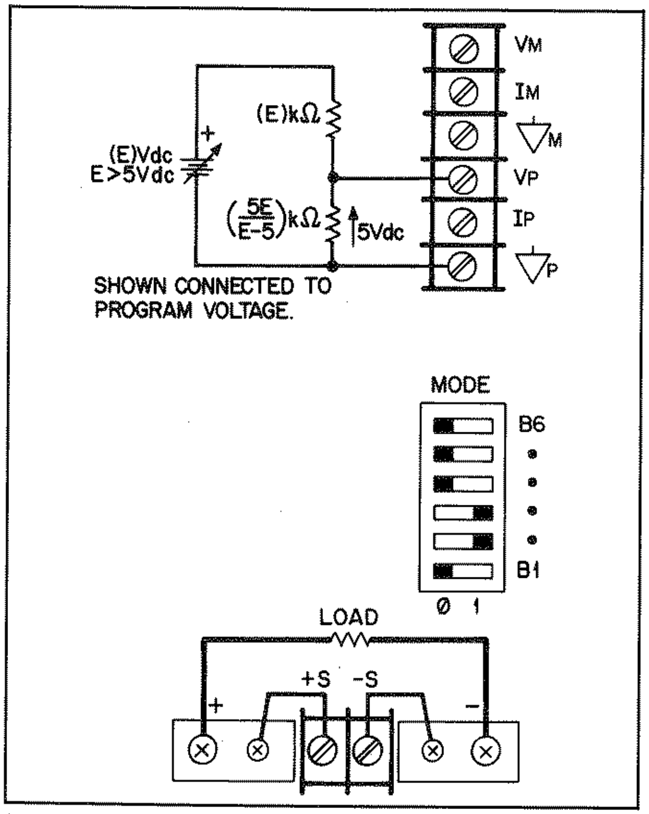


Figure 3-5. Optional Voltage Divider for Program Source

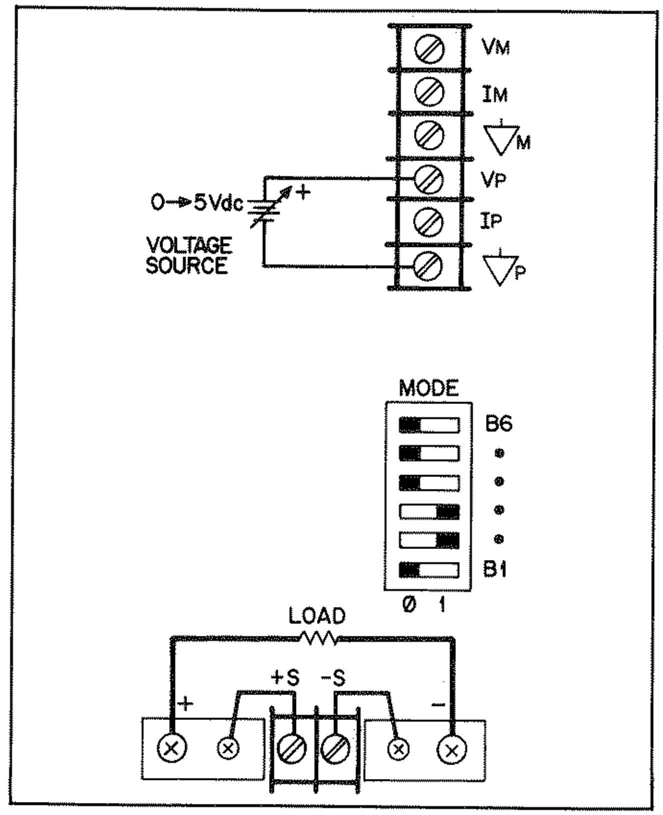


Figure 3-6. Voltage Programming of Output Voltage

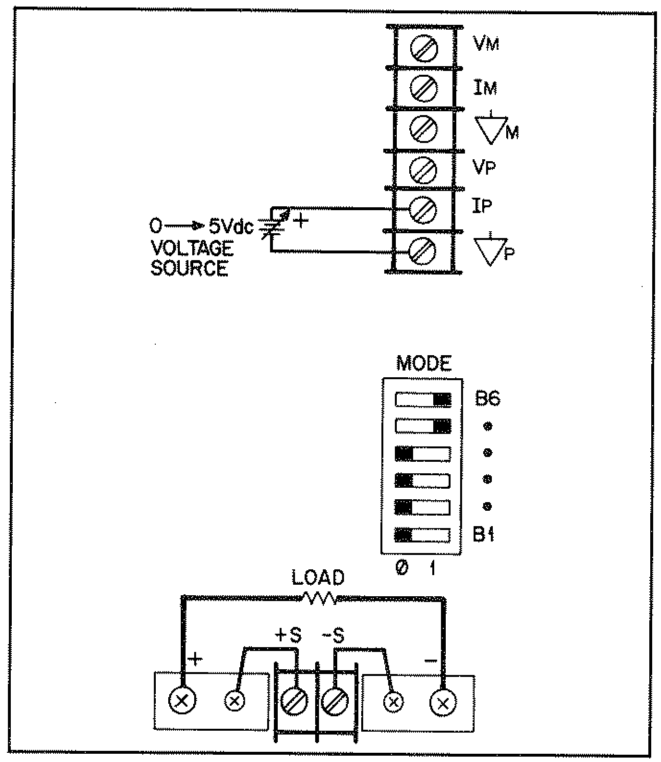


Figure 3-7. Voltage Programming of Output Current

NOTE

When external resistors are used to limit the the remote-programming voltage to 5 Vdc, the resulting high programming-source resistance can degrade the unit's programming speed, offset and drift performance. Limit the equivalent source resistance to 10 kΩ maximum. Figure 3-5 shows a convenient way of calculating suitable voltage-divider resistance values for a 5 kΩ source resistance.

3-49 Any noise picked up on the programming leads will appear on the unit's output and may degrade regulation. To reduce noise pickup, use a shielded pair of wires for programming with the shield grounded at one end only. Do not use the shield as a conductor.

3-50 CV Output, Remote Voltage Control

3-51 Figure 3-6 shows the rear-panel MODE switch settings and terminal connections for remote-voltage control of output voltage. A dc voltage source 0 Vdc to 5 Vdc produces a four-times output voltage, 0 Vdc to 20 Vdc. The load on the programming voltage source is less than 5μA.

3-52 CC output, Remote Voltage Control

3-53 Figure 3-7 shows the rear-panel MODE switch settings and terminal connections for remote-voltage control of output current. A dc voltage source 0 Vdc to 5 Vdc produces a six-times output current, 0 Adc to 30 Adc. The load on the programming voltage source is less than 5μA.

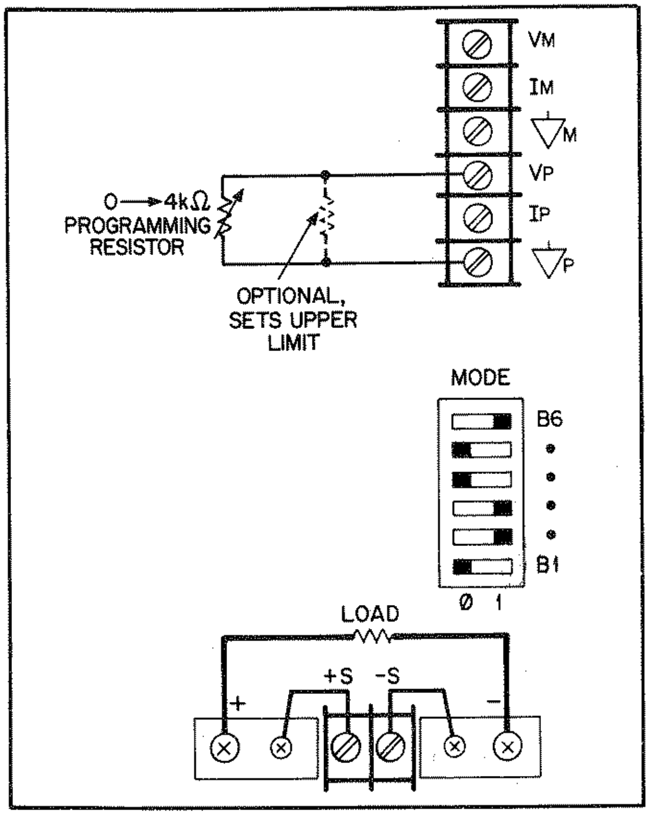


Figure 3-8. Resistance Programming of Output Voltage

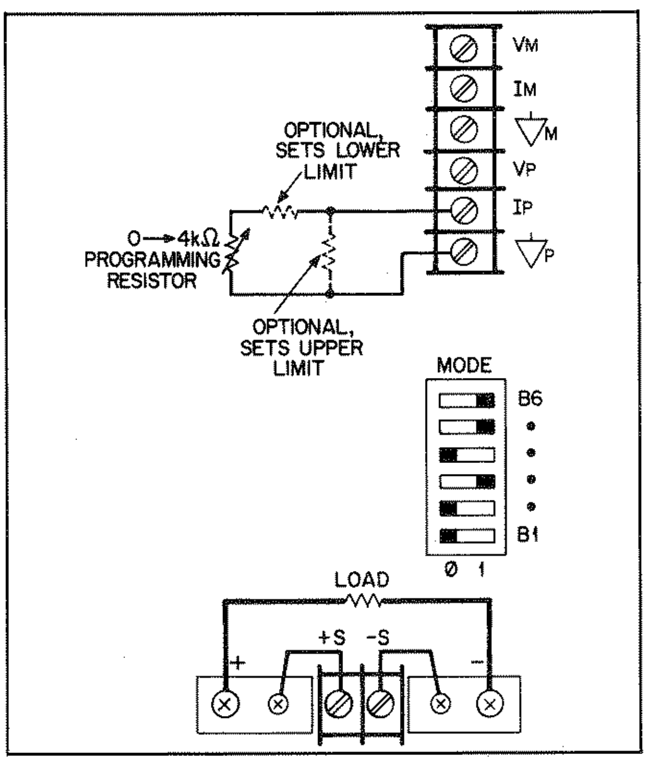


Figure 3-9. Resistance Programming Of Output Current

3-54 CV Output, Remote Resistance Control

3-55 Figure 3-8 shows the rear-panel MODE switch settings and terminal connections for remote-resistance control of output voltage. A resistance from 0 kΩ to 4 kΩ produces a five-times output voltage, 0 Vdc to 20 Vdc. The current applied to the programming resistor is 1.25 mA.

3-56 CC Output, Remote Resistance Control

3-57 Figure 3-9 shows the rear-panel MODE switch settings and terminal connections for remote-resistance control of output current. A resistance from 0 kΩ to 4 kΩ produces a 7½ times output current, 0 Adc to 30 Adc. The current through the programming resistor is 1.25 mA.

CAUTION

If the connection of a programming resistor to a programming terminal opens during resistance programming, the output of the unit goes to about 24 Vdc or 35 Adc depending on whether CV or CC programming is interrupted. OVP shutdown prevents operation at 24 Vdc, and operation with 35 Adc of output current does not damage the unit but it may damage the load. Protect against OVP shutdown when switching CV programming resistors, and protect the load against over current when switching CC programming resistors by connecting a parallel, upper-limit programming resistor directly to the programming terminals as shown in Figures 3-8 and 3-9. (The resistance value programming the output is the parallel combination.)

3-58 MULTIPLE-SUPPLY OPERATION

3-59 This section includes procedures for interconnecting two or more units and then controlling all from one—the master. To connect the unit as a master or slave with other HP autoranging power supplies, use the information here to help develop interconnection diagrams which accomodate the different rear-panel terminal strips on other supplies. Auto-Parallel operation provides increased output current while Auto-Series provides increased output voltage, and Auto-Tracking provides single control of more than one supply.

3-60 Auto-Parallel Operation

3-61 Figure 3-10 shows the rear-panel MODE switch settings and terminal connections for Auto-Parallel operation of two units. The master regulates the output and the slave—operating in CC mode—contributes proportionally to the load current. This configuration provides 0 to 20 Vdc at an output current of up to 60 Adc for two units. You can Auto-Parallel the unit with other HP autoranging power supplies and with any supplies which can be configured to provide 5 Vdc fullscale current-monitoring outputs referenced to −OUT of the supplies.

3-62 Setting Voltage and Current. Set the slave unit's output voltages above the master's to avoid interference with

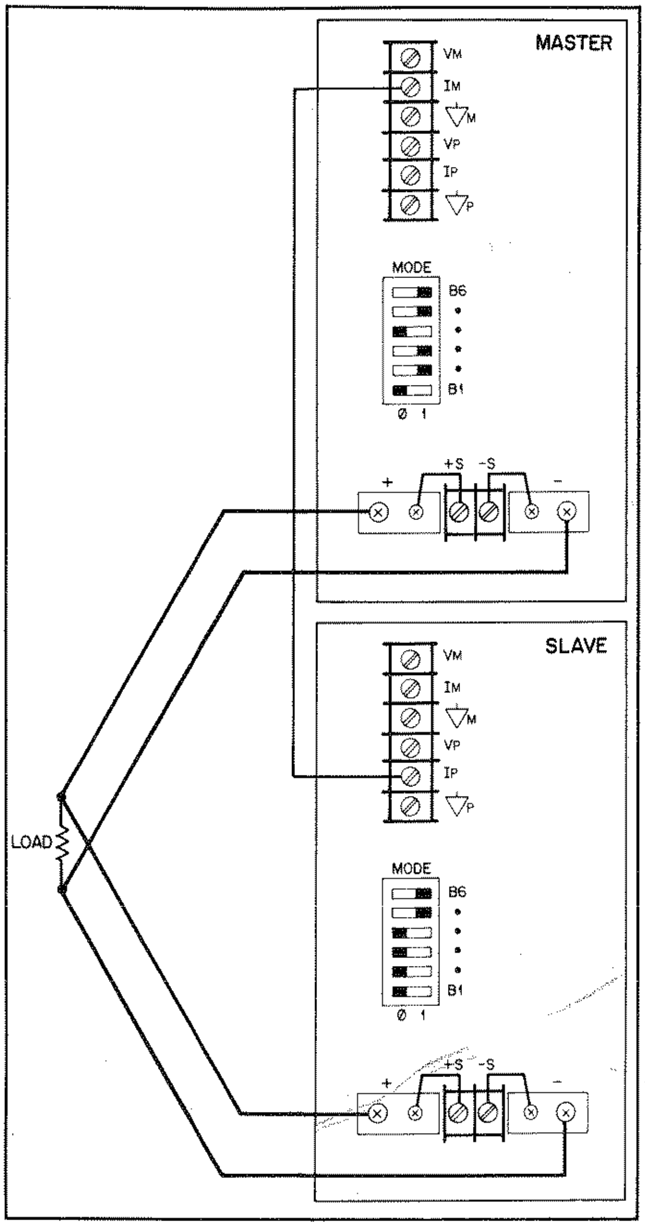


Figure 3-10. Auto-Parallel Operation

master-unit CV control. Adjust the master unit's controls to set the desired output voltage and current. Verify that the slave is in CC operation.

3-63 In CV operation the output voltage is the same as the master unit's voltage setting, and the output current is two times the master unit's current if the master and slave units have the same rated current. In general, for more than two units or for units with different full-rated currents, the Auto-Parallel output current (Io) is

Io= Im[1 + j1 + j2 +...+ jn]

Im= master unit's output current
j1...n= ratio of slave unit's rated current to master unit's
n= number of slave units

NOTE

Proportional currents from Auto-Paralleled units require equal load-lead voltage drops. Connect each unit to the load using separate pairs of wire with length and gauge chosen to provide equal voltage drops from pair to pair. If this is not feasible, connect each unit to a pair of distribution terminals using equal-voltage-drop wire pairs, and then connect the distribution terminals to the load with a single pair of leads.

3-64 Connect only two units in Auto-Parallel. The output current is the sum of both units' full output.

3-65 **Overvoltage Protection.** Adjust the desired OVP shutdown limit using the master unit's OVP ADJUST control. Set the slave units' OVP limits above the master's. When a master-unit shuts down, the master programs the slave units to zero voltage output. If a slave unit shuts down (because its OVP shutdown limit is set lower than the master's), it shuts down only itself, and the other units supply all the load current plus 1 to 4 Adc of current to the shut-down slave. If the required current is great enough, the master will switch from CV to CC operation.

3-66 **Remote Sensing.** To remote sense with Auto-Parallel operation, connect remote-sense leads only to the master unit and according to the remote-sensing instructions under paragraph 3-39.

3-67 **Remote Programming.** To remote program with Auto-Parallel operation, set up only the master unit for remote programming and according to the remote-programming instructions under paragraph 3-44.

NOTE

Down-programming speed is slower with Auto-Parallel operation because only the master unit's Down-Programmer operates.

3-68 Auto-Series Operation

3-69 Figure 3-11 shows the rear-panel MODE switch settings and terminal connections for Auto-Series operation of two units. +OUT of the master unit connects directly to the load. This configuration provides 0 to 30 Adc of output current at an output voltage of up to 40 Vdc for two 6023As. (In general, the output voltage is up to the sum of all units' full output.)

3-70 To provide positive and negative tracking outputs, connect two units in Auto-Series, and provide separate loads as shown in Figure 3-12. Connect to ground at one point, either at the master unit's −S terminal or at a common connection between the loads. The master unit has a positive output and controls a negative output voltage from the slave unit. The positive and negative tracking outputs can include more than one unit. For example, if in a 5-unit Auto-Series chain the +OUT of the second unit from the bottom is grounded, the sum of the bottom-2 units' outputs is the negative output, and

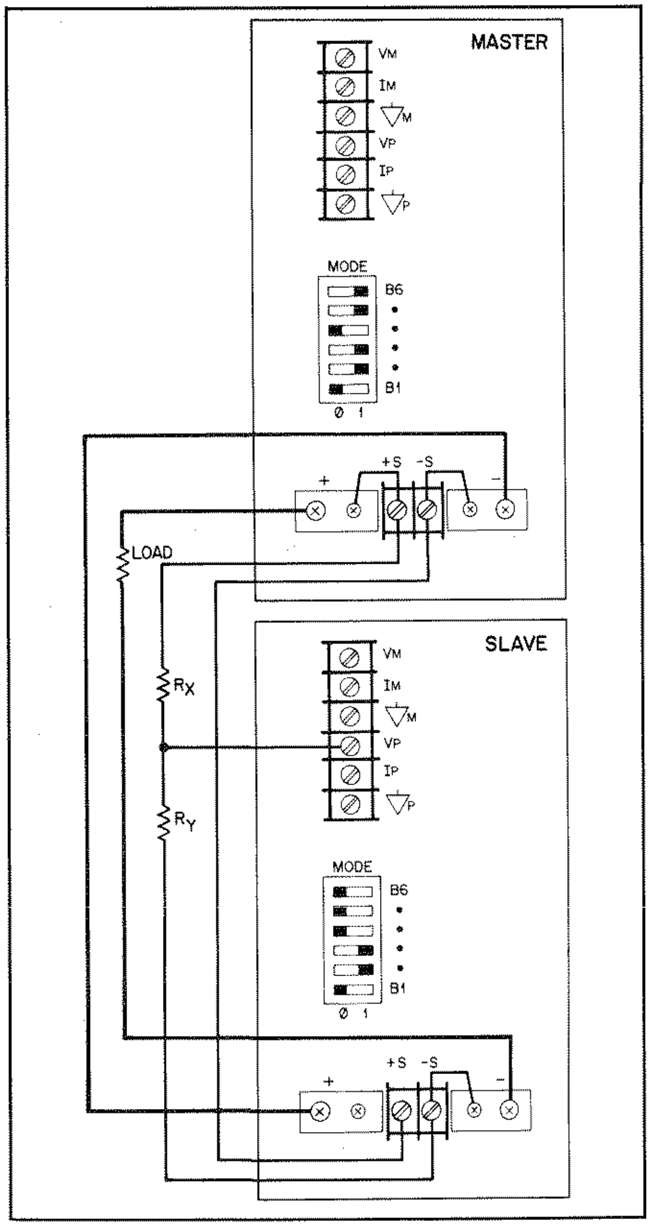


Figure 3-11. Auto-Series Operation

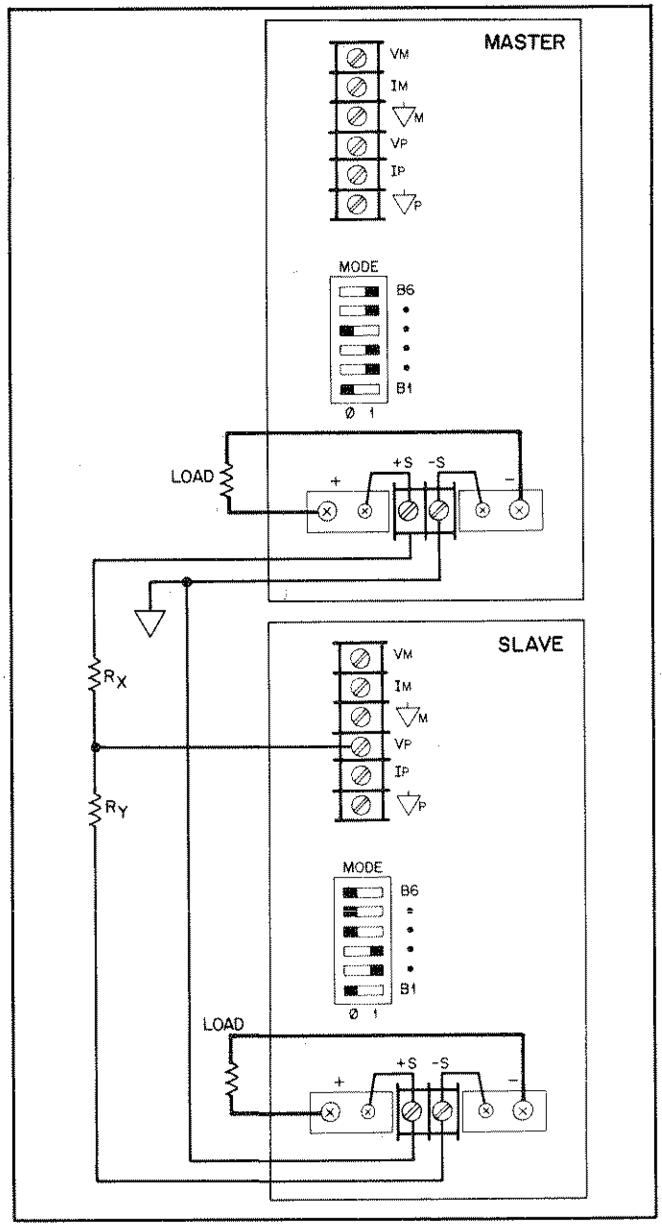


Figure 3-12. Positive and Negative Tracking Output

the sum of the top-3 units' outputs is the positive output. Ground any one output terminal as required to achieve the desired range of positive and negative outputs.

3-71 Connect up to eight units in Auto-Series so long as no output terminal is more than 240 volts from ground. Add each unit to the Auto-Series stack by considering the bottom unit as the master. Duplicate the connections shown in Figure 3-11 and determine values for new resistors Rx and Ry by considering the most negative unit as the master unit for the unit to be added.

3-72 Connect the 6023A in Auto-Series with any slave unit designed for Auto-Series operation, or use any well-regulated supply as the master unit. The supply with the lower current rating sets the maximum current for the Auto-Series combination. Determine values of resistors Rx and Ry for slave unit as required to provide the needed remote programming voltage. The method of paragraph 3-74 assumes a 5 Vdc programming voltage produces 20 Vdc output (K = 4).

3-73 Determining Resistors. Resistors Rx and Ry control the fraction (or multiple) of the master unit's voltage setting that is supplied from the slave unit. For two units in Auto-Series the ratio of Rx to Ry is

$$Rx/Ry = K(Vo/Vs) - 1$$
$$= K(Vm/Vs) + (k-1)$$

Where Vo = Auto-Series voltage
= Vs + Vm
Vs = slave output voltage
Vm = master output voltage
K = ratio of slave output voltage voltage to slave program voltage

3-74 For the 6023A, K = 4. Using the 6023 as a slave unit and putting Ry = 10 kΩ (¼ watt), then from the above equations

$$Rx = (Vo/Vs) - 10\ k\Omega \text{ at 1 Watt}$$

or

$$Rx = 40\ (Vm/Vs) + 30\ k\Omega \text{ at 1 Watt.}$$

3-75 To maintain the temperature coefficient and stability performance of the units, choose low noise resistors with temperature coefficients of less than 25 ppm°C. When Ry is 10 kΩ, appropriate power ratings are ¼ watt for Ry and 1 watt for Rx. In general, set Ry to 10 kΩ or less and use power ratings 30 times actual to avoid degrading program speed, offset and drift performance. Lower resistance values allow faster programming but dissipate more power.

3-76 Setting Voltage and Current. Use the master unit's controls to set the desired output voltage and current. The VOLTAGE control of the slave unit is disabled. Set the CURRENT control of slave unit above the master unit's current setting to avoid having the slave switch to CC operation.

NOTE

To disable the slave unit's CURRENT control and set its current limit to about 35 Adc, change the slave unit's B2 MODE switch setting from mode 1 to mode 0.

3-77 When in CC operation the output current is the same as the master unit's current setting, and when in CV operation the output voltage is the sum of the master unit's and the slave unit's output voltages. Read the output voltage by adding the voltages displayed on the master and slave units. For two 6023As the Auto-Series output voltage (Vo) is equal to (Vm)(Rx + Ry)/(Rx − 3Ry). If Rx is 70 kΩ and Ry is 10 kΩ then Vm and Vs are equal and the output voltage is 2 Vm.

3-78 Overvoltage Protection. Set the OVP shutdown voltage in each unit so that it shuts down at a voltage higher than its output voltage during Auto-Series operation. When a master unit shuts down, it programs the slave(s) to zero output. When a slave shuts down, it only shuts down itself (and any slaves below it in the stack). The master (and all slaves above the shut-down slave) continues to supply output voltage.

3-79 Remote Sensing. To remote sense with Auto-Series operation, remove the +S jumper from the master unit and the −S jumper from the slave unit (or most-negative slave if more than one). Connect the +S terminal of the master and the −S terminal of the slave to the load according to the remote-sensing instructions under paragraph 3-39.

3-81 Auto-Tracking Operation

3-82 Figure 3-13 shows the rear-panel MODE switch settings and terminal connections for Auto-Tracking operation of two units using V-MON and I-MON monitor signals (0-5 Vdc) from the master unit to remote-voltage program the output voltage and current of the slave unit. The 10.2 kΩ source

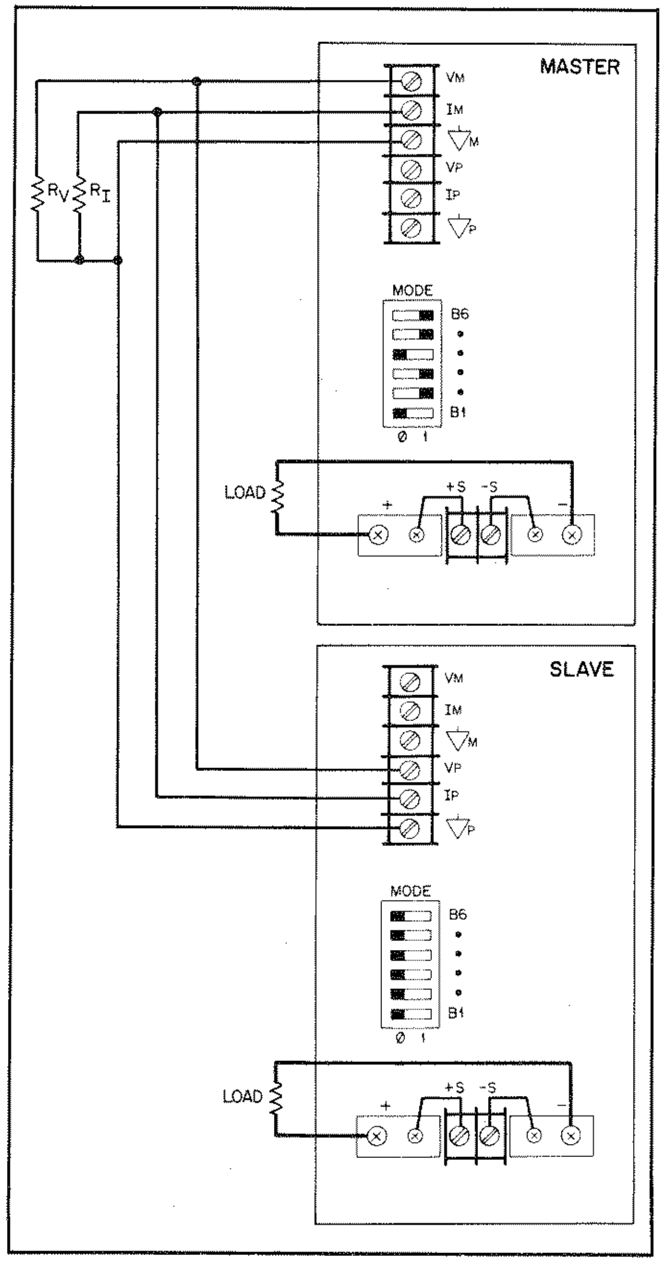


Figure 3-13. V-MON/I-MON Auto-Tracking Operation

resistances of V-MON and I-MON from voltage dividers with the Rv and Ri resistors which set the programming voltages for the slave-unit's programming. Slave unit's fractional output cannot be greater than the master's. The program voltages thus developed can remote program output voltage and current for any number of units, but since all slave units share the same programming voltages, they all are driven to the same fractional output (assuming all slave units require 5 Vdc program for full output).

3-83 Determining Resistors. The Rv and Ri resistors control the fraction of the master unit's output voltage and current to which the slave unit is programmed. Calculate values form the equations below. Eliminate the resistors for one-to-one tracking with the master.

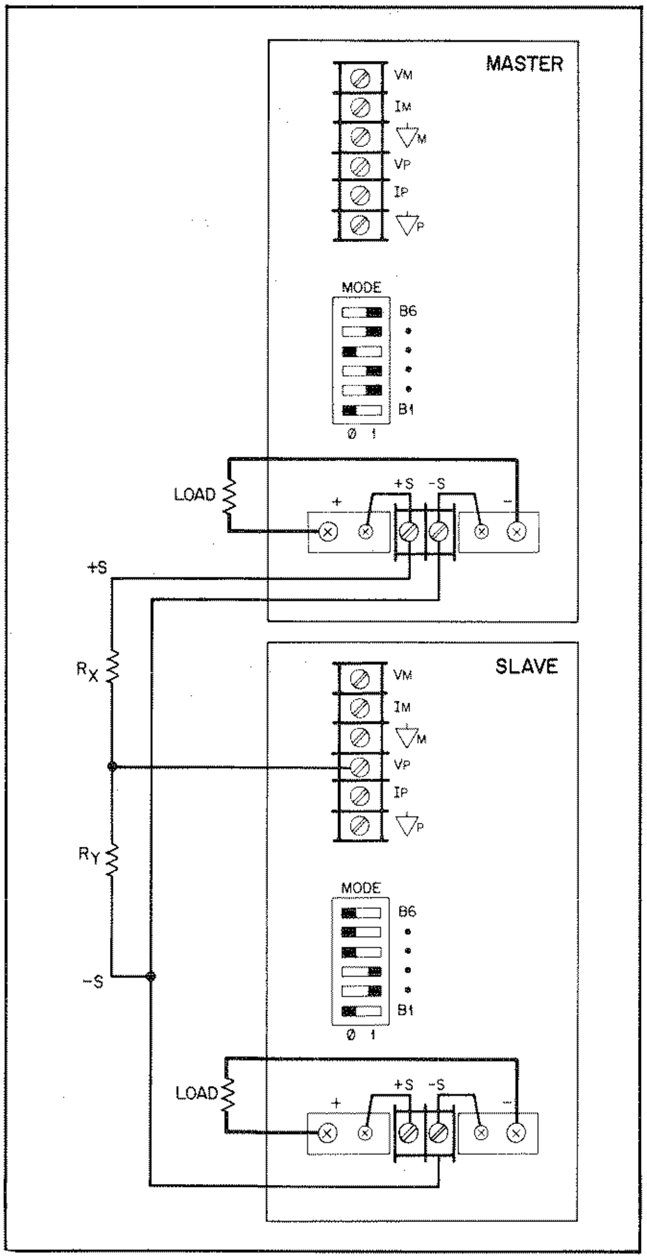


Figure 3-14. Conventional Auto-Tracking Operation

Rv = 10.2 Vs/(Vm-Vs) kΩ, ¼ watt
Ri = 10.2 Is/(Im-Is) kΩ, ¼ watt

Where Vs = slave output voltage
Vm = master output voltage
Is = slave output current
Im = master output current

3-84 Accurate setting of low slave outputs requires using variable resistors as the V-MON and I-MON 10.2 kΩ source resistances have ±5% tolerance. This tolerance produces no error in one-to-one tracking. To maintain the temperature coefficient and stability performance of the slave unit, use low-noise resistors with a temperature coefficient of 25 ppm/ °C and power rating of ¼ W or more.

3-85 Figure 3-14 shows the rear-panel MODE switch settings and terminal connections for conventional Auto-Tracking operation of two units. Although requiring more complex setup, conventional Auto-Tracking can program the output of each slave to a different voltage and can control positive and negative output voltages. In this mode the slave unit is remote voltage programmed by voltage from a voltage divider across the output of the master. The master units output voltage controls the slave unit's output voltage. The units' share a common output connection, either +S or -S. Since each unit powers its own load, the slave unit's load (or CURRENT control if in CC operation) determines its output current.

3-86 To provide positive and negative tracking no error in one-to-one tracking. To maintain the temperature coefficient and stability performance of the slave unit, use low-noise resistors with a temperature coefficient of 25 ppm/ ± °C and power rating of ¼ W or more.

3-87 To connect any number of units in conventional Auto-Tracking, first extend the master +S and −S terminals to become a control bus to which each slave unit's voltage-divider resistors Rx and Ry are to be connected. Then, duplicate the connections shown in Figure 3-13 and determine values for new resistors Rx and Ry ignoring the other slave units. Make voltage programming connections only to the control bus, and make load connections with separate load-lead pairs to the output-terminal pairs. If both positive-output and negative-output slaves are controlled, the −S side of the control bus becomes the system ground.

3-88 Determining Resistors. Resistors Rx and Ry control the fraction (or multiple) of the master unit's voltage that is supplied from the slave unit. the ratio of Rx to Ry is

Rx/Ry = KVm/Vs-1

Vm = master output voltage
Vs = slave output voltage
K = ratio of slave output voltage to slave program voltage

3-89 Set the value of Ry to 10 k Ωand calculate the value of Rx from the equation above. For the 6023A the constant K equals 4, so when using the 6023A as the slave unit and with Ry set to 10 k Ω, the equation reduce to

Rx = 40Vm/Vs-1 k Ω, ½ watt
Ry = 10 k Ω, ¼ watt

3-90 To maintain the temperature coefficient and stability performance of the units, choose low noise resistors with temperature coefficients of less than 25 ppm/ °C. When Ry is set to 10 k Ω, appropriate power ratings are ¼ W for Ry and ½ W for Rx. In general, set Ry to 10 k Ω or less and use power ratings 30-times actual to not significantly degrade programming speed, offset and drift performance. Lower resistance values allow faster programming but dissipate more power.

3-91 Setting Voltage and Current. Use the master unit's VOLTAGE control to set the output voltage from both units.

When the master is in CV operation, the master's output voltage (Vm) is the same as its voltage setting, and the slave's output voltage is 4VmRy/(Rx + Ry). The VOLTAGE control of the slave unit is disabled. Set the CURRENT controls of master and slave units above required load currents to assure CV operation of master and slave units.

3-92 Overvoltage Protection. Set the OVP shutdown voltage in each unit so that it shuts down at a voltage higher than its output voltage during Auto-Tracking operation. When the master unit shuts down, it programs the slave(s) to zero output. When a slave shuts down, it only shuts down itself.

3-93 Remote Sensing. To include remote sensing with Auto-Tracking operation independently set up each unit for remote sensing according to the remote-sensing instructions under paragraph 3-39.

3-94 Remote Programming. To simulataneously remote program both units' output voltages, set up only the master unit for remote voltage programming and according to the remote-programming instructions under paragraph 3-44. To vary the fraction of the output voltage contribute by the slave unit, connect a variable resistor in place of Ry. To independently remote program each unit's output current setting, set up each unit for remote control of output current according to the instructions under paragraph 3-51.

3-95 OUTPUT MONITORS: V-MON & I-MON

3-96 The unit provides, at rear-panel terminals two dc output signals which monitor the output voltage and current. Both are referenced to the unit's output common. V-MON varies from 0 to 5 Vdc as the voltage between +S and −S varies from 0 to 20 Vdc. V-MON is connected + to voltage-monitor terminal VM and to − monitor-common terminal M. I-MON varies from 0 to 5 Adc as the current into −OUT varies from 0 to 30 Adc. I-MON is connected to + to current-monitor terminal IM and − to monitor-common M.

3-97 To monitor output voltage or current with a remote voltmeter, simply connect a dc voltmeter to V-MON and multiply the voltage reading by 4 to obtain the output voltage, or connect a dc voltmeter to I-MON and multiply the reading by 6 to obtain the output current. Use at least a 20,000 Ω per voltmeter or a 1 megohm impedance electronic meter to avoid significant error caused by the monitor signals' 10.2 kΩ output impedances.

Section IV
PRINCIPLES OF OPERATION

4-1 AUTORANGING POWER

4-2 Autoranging allows the unit to be compact and light weight and yet to deliver a range of output voltage-current combinations which otherwise would require the use of more than one supply or a higher rated-power supply. Autoranging is a name for circuitry which automatically makes full power available at all but low rated output voltages and currents. By comparison, a conventional constant-voltage/constant-current (CV/CC) power supply can provide full output power only at maximum rated output voltage and current. For example the power available from a 200 watt, 20V,10A CV/CC supply adjusted to deliver 10V is only 100 watts. The power available from the 6023A when adjusted to 10V is more than 200 watts. The permitted maximum voltage and current of the unit change as current and voltage are adjusted by the user. Thus the unit can be a 20V,10A supply; a 10V,20A supply; a 6.7V,30A supply, or any other supply in the range shown graphically in Figure 4-1.

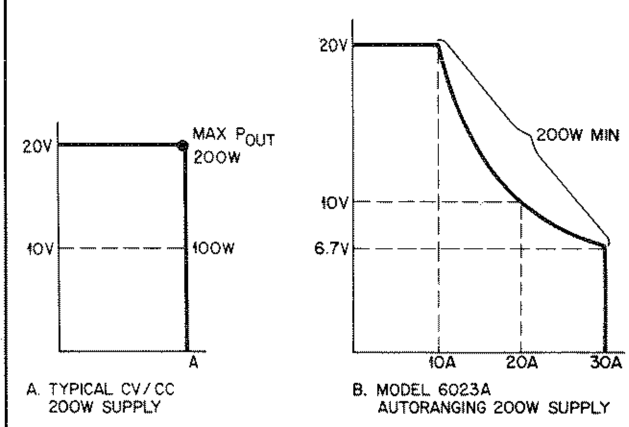


Figure 4-1. Output Characteristics: Typical CV/CC and Autoranging Power Supplies.

4-3 BLOCK DIAGRAM OVERVIEW

4-4 This section is an overview. Using the block diagram, Figure 4-2, it explains how the unit works, how major circuits are interconnected and what signals are called. The next section, beginning at paragraph 4-12, explains more thoroughly how major circuits operate and uses the simplified schematic, Figure 4-3.

4-5 Power flows from the ac mains at the left of the block diagram through circuit blocks connected by heavy lines to the load on the output terminals at the right. The Down Programmer lowers the output voltage when required by the CV Circuit. Overvoltage Protection senses the output and shuts down the unit by inhibiting the Pulse Width Modulator (PWM) through the MASTER ENABLE input when an overvoltage is detected. Other protection circuits (not shown) also can inhibit the PWM through the Inhibit Gate.

4-6 Control signals flow from right to left with separate circuits for constant-voltage, constant-current and power-limit control. These three control circuits jointly provide the Autoranging characteristic of Figure 4-1B. AC Turn-on Circuits limit inrush current to the input filter and assure transient-free turn-on. Internal Bias Supplies provide five bias and two reference voltages to the unit's circuits and provide input signals to the AC Turn-On Circuits.

4-7 The unit is a flyback switching power supply. The power transformer stores energy in its magnetic field while current flows in its primary, and energy transfers to the secondary when current flow in the primary turns off. A pair of PFET switches in series with the primary turns on and off at a 20 kHz rate controlling the current flow; and the PWM varies the on-time of the PFET switches to regulate the output voltage or current.

4-8 In CV or CC operation the PWM turns the PFET switches on at each clock pulse and turns them off when the Ip-RAMP VOLTAGE exceeds the CP control-port voltage. The Ip-RAMP VOLTAGE is derived from a sensing transformer in series with the power transformer primary and is proportional to the primary current. The CP control-port voltage is determined by the CV Control Circuit when the 6023A is in constant-voltage operation and is determined by the CC Control Circuit when in constant-current operation.

4-9 Follow the block diagram from right to left to see how the output voltage is regulated during CV mode of operation. The output voltage is monitored both at the output sense terminals +S and −S (OVS outerloop voltage) and also before the two stages of output filter (IVS innerloop voltage). Sensing with output sense terminals provides accurate load-voltage control, and sensing before the output filter stabilizes the supply and permits it to power highly reactive loads. The CV Monitor Amplifier buffers the OVS outerloop voltage to produce the V-MON output monitoring voltage. A buffer amplifier (not shown) monitors the voltage before the output filter to produce the IVS innerloop voltage. CV Error and Innerloop Amplifiers compare V-MON and IVS with the CV PROGRAM Voltage—which is set by the front-panel VOLTAGE control or by remote programming—to develop the CV CONTROL Voltage. When the CV CONTROL Voltage is lower than the CC CONTROL Voltage, CV determines CP and regulates the output voltage by controlling the turn-off of the PWM.

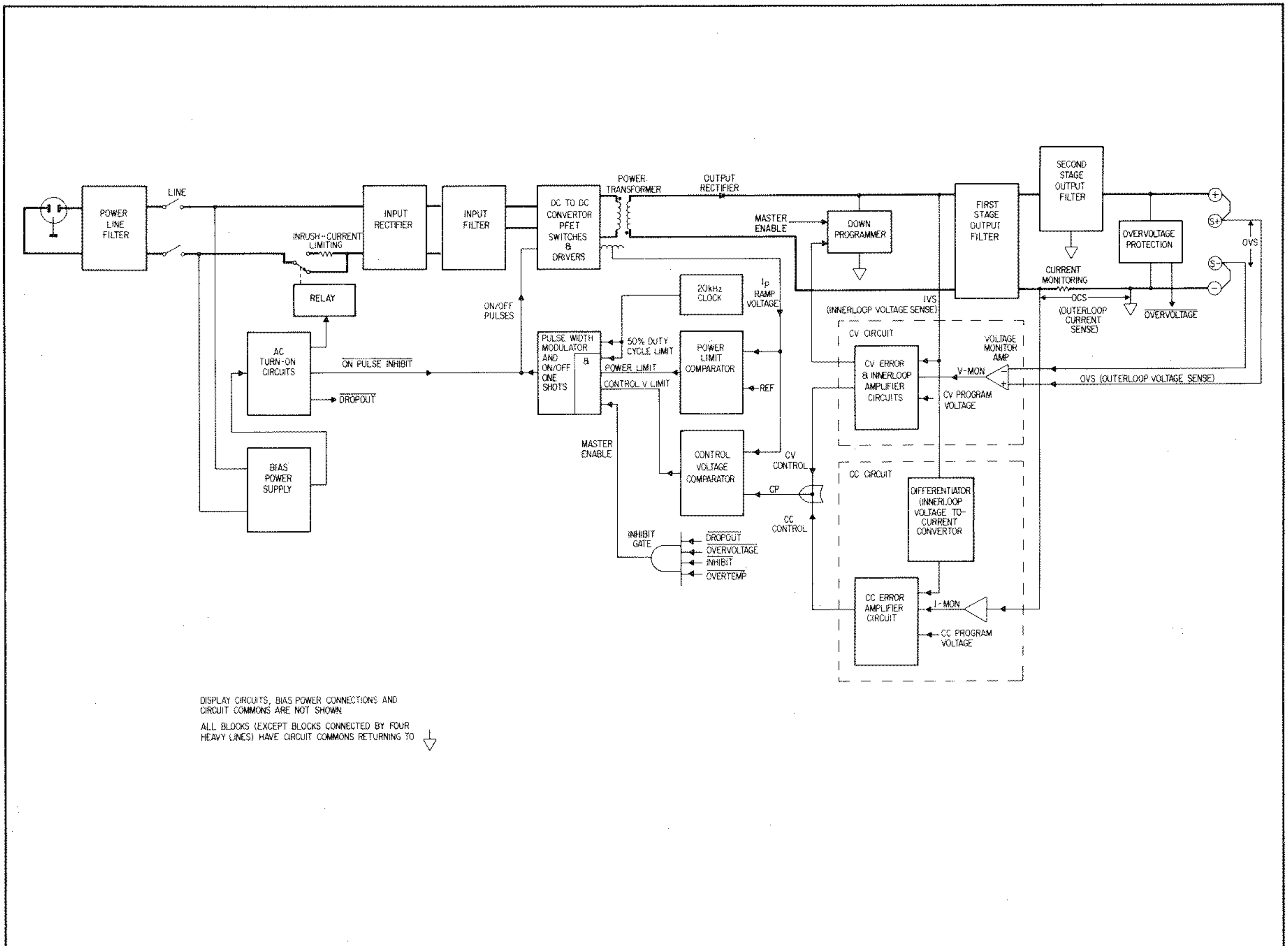


Figure 4-2. 6023A Block Diagram

4-10 While the PWM turns off when any of the four inputs shown go low, in CV and CC operation it is controlled by the CONTROL V LIMIT input from the Control Voltage Comparator. When the Ip-RAMP VOLTAGE exceeds CP, CONTROL V LIMIT goes low and the PWM turns off the PFET switches. The next clock pulse causes the PWM to turn on the PFET switches, and thus the cycle repeats at a 20 kHz rate. Power is transferred through the transformer as required to produce the output voltage determined by the CV PROGRAM Voltage.

4-11 When in CC operation, the output current is regulated in a similar manner. Output current is sensed as the OCS outerloop voltage across a Current Monitoring resistor. OCS is buffered to produce I-MON. IVS is differentiated to produce an innerloop current-sensing voltage; and CC Error amplifier compares these to the CC PROGRAM Voltage from the front-panel CURRENT control or remote programming to develop the CC CONTROL Voltage.

4-12 SIMPLIFIED SCHEMATIC

4-13 The simplified schematic, Figure 4-3, shows the basic operating circuits of the unit. Detailed descriptions follow for major circuits and components in clockwise order. The circuit names and layout of the simplified schematic are the same as used on the complete schematic in Section VII. The heavy lines are the path of power flow through the unit. Please see Figure 4-5 for the display circuits.

4-15 Primary power comes to the Input Rectifier through a resistor which limits turn-on inrush current to the input filter. Jumper A1W1 connects the Input Rectifier and Filter as a voltage doubler for 120 Vac mains. This jumper is not used for 220/240 Vac; thus the Input Filter develops a dc bus voltage of about 300 Vdc for either 120 or 220/240 Vac ac mains voltages. Primary power also comes through Mains-Voltage Select switches to the Bias Power Supplies which provide the internal operating voltages for the unit. The Mains-Voltage Select switches connect the primary windings of the bias-supplies' transformer for operation at 120, 220, or 240 Vac.

4-16 The unit checks that the +5 Vdc bias voltage and the ac mains voltage are within acceptable limits as part of its turn-on sequence. When +5 Vdc comes up, the Bias Voltage Detector resets the Overvoltage-Protection circuit, enables the On-Pulse Driver for the PFET switches, and with the AC-Surge-&-Dropout Detector starts the 1-Second-Delay circuit. After one second, relay A1K1 bypasses the Inrush-Current-Limiting resistor. After 0.1 seconds more, the 1-Second-Delay circuit enables the PWM through the $\overline{\text{DROPOUT}}$ signal. The unit is then ready to deliver power.

4-17 When the AC-Surge & Dropout Detector detects high or low mains voltage, the unit shuts down until an acceptable ac mains voltage returns. Then it repeats the above turn-on sequence. This protects the unit from damage from ac mains surges and brownouts.

4-18 DC-to-DC Converter

4-19 PFET switches A4Q3 and A4Q4 control current flow from the Input Filter through power transformer T1. The PWM triggers on-pulses and off-pulses forthe PFETs. A train of on-pulses comes through diodes A4CR4 and A4CR3 to the PFETs' gates to turn on the PFETs. The PFETs' input capacitances hold the PFETs on between on-pulses. Off-pulses turn on transistors A4Q1 and A4Q2 which then short the PFETs input capacitances and turn off the PFETS.

4-20 The On-Pulse one-shot A2U15B and Off-Pulse one-shot A2U15A generate the on- and off-pulses. A2U15B produces a train of up-to four 160 kHz on-pulses during the PWM output pulse. A2U15A triggers an off pulse at each trailing edge of the PWM pulses. Figure 4-4 shows the timing.

4-21 When the PFETs turn on, current flows through the primary of power transformer A1T1 and primary-current monitor transformer A4T3. The Output Rectifier A4CR7 is reverse biased and blocks current flow in the A1T1 secondary. Consequently, the A1T1 transformer stores energy. When the PFETs apply the dc bus voltage to the primary, the primary current ramps up storing more and more energy. The A4T3 transformer senses the A1T1 primary current, and the secondary of A4T3 develops the Ip-Ramp Voltage across resistor A2R108. This linearily increasing voltage predicts the correction in the supply's output voltage or current which will occur when the PFETs are turned off. Comparators monitoring the Ip-Ramp Voltage signal the PWM to turn off the PFETs when it exceeds either the CP control-port voltage or the Power-Limit reference voltage.

4-22 When the PFETs turn off, the collapsing magnetic field reverses the polarity of the voltages across the A1T1 primary and secondary, and current flows from the A1T1 secondary through Output Rectifier A4CR7 to charge output capacitors A1C8, A1C9 and A1C10. When the PFETs turn off, the leakage inductance of T1 forces current to continue to flow in the primary. Flyback Diodes A4CR13 and A4CR14 protect the PFETs from excess reverse voltage by conducting this current around the PFETs and back to the input filter.

4-23 Down Programmer

4-24 The Down Programmer lowers the output voltage by rapidly discharging the output-filter capacitors. The Down Programmer causes the output voltage to drop more quickly than it would if only the load discharged the capacitors. Its negative-resistance load characteristic discharges the output-filter capacitors at about a 1 ampere rate when the output voltage is high (20 Vdc) and increases to about a 4 ampere rate when the output voltage is low (1 Vdc). Five conditions can trigger down programming: Programming of a lower output voltage, an overvoltage, an overtemperature, a remote disable, or a primary power failure.

4-25 The Down-Programmer's input circuit is the diode-OR connection of the Master enable output from Inhibit Gate A2U19B and the CV Error Voltage from CV Error Amplifier A2U8. The Down Programmer turns on when either the Master Enable is low or when the CV Error Voltage is more negative than about −6 Vdc. The +8.9 Vdc bias supply for the Down Programmer stores enough energy in its input capacitor to

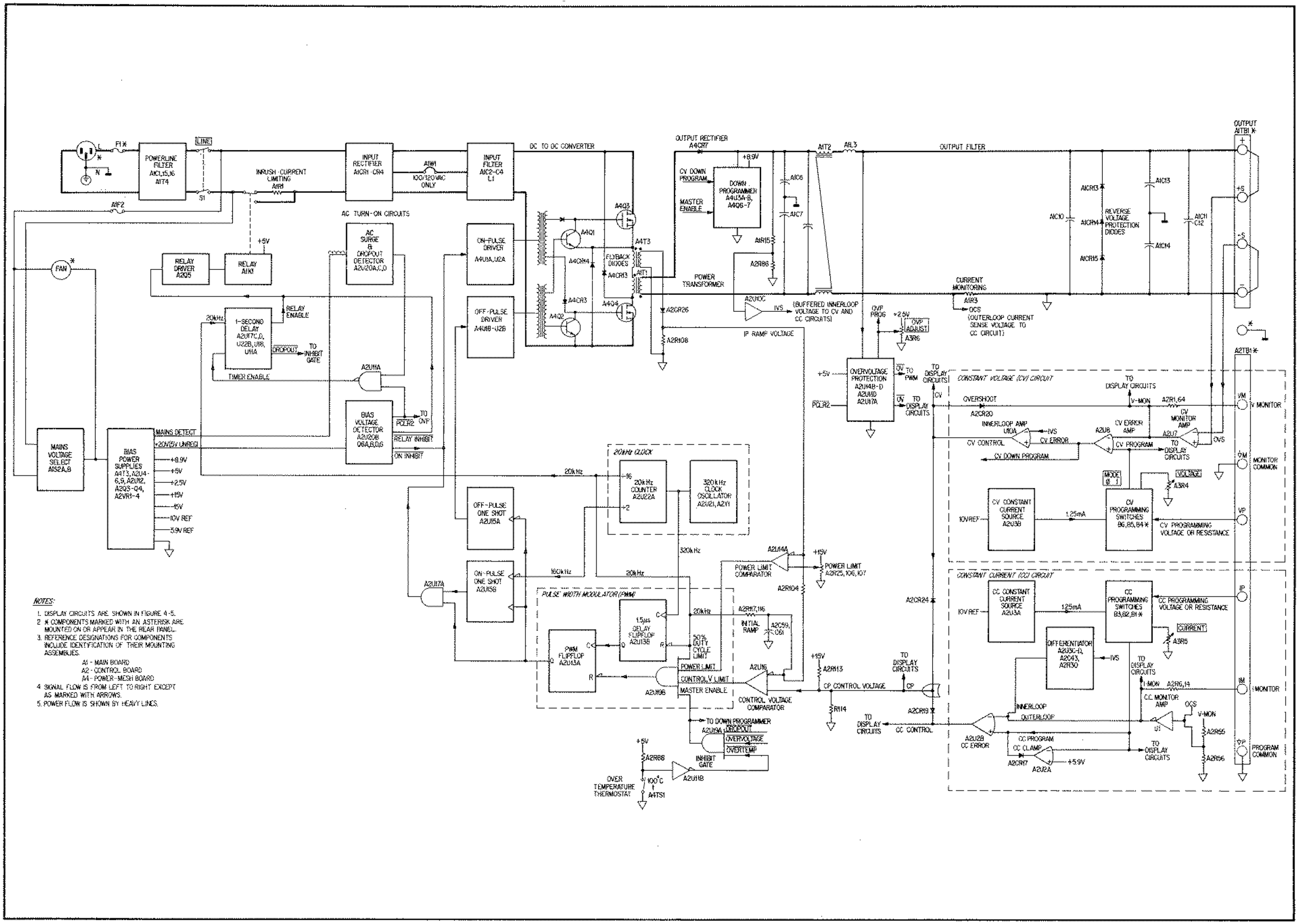


Figure 4-3. 6023A Simplified Schematic

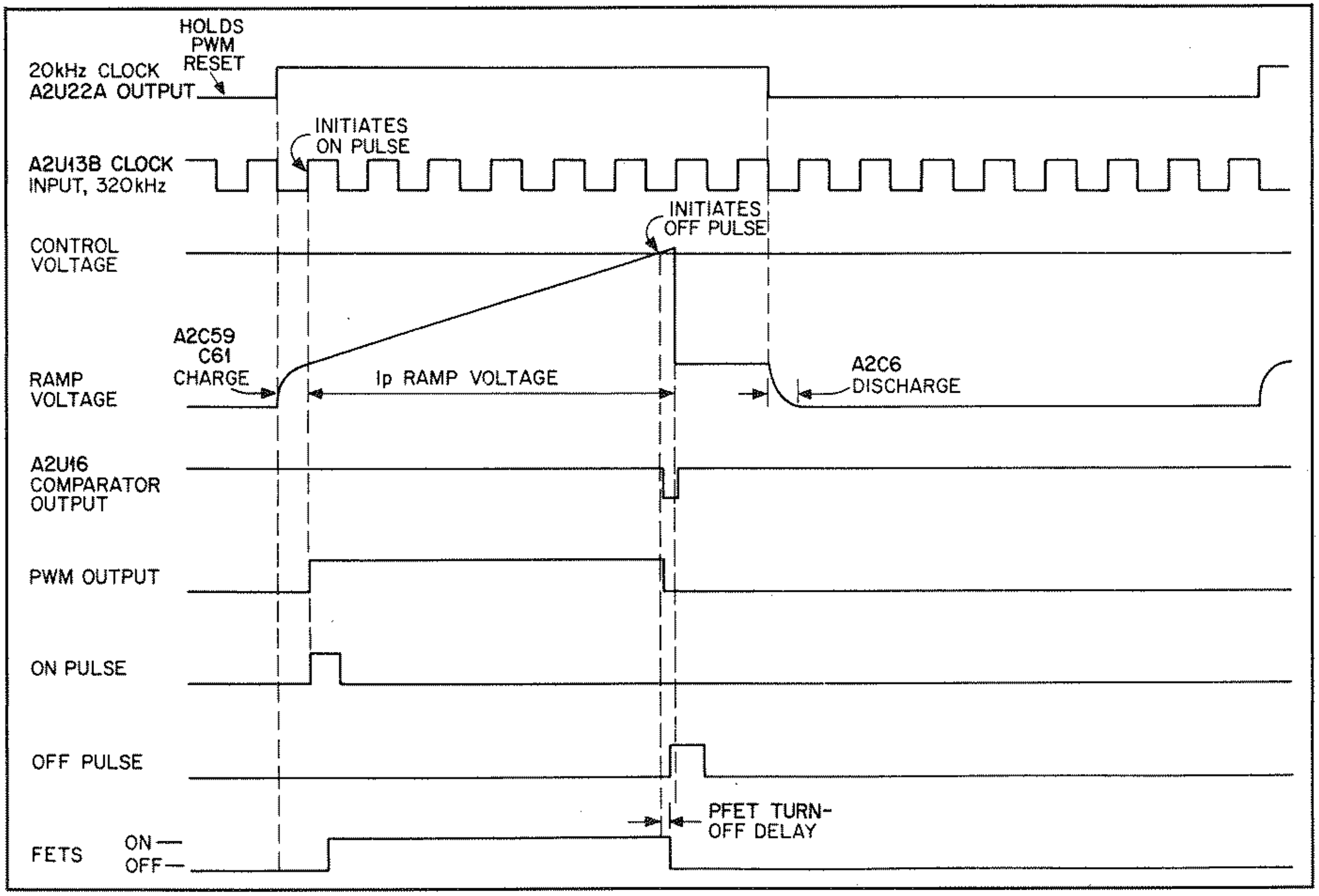


Figure 4-4. PFET Control Signals Timing Diagram

operate the Down Programmer after loss of primary power. This ensures that the Down Programmer will be able to discharge the output circuit when primary power is turned off.

4-26 Constant-Voltage (CV) Circuit

4-27 The Constant-Voltage Circuit compares the output voltage to the user-set CV PROGRAM Voltage to produce the CV CONTROL Voltage. Two comparison amplifier loops accomplish the comparison. In the outerloop, CV Error Amplifier A2U8 compares V-MON, a buffered fraction of the sensed output voltage OVS, to the program voltage from the CV Programming Switches to create the CV ERROR Voltage. Then in the inner-loop, Innerloop Amplifier A2U10A compares this error voltage to IVS, a buffered fraction of the innerloop output voltage to produce the CV CONTROL Voltage. The CV ERROR Voltage is also diode-OR connected through diode A2CR21 as an input to the Down Programmer.

4-28 V-MON also connects through protective circuitry to rear-panel terminal VM for remote monitoring of the output voltage. It is equal to ¼ of the sensed output voltage OVS, and is 5 Vdc for 20 Vdc full output.

4-29 Settings of the CV Programming Switches—the B6, B5 and B4 MODE switch settings—allow the CV PROGRAM Voltage to come from the front-panel VOLTAGE Control; from an external voltage applied between rear-panel terminals VP and ∇P ; or from an external resistor between VP and ∇ P. When using either the VOLTAGE Control or external resistor, current from the CV Constant-Current Source flows through the applicable resistance to develop the CV PROGRAM Voltage.

4-30 In CV mode the CV CONTROL Voltage varies between about −0.5 Vdc and about +1.0 Vdc. It is most negative when the load is drawing no power. As the load draws more power, the voltage becomes more positive. The CV CONTROL Voltage is at the cathode of diode A2CR24, part of the diode-OR input to the Control-Voltage Comparator. Diode A2CR20 prevents voltage overshoots during transient load changes and program changes.

4-31 Constant-Current (CC) Circuit

4-32 The Constant-Current Circuit compares the output current to the user-set CC PROGRAM Voltage to produce the CC CONTROL Voltage. As with the CV Circuit, two comparison amplifier loops accomplish the comparison. OCS is the voltage across Current-Monitoring resistor A1R3, and it senses the output current for the outerloop which is the unit's output current. To compensate for the fraction of the output current which flows through the unit's output-voltage sensing resistors and not through the load, CC Monitor Amplifier A2U1 adds a fraction of V-MON to OCS. It amplifies that sum to produce the outerloop current-sense voltage, I-MON.

4-33 I-MON also connects through protective circuitry to rear-panel terminal IM for remote monitoring of the output current. In volts it is equal to 1/6 of the output current in amperes, and is 5 Vdc for 30 Adc full output.

4-34 Differentiation of IVS develops a current-proportional voltage which senses the innerloop current flowing into the capacitive output filter. CC Error Amplifier A2U2B sums this differentiated innerloop voltage with I-MON and subtracts the sum from the CC PROGRAM Voltage to produce the CC CONTROL Voltage. In CC mode the CC CONTROL Voltage varies from about −0.5 Vdc to +1.0 Vdc at the cathode of diode A2CR19. CC Clamp A2U2A limits the CC PROGRAM Voltage to about 5.6 peak volts.

4-35 Settings of the rear-panel CC Programming Switches—the B3, B2 and B1 MODE switch settings—allow the CC PROGRAM Voltage to come from the front-panel CURRENT Control, from an external voltage applied between terminals IP and /P, or from an external resistor between IP and /P. When using either the CURRENT Control or external resistor, current from the CC Constant-Current Source flows through the applicable resistance to develop the CC PROGRAM Voltage.

4-36 Overvoltage Protection (OVP) Circuit

4-37 The Overvoltage Protection Circuit (OVP) shuts down the unit when a monitored 1/10 fraction of the output voltage exceeds the limit voltage set by the front-panel OVP ADJUST Control. If the output voltage exceeds the preset limit, the OVP inhibits the PWM, triggers the Down Programmer, lights the OV LED and latches itself on until the unit is turned off. The Bias Voltage Detector resets the OVP at turn-on of the unit. Option 002 allows remote reset of OVP.

4-38 Power-Limit Comparator

4-39 Two comparisons with the Ip-RAMP VOLTAGE provide POWER LIMIT and CONTROL V LIMIT, two of the four inputs for the PWM. POWER LIMIT is the output of the Power-Limit Comparator A2U14A. The comparator compares the Ip-RAMP VOLTAGE with the power-limit reference voltage of about 1.0 Vdc. The reference is adjustable with the POWER LIMIT calibration trim pot A2R25. The POWER LIMIT sets the maximum primary current in power transformer A1T1 by going low and turning off the PWM when the Ip-RAMP VOLTAGE exceeds the reference.

4-40 Primary current is proportional to output power, and POWER LIMIT turns off the PWM when the CONTROL V LIMIT would otherwise allow the unit to deliver more than about 200 watts. This occurs during transient load increases, step increases in CV Program Voltage and when the combination of the CV PROGRAM Voltage and the CC PROGRAM Voltage calls for more than 200 watts. The Power-Limit Comparator produces the power-limited portion of the unit's output characteristic curve in Figure 4-1 and is the essence of the unit's Autoranging power.

4-41 Control-Voltage Comparator

4-42 The Control-Voltage Comparator A2U16 produces the CONTROL V LIMIT input to the PWM by comparing the Ip-RAMP VOLTAGE to the CP control-port voltage. In CV or CC operation CP is one diode-drop more than the lower of the CV and CC CONTROL Voltages. CONTROL V LIMIT goes low and turns off the PWM when the Ip-RAMP VOLTAGE exceeds CP. The A2R113-A2R114 voltage divider steers control of CP by its connection at the anodes of series diodes A2CR19 and A2CR24. The A2R113-A2R114 voltage divider sets the maximum CP voltage to +1.5 Vdc and assures that the diode with the lower control voltage will be forward biased when its control voltage is less than +1.5 Vdc. As an illustration of CV-CC selection, suppose the unit is in CV operation and diode A2CR24 is forward biased by a low CV CONTROL Voltage: Then CV sets CP to less than +1.5 Vdc. CV keeps diode A2CR19 reverse biased and prevents CC control until the CC CONTROL Voltage is even lower.

4-43 The lower of the control voltages varies between about −0.5 Vdc and +1.0 Vdc regulating the unit's output. The higher control voltage has no effect on the output and increases in response to the error voltage in its circuit. When higher, the CC CONTROL Voltage limits at about 6 Vdc. When higher, the CV CONTROL Voltage increases only slightly. In CV or CC mode CP remains one diode-drop more than the lower control voltage and varies from about 0.0 to +1.5 Vdc. In UNREGULATED mode CP is +1.5 Vdc and both control voltages are more than about +1.0 Vdc.

4-44 Initial-Ramp Circuit

4-45 The Control Voltage and Ramp Voltage waveforms in Figure 4-4 show that there is a time delay between when the control voltage is exceeded and when the PFETs turn off. This cumulative circuit delay would cause the PFETs to deliver power even when no power is requested by the control circuits. To eliminate the delay, the Initial-Ramp Circuit adds a ramp voltage to the Ip-RAMP VOLTAGE at the input to the Control Voltage Comparator. The added ramp voltage starts with the 20 kHz clock pulse and causes the combined-ramp voltage to exceed the control voltage earlier thereby essentially eliminating the PFET turn-off delay. A two-stage RC integrating network consisting of resistors A2R116 and A2R117 and capacitors A2C59 and A2C61 creates the Initial-Ramp by shaping the 20 kHz clock pulses.

4-46 Pulse-Width Modulator (PWM)

4-47 The PWM generates 20 kHz repetition-rate pulses which vary in length according to the unit's output requirements. The pulses start 1.5 μs after each 20 kHz clock pulse and turn off when any of these four inputs go low: The output of the Control-Voltage Comparator (CONTROL V LIMIT), the output of the Power-Limit Comparator (POWER LIMIT), the 20 kHz clock pulse (50%-DUTY-CYCLE LIMIT), or the output of the Inhibit Gate A2U19A (MASTER ENABLE). As discussed in paragraph 4-19, the PFETs turn on during and turn off at the trailing edges of PWM output pulses.

4-48 The PWM generates pulses as follows: A 20 kHz clock pulse holds the 1.5 μs-Delay Flipflop A2U13B reset; 1.5 μs after the trailing edge of the 20 kHz pulse, the next pulse from the 320 kHz Clock Oscillator clocks the output of A2U13B high, and this initiates the PWM pulse from PWM Flipflop A2U13A. When one of the above four inputs to AND-gate A2U19B goes low, A2U19B resets A2U13A, and the PWM pulse turns off.

4-49 Bias Voltage Detector

4-50 The Bias Voltage Detector prevents spurious operation which might occur at power-on of the unit if circuits tried to operate before the +5 Vdc bias voltage is at the clock, PWM, and logic circuits. After power-on, as the output of the +5 Vdc bias supply rises from 0 Vdc through about 1 Vdc, three transistor switches in the Bias Voltage Detector turn on. They inhibit the Relay Driver and the On-Pulse Driver, and they create the power-clear signal, PCLR2. The transistors inhibit the circuits and hold PCLR2 low until the unregulated input to the +5 Vdc bias supply is greater than about 11 Vdc, an input voltage sufficient to assure +5 Vdc bias output. PCLR2 resets the OVP at turn-on, and Option 002 uses PCLR2 in creating its DROPOUT, OVERVOLTAGE , and POWER-ON RESET outputs.

4-51 AC-Surge-&-Dropout Detector

4-52 The AC-Surge & Dropout Detector protects the unit from damage from ac mains voltage surges and dropouts by shutting down the unit when there is either a 40% overvoltage or a 20 ms voltage interruption in the ac mains voltage. The detector shuts down the unit by inhibiting the PWM through the DROPOUT signal from the 1-Second-Delay Circuit. Mains Detect signal, which is fullwave-rectified ac from the +5 Vdc secondary of the bias-supplies transformer, senses the ac mains voltage.

4-53 The Dropout Detector, including comparators A2U20A and A2U20C, operates by enabling a capacitor-timing ramp when Mains-Detect ceases. Comparator A2U20D monitors the amplitude of Mains-Detect to provide ac surge voltage detection.

4-54 1-Second-Delay Circuit

4-55 The 1-Second-Delay Circuit is the heart of the unit's controlled turn-on. It causes relay A1K1 to bypass inrush-current-limiting resistor A1R1 one second after turn-on, and it enables the PWM 0.1 seconds later. When either the output of the AC-Surge-&-Dropout Detector or PCLR2 is low, NAND gate A2U11A holds the circuit reset. The circuit starts counting at 1/16 the clock frequency (1.25 kHz) when both inputs to A2U11A are high and causes Relay Enable to go high in 1.0 seconds and DROPOUT to go high in 1.1 seconds. When DROPOUT goes high, it stops the count, and it enables the PWM. Option 002 uses DROPOUT in creating its DROPOUT output.

4-56 DISPLAY CIRCUITS

4-57 Figure 4-5 is a simplified schematic for the display circuits. The named signals from the CV and CC Circuits are connected through semiconductor bilateral switches to the VOLTS digital voltage display and to the AMPS digital current display. Either a blank display or a depressing of the DISPLAY OVP switch changes the VOLTS display from low range to high range. A blank display occurs when the Voltage DVM A3U4 receives an over-range voltage, a voltage greater than 0.999 Vdc. The blank display is detected by the Voltage-Range Switching Circuit. The diode-AND connection at inverting amplifier A3U9A senses when two selected segments of the 7-segment LED for the second digit are both not lighted. The detection scheme works because at least one of the selected segments is lighted for all digits 0 though 9.

4-58 The normal display is the actual output voltage and current and has bilateral switches A3U1A and A3U1D closed. Switch A3U1A connects V-MON through buffer amplifier A3U2 and range-switching bilateral switches to the VOLTS DVM. Switch A3U1D connects I-MON through buffer amplifier A3U3A to the AMPS DVM. Depress the DISPLAY LIMITS Switch, and CV and CC PROGRAM Voltages connect through bilateral switches A3U1B and A3U1C to display the programmed output voltage and current. Depress the DISPLAY OVP Switch, and OV PROGRAM Voltage from the OVP ADJUST Control connects through buffer amplifier A3U3B and bilateral switch A3U7B to display the programmed OVP voltage limit.

4-59 The CV and CC CONTROL Voltages also control the front-panel mode LEDs. When CV CONTROL Voltage is more negative than CP, transistor A2Q6C lights CV LED A3DS9 showing that the unit is operating in constant-voltage mode. When CC CONTROL is more negative than CP, transistor A2Q6F lights CC LED A3DS10 showing that the 6023A is operating in constant-current mode. And when both CV and CC are more positive than CP, NAND-gate A2U11C lights UNREGULATED LED A3DS11 showing the unit is operating in power-limited, unregulated mode.

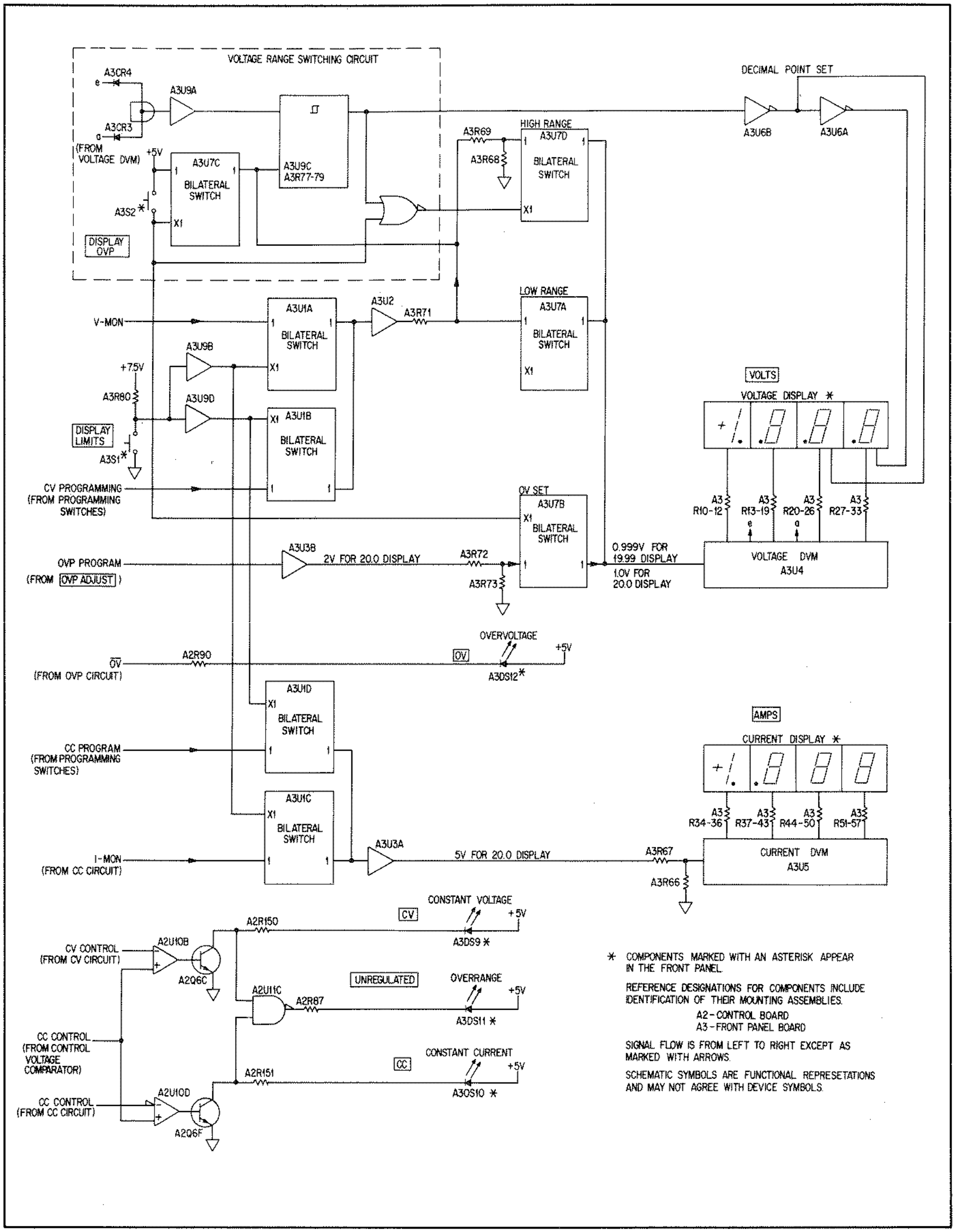


Figure 4-5. 6023A Display Circuits Simplified Schematic

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section provides test and calibration procedures, and troubleshooting and repair information. The operation-verification tests comprise a short procedure to verify that the unit is performing properly, without testing all specified parameters.

5-3 After troubleshooting and repair of a defective power supply you can usually verify proper operation with the functional test procedure in Section III. Repairs to the A1 main board, and the A2 control board can involve circuits which, although functional, may prevent the unit from performing within specified limits. So, after A1 or A2 board repair, decide if recalibration and operation verification tests are needed according to the faults you discover. Use the calibration procedure both to check repairs and for regular maintenance.

5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the equipment required to perform the tests and adjustments of this section. You can separately identify the equipment for performance tests, calibration, and troubleshooting in the USE column of the table.

5-6 OPERATION VERIFICATION TESTS

5-7 The following tests assures, that the unit is performing properly. They do not however check all the specified parameters tested in the complete performance test described below. Proceed as follows:

a. Perform turn-on checkout procedure given in paragraph 3-5.
b. Perform the CV & CC Load Effect performance tests, given in paragraphs 5-17 and 5-26 respectively.

5-8 PERFORMANCE TESTS

5-9 The following paragraphs provide test procedures for verifying the unit's compliance with the specifications of Table 1-1. Please refer to CALIBRATION PROCEDURE or TROUBLESHOOTING if you observe any out-of-specification performance.

5-10 Measurement Techniques

5-11 Setup For All Tests. Measure the output voltage directly at the +S and −S terminals. Connect unit for local sensing, and ensure that MODE switches are set as shown in Figure 3-2. Select an adequate wire gauge for load leads using the procedures given in paragraph 3-27 for connecting the load.

5-12 Electronic Load. The test and calibration procedures use an electronic load to test the unit quickly and accurately. If an electronic load is not available, you may substitute a 2Ω load resistor, capable of safely dissipating 250 watts, for the electronic load in these tests:

CV Source Effect (Line Regulation)
CC Load Effect (Load Regulation)

You may substitute a 0.25Ω, 250 W or more, load resistor in these tests:

CV Load Effect (Load Regulation)
CV PARD (Ripple and Noise)
CC Source Effect (Line Regulation)
CC PARD (Ripple and Noise)

The substitution of the load resistor requires adding a load switch to open and short the load in the CC or CV load regulation tests. The load transient recovery time test procedure cannot be performed using load resistors.

5-13 An electronic load is considerably easier to use than a load resistor. It eliminates the need for connecting resistors or rheostats in parallel to handle the power, it is much more stable than a carbon-pile load, and it makes easy work of switching between load conditions as is required for the load regulation and load transient-response tests.

5-14 Current-Monitoring Resistor Rm. To eliminate output-current measurement error caused by voltage drops in the leads and connections, connect the current-monitoring resistor between −OUT and the load as a four-terminal device. Figure 5-1 shows correct connections. Connect the current-monitoring test leads inside the load-lead connections directly at the monitoring resistor element. Select a resistor with stable characteristics: 0.001Ω, 1% accuracy, 30 ppm/°C or lower temperature coefficient and 20 W power rating (20 times actual power if other than 0.001Ω is used).

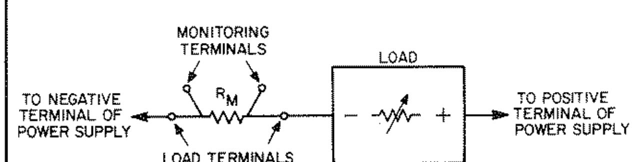


Figure 5-1. Current Monitoring Resistor Connections

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Oscilloscope	Sensitivity: 1 mV Bandwidth: 20 MHz & 100 Mhz Input: differential, 50 Ω & 10 MΩ	P,T	HP1740A
RMS Voltmeter	True rms, 10 MHz bandwidth Sensitivity: 1 mV Accuracy: 5%	P	HP3400A
Logic pulser	4.5 to 5.5Vdc @ 35 mA	T	HP546A
Multimeter	Resolution: 100 nV Accuracy: 0.0035%, 6½ digit	P,A,T	HP3456A
CC PARD Test Current Probe	No saturation at 30 Adc Bandwidth: 20 Hz to 20 MHz	P	Tektronix P6303 Probe/AM503 Amp/ TM500 Power Module
Electronic Load	Voltage range: 30 Vdc Current range: 30 Adc Power range: 250 watts Open and short switches	P,A*	Transistor Devices, Model DLP 130-50-2500
CC PARD Test & Ip Cal. Resistive Load	Value: 0.25 Ω, >250 W Accuracy: 1% Rheostat or Resistor Bank	P,A*	
Current-Monitoring resistors	Value: 30 mV @ 30 A (1 mΩ) Accuracy: 1.0% TC: 30 ppm/°C Value: 30 mV @ 30 A (1 mΩ) Accuracy: .05% ** TC: 30 ppm/°C A,P	P	
Calibration and test resistors	Value: 100 Ω, 5%, 1 W 1 Ω, 5%, ½ W 1 kΩ, 5%, ¼ W 5 kΩ, 5%, ¼ W 2 kΩ, 0.01%, ¼ W	A,T	
Terminating Resistors (4)	Value: 50 Ω ±5%, noninductive	P	
Blocking	Value: 0.01 μF, 100 Vdc Capacitors (2)	P	
Common-mode Toroidal Core		P	Ferrox-Cube 500T600-3C8, HP 9170-0061
Switch	SPST, 30 A @ 20 V	P	
DC Power Supply	Voltage range: 0-60 Vdc Current range: 0-3 Adc	T	HP6296A
Variable Voltage Auto transformer	Range greater than −13% to +6% of nominal input AC Voltage 1 k VA	P,A	

P = performance testing A = calibration adjustments T = troubleshooting.

* For calibration, either the electronic load or the load resistor is required.

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

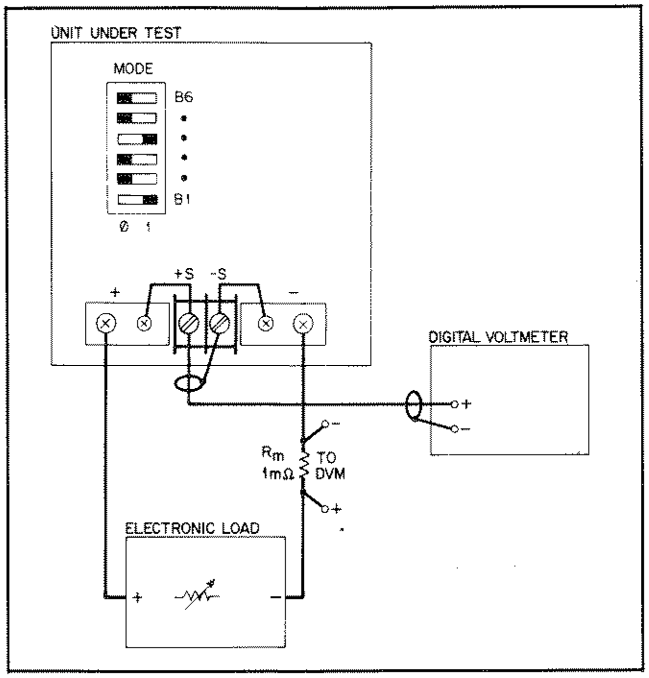


Figure 5-2. Basic Test Setup

5-15 Constant Voltage (CV) Tests

5-16 CV Setup. If more than one meter or a meter and an oscilloscope are used, connect each to the +S and −S terminals by a separate pair of leads to avoid mutual coupling effects. Connect only to +S and −S because the unit regulates the output voltage between +S and −S, not between +OUT and -OUT. Use coaxial cable or shielded 2-wire cable to avoid pickup on test leads. For all CV tests set the output current at full rated output to assure CV operation.

5-17 Load Effect (Load Regulation)

Definition: CV Load Effect is the change in dc output voltage when load resistance changes from open circuit to full load or from full load to open circuit.

Test Parameters: Measured Variable: Output Voltage

Test points: See Figure 5-2

Expected Results: Recorded readings must be within ±0.0027 Vdc

Test Procedure:

a. Connect the test equipment as shown in Figure 5-2. Operate the electronic load in constant resistance mode (Amps/Volt) and set resistance to maximum.
b. Turn the unit's power on, and turn up current setting to full output.
c. Turn up output voltage to 7.0 Vdc as read on the digital voltmeter.
d. Reduce the resistance of the load to draw an output current of 29 Adc (0.029 Vdc across Rm). Check that the unit's CV LED remains lighted.
e. Record the output voltage at the digital voltmeter.
f. Open circuit the load.
g. When the reading settles, record the output voltage again. Check that the two recorded readings differ no more than ±0.0027 Vdc.

5-18 Source Effect (Line Regulation)

Definition: Source effect is the change in dc output voltage when the ac input voltage changes from a minimum to a maximum value.

Test Parameters: Measured variable: Output Voltage

Test Points: See Figure 5-2

Expected Results: Recorded readings must be within a ±0.0030 Vdc range

Test Procedure:

a. Connect the test equipment as shown in Figure 5-2. Operate the electronic load in constant resistance mode (Amps/Volt) and set resistance to maximum.
b. Connect the unit to the ac power line through a variable autotransformer which is set for low line voltage (104 Vac for 120 Vac).
c. Turn the unit's power on, and turn up current setting to full output.
d. Turn up output voltage to 20.0 Vdc as read on the digital voltmeter.
e. Reduce the resistance of the load to draw an output current of 10 Adc (0.010 Vdc across Rm). Check that the unit's CV LED remains lighted.
f. Record the output voltage at the digital voltmeter.
g. Adjust autotransformer to the maximum for your line voltage.
h. When the reading settles record the output voltage again. Check that the two recorded readings differ no more than ±0.0030 Vdc.

5-19 PARD (Ripple & Noise)

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

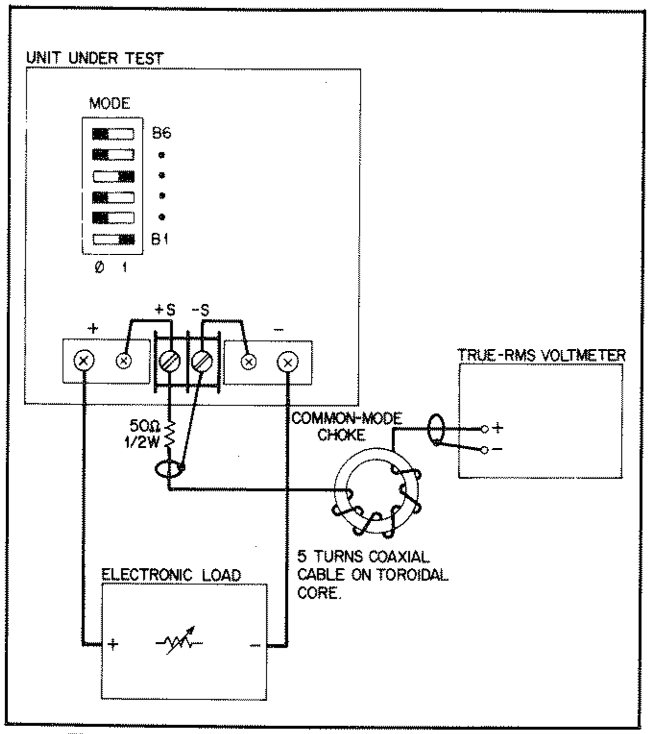


Figure 5-3. RMS Measurement Test Setup, CV PARD

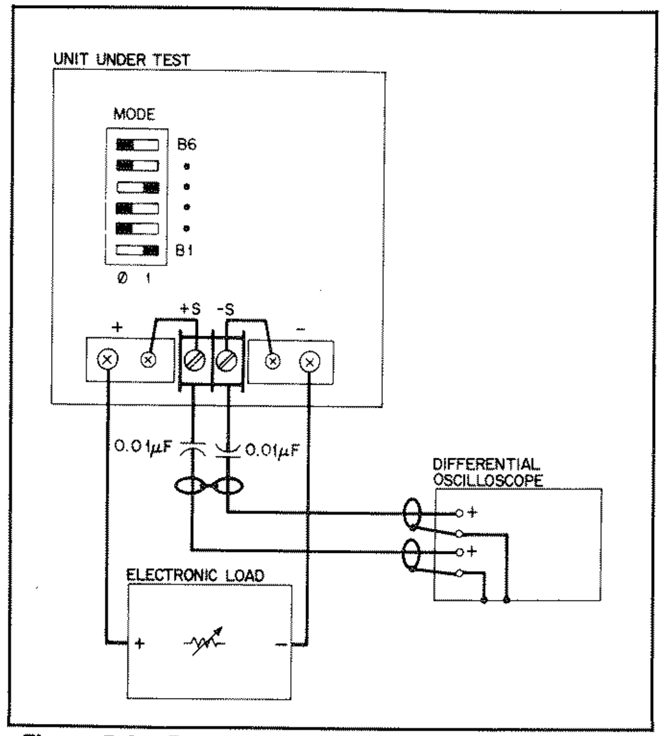


Figure 5-4. Peak-to-Peak Measurement Test Setup, CV PARD Test

PARD RMS Measurement

Test Parameters: Measured Variable: Output Voltage (rms)

Test points: See Figure 5-3

Expected Results: Noise Voltage (rms) < 3.0mV rms

Test Procedure:

a. Connect the test equipment as shown in Figure 5-3. Operate the electronic load in constant resistance mode (Amps/Volt) and set resistance to maximum.
b. Turn the unit's power on and turn up current setting to full output.
c. Turn up output voltage to 7.0 Vdc.
d. Reduce the resistance of the load to draw an output current of 29 Adc. Check that the unit's CV LED remains lighted.
e. Check that the rms noise voltage at the true rms voltmeter is no more than 3.0 mV rms.

NOTE

To ensure that no potential difference exists between the voltmeter and the case of the unit, either connect both to the same ac power outlet or check that the ac outlets have the same earth ground.

Use common mode choke as in Figure 5-3 to reduce ground loop currents from interfering with measurement. Reduce noise pickup on the test leads by using 50Ω coaxial cable, and wind it 5 turns through the magnetic core to form the common-mode choke.

5-20 PARD (Peak-to-Peak) Measurement

Test Parameters: Measured Variable: Output Voltage Peak-to-Peak

Test Points: See Figure 5-4

Expected Results: Peak-to-Peak noise voltage < 30 mV

Test Procedure:

a. Connect the test equipment as shown in Figure 5-4. Operate the electronic load in constant resistance mode (Amps/Volt) and set resistance to maximum.
b. Turn the unit's power on and turn up current setting to full output.
c. Turn up output voltage to 7.0 Vdc.
d. Turn up output current setting to full output and reduce the resistance of the load to draw an output current of 29 Adc. Check that the unit's CV LED remains lighted.
e. Set the oscilloscope's input impedance to 50Ω and bandwidth to 20 MHz. Adjust the

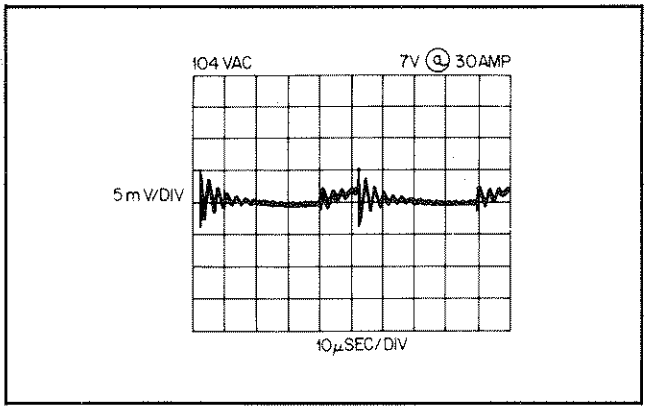


Figure 5-5. . 20 kHz Noise, CV Peak-to-Peak PARD

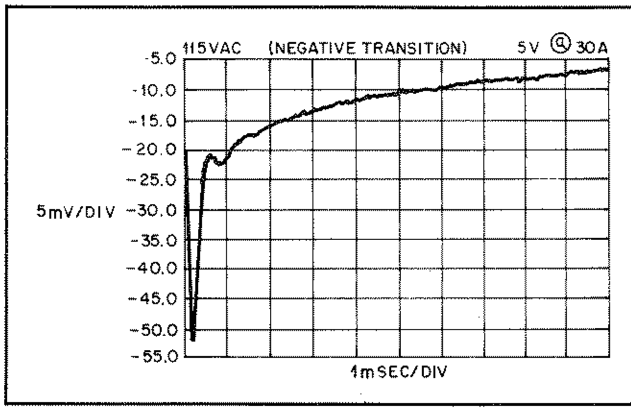


Figure 5-6. Load Transient Recovery Waveform

controls to show the 20 kHz and higher frequency output-noise waveform of Figure 5-5.

f. Check that the peak-to-peak noise is no more than 30 mV.

NOTE

The equipment grounding and power connection remain the same as in the PARD rms test.

Connect the oscilliscope to the +S and −S terminals through 0.01 μF blocking capacitor to protect the oscilliscope's input from the unit's output voltage.

To reduce common-mode noise pick-up, set up the oscilliscope for a differential, two-channel voltage measurement.
To reduce normal mode pick-up, use matched-length, 1 metre or shorter 50 coaxial cable with shields connected to the oscilliscope case and to each other at the other ends.

5-21 Load Transient Recovery Time

Definition: This is the time for the output voltage to return to within a specified band around its voltage following a step change in load.

Test Parameters: Measured Variable: Output Voltage Transients

Test Set-up: See Figure 5-2

Expected Results: Pulse width < 1 ms (at 50 mV from base line)

Test Procedure:

a. Connect the test equipment as shown in Figure 5-2. Operate the electronic load in constant-current mode and set for minimum current.
b. Turn the unit's power on and turn up current setting to full output.
c. Turn up output voltage to 6.70 Vdc as read on the digital voltmeter.
d. Set the load to vary the load current between 27 Adc and 30 Adc at a 30 Hz rate.
e. Set the oscilloscope for ac coupling, internal sync and lock on either the positive or negative load transient.
f. Adjust the oscilloscope to display transients as in Figure 5-6.
g. Check that the pulse width of the transients at 50 mV from the base line is no more than 1 ms as shown.

NOTE

While performing this test, it is important to adhere to the requirements that the change in current must be no greater than 10% of the set current, and that the total current must be no more than the rated current at the set voltage.

5-22 Temperature Coefficient

Definition: Temperature coefficient (TC) is the change in output voltage for each °C change in ambient temperature with constant ac line voltage, constant output voltage setting and constant load resistance.

Test Parameters: Measured Variable(s): Output Voltage

Test Points: +S and −S

Expected Results: Output Voltage change < 32 mV

Test Procedure:

a. Connect DVM between +S and −S.
b. Place power supply in oven, and set temperature to 30°C.

c. Turn the unit's power on and turn up current setting to full output.
d. Turn up output voltage to 20.0 Vdc as read on the DVM
e. After 30 minutes stabilization record the temperature (T1) to the nearest 0.1 °C. Record the output voltage (E1) at the DVM.
f. Set oven temperature to 50 °C.
g. After 30 minutes stabilization, record the temperature (T2) to the nearest 0.1 °C. Record output voltage (E2).
h. Check that the magnitude of the output-voltage change is no greater than 32 mV.

NOTE

Measure temperature coefficient by placing the unit in an oven, varying the temperature over a range within the unit's operating temperature range, and measuring the change in output voltage. Use a large, forced air oven for even temperature distribution. Leave the unit at each temperature measurement for half hour to ensure stability in the measured variable. Measure the output voltage with a stable DVM located outside the oven so voltmeter drift does not affect the measurement accuracy. To measure offset TC, repeat the procedure below with output voltage set to 0.10 Vdc.

5-23 Drift (Stability)

Definition: Drift is the change in output voltage beginning after a 30-minute warm-up during 8 hours operation with constant ac input line voltage, constant load resistance and constant ambient temperature.

Test Parameters: Measured Variable: Output Voltage

Test Points: +S and −S

Expected Results: Output Voltage ±5 mV from reading taken after 30-minute warm-up

Test Procedure:

a. Connect DVM between +S and -S.
b. Turn the unit's power on and turn up current setting to full output.
c. Turn up output voltage to 20.0 Vdc as read on the digital voltmeter.
d. After a 30-minute warmup, note reading on DVM.
e. The output voltage should not deviate more than 5 mV from the reading obtained in step d over a period of 8 hours.

NOTE

Use a DVM and record the output at intervals, or use a strip-chart recorder to provide a continuous record. Check that the DVM's or recorder's specified drift during the 8 hours will be no more than 0.001%. Place the unit in a location with constant air temperature preferably a large forced-air oven set to 30°C and verify that the ambient temperature does not change by monitoring with a thermometer near the unit. Typically the drift during 30-minute warm-up exceeds the drift during the 8-hour test. To measure offset drift, repeat the procedure with output voltage set to 0.10 Vdc.

5-24 Constant Current (CC) Tests

5-25 CC Setup. Constant-current tests are analogous to constant-voltage tests, with the unit's output short circuited and the voltage set to full output to assure CC operation. Follow the general setup instructions of paragraphs 5-9 through 5-14.

5-26 Load Effect (Load Regulation)

Definition: CC Load Effect is the change in dc output current when load resistance changes from short circuit to full load or from full load to short circuit.

Test Parameters: Measured Variable: Output Current

Test Points: See Figure 5-2

Expected Results: Recorded readings must be within ±0.010 mVdc range

Test Procedure:

a. Connect the test equipment as shown in Figure 5-2. Operate the electronic load in constant resistance mode (Amps/Volt) and set resistance to minimum.
b. Turn the unit's power on and turn up voltage setting to full output.
c. Turn up output current to 10.0 Adc(0.010Vdc across Rm). Check that the AMPS display reads about 10 amps.
d. Increase the load resistance until the output voltage at +S and −S increases to 20 Vdc. Check that the CC LED is lighted and AMPS display reads ~10 A.
e. Record voltage across Rm.
f. Short circuit the load.
g. When the reading settles, record the voltage across Rm again. Check that the two recorded readings differ no more than ±0.010 mVdc.
h. Disconnect the short across the load.

5-27 Source Effect (Line Regulation)

Definition: Source effect is the change in dc output current when the ac input voltage changes from the minimum to the maximum value as listed in the Specifications Table.

Test Parameters: Measured variable: Output Current

Test Points: See Figure 5-2

Expected Results: Recorded readings must be within a ±0.0090 mVdc range

Test Procedure:

a. Connect the test equipment as shown in Figure 5-2. Operate the load in constant resistance mode (Amps/Volt) and set resistance to minimum.
b. Connect the unit to the ac power line through a variable autotransformer set for low line voltage (eg. 104 Vac for 120 Vac)
c. Turn the unit's power on and turn up output voltage setting to full output.
d. Turn up output current to 29.0 Adc (0.029 Vdc across Rm). Check that the AMPS display reads 29.0 A.
e. Increase the load resistance until the output voltage between +S and −S increases to 7.0 Vdc. Check that the CC LED is on and the AMPS display still reads 29.0 A.
f. Record the output voltage across Rm.
g. Adjust autotransformer to the maximum for your line voltage.
h. When the reading settles record the voltage across Rm again. Check that the two recorded readings differ no more than ±0.0090 mVdc.

5-28 PARD (Ripple & Noise)

Definition: Periodic and random deviations (PARD) in the unit's output ripple and noise combine to produce a residual ac current as well as an ac voltage superimposed on the dc output. Constant current PARD is specified as the root-mean-square (rms) output current in a frequency range of 20 Hz to 20 MHz with the unit in CC operation.

Test Parameters: Measured Variable: Output Current (rms)

Test points: See Figure 5-7

Expected Results: Noise Current (rms) <15.0 mA rms

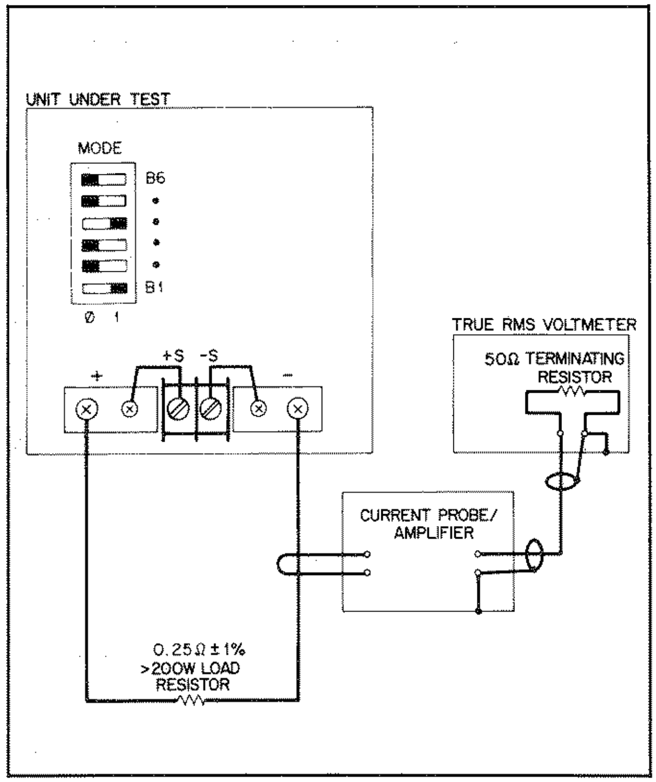


Figure 5-7. CC PARD Test Setup

NOTE

To avoid incorrect measurements caused by the impedance of the electronic load at noise frequencies, use a 0.25Ω load resistor that is capable of safely dissipating 250 watts.

Test Procedure:

a. Connect the test equipment as shown in Figure 5-7.
b. Turn the unit's power on and turn the output voltage all the way up.
c. Turn up output current to 29.0 Vdc. Check that the CC LED remains lighted.
d. Check that the rms noise current measured by the current probe and rms voltmeter is no more than 15 mA rms.

5-29 CALIBRATION PROCEDURE

5-30 Calibrate the unit twice per year and when required during repair. The calibration procedures which follow should be performed in the sequence given. Table 5-2 describes in detail these calibration procedures and lists the expected results to which each adjustment must be made. Some of the calibration procedures for this instrument can be performed

Table 5-2. Calibration Procedure

TEST	TESTED VARIABLE	TEST POINTS	TEST SEQUENCE AND ADJUSTMENTS	EXPECTED RESULTS
Meter F/S Adjust.	Meter Ref. Voltage	A2J3 pin 6 (+) ∇M(−)	a. Connect DVM across test points and turn on ac power. b. Adjust A2R24 to obtain the voltage range specified in the results.	0.5 V±50μV
Resistance Programminng F/S Adjust.	Prog. Voltage	VP(+) ∇P(−)	a. Connect a 2 kΩ 0.01%, ¼ W programming resistor and DVM between test points. b. Set MODE switch as in Figure 3-8 and turn on ac power. c. Adjust A2R23 to obtain the voltage range specified in the results.	2.5 V ±4 mV
V-MON Zero Adjust.	V-MON	VM(+) ∇M(−)	a. Set voltage and current controls to minimum settings. b. Disable power supply as in paragraph 5-32(I) c. Short circuit output terminals and connect the DVM between test points. Turn on power supply. d. Adjust V-MON Zero trim pot A2R22 to voltage range specified in the results.	0±20μV
Common Mode Adjust.	Residual Output Voltage	VM(+) ∇M(−)	a. Set voltage and current controls to minimum. b. Disable power supply as in paragraph 5-32(I) c. Turn on ac power and record the initial voltage (IR)with DVM across test points. d. Remove the −S & +S jumpers and connect a 1 Vdc power supply between −S(+) and −OUT(−). See Figure 5-8. e. Adjust A2R21 to the voltage range specified. f. Remove the 1 V supply and replace jumpers.	IR±20μV
I-MON Zero Adjust.	I-MON	IM (+) ∇M(−)	a. Set voltage and current controls to minimum. b. Turn on ac power. c. Connect DVM across test points and adjust I-MON Zero trim pot A2R8 as shown in results.	0±100μV
I-MON F/S Adjust.	I-MON	IM (+) ∇M−)	a. Perform I-MON Zero Adjust before proceeding. b. Connect a 0.001Ω, 0.05% current monitoring resistor Rm across the output terminals. c. Turn on ac power and using the "Display Settings", set current control to 30 A and voltage control to 5 V. d. Connect DVM across test points and take an initial reading (IR).	IR*
		Rm+ Rm−)	e. Connect DVM across Rm monitoring terminals and adjust A2R9 as shown in the results	0.006*IR+40μV
Power Limit Adjust.	V(OUT) I(OUT)		a. Perform I-MON F/S Adjust before proceeding. b. Connect the unit to the ac powerline via the external variable auto-transformer which is set to nominal line voltage. c. Connect a 0.25Ω, 250 W load resistor across the unit's output and turn on ac power. d. Set voltage control to 9 V & current control to 30.2 A. Set auto-xfmr to minimum line voltage. e. Turn A2R25 fully counter clockwise. f. Slowly adjust A2R25 clk/wise until CC Led just lights.	30.2 A 7.55 V for CC operation

*IR = Initial Reading

Table 5-3. Guide to Recalibration after Repair

Printed Circuit Board	Block Name	Circuit Within Block	Reference Designator	Perform These Procedures *
A1 Main Board			R3	4
A1 Main Board			T1	4 then 5
A4 Power Mesh			T3	4 then 5 Board
A4 Power Mesh			CR7	4 then 5 Board
A2 Control Board	Constant Voltage (CV) Circuit	All Except Current Source	All	1 then 2
A2 Control Board	Constant Voltage (CV) Circuit	Current Source	All	6
A2 Control Board	Constant Current (CC) Circuit		All	3 then 4
A2 Control Board	Power Limit Comparator		All	4 then 5
A2 Control Board	Bias Power Supplies	+ & −15 V Supplies	All	All
A2 Control Board			U9, R79 R80, R24	7

* Code To Calibration Procedures To Be Performed

1. V-MON Zero Calibration
2. Common-Mode Calibration
3. I-MON Full Scale (F/S) Zero Calibration
4. I-MON Full Scale (F/S) Calibration
5. Power Limit Calibration
6. Resistance Programming Full Scale (F/S) Calibration
7. Meter Full Scale (F/S) Calibration

independently and some must be performed together and/or in the prescribed order. If a procedure makes no cross-references to other procedures (Table 5-3, column 5) then it can be assumed that that procedure can be independently calibrated.

5-31 To return a serviced unit to specifications as quickly as possible with minimal calibration, the technician need only perform calibration procedures that affect the repaired circuit. Table 5-3 lists various power supply circuits with calibration procedures that should be performed after those circuits are serviced. Circuits are identified by schematic designators; either the tinted block and/or specific circuit area within a tint block, or the reference designator of specific components. In both cases, the printed circuit board containing the circuit is also listed.

5-32 Initial Setup

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Turn off ac power when making or removing connections to the power supply.

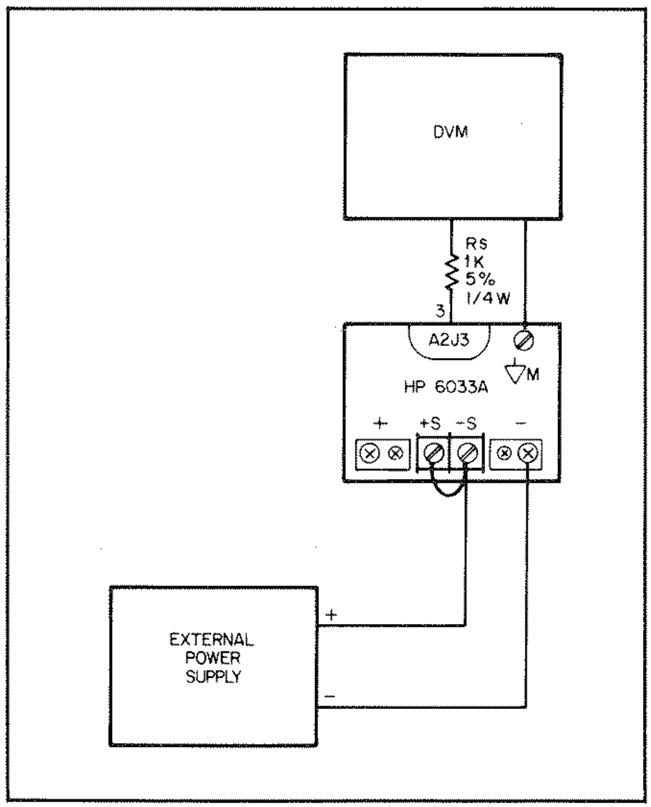
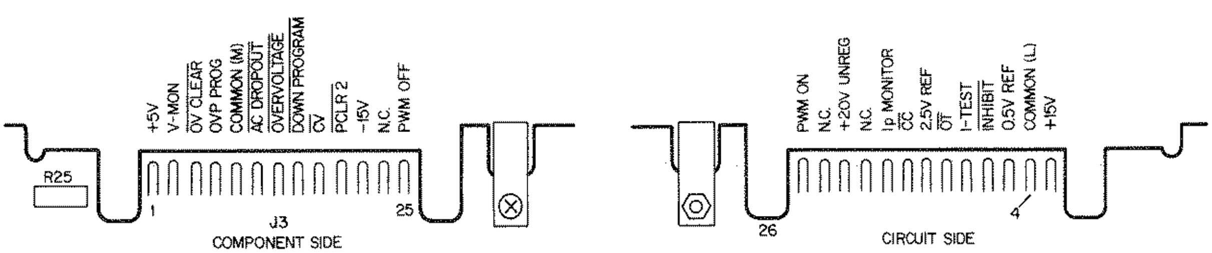


Figure 5-8. Common Mode Setup

Table 5-4. Control Board Test Connector, A2J3

PIN NO.	SIGNAL NAME	Vdc	WAVEFORM/CONDITIONS	SOURCE
Digital-Circuits Bias & Reference Voltages				
1	+5 V	5.0		A2Q3 (emitter)
22	+20 V(5 V UNREG)	20.0	with 120 Hz & 45 kHz ripple	A1CR6, A1CR7
14	2.5 V ref	2.50		A2U9 (OUT)
6	0.5V ref	0.50		A2R79, A2R80
Analog-Circuits Bias Voltages				
2	+15 V	15.0		A2U12 (OUT)
21	−15 V	−15.0		A2U4 (OUT)
Status Signals				
17	$\overline{\text{CV}}$	TTL lo	if in CV operation	A2Q6C-7 (collector)
16	$\overline{\text{CC}}$	TTL lo	if in CC operation	A2Q6F-14(collector)
13	$\overline{\text{OV}}$	TTL hi	if not OVP shutdown	A2U11D-11
11	$\overline{\text{DROPOUT}}$	TTL hi	if ac mains okay	A2U17D-11
12	$\overline{\text{OT}}$	TTL hi	if not overtemp shutdown	A2U11B-6
Control Signals				
25	PWM OFF	<0.5	1.7 μs TTL pulses, 20kHz	U1A-5
26	PWM ON	<1.0	1.7 μs TTL pulses, 20 kHz	U2B-6
18	Ip MONITOR	<0.5	1 V pk, ½ sawtooth, 20 kHz	A2CR26 (cathode)
8	$\overline{\text{INHIBIT}}$	TTL hi	if not remotely inhibited	A2R185C,U19A-2
15	$\overline{\text{DOWN PROGRAM}}$	1.2-3.0		A2CR21, A2CR27
7	OVP PROGRAM	1/10 OVP	e.g.: 2 Vdc if OVP set to 20	A3R6 (wiper)
5	$\overline{\text{OV CLR}}$	+5V	inverted OV reset line	A7U29-5
19	$\overline{\text{PCLR 2}}$	+5V	if +5Vdc bias is OK	A2Q60-9
Commons & Current-Monitor				
4	L COMMON	0.0	common return for all bias voltages and status and control signals	A2C20(−), A2R50, A2U6-4
9	M COMMON	0.0	common return for 2.5V ref and 0.5V ref	A2R83, A21-20
10	I-TEST	≈0.005(Iout)	inboard-side monitoring res.	A1R3, A1T2
3	NOT USED			



a. Unplug the line cable and remove the top cover by removing three screws; the rear handle screw and the two top-rear-corner screws. Do not remove the front handle screw as the retaining nut will fall into the unit.

b. Slide the cover to the rear.

c. Plug a control board test connector A2P3 onto the A2J3 card-edge fingers.

d. Turn OVERVOLTAGE ADJUST control A3R59 fully clockwise.

e. Disconnect all loads from output terminals.

f. Connect power supply for local sensing, and ensure that MODE switches are set as shown in Figure 3-2.

g. Reconnect line cable and turn on ac power.

h. Allow unit to warm up for 30 minutes.

i. When attaching the DVM, the minus lead of the DVM should be connected to the first node listed, and the plus lead should be connected to the second node listed.

j. At the beginning of each calibration procedure, the power supply should be in its power-off state, with no external circuitry connected except as instructed.

k. The POWER LIMIT adjustment (A2R25) must be adjusted at least coarsely before many of the calibration procedures can be performed. If you have no reason to suspect that the Power Limit circuit is out of adjustment, and you do not intend to recalibrate it, do not disturb its setting. Otherwise, center A2R25 before you begin to calibrate the power supply.

l. To disable the power supply, short INHIBIT line A2J3 pin 8 to COMMON A2J3 pin 4.

5-33 TROUBLESHOOTING-GENERAL

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

5-34 Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument itself and not with an associated circuit. The performance test enables this to be determined without having to remove the covers from the supply.

5-35 The most important aspect of troubleshooting is the formulation of a logical approach to locating the source of trouble. A good understanding of the principles of operation is particularly helpful, and it is recommended that Section IV of this manual be reviewed before attempting to troubleshoot the unit. Often the user will then be able to isolate a problem simply by using the operating controls and indicators. Once the principles of operation are understood, refer to the following paragraphs.

5-36 Section V contains schematic diagrams and information concerning the voltage levels and waveforms at many of the important test points. Most of the test points used for troubleshooting the supply are located on the control board test "fingers", which are accessible close to the top of the board, see Table 5-4. If a component is found to be defective, replace it and re-conduct the performance test. When a component is replaced, refer to the Calibration Procedure of this section. It may be necessary to perform one or more of the adjustment procedures after a component is replaced.

5-37 Initial Troubleshooting Procedures

5-38 If a problem occurs, follow the steps below in sequence:

a. Check that input power is available, and check the power cord and rear-panel line fuse. When replacing line fuse, be certain to select fuse of proper rating for line voltage being used.

b. Check that the settings of MODE switch A2S1 are correct for the desired mode of operation (see Table 3-4).

c. Check that all connections to the power supply are secure and that circuits between the supply and external devices are not interrupted.

d. If the power supply fails the turn-on self-test or gives any other indication of malfunction, remove the unit from the operating system before proceeding with further testing.

WARNING

Some circuits on the power mesh are connected directly to the ac power line. Exercise extreme caution when working on energized circuits. Energize the supply through an isolation transformer to avoid shorting ac energized circuits through the test instrument's input leads. The isolation transformer must have a power rating of at least 1 k VA. During work on energized circuits, the safest practice is to disconnect power, make or change the test connections, and then re-apply power.

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

5-39 Electrostatic Protection

5-40 The following caution outlines important pre-cautions which should be observed when working with static sensitive components in the power supply.

CAUTION

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

a. Always turn power off before removing or installing printed-circuit boards.

b. Always store or transport static-sensitive devices (all semiconductors and thin-film devices) in conductive material. Attach warning labels to the container or bag enclosing the device.

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

WARNING

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

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

5-41 Repair And Replacement

5-42 Repair and replacement of most components in the power supply require only standard techniques that should be apparent to the technician. The following paragraphs provide instructions for removing certain assemblies and components for which the procedure may not be obvious upon inspection.

WARNING

To avoid the possibility of personal injury, remove the power supply from operation before opening the cabinet. Turn off ac power and disconnect the line cord, load, and remote sense leads before attempting any repair or replacement.

CAUTION

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

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

CAUTION

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

a. lock-link/shelf-mounting blocks (4 on rear panel, one at each corner)
b. rear-panel fuse holder
c. rear-panel ground binding post
d. strap-handle screws (2)
e. screws that secure side chassis to front-frame casting (8, 4 on each side)
f. screws that secure front panel to front-frame casting (4, 2 on top and 2 on bottom)

5-43 Top Outside Cover Removal. Remove three screws—the rear handle screw (Phillips, 10x32) and the two top-rear-corner screws (Pozidriv, M4x.7) using a Size 1, Pozidriv screwdriver. A Phillips head screwdriver does not fully seat into Pozidriv screws and risks stripping the heads. (Do not remove the front handle screw, as the retaining nut will fall into the unit.) Remove the top cover by sliding it to the rear and lifting at the front.

5-44 Bottom Cover Removal. Remove only for repair of main board. Remove two bottom-rear-corner screws (Pozidriv, M4x.7), and remove the bottom cover by sliding it to the rear. You don't need to remove the unit's feet.

5-45 Inside Top Cover Removal. The unit includes an inside cover which secures the vertical board assemblies. Remove the inside cover for repair but not for calibration.

5-46 Remove the six mounting screws (Pozidriv, M4x.7)—three on each side—and the five board-fastening screws (Pozidriv, M4x.7)—all on top. Remove the inside cover by lifting at the front edge.

5-47 When installing the inside cover, insert it first at the right side. While holding it tilted up at the left, reach through the cutouts in the cover and fit the top tabs of the A2 board into the mating slots in the cover. With the top cover in place reach through the cutout above the A4 power mesh board, align the board-fastening screw holes, and replace the rear-most screw to secure the A4 board. Press the inside cover down firmly while tightening screws that secure cover to chassis. Complete the installation by replacing the remaining ten screws.

5-48 Be careful when replacing printed-circuit assemblies and covers not to bend any boards or components.

5-49 A2 Control Board Removal

5-50 After removing the inside cover,remove the A2 board by lifting first at the front edge and then pulling it up and out of the unit. Two connectors hold the A2 board at its bottom edge.

5-51 When installing the A2 board, insert it first at the rear of the unit. While holding it tilted up at the front fit the A2TB1 terminal strip into the mating cutout in the rear panel. Then lower the A2 board's bottom connectors into the mating connectors on the main board. Press the A2 board into the connectors.

5-52 A4 Power Mesh Board Removal

5-53 After removing the inside cover, remove the A4 power mesh board by lifting using the large aluminum heatsink as a handle. Two connectors hold the A4 board at its bottom edge.

5-54 When installing the A4 power mesh board, lower it vertically into its connectors and press in place.

5-55 A3 Front-Panel Board Removal

5-56 Remove the A3 front-panel board by first removing the entire front panel assembly. You don't need to remove the top cover. Follow this procedure:

a. Remove the top plastic insert by prying up with a flat-blade screwdriver, and remove the front feet by lifting the tabs and sliding toward the front of the unit.

b. Remove the four front-panel assembly mounting screws (Phillips, 8/32) on the top and bottom at the corners using a Pozidriv or Phillips head screwdriver (Phillips head screwdriver may be used only with these four screws).

c. Gently pull the front-panel assembly away from the unit as far as permited by the connecting cables.

d. Remove the ground-wire screw (Pozidriv, M4x.7) holding the green-yellow ground wire.

e. Note the locations of the four power-wire connections to the power switch, and then unplug the quick-connect plugs.

f. Unplug the W3 3-wire cable from connector A1J3 on the A1 main board.

g. Remove the A3 board from the front-panel assembly by removing the five mounting screws (Pozidriv, M4x.7).

5-57 Install the A3 board by reversing the above steps. The power wires are correctly connected to the power switch if they do not cross each other.

5-58 A1 Main Board Removal

5-59 Removing the A1 main board requires removing the rear panel, all boards except the A3 front-panel board, and 17 A1-board mounting screws. Component-access cutouts in the bottom inside cover allow unsoldering most A1-board components for repair without removing the rear panel and the A1 board.

5-60 To remove the A1 board proceed as follows:

a. Remove the A2, and A4 boards according to the above instructions.

b. Detach the rear panel by removing the four mounting screws (Pozidriv, M4x.7)—two on each side. Gently pull the rear panel away from the unit as far as permitted by the four wires connected to the A1 board.

c. Unplug the W1 ribbon cable from connector A1J1.

d. Remove the A1 board by removing the 17 mounting screws (Pozidriv, M4x.7).

e. Note locations and then unplug the two ac power wires and the two fan wires to the A1 board.

5-61 TROUBLESHOOTING PROCEDURE

WARNING

Perform the troubleshooting and repair procedures which follow only if you are trained in equipment service and are aware of the danger from fire and electrical-shock hazards. Some of the procedures include removing the unit's protective covers which may expose you to potentially lethal electrical shock. Whenever possible, make test connections and perform service with the power removed.

5-62 After performing the Initial Troubleshooting Procedures paragraph 5-37, focus on developing a logical approach to locating the source of the trouble. The underlying strategy for the troubleshooting procedures here is to guide you to the faulty circuit nodes which have improper signals or voltages. It relies on you to identify the particular functional circuit to troubleshoot from symptom tables and by understanding how the unit works. It then relies on you to discover the defective component or components which cause the faulty circuit nodes. So, read the BLOCK DIAGRAM OVERVIEW under paragraph 4-3 and read the functional circuit descriptions for the circuits that you suspect may be defective. (Functional circuit descriptions begin at paragraph 4-12.) Then return to this section for help finding the faulty circuit nodes.

5-63 Table 5-4 gives the signals for each of the test points on the control board test connector. This connector is provided in service kit P/N 06033-60005. The measurements given here include bias and reference voltages as well as power supply status signals and waveform information.

5-64 Table 5-5 provides troubleshooting information based on the status of the PWM-ON and PWM-OFF signals which drive the PFETs. This table is used for no-output failures.

5-65 Tables 5-6 and 5-7 give measurements for the test points on the A3 front panel board and possible failure symptoms respectively.

5-66 Table 5-8 describes possible symptoms for overall performance failures of the power supply. It is necessary to have a properly working front panel before using this table.

5-67 Section VII contains schematic diagrams and voltage levels component location diagrams to help you locate components and test points.

5-68 Make voltage measurements (except DC-to-DC Converter and ac mains-connected circuits) referenced to the unit's output common which is accessible at rear-panel terminal VM. All voltages are +5% unless a range is given.

5-69 Using the Tables

5-70 Typically there will be two types of power supply failures; no-output and performance failures.

1. NO-OUTPUT FAILURE: Start with the TROUBLESHOOTING NO-OUTPUT FAILURES section at paragraph 5-77 which references Tables 5-4 and 5-6.
2. PERFORMANCE FAILURE: If the power supply produces an output but does not perform to specifications, begin by verifying the measurements at the A2J3 test connector using Table 5-4. Next, verify the front panel by doing the procedure outlined in the FRONT PANEL TROUBLESHOOTING section starting at paragraph 5-79. After the front panel has been verified consult Table 5-8 for the performance failure symptom which seems closest to the one observed and proceed to the functional circuit given for that failure.

5-71 The circuits referenced in Tables 5-5 and 5-8 are derived from functional blocks of circuits in the power supply. These blocks are given in the Power Supply Blocks section starting in Paragraph 5-102. Troubleshooting information for each block will include a brief description of the circuit involved. The columns provided in each block are as follows:

NODE:	This column lists the nodes where the measurements should be taken. In some cases this will be stated as NODE(+) and NODE(−) where the first is the test node and the second is the reference.
SETUP:	If a certain setup is required for the measurement, it will be given in this column.
MEASUREMENT:	This column indicates what the expected measurement is for the given node.
SOURCE:	If applicable, the components which generate the signal will be provided in this column.

5-72 Some blocks will have Input and Output sections. The input section will have a source column to indicate which components generated the measured signal. The output section will list all the important output signals from that block. However, because the outputs of one block are the inputs to another, the schematic should be consulted if an output measurement is incorrect. This will indicate the next circuit block to be trouble shot.

5-73 Main Troubleshooting Setup

5-74 Figure 5-9 shows the troubleshooting setup for trouble shooting all of the unit except the front panel and initial no-output failures (see paragraph 5-77). The external power supply provides the unit's internal bus voltage. The ac mains cord connects directly to the unit's A1T3 bias transformer thereby energizing the bias supplies, but it does not connect to the input rectifier and filter because that would create the bus voltage. With the external supply the unit operates as a dc-to-dc converter. The supply biases the A4Q3 and A4Q4 PFETs with a low voltage rather than the 320 Vdc bus voltage. This protects the PFETs from failure from excess power dissipation

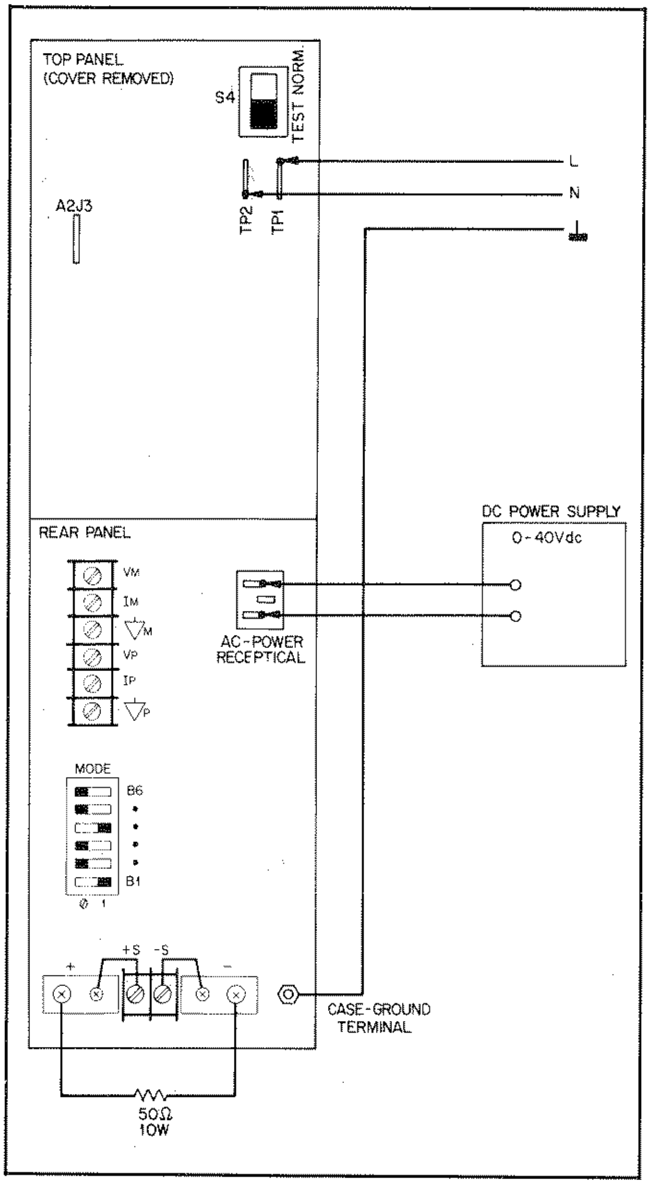


Figure 5-9. Main Troubleshooting Setup

if the power-limit comparator or the off-pulse circuitry are defective. It also reduces the possibility of electrical shock to the troubleshooter.

WARNING

The troubleshooting setup of Figure 5-9 connects the ac mains voltage to the A1F2 fuse, the A1S2 Mains-Voltage Select Switch, the fan and printed-circuit traces at the left edge of the A1 main board. Be extremely careful when working on the unit with the protective inside cover removed to avoid touching the ac mains voltage.

5-75 As a convenience in implementing the troubleshooting setup, modify a spare mains cord set as shown in Figure 5-10. This facilitates connecting the unit's power receptacle to the

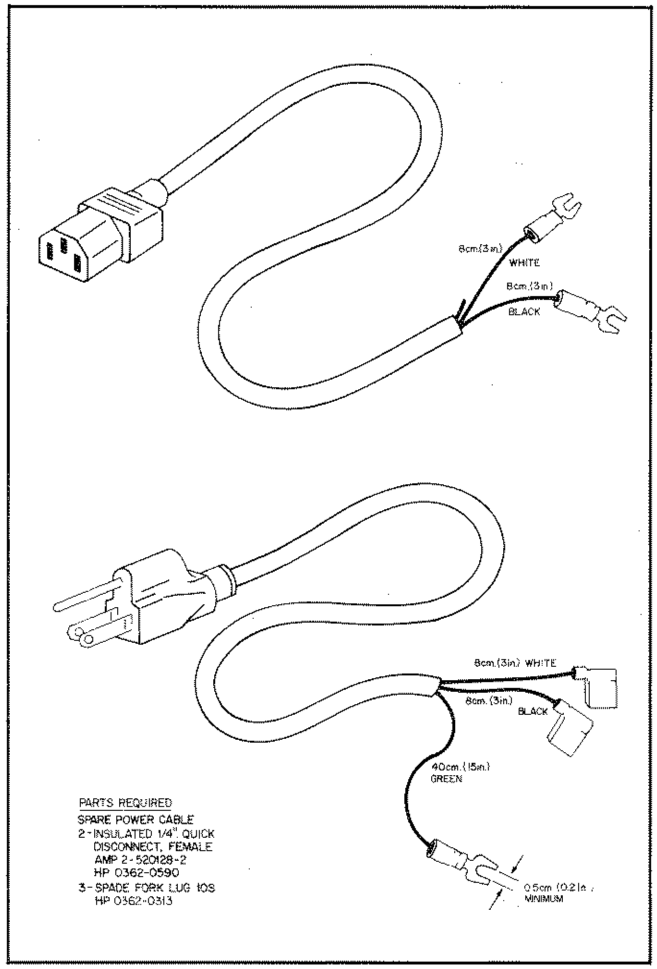


Figure 5-10. Modified Mains Cord Set For Troubleshooting

external supply and connecting the bias transformer to the ac mains.

5-76 With the mains cord unplugged proceed as follows:

a. Remove the top cover and the inside cover per paragraphs 5-43 and 5-45. Set switch S4 (front-left corner of the A1 main board) in the TEST position.

WARNING

If switch S4 is not in the TEST position and remains in the NORM position, completion of step e below will allow the unit to develop its 320 Vdc bus voltage across PFETs A3Q3 and A3Q4 and will connect the ac mains voltage to the output of the external power supply. This will probably damage the external supply and is an electrical shock hazard to you.

b. Install control board test connector onto the A2J3 card-edge fingers.
c. Connect a 50 Ω, 10 W, load resistor to the unit's output terminals.

d. With the LINE switch off connect an external dc power supply to the outside prongs of the unit's power receptacle. Ignore polarity as the unit's input rectifying diodes steer the dc power to the correct nodes.

e. Complete the setup of Figure 5-9 by attaching an ac mains cord to test points TP1 (L, black wire) and TP2 (N, white wire) and connect the green ground wire to the unit's case ground terminal or a suitably grounded cabinet screw. TP1 and TP2 are accessible through the cutout on the left side of the unit and are at the left edge of the A1 main board.

5-77 Troubleshooting No-Output Failures

5-78 No-output failures often include failure of the A4Q3 and A4Q4 PFETs and their fuses, A4F1 and A4F2. When either the off-pulses or the power-limit comparator fails, the PFETs can fail from excessive power dissipation. The strategy for localizing no-output failures is to check the voltages and waveforms at the control board test connector to predict if that circuit failure would cause the the PFETs to fail. This makes it possible to develop your troubleshooting approach without an extensive equipment setup. Proceed as follows:

a. With the mains cord unplugged remove the A4 power mesh board per paragraph 5-52. Plug in the mains cord and switch on power.

b. Using Table 5-4 check the bias voltages, the PWM-OFF, PWM-ON and other signals of interest at the A2 control board test fingers, A2J3.

c. Check for the presence of program voltages, VP and IP, at the rear panel.

d. Check for presence of the 320 Vdc rail voltage between the cathodes of diodes A1CR1 and A1CR2 and the anode of diodes A1CR3 and A1CR4. If there is no rail voltage, check diodes A1CR1 through A1CR4.

WARNING

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

e. Select the functional circuit for troubleshooting based on your measurements and Table 5-5, which provides direction based on the status of the PWM OFF and PWM ON signals.

5-79 Front-Panel Troubleshooting

5-80 The A3 front panel board can be troubeleshot by first doing the following setup.

a. Remove the top cover of the unit.

b. Remove the 4 side screws holding the front panel assembly to the power supply chassis and pull the entire assembly forward.

c. Disconnect the W1 ribbon cable from connector A1J1 on the A1 main board and remove the ground wire screw holding the green/yellow ground wire. Unplug the 4 wires to the LINE switch noting the configuration.

d. Detach the A3 board from the front panel assembly by removing the 5 mounting screws.

e. Reconnect the W1 jumper to connector A1J1 and place the A3 board vertically against the supply with a piece of insulating material between. The test connector can then be attached to the A3 board. The rest of the front panel assembly can stand vertically so that the pots and the switches can be accessed while troubleshooting.

f. Attach the external line cord as outlined in paragraph 5-76 (e) and place switch A1S4 in the TEST position.

5-81 Start troubleshooting by performing the tests given in Table 5-6. This table provides the measurements for the test points on the test connector as well as the source components for that measurement. Switch A1S4 should be in the TEST position for all measurements except where noted. Table 5-7 gives front panel symptoms as well as the circuits or components that may cause the supply to exhibit those symptoms. Both Table 5-6 and 5-7 should be used to check out and troubleshoot the front panel.

WARNING

The ac mains voltage connects directly to the LINE switch. Be extremely careful to avoid touching the ac mains voltage.

5-82 Troubleshooting Bias Supplies

5-83 **+5 V On A2 Control Board.** The PWM A2U6 includes a clock generator (45 kHz set by A2R53 and A2C26) and a current limit (2 Adc set by 0.15 Vdc across A2R50). It turns off each output pulse using the difference between the voltage at voltage divider A2R46-A2R47 and the 2.5 Vdc set by voltage regulator A2U5.

5-84 **Circuit Included.** +5 Vdc bias supply circuitry from connector pin A2P1-15 through jumper A2W3 on A2 control board.

5-85 **Setup.** The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, and set the external supply to 0 Vdc.

5-86 **Input:**

NODE	MEASUREMENT	SOURCE
A2J3-22	~20 Vdc	A1CR6,A1CR7

Table 5-5. No-Output Failures
(Bias supplies and AC turn-on circuit functioning)

Status of PFET on/Off-Pulses

PWM-ON A2J3-26	PWM-OFF A2J3-25	DEFECTIVE BOARD	CHECK FUNCTIONAL CIRCUITS
lo	lo	A2	Control ckts: CV & CC thru On- & Off-Pulse Oneshots *
lo	hi	A2&A4	PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed
hi	lo	A2&A4	PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed
hi	hi	A2&A4	PWM and DC-to-DC Converter: A4Q3 and A4Q4 probably failed
lo	N	A2	A2U17B,On-Pulse Oneshot and A2Q6A
N	lo	A2&A4	Off-Pulse Oneshot and DC-to-DC: A4Q3 and A4Q4 probably failed
hi	N	A2&A4	A2U17B, On-Pulse Oneshot & DC-to-DC: A4Q3 and A4Q4 probably failed
N	hi	A2&A4	Off-Pulse Oneshot and DC-to-DC: A4Q3 and A4Q4 probably failed
N	N	A2&A4	Power-Limit Comparator and DC-to-DC: A4Q3 and A4Q4 probably failed

lo= TTL low hi= TTL high N= normal 20 kHz pulse train, TTL levels

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

Table 5-6. Front Panel Board Tests

Pin No.	Signal Name	Measurement	Description	Source
1	+7.5 V	7.5 V	derived from +15 V bias	A3VR2, A3R3
2	−1 V	−1.0 V	derived from −15 V bias	A3R86, A3R85, A3C17
*3	CV VOLTAGE	0-5 V	for 0 to full scale output voltage	A3U2-2, A3R1, A3R87
*4	CC VOLTAGE	0-5 V	for 0 to full scale output current	A3U3A-1, A3R67
5	VOLTS test	−1888 on volts display	jumper to +5 V on A3 board	A3U4-37
6	AMPS test	−1888 on amps display	jumper to +5 V on A3 board	A3U5-37
*7	VOLTS input	0-1 V	for 0 to full scale output voltage	A3R8, A3U7-2,3,10
8	VOLTS lowrange	TTL high	if VOLTS display is below 20 volts (press DISPLAY SETTINGS)	A3U9C-13,A3U6B-5
9	DISPLAY SETTINGS	TTL high	if DISPLAY SETTINGS switch on front panel is depressed	A3S1,A3R80
10	DISPLAY OVP	TTL high	if DISPLAY OVP switchon front panel is depressed	A3S2,A3R82,A3U6C-8
*11	AMPS input	0-150 mV	for 0 to full scale output current	A3R65,A3R66,A3R67
12	−5 V	−5.0 V	derived from −15 V bias	A3VR1, A3R2
13	buffered OVP	0-2.2 V	1/10 of OVP voltage setting when DISPLAY OVP switch is depressed. Varies with OVP ADJUST pot	A3U3B-6,A3CR5, A3R72

*Switch A1S4 should be in the NORM position for these tests.

Table 5-7. A3 Front Panel Board Failure Symptoms

SYMPTOMS	DEFECTIVE CIRCUIT	CHECK COMPONENTS
pressing DISPLAY LIMITS	limits display	A3U1, A3U9
error in VOLTS or AMPS	input ranging or DVMS	A3U1,A3U2,A3U4,A3U5,A3U7
* one or more display digits out	display LEDs	A3DS1 through A3DS7
unable to ajdust VOLTAGE or CURRENT or always max	potentiometers	A3R4, A3R5
VOLTS decimal point error	decimal drivers	A3U6

*Note that the Volts and Amps tests (Table 5-6 pins 5 and 6) verify that all the current and voltage display segments light except for the decimal points.

Table 5-8. Performance Failure Symptoms

SYMPTOMS	DEFECTIVE BOARD	CHECK FUNCTIONAL CIRCUITS
unexplained OVP shutdowns	A2	OVP Circuit, CV Circuit
no current limit	A2	CC Circuit
max current < 30 Adc	A2	CC Clamp, CC Circuit
max power < specified	A2, A1	Power Limit, 20 kHz clock, transformer A1T1
max voltage < 20 Vdc	A2, A1	CV Circuit, diodes A1CR1-CR4
cycles on & off randomly	A2, A1	AC-Surge-&-Dropout Detector, Mains Voltage Select switch A1S2
CV overshoots	A2	A2U10A, A2CR20, A2R94
output noise (< 1 kHz)	A2	CV Circuit
output noise (>1 kHz)	A1, A4	transformer A1T1, Output Filter, snubbers A4R7/R8/C5/CR5, A4R13/R14/C6/CR6, A4R33/C13
CV regulation, transient response, programming time	A2, A1	wrong sensing (paragraph 3-40), low ac mains voltage, CV Circuit
CC regulation	A2	low ac mains voltage, CC circuit
CV oscillates with capacitive loads	A2	A2U10, A2C51, A2R95, A2R96, A2R86, A2C47, A2R71, A2C36
CC oscillates with inductive loads	A2	A2U10, A2R86, A2C47, A2C43, A2R77, A2U3D, A2R30, A2C44, A2R76, A2R75, A2C42, A2C41, A2R16

5-87 Outputs:

NODE	MEASUREMENT
A2U6-6	~2 to 4 Vdc sawtooth, 45 kHz
A2U6-12,13	~19 Vpk, 15 μs pulses, 45 kHz
A2Q3 (emit.)	~20 Vpk, 5 μs pulses, 45 kHz
A2U5 (OUT)	2.5 Vdc
A2R50, A2CR11 (anode)	~0 > V > −0.07 Vdc
A2R46, A2R47	2.5 Vdc

5-88 To check if load on +5 V is shorted, remove jumper A2W3.

5-89 +15 V On A2 Control Board. Voltage regulator A2U12 regulates the voltage across resistor A2R29 to be 1.25 Vdc. That sets the current through zener diode A2VR1 at 7.5 mAdc. The output voltage is 1.25 Vdc plus 11.7 Vdc across A2VR1 plus the voltage across A2R34.

5-90 Circuit Included. +15 Vdc bias supply circuitry from connector pin A2P1-27 through test point A2J3-2 on A2 control board.

5-91 Setup. The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, and set the external supply to 0 Vdc.

5-92 Input:

NODE	MEASUREMENT	SOURCE
A2U12(IN), A2C17(+)	~24 Vdc	A1U1, A1C1 (+)

5-93 Outputs:

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

5-94 To check if load on +15 V is shorted, remove jumper A2W1.

5-95 −15 V On A2 Control Board. Voltage regulator A2U4 regulates the voltage across resistor A2R32 to be 1.25 Vdc.

5-96 Circuit Included. −15 Vdc bias supply circuitry from connector pin A2P1-30 through test point A2J3-21 on A2 control board.

5-97 Setup. The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, and set the external supply to 0 Vdc.

5-98 Input:

NODE	MEASUREMENT	SOURCE
A2U4(IN), A2C16(−)	~ −24 Vdc	A1U1, A1C1(+)

5-99 Outputs:

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

5-100 To check if load on −15 V is shorted, remove jumper A2W3.

5-101 Refer to Down Programmer, paragraph 5-136, for the +8.9 V bias supply, and refer to OVP Circuit, paragraph 5-141, for the +2.5 V bias supply.

5-102 Power Section Blocks

5-103 This section contains the blocks referenced in Tables 5-5 and 5-8.

5-104 Troubleshooting AC-Turn-On Circuits

5-105 Relay A1K1 closes at 1.0 seconds and DROPOUT goes high at 1.1 seconds after 20 V (5V UNREG) reaches about 11 Vdc. DROPOUT high enables the PWM if OVERVOLTAGE, INHIBIT, and OVERTEMPERATURE are also high.

5-106 Circuits Included. AC-Surge-&-Dropout Detector, Bias Voltage Detector, U11A, 1-Second Delay and Relay Driver—all on A2 control board.

5-107 Setup. The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, and set the external supply to 0 Vdc.

5-108 Inputs:

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

5-109 Outputs:

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

5-110 Troubleshooting PWM & Clock

5-111 The inputs to Inhibit Gate A2U19A and PWM gate A2U19B are the keys to PWM troubleshooting. The 20 kHz Clock starts each PWM output pulse, and the pulse stops when any of the inputs to A2U19A or A2U19B goes low. The PWM is inhibited and prevented from initiating output pulses as long as any of the eight inputs are low.

5-112 Circuits included. Pulse Width Modulator (PWM), Inhibit Gate A2U19A, Off-Pulse Oneshot, On-Pulse Oneshot, A2U17B, 20 kHz Clock.

5-113 Setup. The Main Troubleshooting Setup, Paragraph 5-73. Apply the ac mains voltage to the bias transformer and switch on the LINE switch. Adjust the unit's current setting above 1.0 Adc. Set the external supply (EXTERNAL) and adjust the unit's voltage setting (INTERNAL) as instructed below.

5-114 Outputs:

NODE	EXTERNAL	INTERNAL	SETUP	MEASUREMENT
	SET VOLTAGE (Vdc)			
A2U21-7	0	0		TTL sq wave, 320 kHz
A2U22-3	0	0		TTL sq wave, 160 kHz
A2U22-6	0	0		TTL sq wave, 20 kHz
A2U13-5	0	0		23.5 μs TTL pulses, 20 kHz
A2U13-9	0	0		23.5 μs TTL pulses, 20 kHz
A2U14-2	40	0	POWER LIMIT fully CCW	lo
A2U19-8	40	0		lo
A2U13-9	40	0		lo
A2U17-6	40	0		lo
A2U15-13	40	0		lo
A2U15-5	40	0		lo
A2U17-6	40	0	POWER LIMIT fully CW	groups of 4 pulses, 1.7 μs, TTL, 20 kHz
A2U15-5	40	0		1.7 μs TTL pulses, 20 kHz
+OUT	40	10		3.8 Vdc (OVERRANGE)
+OUT	40	2		2.0 Vdc (CV)
+OUT	40	2	short A2J3-4 to A2J3-8	0.0 Vdc

5-115 Inputs:

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

5-116 Troubleshooting DC-to-DC Converter

5-117 Parallel NOR gates A4U2A, A4U2B and A4U1A act as drivers and switch on PFETs A4Q3 and A4Q4 through pulse transformer A4T1. NOR gate A4U1B turns off the PFETs through pulse transformer A4T2 and transistors A4Q1 and A4Q2.

5-118 Circuits included: On-Pulse Driver, Off-Pulse Driver, PFET Switches and Drivers on A4 powermesh board.

5-119 Setup: The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, set the external supply to 40 Vdc, and switch on the LINE switch. Set the unit's output voltage to 20 Vdc and current to above 1 Adc. Verify the UNREGULATED LED lights.

5-120 Inputs:

NODE (+)	NODE (−)	MEASUREMENT	SOURCE
A2J3-26 (PWM-ON)	VM	waveform 1	A2U17-6,A2P1-7, A4P1-24,C
A2J3-25 (PWM-OFF)	VM	waveform 2	A2U15-5,A2P1-13 A4P1-26,A
A4Q3-D	A4Q4-S	39 Vdc	A1C4(+),A4P1-10, A,C A1C4 (−),A4P1-4,A,C

5-121 Outputs:

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

NOTE

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

5-122 If all the INPUT measurements are correct but the OUTPUT Vgs waveform (3) is incorrect, the problem may be caused by weak PFETs. Two 6800pF capacitors (HP P/N 0160-0159) can be substituted for the PFETs (G to S) to check waveform 3. If the waveform is still incorrect, the problem may be located in the drive components.

CAUTION

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

5-123 Troubleshooting CV Circuit

5-124 V-MON, the output of CV Monitor Amp A2U7, is ¼ the voltage between +S and −S. CV Error Amp A2U8 compares V-MON to CV PROGRAM. Innerloop Amp A2U10A stabilizes the CV loop with IVS input from A2U10C. The measurements below verify that the operational amplifier circuits provide expected positive and negative dc voltage excursion when the CV loop is open and the power mesh shut down.

5-125 Circuits Included. Constant Voltage (CV) Circuit and buffer amplifier A2U10C.

5-126 Setup. The Main Troubleshooting Setup, paragraph 5-73. Apply the ac mains voltage to the bias transformer, and disconnect the external supply. Remove the +S jumper and connect A2J3-2 (+15 V) to +S. Set MODE switch settings B4, B5 and B6 all to 0. Set VP to 0 Vdc by connecting to P ∇ or set VP to +5 Vdc by connecting to A2J3-1 according to SETUP below.

5-127 Outputs:

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

5-128 If the failure symptoms include output voltage oscillation, check if the CV Error Amp circuit is at fault by shorting A2U8-6 to A2U8-2. If oscillations stop, the CV Error Amp circuit is probably at fault.

5-129 Troubleshooting CC Circuit

5-130 I-MON, output of CC Monitor Amp A2U1, in volts is 1/6 the output current in amperes. CC Error Amp A2U2B compares I-MON to CC PROGRAM. Differentiator circuit, A2U3D and A2U3C, stabilizes the CC loop. It differentiates IVS

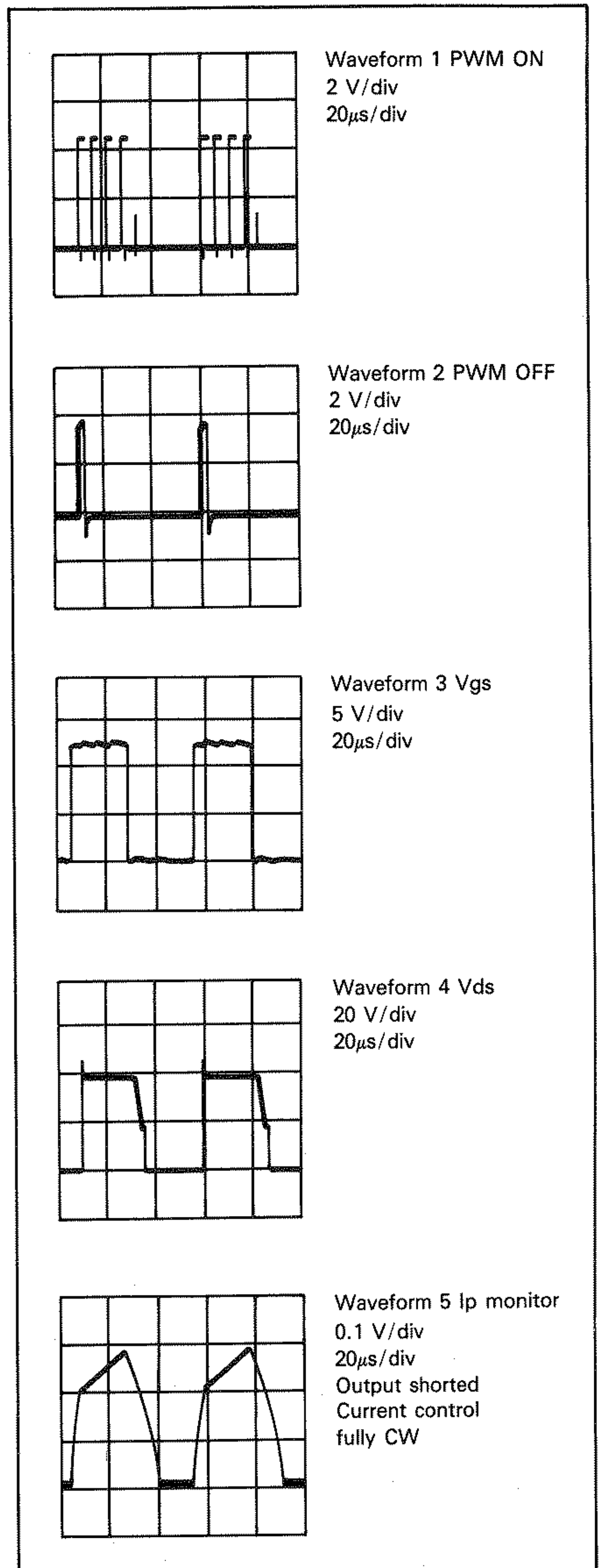


Figure 5.11 Waveforms

and has a voltage gain of 16. Its output is summed with CC PROGRAM at CC Error Amp A2U2B.

5-131 The measurements below verify that the operational amplifier circuits provide expected positive and negative dc voltage gain when the CC loop is open and the power mesh shut down.

5-132 Circuits Included. Constant Current (CC) Circuit on A2 control board.

5-133 Setup. The Main Troubleshooting Setup, paragraph 5-73, except connect the external supply with polarity reversed to the unit's +OUT (−) and −OUT (+) terminals. Apply the ac mains voltage to the bias transformer. Set the external supply to 3.0 Adc constant current with a voltage limit in the range 5 to 20 Vdc. Set IP to 0 Vdc by connecting to P ▽ or set IP to +5 Vdc by connecting to A2J3-1 according to SETUP below.

5-134 Outputs:

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

5-135 If the failure symptoms include output current oscillation, check if the differentiator circuit is at fault by removing resistor A2R16 (3.3 MΩ). If oscillations stop, the differentiator is probably at fault.

5-136 Troubleshooting Down Programmer

5-137 The down programmer decreases the output when either MASTER ENABLE is low or CV ERROR is more negative than about −6 Vdc. Comparator A4U3B triggers down programming when the voltage at A4U3B-5 is less than about 3 Vdc. The collector-emitter current through transistor A4Q6 increases as the output voltage decreases because of feedback from voltage divider A4R24-A4R27 at A4U3A-2.

5-138 Circuit Included. Down programmer and 8.9 V bias supply on A4 power mesh board.

5-139 Setup. The Main Troubleshooting Setup, Paragraph 5-73, except connect the external supply to the unit's +OUT (+) and −OUT (−) terminals. Apply the ac mains voltage to the bias transformer. Set the external supply (EXTERNAL) and adjust the unit's voltage setting (INTERNAL) as instructed below.

5-140 Outputs:

	SET VOLTAGE (Vdc)			
NODE	EXT.	INT.	SETUP	MEASUREMENT
A4U4(OUT)	–	–		8.9 Vdc
A4U3B-7	0	2	unplug TS1	0 Vdc
A4U3B-7	10	0	reconnect TS1	0 Vdc
A4U3B-7	0	2		7.8 Vdc
A4U3A-2	0	2	unplug TS1	0.43 Vdc
A4F1	0	2		0.2 Vdc
A4Q6(base)	0	2		1.0 Vdc
A4U3A-1	20	2		4.0 Vdc
A4F1	20	2		0.11 Vdc

5-141 Troubleshooting OVP Circuit

5-142 Comparator A2U14D sets, and gate A2U17A resets, flipflop A2U14B-A2U14C. TTL low at A2U14-1,8,13 inhibits the PWM.

5-143 Circuit included. OVP Circuit and 2.5V bias supply on A2 control board.

5-144 Setup. The Main Troubleshooting Setup, Paragraph 5-73, except connect the external supply to the unit's +OUT (+) and −OUT (−) terminals. Apply the ac mains voltage to the bias transformer. Adjust the unit's OVP limit to 15 Vdc. Set the external supply (EXTERNAL) as instructed below.

5-145 Outputs:

	SET VOLTAGE (Vdc)			
NODE	EXT.	INT.	SETUP	MEASUREMENT
A2U9(OUT)	–			2.5 Vdc
A2U14-10	10			1.0 Vdc
A2U14-11	–			1.5 Vdc
A2J3-13	10			hi
A2J3-13	20			lo
A2J3-13	10			lo
A2J3-13	10		cycle power	hi

NOTE

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

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. Hewlett-Packard Part Number.
c. Total Quantity (TQ) used in that assembly (given the first time the particular part number appears).
d. Description. Refer to Table 6-2 for abbreviations.
e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.
f. Manufacturer's Part Number or Type.

6-3 Parts not identified by reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous.

Table 6-1. Reference Designators

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

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

6-4 ORDERING INFORMATION

6-5 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 6-2. Description Abbreviations

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

Table 6-3. Code List of Manufacturers

Code	Manufacturer	Address
00853	Sangamo Electric Company	Pickens, Sc
01121	Allen Bradley Company	Milwaukee, WI
01295	Texas Instruments Inc, Semicon Comp Div.	Dallas, TX
03508	G.E. Company, Semicon Prod. Dept.	Auburn, N.Y.
04713	Motorola Semiconductor Products	Phoenix, AZ
07263	Fairchild Semiconductor Div.	Hicksville, N.Y.
14936	General Instruments Corp, Semicon Prod	Hicksville, N.Y.
16299	Corning Glass Works, Component Division	Raleigh, NC
19701	Mepco/Electra Corporation	Mineral Wells, TX
20940	Micro-Ohm Corporation	El Monte, CA
24546	Corning Glassworks	Bradford, PA
27014	National Semiconductor Corporation	Santa Clara, CA
27167	Corning Glassworks	Wilmington, NC
28480	Hewlett-Packard	Palo Alto, CA
32997	Bourns Inc.	Riverside, CA
55576	Synertek	Santa Clara, CA
56289	Sprague Electric Company	North Adams, MA
71400	Bussman Division of McGraw Edison Co.	St. Louis, MO
75042	TRW Inc, Philadelphia Division	Philadelphia, PA
82877	Rotron Inc	Woodkstock, N.Y.
IB546	Varo Semiconductor Inc	Garland, TX
3L585	RCA Corporation, Solid State Div	Somerville, N.J.
H9027	Schurter AGH	Luzern, Switzerland
S0545	Nippon Electric Company	Tokyo, Japan

Table 6-4. Replacement Parts List

Ref Desig	HP Part No	Qty	Description 6023A POWER SUPPLY	Mfr Code	Mfr Part No
	06023-60021	1	A1 Main Board Assembly	28480	
C1	0160-4962	2	fxd cer 1uF +20% 250Vac	28480	
C2,3	0180-3426	2	fxd elect 590uF +50-10% 200V	28480	
C4	0180-3427	1	fxd cer 300uF +50-10% 400V	28480	
C5	0160-4962		fxd cer 1uF +20% 250Vac	28480	
C6,7	0160-5933	4	fxd cer .022uF 10% 1500V	28480	
C8-10	0180-3425	3	fxd elect 5500uF +50-10% 40V	28480	
C11,12	0160-5377	2	fxd cer 2.2uF +10% 6.3V	28480	
C13,14	0160-5933		fxd cer .022uF 10% 1500V	28480	
C15,16	0160-4355	2	fxd met ppr .01uF +10% 250Vac	28480	
C17	0160-5422	1	fxd cer .047uF +20% 50V	28480	
C18,19			NOT USED		
C20,21	0180-3428	2	fxd elect 1000uF 50V		
C22,23	0160-4439	2	fxd met ppr 4700pF +20% 250V	28480	
CR1	1901-1087	2	pwr rect 600V 3A 200ns	04713	MR856
CR2	1901-0759	2	pwr rect 600V 3A	14936	1N5406
CR3	1901-1087		pwr rect 600V 3A 200ns	04713	MR856
CR4	1901-0759		pwr rect 600V 3A	14936	1N5406
CR5			NOT USED		
CR6,7	1901-0731	5	pwr rect 400V 1A	28480	
CR8,9	1901-0050	2	switching 80V 200mA	28480	
CR10-12			NOT USED		
CR13-15	1901-0731		pwr rect 400V 1A	28480	
F1			NOT USED		
F2	2110-0007	1	fuse, 1A 250V	75915	313001
J1	1251-5927	1	connector, post type 26-cont	28480	
J2	1251-5384	1	connector, post type 3-cont	28480	
J3	1251-8676	1	connector, post type 5-cont	28480	
K1	0490-1417	1	relay, DPST		
L1	06024-80094	1	choke, RFI, 3A (used with magnetic core 9170-0721)	28480	
L2			NOT USED		
L3	5080-1981	1	choke, output, 0.5uH	28480	
R1	0811-3667	1	fxd ww 20 5% 7W	28480	
R2	0811-1856	1	fxd ww 250 5% 5W	28480	
R3	5080-2007	1	sensing resistor .005	28480	
R4	0683-1025	2	fxd comp 1k 5% 1/4W	01121	CB1025
R5	8151-0013	5	wire, 22 AWG	28480	
R6	0683-1025		fxd comp 1k 5% 1/4W	01121	CB1025
R7			NOT USED		
R8-10	8151-0013		wire, 22 AWG	28480	
R11	0698-6322	1	fxd film 4k 0.1% 1/8W	28480	
R12	0698-8695	1	fxd film 36k 0.1% 1/8W	28480	
R13			NOT USED		
R14	0698-3572	1	fxd film 60.4 1% 1/8W	24546	C4-1/8-T0-6042-F
R15	8151-0013		wire, 22 AWG	28480	
R16			NOT USED		
R17,18	0683-1005	2	fxd comp 10 5% 1/4W	01121	CB1005
R19	0683-1055	1	fxd comp 1M 5% 1/4W	01121	CB1055
R20,21	0811-1867	2	fxd ww 15k 5% 5W	28480	
R22,23	0686-1065	2	fxd comp 10M 5% 1/2W	01121	EB1055
R24,25	0686-1035	2	fxd comp 10k 5% 1/2W	01121	EB1035

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R26	0683-3315	1	fxd comp 330 5% 1/4W	01121	CB3315
S1	3101-0402	1	switch, DPST rocker (mounted on front chassis)	28480	
S2	3101-1914	1	switch 2-DPDT, slide	28480	
S3			NOT USED		
S4	3101-2046	1	switch DPDT, slide	28480	
T1	5080-1978	1	transformer, power	28480	
T2	9170-1264	1	core, magnetic (used with primary wire 06023-80004)	28480	
T3	5080-1982	1	transformer, bias	28480	
T4	5080-1984	1	choke, line, 2mH	28480	
TP1,2	1251-5613	2	connector, single contact	28480	
U1	1906-0006	1	rectifier bridge 400V 1A	1B546	VE48
W1,2	06023-80003	2	jumper, output 10 AWG	28480	
XA2P1	1251-8665	1	connector, post type 30-cont	28480	
XA2P2	1251-8667	1	connector, post type 20-cont	28480	
XA4P1,2	1251-8806	2	connector, DIN type 32-cont F	28480	
	06023-60023	1	A2 Control Board Assembly	28480	
C1	0160-5469	3	fxd film 1uf +10% 50V	28480	
C2	0160-5422	22	fxd cer. .047uf +20% 50V	28480	
C3	0160-4801	6	fxd cer. 100pf +5% 100V	28480	
C4-6			NOT USED		
C7	0160-5422	24	fxd cer. .47uf +20% 50V	28480	
C8	0160-4812	5	fxd cer. 330pf +5% 100V	28480	
C9	0160-5377	1	fxd cer. 2.2uf +10% 63V	28480	
C10,11	0160-5469		fxd film 1uf +10% 50V	28480	
C12,13	0160-5422		fxd cer .047uf +20% 50V	28480	
C14	0180-0291	3	fxd elec 1uf +10% 35V	56289	150D105X9035A2
C15	0180-1731	1	fxd elec 4.7uf +10% 50V	56289	150D475X9050B2
C16,17	0180-0230	2	fxd elec 1uf +20% 50V	56289	150D105X0050A2
C18,19	0180-0291		fxd elec 1uf +10% 35V	56289	150D105X9035A2
C20	0180-2624	1	fxd elec 2000uf +75-25% 10V	28480	
C21	0160-5098	2	fxd cer 0.22uf +10% 50V	28480	
C22	0160-4832	2	fxd cer .01uf +10% 100V	28480	
C23	0180-3407	1	fxd elec 2200uf +50V-10% 35V		
C24	0160-5098		fxd cer 0.22uf +10% 50V	28480	
C25	0160-4833	1	fxd cer .022uf +10% 100V	28480	
C26	0160-0154	1	fxd poly 2200pf +10% 200V	28480	
C27,28	0160-5422		fxd cer .047uf +20% 50V	28480	
C29	0160-4808	3	fxd cer 470pf +5% 100V	28480	
C30	0160-4830	1	fxd 2200pf +10% 100V	28480	
C31	0160-4808		fxd cer 470pf +5% 100V	28480	
C32	0160-4801	6	fxd cer 10pf +5% 100V	28480	
C33-37	0160-5422		fxd cer .047uf +20% 50V	28480	
C38	0160-4801	2	fxd cer 100pf +5% 100V	28480	
C39	0160-5422		fxd cer .047uf +20% 50V	28480	
C40	0160-5422		fxd cer .047uf +20% 50V	28480	
C41	0160-4835	1	fxd cer 0.1uf +10% 50V	28480	
C42	0160-4805	2	fxd cer 47pf +5% 100V	28480	
C43	0160-5422		fxd cer .047uf +20% 50V	28480	
C44	0160-4805		fxd cer 47pf +5% 100V	28480	
C45	0160-4808		fxd cer 470pf +5% 100V	28480	
C46	0160-4807	1	fxd cer 33pf +5% 100V	28480	

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
C47	0160-4822	1	fxd cer 1000pF +5% 100V	28480	
C48	0160-5422		fxd cer .047uf +20% 50V	28480	
C49	0160-5644	1	fxd cer .033uf +10% 50V	28480	
C50	0160-0167	1	fxd poly .082uf +10% 200V	28480	
C51	0160-4801		fxd cer 100pf +5% 100V	28480	
C52,53	0160-4831		fxd cer 4700pf +10% 100V	28480	
C54	0160-5422		fxd cer .047uf +20% 50V	28480	
C55,56	0160-4801		fxd cer 100pf +5% 100V	28480	
C57	0160-5422		fxd cer .047uf +20% 50V	28480	
C58	0160-5422		fxd cer 0.047uf +20% 50V	28480	
C59	0160-4812	4	fxd cer 220pf +5% 100V	28480	
C60	0160-5422		fxd cer .047pf +20% 50V	28480	
C61	0160-4812		fxd cer 220pf ;5% 100V	28480	
C62	0160-5422		fxd cer .047pf ;20% 50V	28480	
C63	0180-0116	1	fxd elect 6.8uf +10% 35V	28480	
C64,65	0160-5422		fxd cer .047pf +20% 50V	28480	
C66	0180-0376	1	fxd elect .47uf +10% 35V	56289	150D105X9035A2
C67,68	0160-4812		fxd cer 220pf +5% 100V	28480	
C69	0160-4832		fxd cer .01uf +10% 100V	28480	
C70	0180-1980	1	fxd elect 1uf +5% 35V	28480	
C71	0160-5422		fxd cer .047pf +20% 50V	28480	
CR1,2	1901-0033	12	gen prp 180V 200mA	28480	
CR3	1901-0050	15	switching 80V 200mA	28480	
CR5-7	1901-0033		gen prp 180V 200mA	28480	
CR8-10	1901-0050		switching 80V 200mA	28480	
CR11	1901-0992	1	pwr rect 40V 3A	28480	
CR12-16	1901-0033		gen prp 180V 200mA	28480	
CR17			NOT USED		
CR18	1901-0033		gen prp 180V 200ma	28480	
CR19	1901-0050		switching 80V 200mA	28480	
CR20	1901-0033		gen prp 180V 200ma	28480	
CR21-30	1901-0050		switching 80V 200mA	28480	
J1,2	1251-8417	2	connector, post type 16-cont	28480	
L1	06023-80090	1	choke, bias, 820uH	28480	
L2			NOT USED		
P1	1251-8664	1	connector, post type 30-cont	28480	
P2	1251-8666	1	connector, post type 20-cont	28480	
Q1,2	1855-0413	2	J-FET P-chan D-mode SI	27014	2N5116
Q3	1854-0635	1	NPN SI	03508	D44H5
Q4	1853-0012	1	PNP SI	01295	2N2904A
Q5	1854-0823	1	NPN SI	28480	
Q6	1858-0023	1	transistor array, 16-pin	3L585	CA3081E
R1	0683-5125	4	fxd comp 5.1K 5% 1/2W	01121	EB5125
R2	0683-3925	2	fxd comp 39K 5% 1/4W	01121	CB3925
R3	0698-6329	1	fxd film 845 1% 1/8W	28480	
R4	0683-1035	6	fxd comp 10k 5% 1/4W	01121	CB1035
R5	0698-7880	1	fxd film 28.7k 1% 1/8W	19701	MF4C1/8-T9-2875F
R6	0683-5125	5	fxd comp 5.1k 5% 1/4W	01121	CB5125
R7	0683-4745	1	fxd comp 470k 5% 1/4W	01121	CB4745
R8	2100-3353	2	trmr 20k 10% 1-turn side adj	28480	
R9	2100-3350	3	trmr 200 10% 1-turn side adj	28480	
R10	0683-5625	2	fxd comp 5.6k 5% 1/4W	01121	CB5625
R11	0698-3136	1	fxd film 17.8K 1% 1/8W	24526	CT4-1/8-T0-1782-F
R12	0683-1025	2	fxd comp 1k 5% 1/4W	01121	CB1025
R13	0683-2735	4	fxd comp 27k 5% 1/4W	01121	CB2735

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R14	0686-5125		fxd comp 5.1K 5% 1/2W	01121	EB5125
R15	0683-2015	4	fxd comp 200 5% 1/4W	01121	CB2015
R16	0683-3355	1	fxd comp 3.3M 5% 1/4W	01121	CB3355
R17	0683-6835	2	fxd comp 68k 5% 1/4W	01121	CB6835
R18	0683-3035	1	fxd film 30K 5% 1/4W	01121	CB3035
R19	0683-4735	2	fxd comp 47k 5% 1/4W	01121	CB4735
R20	0683-1035		fxd comp 10k 5% 1/4W	01121	CB1035
R21	2100-3350		trmr 200 10% 1-turn side adj	28480	
R22	2100-3353		trmr 20k 10% 1-turn side adj	28480	
R23	2100-3273	1	trmr 2k 10% 1-turn side adj	28480	
R24	2100-3350		trmr 200 10% 1-turn side adj	28480	
R25	2100-3207	1	trmr 5k 10% 1-turn side adj	28480	
R26	0683-1045	4	fxd comp 100k 5% 1/4W	01121	CB1045
R27	0698-6322	2	fxd film 4k 0.1% 1/8W	28480	
R28	0683-1045		fxd comp 100k 5% 1/4W	01121	CB1045
R29	0698-4416	2	fxd film 169 1% 1/8W	24546	C4-1/8-T0-169R-F
R30	0683-7545	3	fxd comp 750k 5% 1/4W	01121	CB7545
R31	0698-6322		fxd film 4k 0.1% 1/8W	28480	
R32	0698-4416		fxd film 169 1% 1/8W	24546	C4-1/8-T0-169R-F
R33	0698-4447	1	fxd film 280 1% 1/8W	24546	C4-1/8-T0-280R-F
R34	0757-0404	1	fxd film 130 1% 1/8W	24546	C4-1/8-T0-131-F
R35	0698-4608	1	fxd film 806 1% 1/8W	24546	C4-1/8-T0-806R-F
R36	0757-0438	2	fxd film 5.11k 1% 1/8W	24546	C4-1/8-T0-5111-F
R37,38	0683-1035		fxd comp 10k 5% 1/4W	01121	CB1035
R39	0686-2005	1	fxd comp 20 5% 1/2W	01121	EB2005
R40	0683-1005	2	fxd comp 10 5% 1/4W	01121	CB1005
R41,42	0686-6215	2	fxd comp 620 5% 1/2W	01121	EB6215
R43	0683-1515	1	fxd comp 150 5% 1/4W	01121	CB1515
R44	0757-0434	1	fxd film 3.65k 1% 1/8W	24546	C4-1/8-T0-3651-F
R45	0757-0442	6	fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F
R46,47	0757-0283	2	fxd film 2k 1% 1/8W	24546	C4-1/8-T0-2001-F
R48,49	0686-1315	2	fxd comp 130.5% 1/2W	01121	EB1315
R50	0811-3174	1	fxd ww .07 5% 5W	28480	
R51	0698-6076	1	fxd film 39k 1% 1/8W	24546	C4-1/8-T0-3902-F
R52	0757-0280	2	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
R53	0698-4121	1	fxd film 11.3k 1% 1/8W	24546	C4-1/8-T0-1132-F
R54	0683-2015		fxd comp 200 5% 1/4W	01121	CB2015
R55	0683-5655	1	fxd comp 5.6M 5% 1/4W	01121	CB5655
R56	0757-0408	1	fxd film 243 1% 1/4W	28480	
R57	0683-1325	1	fxd comp 1.3k 5% 1/4W	01121	CB1325
R58	0683-1045		fxd comp 100k 5% 1/4W	01121	CB1045
R59	0698-8816	1	fxd film 2.15 1% 1/8W	28480	
R60	0757-0199	1	fxd film 21.5k 1% 1/8W	24546	C4-1/8-T0-2152-F
R61	0699-0059	2	fxd film 5k 0.1% 0.1W	28480	
R62	0698-3432	1	fxd film 26.1 1% 1/8W	03888	PME551/8T026R1F
R63	0699-0059		fxd film 5k 0.1% 0.1W	28480	
R64	0683-5125		fxd comp 5.1k 5% 1/4W	01121	CB5125
R65,66	0699-0118	2	fxd film 20k 0.1% 0.1W	28480	
R67,68	0686-5125		fxd comp 5.1K 5% 1/2W	01121	EB5125
R69	0683-2225	7	fxd comp 2.2k 5% 1/4W	01121	CB2225
R70	0683-2015		fxd comp 200 5% 1/4W	01121	CB2015
R71	0683-2735		fxd comp 27k 5% 1/4W	01121	CB2735
R72	0757-0465	1	fxd film 100k 1% 1/8W	24546	C4-1/8-T0-1003-F
R73,74	0683-2035	3	fxd comp 20k 5% 1/4W	01121	CB2035

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No.	Qty	Description	Mfr Code	Mfr Part No.
R75	0683-7545		fxd comp 750k 5% 1/4W	01121	CB7545
R76	0683-4735		fxd comp 47K 5% 1/4W	01121	CB4735
R77	0683-7545		fxd comp 750K 5% 1/4W	01121	CB7545
R78	0757-0415	1	fxd film 475 1% 1/8W	28480	
R79	0698-6983	1	fxd film 20.4k 0.1% 1/8W	19701	MF4C1/8-T9-2042B
R80	0698-6320	1	fxd film 5k 0.1% 1/8W	03888	PME551/8T95001B
R81	0757-0459	1	fxd film 56.2k 1% 1/8W	24546	C4-1/8-T0-5622-F
R82	0683-3325	1	fxd comp 3.3k 5% 1/4W	01121	CB3325
R83	0757-0270	1	fxd film 249k 1% 1/8W	24546	C4-1/8-T0-2493-F
R84	0683-5125		fxd comp 5.1k 5% 1/4W	01121	CB5125
R85	0698-3450	1	fxd film 42.2k 1% 1/8W	24546	C4-1/8-T0-4222-F
R86	0757-0452	1	fxd film 27.4k 1% 1/8W	24546	C4-1/8-T0-2742-F
R87	0683-2715	2	fxd comp 270 5% 1/4W	01121	CB2715
R88,89	0683-2225		fxd comp 2.2k 5% 1/4W	01121	CB2225
R90	0683-2715		fxd comp 270 5% 1/4W	01121	CB2715
R91	0683-2225		fxd comp 2.2k 5% 1/4W	01121	CB2225
R92	0683-2015		fxd comp 200 5% 1/4W	01121	CB2015
R93	0683-5125		fxd comp 5.1k 5% 1/4W	01121	CB5125
R94	0683-1035		fxd comp 10k 5% 1/4W	01121	CB1035
R95	0757-0472	1	fxd film 200k 1% 1/8W	24546	C4-1/8-T0-2003F
R96	0698-3572	1	fxd film 60.4 1% 1/8W	24546	C4-1/8-T0-6042-F
R97	0683-5125		fxo comp 5.1k 5% 1/4W	01121	CB5125
R98	0683-2735		fxd comp 27k 5% 1/4W	01121	CB2735
R99	0683-1035		fxd comp 10k 5% 1/4W	01121	CB1035
R100,101	1810-0365	4	res network 6-SIP 2.2K x 5	01121	206A222
R102,103	0757-0449	2	fxd film 20k 1% 1/8W	24546	C4-1/8-T0-2002-F
R104	0757-0280		fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
R105	0698-3430	1	fxd film 21.5 1% 1/8W	03888	PME551/8T021R5F
R106	0698-3449	1	fxd film 28.7k 1% 1/8W	24546	C4-1/8-T0-2872-F
R107	0698-3153	1	fxd film 3.83k 1% 1/8W	24546	C4-1/8-T0-3831-F
R108	0683-2035		fxd comp 20k 5% 1/4W	01121	CB2035
R109	0683-2225		fxd comp 2.2k 5% 1/4W	01121	CB2225
R110	0683-4725	6	fxd comp 4.7k 5% 1/4W	01121	CB4725
R111	0683-2025	2	fxd comp 2k 5% 1/4W	01121	CB2025
R112	0683-1125	3	fxd comp 1.1k 5% 1/4W	01121	CB1125
R113	0757-0442		fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F
R114	0757-0424	1	fxd film 1.1k 1% 1/8W	24546	C4-1/8-T0-1101-F
R115	0683-1015	1	fxd comp 100 5% 1/4W	01121	CB1015
R116	0698-3498	1	fxd film 8.66k 1% 1/8W	24546	C4-1/8-T0-8661-F
R117	0757-0438		fxd film 5.11k 1% 1/8W	24546	C4-1/8-T0-5111-F
R118	1810-0365		res network 6-SIP 2.2k x 5	01121	206A222
R119	0757-0288	1	fxd film 9.09 1% 1/8W	19701	MF4C1/8-T0-9091F
R120	0683-1005		fxd comp 10 5% 1/4W	01121	CB1005
R121	0757-0442		fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F
R122	0683-5135	1	fxd film 51K 5% 1/4W	19701	(CR-25)1-4-5P-51
R123-126	0683-4725		fxd comp 4.7k 5% 1/4W	01121	CB4725
R127	0683-1855	1	fxd comp 1.8M 5% 1/4W	01121	CB1855
R128	0683-6835		fxd comp 68k 5% 1/4W	01121	CB6835
R129	0757-0439	1	fxd film 6.81k 1% 1/8W	24546	C4-1/8-T0-6811-F
R130	0683-1055	1	fxd comp 1M 5% 1/4W	01121	CB1055
R131	0683-3335	1	fxd comp 33k 5% 1/4W	01121	CB3335
R132	0683-2225		fxd comp 2.2K 5% 1/4W	01121	CB2225
R133	0683-2735		fxd comp 27k 5% 1/4W	01121	CB2735
R134	0757-0466	1	fxd film 110k 1% 1/8W	24546	C4-1/8-T0-1103-F
R135,136	0757-0442		fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R137	0698-3455	1	fxd film 261k 1% 1/8W	24546	C4-1/8-T0-2613-F
R138	0683-2045	1	fxd comp 200k 5% 1/4W	01121	CB2045
R139	0757-0442		fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F
R140	0698-3160	1	fxd film 31.6K 1% 1/8W	24546	CT4-1/8-T0-3162-F
R141	0683-1025		fxd comp 1k 5% 1/4W	01121	CB1025
R142	0683-2225		fxd comp 2.2k 5% 1/4W	01121	CB2225
R143	0683-1045		fxd comp 100k 5% 1/4W	01121	CB1045
R144	0683-4725		fxd comp 4.7k 5% 1/4W	01121	CB4725
R145	0683-4715		fxd comp 470 5% 1/4W	01121	CB4715
R146,147	0683-1125		fxd comp 1.1k 5% 1/4W	01121	CB1125
R148	0683-3925		fxd comp 3.9K 5% 1/4W	01121	CB3925
R149	1810-0365		res network 6-SIP 2.2K x 5	01121	206A222
R150,151	0683-1815	2	fxd comp 180 5% 1/4W	01121	CB1815
R165,183			NOT USED		
S1	3101-2097	1	switch 6-1A slide assy	28480	
U1	1826-0493	3	IC op amp L-bias H-impd	04713	MLM308AP1
U2	1826-0346	1	IC op amp GP dual	27014	LM358N
U3	1826-0161	2	IC op amp GP quad	04713	MLM324P
U4	1826-0527	1	IC voltage regulator 1.2/37V neg.	27014	LM337T
U5	1826-0544	2	IC 2.5V voltage reference	04713	MC1403U
U6	1826-0428	1	IC modulator	01295	SG3524J
U7,8	1826-0493		IC op amp L-bias H-impd	04713	MLM308AP1
U9	1826-0544		IC 2.5V voltage reference	04713	MC1403U
U10	1826-0161		IC op amp GP quad	04713	MLM324P
U11	1820-1209	1	IC BFR TTL LS NAND quad	01295	SN74LS38N
U12	1826-0393	1	IC voltage regulator 1.2/37V pos.	27014	LM317T
U13	1820-1112	1	IC FF TTL LS D-type pos-edge-trig	01295	SN74LS74AN
U14	1826-0138	2	IC comparator GP quad	01295	LM339N
U15	1820-1437	1	IC MV TTL LS MONOSTBL dual	01295	SN74LS221N
U16	1826-0065	2	IC comparator PRCN	S0545	UPC311C
U17	1820-1246	1	IC gate TTL LS AND quad	01295	SN74LS09N
U18	1820-0935	1	IC CTR CMOS BIN neg-edge-trig	3L585	CD4020BE
U19	1820-1205	1	IC gate TTL LS AND dual	01295	SN74LS21N
U20	1826-0138				
U21	1826-0065		IC comparator PRCN	S0545	UPC311C
U22	1820-2096	1	IC SHF-RGTR CMOS	3L585	CD4006BE
VR1,2	1902-0018	2	zener 11.7V 5%	04713	1N941
VR3	1902-0777	1	zener 6.2V 5%	04713	1N825
VR4	1902-3110	1	zener 5.9V 2%	28480	
VR5	1902-0575	1	zener 6.5V 2%	28480	
W1-3	7175-0057	3	jumpers wire 22	28480	
Y1	0960-0586	1	cer resonator 320KHZ	28480	
	06023-60020	1	A3 Front Panel Board Assembly		
C1	0160-4807	1	fxd cer 33pF ±5% 100V	28480	
C2-4	0160-5422	8	fxd cer .047uF ±20% 50V	28480	
C5	0160-4805	2	fxd cer 47pF ±5% 100V	28480	
C6	0160-4835	3	fxd cer 0.1uF ±10% 50V	28480	
C7	0160-0168	2	fxd cer 0.1uF ±10% 200V	28480	
C8	0160-5893	2	fxd met .047uF ±10% 100V	28480	
C9	0160-5422		fxd cer .047uF ±20% 50V	28480	

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
C10	0160-4805		fxd cer 47pF ±5% 100V	28480	
C11	0160-4835		fxd cer 0.1uF ±10% 50V	28480	
C12	0160-0168		fxd cer 0.1uF ±10% 200V	28480	
C13	0160-5893		fxd met .047uF ±10% 100V	28480	
C14-15	0160-5422		fxd cer .047uF ±20% 50V	28480	
C16	0160-4831		fxd cer 4700pf ±10% 100V	28480	
C17	0160-5422		fxd cer .047uf ±20% 50V	28480	
C18-79			NOT USED		
C80	0160-4835		fxd cer 0.1uF ±10% 50V	28480	
CR1,2	1901-0033	3	gen prp 180V 200mA	28480	
CR3,4	1901-0050	2	switching 80V 200mA	28480	
CR5	1901-0033		gen prp 180V 200mA	28480	
DS1	1990-0681	2	display, analog	28480	
DS2-4	1990-0540	6	display, numeric	28480	
DS5	1990-0681		display, analog	28480	
DS6-8	1990-0540		dispaly, numeric	28480	
DS9,10	1990-0951	2	LED, green	28480	
J1	1251-5055	1	connector, post type 26-cont	28480	
R1	0683-3925	1	fxd comp 3.9k 5% 1/4W	01121	CB3925
R2	0683-6815	1	fxd comp 680 5% 1/2W	01121	CB6815
R3	0683-2025	1	fxd comp 2k 5% 1/4W	01121	CB2025
R4,5			NOT USED		
R6	2100-1775	1	trmr 5k 5% 1-turn side adj	28480	
R7	0757-0415	1	fxd film 475 1% 1/8W	24546	C4-1/8-T0-475R-F
R8	0683-1045	2	fxd comp 100k 5% 1/4W	01121	CB1045
R9			NOT USED		
R10-57	0683-2015	48	fxd comp 200 5% 1/4W	01121	CB2015
R58	0683-6215	1	fxd comp 620 5% 1/4W	01121	CB6215
R59	0757-0458	3	fxd film 51.1k 1% 1/8W	24546	C4-1/8-T0-5112-F
R60	0757-0270	2	fxd film 249k 1% 1/8W	24546	C4-1/8-T0-2493-F
R61,62	0683-5615	2	fxd comp 560 5% 1/4W	01121	CB5615
R63	0757-0458		fxd film 51.1k 1% 1/8W	24546	C4-1/8-T0-5112-F
R64	0757-0270		fxd film 249k 1% 1/8W	24546	C4-1/8-T0-2493-F
R65	0683-1045		fxd comp 100k 5% 1/4W	01121	CB1045
R66	0698-8498	1	fxd film 1.02k 0.1% 1/8W	28480	
R67	0699-0721	1	fxd film 33k 0.1% 1/8W	28480	
R68	0698-6362	1	fxd film 1k 0.1% 1/8W	28480	
R69	0698-6343	1	fxd film 9k 0.1% 1/8W	28480	
R70			NOT USED		
R71	0698-6363	1	fxd film 40k 0.1% 1/8W	28480	
R72	0698-7353	1	fxd film 19k 1% 1/8W	19701	MF4C1/8-T0-1902F
R73	0757-0280	2	fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
R74	0683-1025	3	fxd comp 1k 5% 1/4W	01121	CB1025
R75	0683-3025	1	fxd comp 3k 5% 1/4W	01121	CB3025
R76			NOT USED		
R77	0757-0458		fxd film 51.1k 1% 1/8W	24546	C4-1/8-T0-5112-F
R78	0698-3159	1	fxd film 26.1k 1% 1/8W	24546	C4-1/8-T0-2612-F
R79	0757-0441	1	fxd film 8.25K 1% 1/8W	28480	
R80	0757-0438	1	fxd film 5.11K ±1% 1/8W	24546	CT4-1/8-T0-5111-F
R81	0683-5135	5	fxd comp 51k 5% 1/4W	01121	CB5135
R82	0683-1025		fxd comp 1k 5% 1/4W	01121	CB1025
R83	0683-5125		fxd comp 5.1k 5% 1/4W	01121	CB5125
R84	0683-1025		fxd comp 1k 5% 1/4W	01121	CB1025
R85	0757-0280		fxd film 1k 1% 1/8W	24546	C4-1/8-T0-1001-F
R86	0698-5808	1	fxd film 4k 1% 1/8W	24546	C4-1/8-T0-4001-F
R87	0698-3201	1	fxd film 80k 1% 1/8W	24546	C4-1/8-T0-8002-F

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R88	0757-0449	1	fxd film 20k 1% 1/8W	24546	C4-1/8-T0-2002-F
R89	0683-5135		fxd comp 51k 5% 1/4W	01121	CB5135
R90	0757-0199	1	fxd film 21.5K ±1% 1/8W	24546	CT4-1/8-T0-2152-F
R91	0683-5235		fxd comp 51K 5% 1/4W	01121	CB5135
R92,93	0757-0452	2	fxd film 27.4k 1% 1/8W	24546	C4-1/8-T0-2742-F
S1,2	5060-9436	2	switch, lighted pushbutton	28480	
U1	1826-0502	2	IC switch analog quad	04713	MC14066BCP
U2	1826-0493	1	IC op amp L-bias H-impd	04713	MLM308AP1
U3	1826-0346	1	IC op amp GP quad	27014	LM358N
U4,5	1826-0876	2	IC A/D CMOS 3-1/2 DGT	15818	ICL7107CPL
U6	1820-1144	1	IC gate TTL LS NOR quad	01295	SN74LS02N
U7	1826-0502		IC switch analog quad	04713	MC14066BCP
U8			NOT USED		
U9	1826-0138	1	IC comparator GP quad	01295	LM339N
VR1	1902-3092	1	zener 4.99V 2%	28480	
VR2	1902-0064	1	zener 7.5V 5%	28480	
W1-3			NOT USED		
W4	7175-0057	3	wire, 22 AWG	28480	
W5-7			NOT USED		
W8	7175-0057		wire, 22 AWG	28480	
W9,10			NOT USED		
W11	7175-0057		wire, 22 AWG	28480	
			A4 Power Mesh Assembly		
C1	0160-5891	1	fxd met 0.47uF +10% 630V	28480	
C2	0160-5422	1	fxd cer .047uF +20% 50V	28480	
C3,4			NOT USED		
C5,6	0160-4960	2	fxd film 2200pF +10% 1.6kV	56289	715P222916LD3
C7	0180-0155	1	fxd elect 2.2uF +20% 20V	56289	150D225X0020A2
C8	0160-0127	1	fxd cer 1uF +20% 25V	28480	
C9	0180-2780	1	fxd elect 470uF +75-10% 16V	28480	
C10	0160-4834	1	fxd cer .047uF +10% 100V	28480	
C11,12	0160-4835	2	fxd cer 0.1uF +10% 50V	28480	
C13	0160-0161	1	fxd poly .01uF +10% 200v	28480	
CR1-4	1901-0050	6	switching 80V 200mA	28480	
CR5,6	1901-1065	2	pwr rect 400V 1A	14936	1N4936
CR7	1901-1127	1	pwr rect 150V 70A	28480	
CR8,9			NOT USED		
CR10,11	1901-0050		switching 80V 200mA	28480	
CR12			NOT USED		
CR13,14	1901-1087	2	pwr rect 600V 3A	04713	MR856
F1,2	2110-0671	2	axial lead, 1/8A	28480	
F3	2110-0546	1	fuse, 5A 125V	28480	
L1,2			NOT USED		
L3	06024-80096	1	inductor, 3A	28480	
L4	9170-1265	1	core, ferrite, 5uH	28480	
P1,2	1251-8807	2	connector, DIN type 32-cont F	28480	
Q1,2	1854-0477	2	NPN SI	04713	2N2222A
Q3,4	1855-0547	2	PFET	28480	
Q5			NOT USED		
Q6	1854-0264	1	NPN SI	04713	2N3715
Q7	1855-0549	1	PFET	28480	
R1,2	0686-0275	2	fxd comp 2.7 5% 1/2W	01121	EB0275
R3	0683-3915	2	fxd comp 390 5% 1/4W	01121	CB3915
R4	0683-1015	2	fxd comp 100 5% 1/4W	01121	CB1015

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
R5	0683-4705	2	fxd comp 47 5% 1/4W	01121	CB4705
R6	0683-1045	2	fxd comp 100k 5% 1/4W	01121	CB1045
R7	0811-1857	2	fxd ww 400 5% 5W	28480	
R8	0698-3601	3	fxd met ox 10 5% 2W	27167	FP42-2-T00-10R0J
R9	0683-3915		fxd comp 390 5% 1/4W	01121	CB3915
R10	0683-1015		fxd comp 100 5% 1/4W	01121	CB1015
R11	0683-4705		fxd comp 47 5% 1/4W	01121	CB4705
R12	0683-1045		fxd comp 100k 5% 1/4W	01121	CB1045
R13	0811-1857		fxd ww 400 5% 5W	28480	
R14	0698-3601		fxd met ox 10 5% 2W	27167	FP42-2-T00-10R0J
R15	0757-0403	1	fxd film 121 1% 1/8W	24546	C4-1/8-T0-121R-F
R16	0683-3305	3	fxd comp 33 5% 1/4W	01121	CB3305
R17	0683-1025	1	fxd comp 1k 5% 1/4W	01121	CB1025
R18	0683-0475	3	fxd comp 4.7 5% 1/4W	01121	CB0475
R19	0683-2025	1	fxd comp 2k 5% 1/4W	01121	CB2025
R20	0683-0275	1	fxd comp 2.7 5% 1/4W	01121	CB0275
R21,22	0683-0475		fxd comp 4.7 5% 1/4W	01121	CB0475
R23	0683-2725	1	fxd comp 2.7k 5% 1/4W	01121	CB2725
R24	0757-0464	1	fxd film 90.9k 1% 1/8W	24546	C4-1/8-T0-9092-F
R25	0686-1005	1	fxd comp 10 5% 1/2W	01121	EB1005
R26	0811-2490	1	fxd ww 0.1 3% 5W	28480	
R27	0698-3225	1	fxd film 1.43k 1% 1/8W	24546	C4-1/8-T0-1431-F
R28	0757-0279	1	fxd film 3.16k 1% 1/8W	24546	C4-1/8-T0-3161-F
R29	0698-3159	1	fxd film 26.1k 1% 1/8W	24546	C4-1/8-T0-2612-F
R30	0698-3202	1	fxd film 1.74k 1% 1/8W	24546	C4-1/8-T0-1741-F
R31	0698-4046	1	fxd film 732 1% 1/8W	24546	C4-1/8-T0-732R-F
R32	0757-0442	1	fxd film 10k 1% 1/8W	24546	C4-1/8-T0-1002-F
R33	0698-3601		fxd met ox 10 5% 2W	27167	FP42-2-T00-10R0J
R34	0698-4484	1	fxd film 19.1k 1% 1/8W	24546	C4-1/8-T0-1912-F
R35,36	0683-3305		fxd comp 33 5% 1/4W	01121	CB3305
R37	0683-3325	1	fxd comp 3.3k 5% 1/4W	01121	CB3325
R38			NOT USED		
R39	0683-1055	1	fxd comp 1M 5% 1/4W	01121	CB1055
T1,2	5080-1983	2	transformer, FET driver	28480	
T3	9100-4350	1	transformer, current	28480	
TS1	3103-0116	1	switch, thermal 100 C	28480	
TP1-4	1251-0646	4	contact connector, post type	28480	
U1,2	1820-1050	2	IC DRVR TTL NOR dual	01295	SN75454BP
U3	1826-0346	1	IC op amp GP dual	27014	LM358N
U4	1826-0393	1	IC voltage regulator 1.2/37V pos	27014	LM317T
VR1			NOT USED		
VR2	1902-3002	1	zener 2.37V 5%	28480	
VR3	1902-0057	1	zener 6.49V 5%	28480	
VR4	1902-0575	1	zener 6.5V 2%	28480	
			Chassis Electrical		
	3160-0343	1	fan, axial tube	28480	
	9135-0223	1	line filter, IEC	28480	
	8120-1348	1	cable assembly (power cord) 18AWG	28480	
	8120-4353	1	cable assembly (A1 board to A3 board)	28480	
	8120-4383	1	cable assembly (Line Cord)	28480	

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
			A1 Board Mechanical Parts		
	1251-0600	2	contact-conn M (Ref Fan)	28480	
A1J1	1251-5927	1	connector post type header	28480	
A1J2	1251-5384	1	connector post type header	28480	
A1J3	1251-8676	1	conncector post type	28480	
XA2P1	1251-8665	1	connector post type	28480	
XA2P2	1251-8667	1	connector post type	28480	
XA4P1,P2	1251-8806	2	Din connector	28480	
	1251-5613	6	single contact connector (ref. AC line voltge select)	28480	
	1480-0552	1	pin, escutcheon (ref. L1)	28480	
	2110-0269	2	fuseholder, clip type (ref. F2)	28480	
A1TB1	0360-2192	1	barrier block	28480	
	0360-2190	4	jumper, barrier block	28480	
			A2 Board Mechanical Parts		
A2P1	1251-8664	1	connector post type	28480	
A2P2	1251-86[illegible]6	1	connector post type	28480	
A2J1,J2	1251-8417	2	Din connector	28480	
	1200-0485	1	socket, IC 14-contact (ref. S1)	28480	
	1205-0282	3	heatsink (ref. Q2, U15, U16)	28480	
	1531-0309	2	clevis (ref. A2 Board)	28480	
	0360-2195	1	barrier block	28480	
			A3 Board Mechanical Parts		
	4040-2121	4	plastic (ref. DS9-12)	28480	
A1J1	1251-5055	1	connector post type header	28480	
			A4 Board Mechanical Parts		
A4P1,P2	1251-8807	2	Din connector	28480	
	0362-0335	2	single contact connector (AC)	28480	
	1205-0256	2	heatsink (ref. Q3, Q4)	28480	
	1205-0282	1	heatsink (ref. Q7)	28480	
	1531-0309	3	clevis (ref. A4 Board)	28480	
	06023-20001	1	heatsink (ref. CR7)	28480	
	06023-80002	1	jumper, 10 AWG	28480	
	0380-1679	4	hex head stand off (ref.Q3, Q4)	28480	
TP1-4	1251-0646	4	connector single contact (pin)	28480	
			Chassis Mechanical Parts		
	0380-1489	1	spacer, snap in	28480	
	0370-1091	2	knob, base round	28480	
	0403-0282	6	bumper feet	28480	
	1510-0044	1	binding post, single	28480	
	2110-0564	1	fuseholder body (chassis fuse)	H9027	031.1657

Table 6-4. Replacement Parts List (Cont.)

Ref Desig	HP Part No	Qty	Description	Mfr Code	Mfr Part No
	2110-0565	1	fuseholder cap (chassis fuse)	28480	
	2110-0569	1	fuseholder nut (chassis fuse)	28480	
	3160-0309	1	finger guard (ref.fan)	28480	
	4040-1954	1	window, display	28480	
	5020-8847	2	trim strip	28480	
	5001-0440	2	trim, side 7"	28480	
	5020-8817	1	frame front	28480	
	5040-7201	4	foot	28480	
	5040-7203	1	strip, top trim	28480	
	5040-7219	1	retainer, strap handle	28480	
	5040-7220	1	retainer, strap handle	28480	
	5041-0309	3	key cap, quarter	28480	
	5060-9803	1	assembly, handle strap	28480	
	7120-1254	1	nameplate	28480	
	7120-8572	1	Canadian Standards Association Label (ref. rear panel)		
	7121-2527	1	Metric and Inch Label (ref. rear panel)	28480	
	7121-2794	1	Serial Identification Label (ref. rear panel)	28480	
	06023-00001	1	chassis	28480	
	06023-00002	1	cover, top	28480	
	06023-00003	1	cover, bottom	28480	
	06023-00004	1	bracket, upper	28480	
	06023-00006	1	panel, sub	28480	
	06023-00007	1	bus bar, negative	28480	
	06023-00008	1	bus bar, positive	28480	
	06023-00009	1	cover, bar block	28480	
	06023-00010	1	cover, (top plate screened)	28480	
	06023-00011	1	rear panel, screened	28480	
	06023-00012	1	front panel, screened	28480	
	06023-81003	1	Line Voltage Lable (ref. rear panel)	28480	
	06023-90001	1	operating and service manual	28480	
			Option 220 (220V Operation)		
	2110-0055	1	fuse 4A 250V (rear chassis)	28480	
	2110-0383	1	fuse 8A 250V (rear chassis)	28480	
	7120-8572	1	label, info	28480	
	06023-81001	1	label, info	28480	
			Option 240 (240V Operation)		
	2110-0055	1	fuse 4A 250V (rear chassis)	28480	
	2110-0383	1	fuse 8A 250V (rear chassis)	28480	
	7120-8572	1	label, info	28480	
	06023-81002	1	label, info	28480	

Section VII
COMPONENT LOCATION ILLUSTRATIONS AND CIRCUIT DIAGRAMS

7-1 This section contains component location diagrams, schematics, and other drawings useful for maintenance of the power supply. Included in this section are:

a. Component location illustrations (Figure 7-2 through 7-5), showing the physical location and reference designators of almost all electrical parts. (Components located on the rear panel are easily identified.)

b. Notes (Table 7-1) that appy to all schematic diagrams.

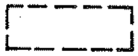
c. Figures 7-6 and 7-7 illustrate the detailed schematic of the HP 6023. Test points are called out and short explantory notes are positioned close to the related circuit to enchance schematic readability.

WARNING

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

Table 7-1. Schematic Diagram Notes

1.  denotes front-panel marking.

2.  denotes rear-panel marking.

3. Complete reference designator consists of component reference designator prefixed with assembly number (e.g.: A2R14).

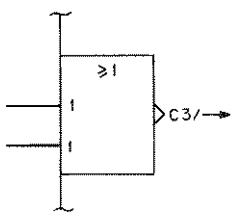
4. Resistor values are in ohms. Unless otherwise noted, resistors are either 1/4 W, 5% or 1/8 W, 1%. Parts list provides power rating and tolerance for all resistors.

5. Unless otherwise noted, capacitor values are in microfarads.

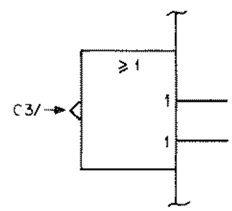
6. Square p.c. pads indicate one of the following:
   a. pin 1 of an integrated circuit.
   b. the cathode of a diode or emitter of a transistor.
   c. the positive end of a polarized capacitor.

7. In schematic symbols drawn to show right-to-left signal flow, blocks of information are still read left to right. For example:

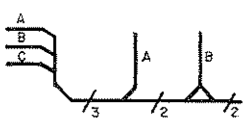
left to right



right to left



→ indicates shift away from control block (normally down and to right), ← indicates shift toward control block (normally up and to left).

8. 

indicates multiple paths represented by only one line. Reference designators with pin numbers indicate destination, or signal names identify individual paths. Numbers indicate number of paths represented by the line.

9. Inter-board commons have letter identifications (e.g.: ∇L); commons existing on a single assembly have number identifications (e.g.: ∇2).

10. For single in-line resistor packages, pin 1 is marked with a dot. For dual in-line integrated circuit packages, pin 1 is either marked with a dot, or pin 1 is to the left (as viewed from top) of indentation at end of integrated circuit package, e.g.:

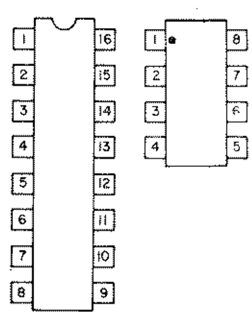
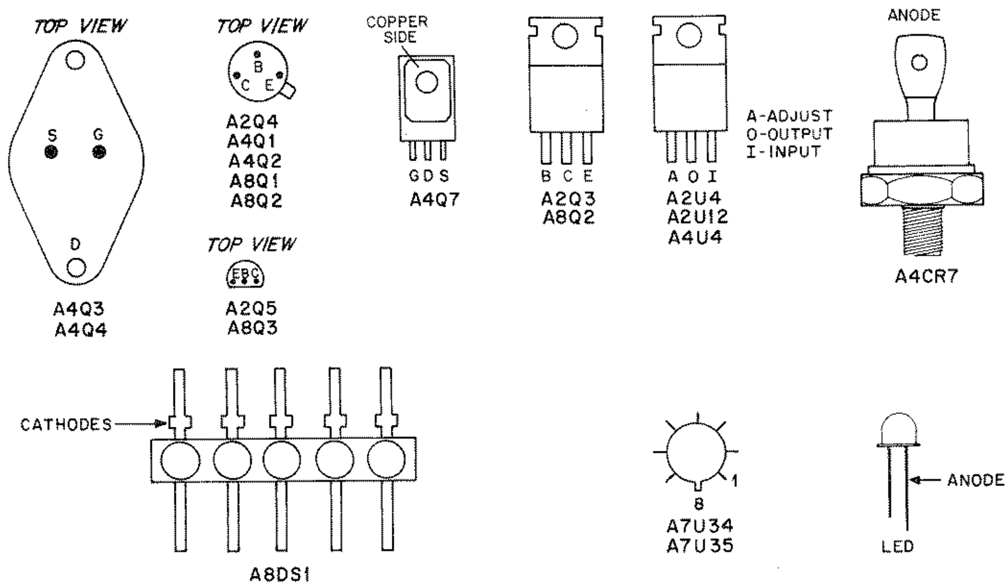


Table 7-1. Schematic Diagram Notes (cont.)

Pin locations for other semi-conductors are shown below:



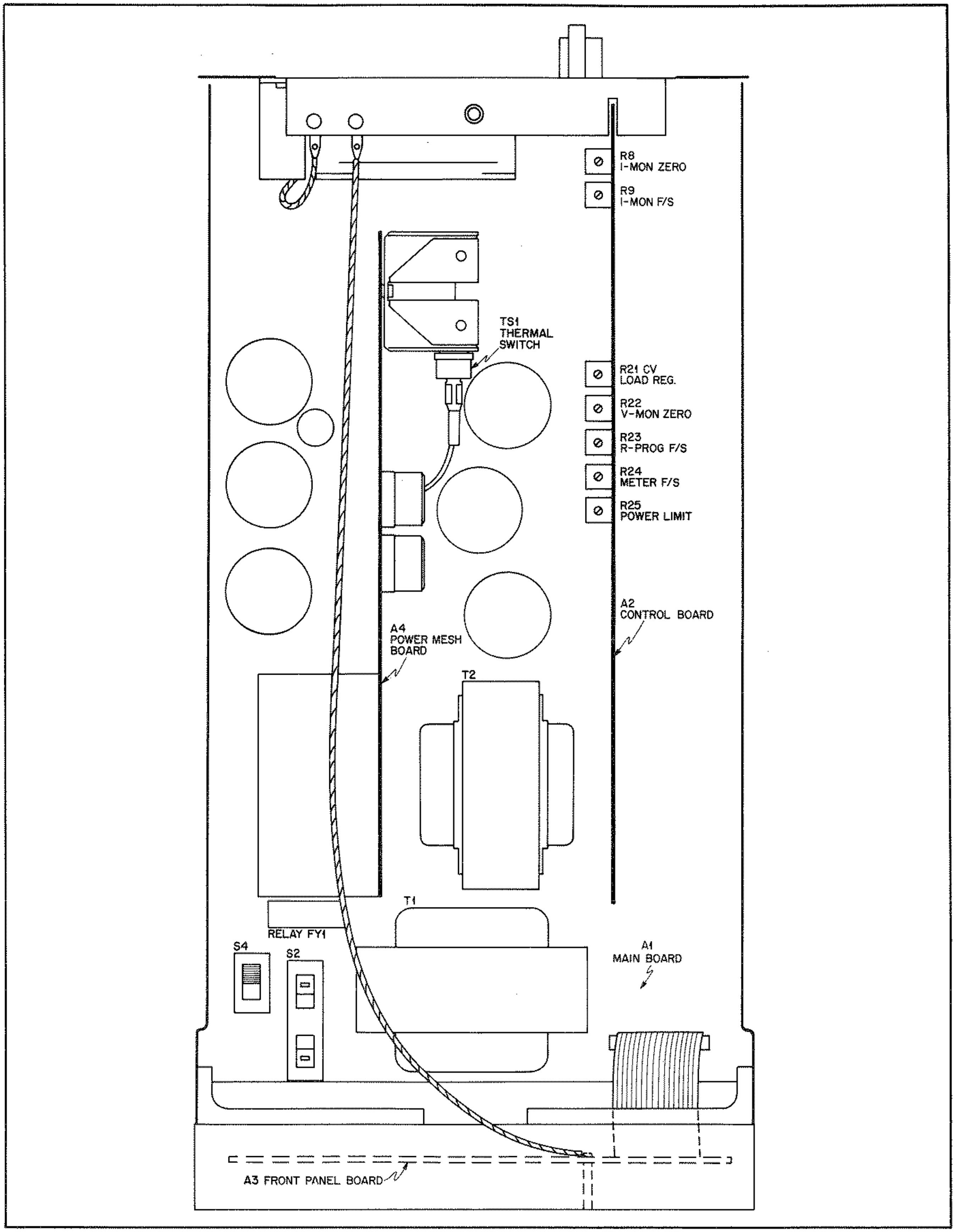


Figure 7-1. Top View — Top Cover Removed

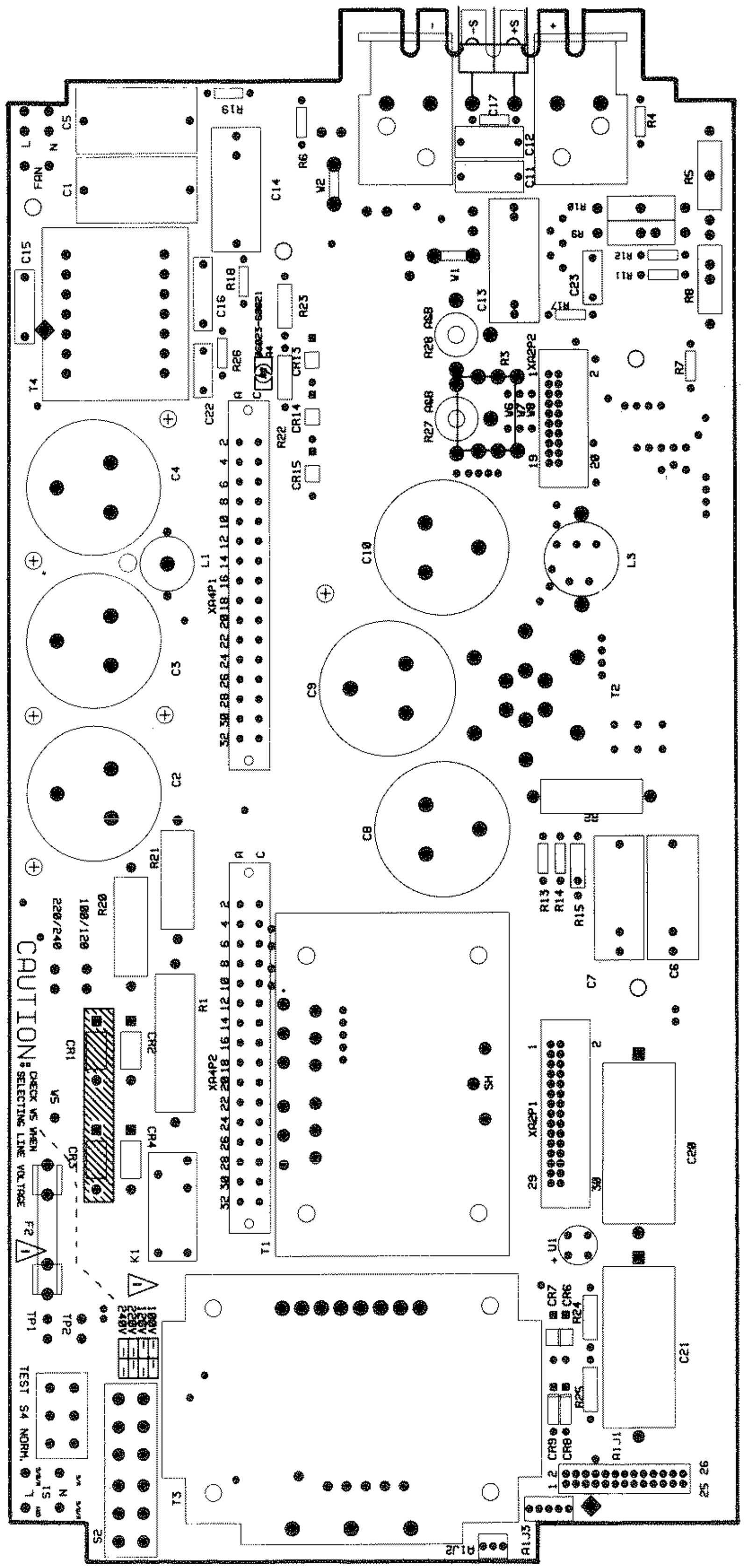


Figure 7-2. Main Board (A1) Component Location

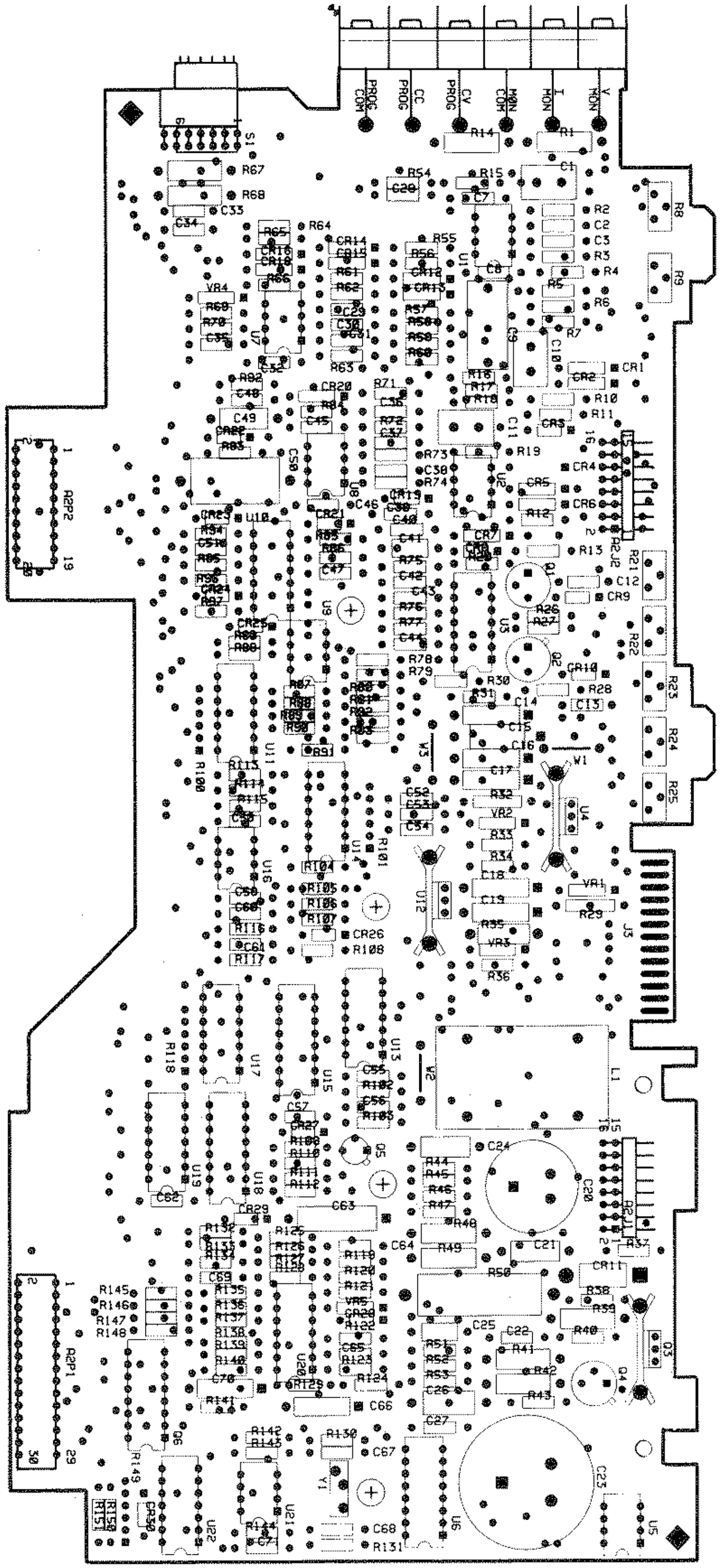


Figure 7-3. Control Board (A2) Component Location

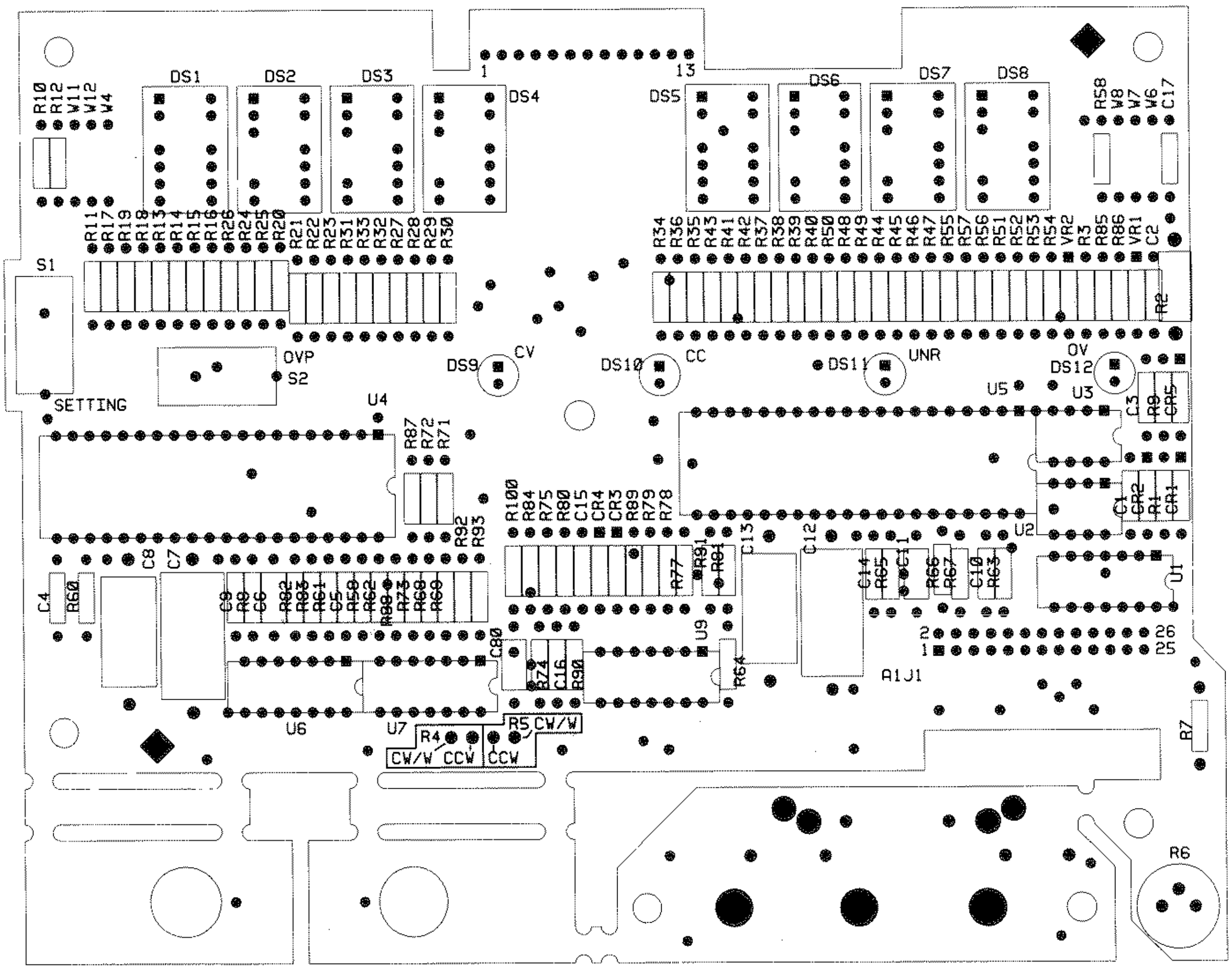


Figure 7-4. Front Panel Board (A3) Component Location

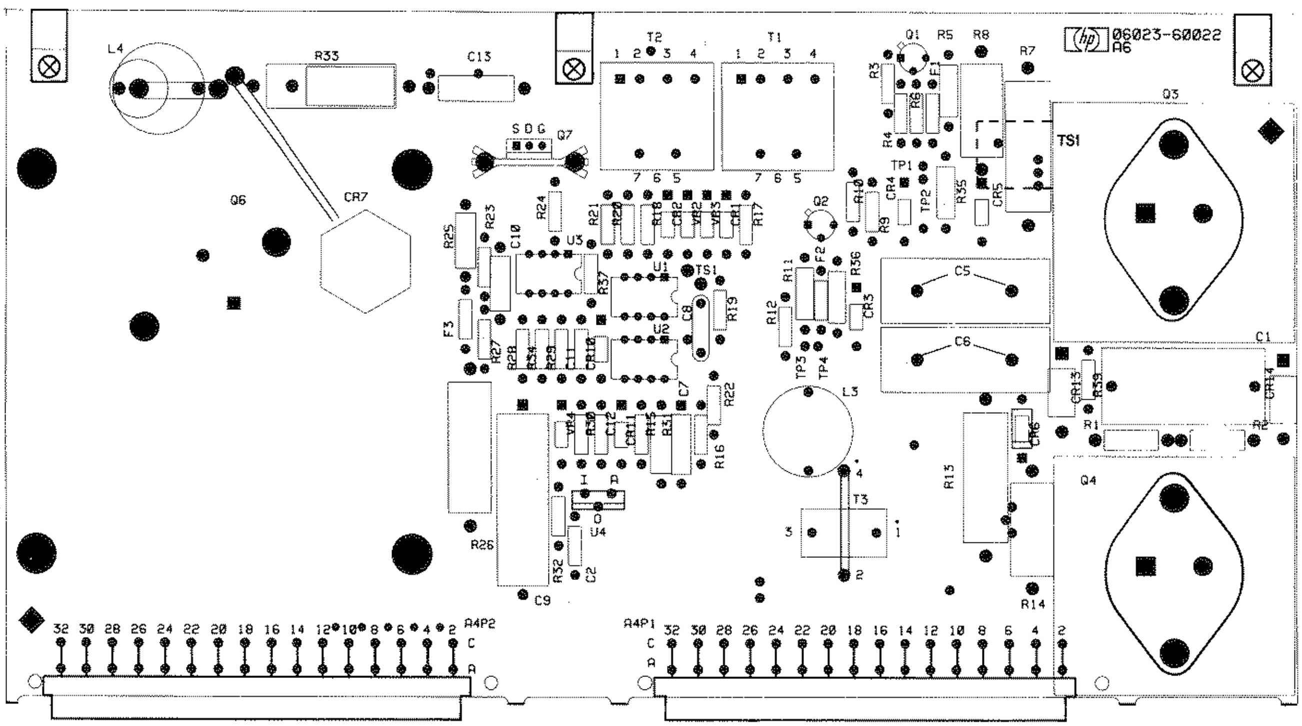


Figure 7-5. Power Mesh Board (A4) Component Location

Appendix A
SYSTEM OPTION 002

A-1 GENERAL INFORMATION

A-2 This option facilitates the operation of the power supply in an automated system. Four major circuit blocks provide: 1) remote analog programming of the supply's output by three different control methods; 2) signals indicating the power supply modes and conditions; 3) two different digital methods of remote control; and 4) the outputs of three bias supplies for use with external circuitry.

A-3 The power supply equipped with this option can be operated from either a 6940B Multiprogrammer equipped with a 69520A power supply programming card or a 6942A Multiprogrammer equipped with a 69709A power supply programming card.

A-4 **Remote Programming.** Through this interface both the output voltage and current can be remote programmed by either an external voltage source, resistance, or a current sink.

A-5 **Status Indicators.** Six optically isolated lines provide open-collector digital outputs which indicate the following states: constant voltage mode, constant current mode, output unregulated, ac dropout, overvoltage, and overtemperature.

A-6 **Remote Control.** Two optically isolated methods of remote control are available. One method requires a negative going edge, which sets a latch on the 002 card to inhibit the power supply. The latch and OVP are reset by a negative-going pulse on another input line. The second method of remote control requires a low logic level to inhibit the power supply for the duration of the low level.

A-7 **Bias Supplies.** The outputs of three bias supplies are also available at the option connector. These outputs are +15 V, −15 V, and +5 V.

A-8 **Monitoring.** The 002 Option Board provides two monitoring outputs (I.MON. and V.MON) available at the option connector. They both vary from 0 to 5 V corresponding to a 0 to full scale output.

A-9 Other modes of operation, such as multiple supply system control, are described in detail in later paragraphs. Modes such as Auto series, Auto Parallel, and Auto tracking operation are decsribed in section three of the main text.

A-10 Specifications

A-11 Table A-1 provides specifications for the Option 002. This table is referred to periodically throughout the text of this Appendix.

A-12 Option 002 Hardware

A-13 The Option 002 hardware consists of a single printed circuit board installed at the right side (facing the front panel) of the 6023A chassis. Two cables connect the option board to the A2 control board at A2J1 and A2J2. Connections between the option board and external circuits are made via the 37-pin connector mounted on the option board and available at the rear of the power supply. A mating connector is also included for the user's convenience.

Table A-1. Specifications, Option 002

Remote Programming

Resistance Programming: 0 to 4 k ohm provides 0 to maximum rated voltage or current output.

Accuracy: @ 25 °C:
CV: 0.5% +12 mV TC: 70 ppm+0.6 mV/°C
CC: 1.0% +110 mA TC: 100 ppm +1.5 mA/°C

Voltage Programming: 0 to 5 V provides 0 to maximum rated voltage or current output.

Accuracy: @25°C
CV: 0.25% +12 mV TC: 10 ppm +0.6 mV/°C
CC: 0.30% +110 mA TC: 70 ppm +1.5 mA/°C

Current Programming: 0 to 2 mA current sink provides 0 to maximum rated voltage or current output.

Accuracy: @25°C
CV: 0.38% +16 mV TC: 30 ppm +0.65 mV/°C
CC: 0.43% +115 mA TC: 75 ppm +1.6 mA/°C

Input Compliance Voltage: ±1 V

Current Programming Enable:

Relays K2 (CV) and K1 (CC) are biased from the Control Isolator Bias input (see Remote Shutdown and OVP Clear)

Relay Bias Voltage: +4 V minimum
+7 V maximum

Relay Resistance: 500Ω ± 10%

NOTE

For Control Isolator Bias voltages greater than 7 V, a series resistor must be used to maintain the relay bias voltage within specified limits.

Enabling either relay is accomplished by bringing CV or CC enable line to Control Isolator Bias common via a suitable driver; maximum driver off-state leakage =0.5 mA.

Table A-1. Specifications, Option 002 (cont.)

Output Voltage and Current Monitor: 0 to 5 V output indicates 0 to maximum rated output voltage or current.
Accuracy: @ 25 ±5° C:
CV: 0.25% +2 mV TC: 10 ppm +0.2 mV/°C
CC: 0.30% +15 mA TC: 70 ppm +1.5 mA/°C

Output Impedance: 10.2 k ohm ±5%
Temperature Coefficient:
CV: 70 ppm/°C +600 μV/°C
CC: 100 ppm/°C +2.0 mA/°C

Status Indicators:
Status Isolator Bias input (referred to Status Isolator Common)
Voltage Range: +4.75 V to 16 V
Current Drain: 20 mA maximum

Status Indicator output:
Open collector output:
Maximum Output Voltage (logic high): +16 V
Logic Low Output: + 0.4 V maximum at 8 mA

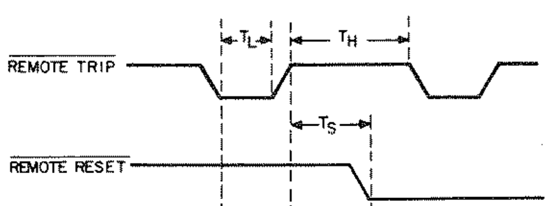
Remote Control (Trip, Reset, Inhibit) Control Isolator Bias Input
Voltage Range: +4.75 V to 16 V

Remote Control Inputs (Remote Trip , Remote Reset) Remote Inhibit
On State (logic low):
Minimum forward current required (I_f): 1.6 mA isolator forward voltage (V_f) at 1.6 mA (I_f): 1.4 V typical, 1.75 maximum.

For Control Isolator Bias voltage greater than +5 V, an optional resistor (Ropt) may be added to reduce drive current.

Off state (logic high) maximum leakage current: 100 μA.

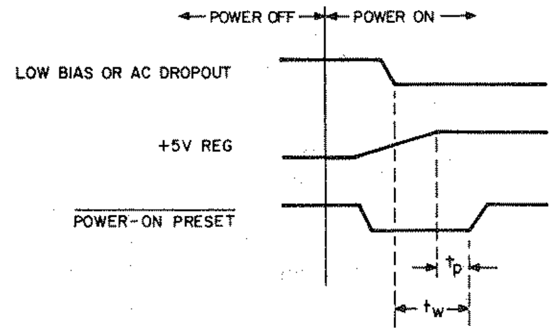
REMOTE TRIP and REMOTE RESET Timing:



Pulse duration (T_L): 15 μs minimum
Reset time (T_H): 125 μs minimum
Set-up time (T_S): 25 μs minimum
OVP clear delay: 1 sec ±30%

Power-On Preset
Output Ratings: open collector output (referred to power supply common)

Maximum output voltage (logic high): +16 V
Logic low output: +0.4 V maximum at 8 mA
Pulse Timing



Low Bias or AC DROPOUT will go false after 5V supply stabilises.

Bias Supplies
DC Output Ratings: (25°C ± 5)
No Load to Full Load 104 V to 127 V line

+5 V ±3% at 100 mA
+15 V ±3% at 75 mA
−15 V ±4% at 75 mA

Short Circuit Output Current:

+5 V	125 mA ±6%
+15 V	103 mA ±6%
−15 V	103 mA ±6%

PARD (Typical):

+5 V	25 mV pk-pk	1.5 mV Rms
+15 V	Same	Same
−15 V	Same	Same

Isolation:

Status Indicator lines and Remote Control lines may be floated a maximum of 250 Vdc from ground from the power supply or from each other. These lines may not be connected to any primary circuits.

Jumpers Designation

W1—jumpered:	OV indication @ A7J3-17 is active (lo) if OVP; Remote Trip or Remote Inhibit is active.
W1—open:	OV indication is active (lo) if OVP or Remote Trip is active.
Normal Operation as shipped:	W3 and W4 jumpered W2 and W5 open.

OVP Programmable
CV: W2 jumpered; W3 open
CC: W5 jumpered; W4 open
S1A,B in open position

A-14 INSTALLATION

A-15 When installing the board, perform the following steps:

a. Remove the top and inner cover of the power supply as discussed in Section 5 under Repair and Replacement.
b. Remove the plate next to the barrier strip on the rear panel of the supply by unscrewing the 2 M3 screws.
c. Insert the already prepared 002 board in the slot closest to the right side (looking from the front panel) of the supply.
d. Use the two M3 screws to connect the rear end of the 002 board to the rear panel of the supply.
e. Attach ribbon cables from the A2 Control Board A2J1 to A7J1 and A2J2 to A7J2.
f. Replace the inner and outer cover of the supply.

A-16 Connector Assembly Procedure

A-17 The following instructions decribe assembly of the mating connector provided to interface the user's system with the option connector, J3. Figure A-1 identifies the parts of the mating connector.

Proceed as follows:

NOTE

It may be desireable to set up a test interface before final assemble of the mating connector to allow checkout of the system. A mating connector with pins accessible for temporary wiring is available from Hewlett-Packard, HP part number 1251-4464.

If the cable assembly presents RFI or ESD problems, a shielded cable assembly accessory HP part number 5060-2890 can be ordered.

a. If a multi-wire cable is being used (as opposed to individual wires), remove approximately 1 ½ inches of cable insulation from the end. Be careful not to cut the insulation on the Individual wires.
b. Strip 3/16 inch of insulation from the end of each wire to be used.
c. Insert each wire into a contact pin (1) and crimp firmly.
d. Insert each pin into a proper hole in connector-pin house (2) from rear. Pins will lock into housing when fully inserted.

NOTE

Once the pins are locked into the connector-pin housing, they are extremely difficult to remove. Therefore, be certain pin is in proper hole before inserting fully.

e. *Screw a slotted set-screw (3) partially into a square nut (4) and place in position in connector shield assembly (6).*
f. Place strain relief (5) in position in connector shield assembly (6), just under set screw (3). Be certain that strain relief is oriented as shown in Figure A-1.
g. Place connector pin housing (2) in shield assembly (6) and route cable through cable entrance.
h. Fold connector assembly (6) and secure with three screws.
i. Strain relief set screw (3) can now be adjusted from top of connector to clamp firmly on cable.
j. Clip fasteners (7) onto ends of connector pin housing (2).
k. Connector can now be plugged onto option connector J3 and secured with two screws (8) into the threaded stand-offs on either side of J3.

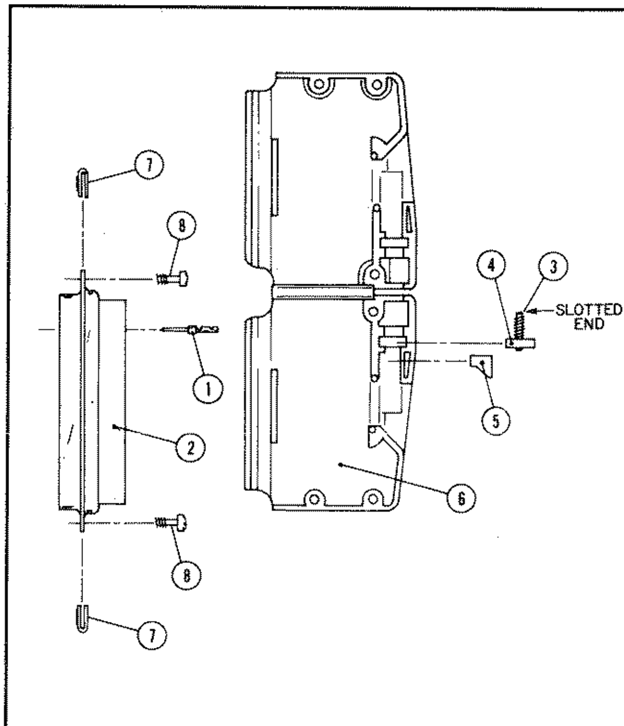


Figure A-1. Mating Connector Assembly

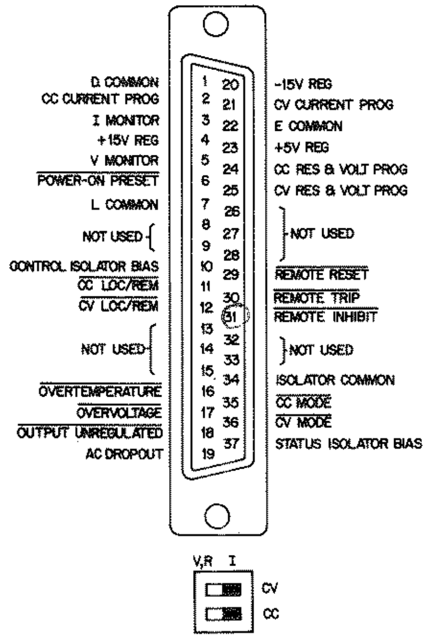
A-18 OPERATION

A-19 The following paragraphs provide the operating instructions necessary to interface a 002-equipped power supply into an automated system. A brief description of some circuits is also provided. The unit is shipped for front panel operation with mode switch settings as follows:

B1	B2	B3	B4	B5	B6
0	1	1	0	1	1

Before beginning, switch the power supply's rear panel MODE switches B1 thru B6 to their correct positions for the programming source being used, (see Table A-2).

Next switch A1 and A2 also on the rear panel, to the correct program source function, see Figure A-2. All connections are made at the 37-pin rear panel connector J3, and can be wired directly into the mating connector supplied for this purpose.



PROGRAM SOURCE FUNCTION	SWITCH POLE CV	CC
CV AND CC CURRENT PROGRAMMING	1	1
CV AND CC RES. & VOLT PROGRAMMING	0	0

Figure A-2. 002 Option Rear Panel Connector J3 and Switches A1 and A2.

A-20 Local/Remote Programming

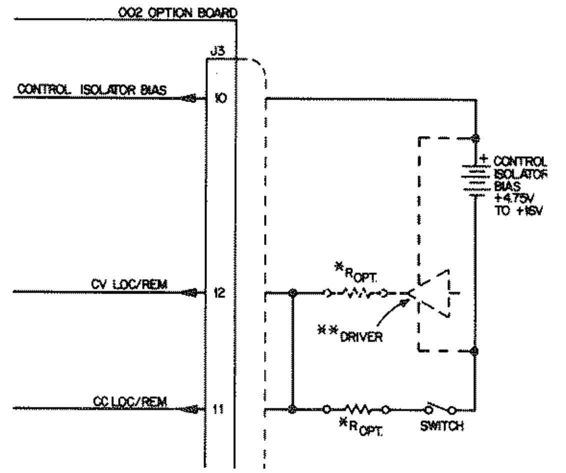
WARNING

When switching to local control, remember to set Front Panel Voltage and Current Control to safe levels.

A-21 Local Programming (Figure A-3). The supply can be switched back and forth between remote and local programming while initially checking out a remote programming circuit. For proper operation of local programming, the user must supply the bias voltage (CONTROL ISOLATOR BIAS). The Control Isolator Bias voltage can range from +4.75 V to +16 V depending upon the user's interface circuits. Refer to Specifications Table A-1. For local programming, take the Control Isolator Bias common and connect it to both of the LOC/REM terminals, and position mode switch as indicated in paragraph A-19.

CAUTION

Although CONTROL ISOLATOR BIAS can be +4.75 V to +16 V, a supply voltage of more than 7 V may damage the relays. Therefore, if CONTROL ISOLATOR BIAS exceeds 7 V it is necessary to use a resistor in series with each of the LOC/REM terminals. Figure A-4 provides a graph



*FOR CONTROL ISOLATOR BIAS VOLTAGES GREATER THAN 7V, A SERIES RESISTOR MUST BE USED TO MAINTAIN THE RELAY BIAS VOLTAGE WITHIN THE SPECIFIED 4 TO 7 VOLTS.

**IF SOLID STATE CIRCUITRY IS USED, THE DRIVER MUST BE CAPABLE OF SINKING 10mA OF CURRENT.

Figure A-3. Accessing Local Programming while in Remote Programming Mode

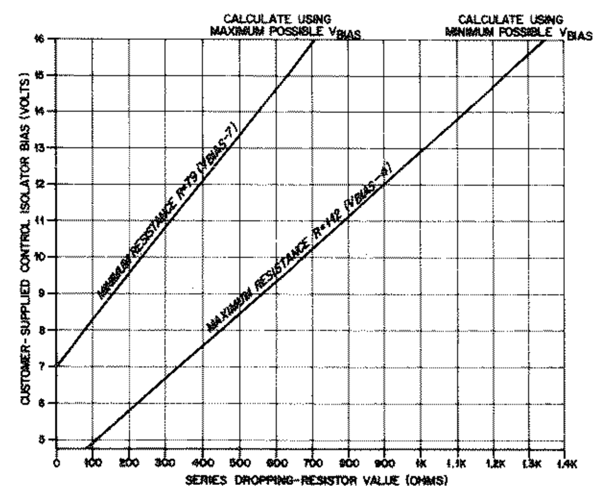


Figure A-4. Calculating Value of Series Dropping Resistor

from which the proper series resistance value can be determined. Note that the tolerances of both the Control Isolator Bias and the resistor must be taken into account. The actual Control Bias used in Figure A-4 is obtained after subtracting any driver gate voltage drop.

If solid state circuitry is used, connect the Control Isolator Bias to a driver capable of sinking 10 mA of current, then connect the driver's output to both of the LOC/REM terminals. Refer to figure A-3. Either method will enable relays K1 (CV) and K2 (CC) to switch regulation to the front panel VOLTAGE and CURRENT controls. For Control Isolator Bias voltages greater than 7 V, a resistor (Ropt) must be used in series with the Control Isolator Bias common or the Driver's output. Figure A-4 provides a graph for determining the proper series resistance value depending on the Control Isolator Bias voltage being used.

A-22 The supply can be returned to the remote programming mode by switching off the Control Isolator Bias common or by increasing the Driver's output signal to within 1 V of the Control Isolator Bias voltage. If remote programming is solely desired, leave the LOC/REM terminals open and make the proper connections to the RESISTOR/VOLTAGE PROG. or CURRENT PROG. terminals (see Figures A-5,A-6, A-7).

Table A-2. Mode Switch settings for enabling different Programming Sources

Program Source	Switch Pole Settings					
	Mode					
	B1	B2	B3	B4	B5	B6
Resistance	0	0	1	0	0	1
Voltage or Current	0	1	0	0	1	0

A-23 Remote Resistance Programming

A-24 Check switches A1 and A2 on the rear panel, they must be in their correct positions for CV and CC resistance/voltage programming (see figure A-2). A resistance variable from 0 to 4 K ohms can be used to program the output voltage or current from 0 to full scale. To program the output voltage, connect the variable resistance between J3-25 (CV RES/VOLT PROG.) and J3-22 (E COM.). To program the output current, connect the variable resistance from J3-24 (CC RES/VOLT PROG.) to J3-22 (E COM).

CAUTION

If the programming lines become open circuited during resistance programming (user's system becomes disconnected from J3), the power supply's output will tend to rise above rating. The supply will not be damaged if this occurs, but the user's load may be damaged. To protect the load, be sure that the overvoltage trip point is properly adjusted and that the CAUTION of paragraph 3-48 is observed.

A-25 Remote Voltage Programming (Figure A-6). Check switches A1 and A2 on the rear panel, they must be in the correct positions for CV and CC resistance/ voltage programming (see figure A-2). A voltage source variable from 0 to 5 volts, can be used to program the output voltage or current from 0 to full scale. The load on the programming source is less than 1 mA. To program voltage, the voltage source should be connected from J3-25 (CV RES & VOLT PROG) to J3-22 (E COM). To program current, the voltage source should be connected from J3-24 (CC RES & VOLT PROG) to J3-22 (E. COMMON). If the programming lines become open circuited (user's system becomes disconnected from J3) during voltage programming, the Programming Protection circuit will reduce the power supply output to zero.

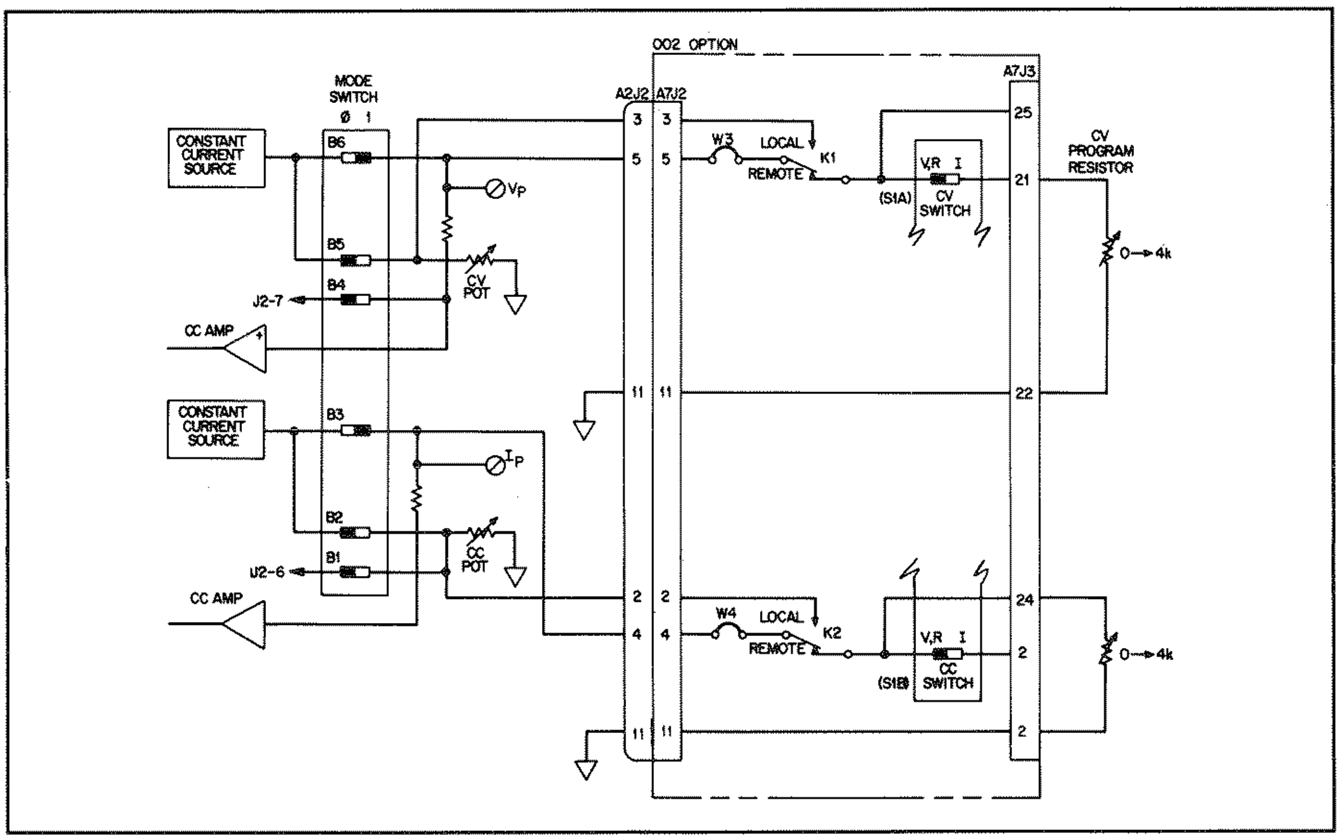


Figure A-5. Remote Resistance Programming

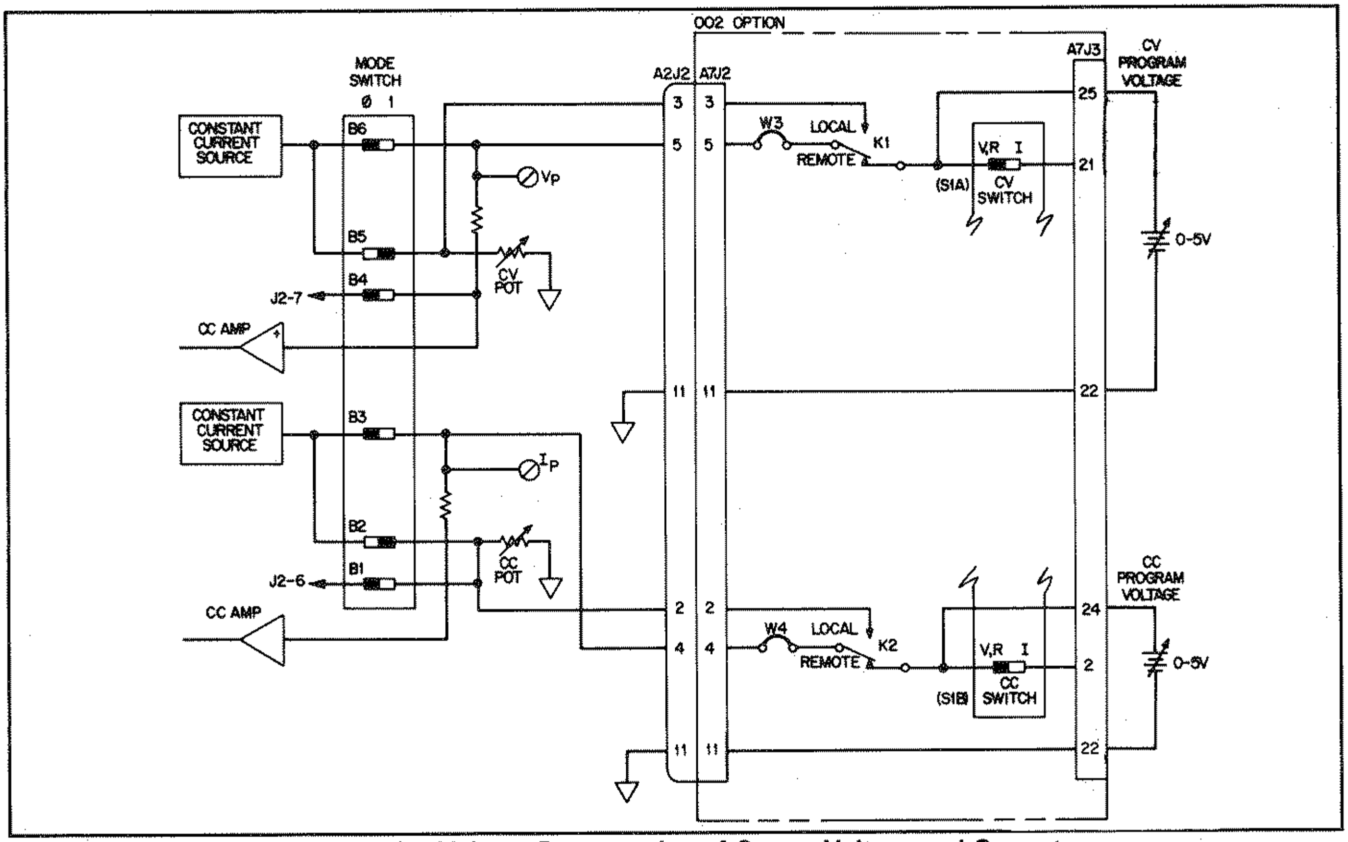


Figure A-6. Voltage Programming of Output Voltage and Current

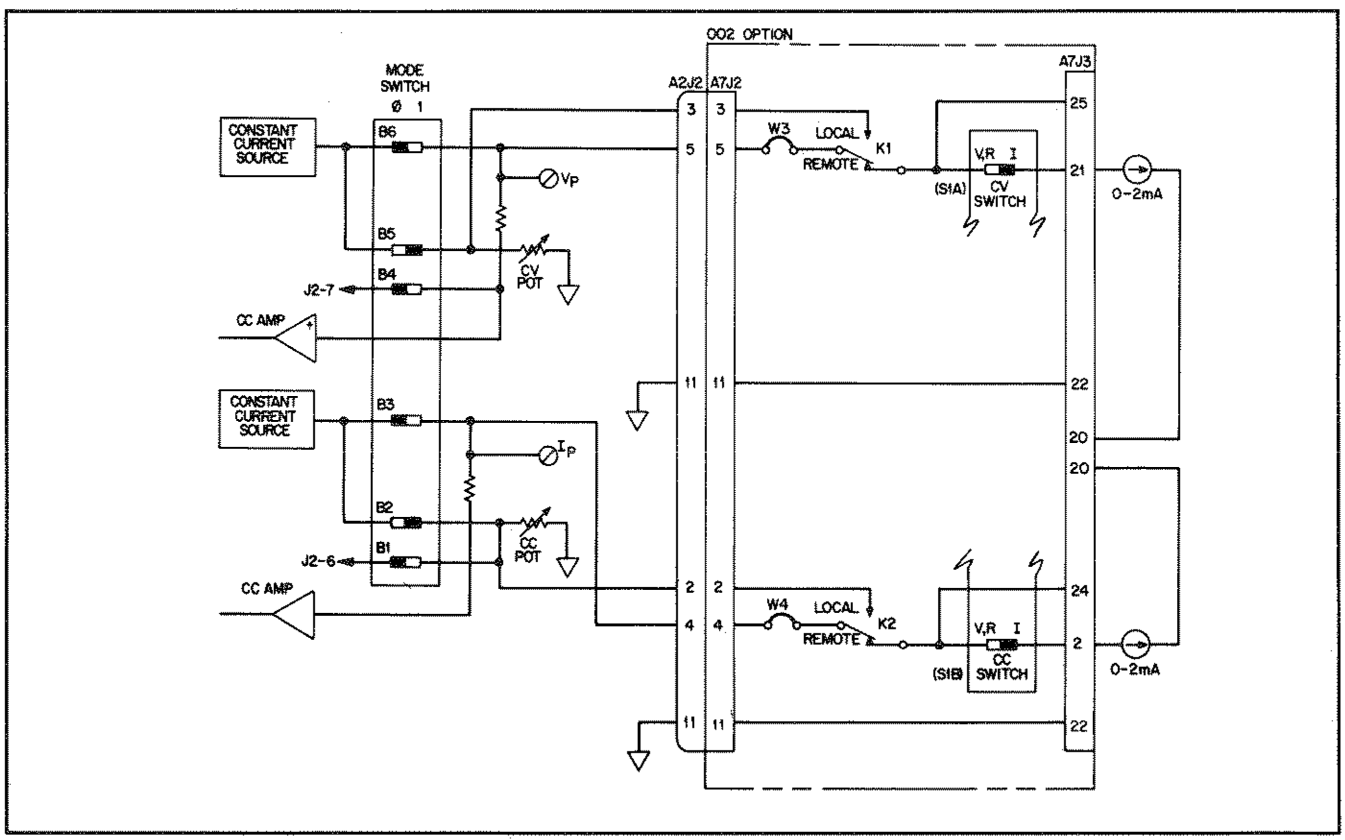


Figure A-7. Current Programming of Output Voltage and Current

A-26 Current Programming (Figure A-7). Check switches A1 and A2 on the rear panel, they must be in the correct positions for CV and CC current programming (see Figure A-2). A current sink variable from 0 to 2mA, can be used to program the output voltage or current from 0 to full scale (see Figure A-7). The following paragraph provides a brief circuit description, refer to schematic diagram.

A-27 To program voltage, the current sink should be connected from J3-21 (CV CURRENT PROG) to J3-20 (− 15 V). To program current, the current sink should be connected from J3-2 (CC CURRENT PROG) to J3-20 (− 15 V). Current sinks can connect to the power supply (− 15 V) or to an external negative supply that is referenced to the L. COMMON of the power supply.

A-28 The 0 to 2mA current sink will cause the output signal of op-amps U17 and U18 to vary proportionally from 0 to 5 volts. These signals are then coupled through relays K1 and K2 and then on to the A2 Board's CV and CC circuits which, in-turn, will program the supply's output from 0 to full scale. If the programming lines become open circuited (user's system becomes disconnected from J3) during current programming, the Programming Protection circuit will bring the power supply output to zero.

A-29 Remote Monitoring

A-30 The 002 Option board provides a protected 0 to 5 V output corresponding to a full scale voltage output. The voltage monitor output is available between pins J3-5 (V. Monitor) and J3-1 (D COMMON).

CAUTION

Observe the caution described in paragraph A-21.

Output impedance is 10 k ohm; the monitoring device input impedance should be at least 1 M ohm to limit error to 1% + basic accuracy; 10 M ohm to limit error to 0.1% + basic accuracy.

A-31 The I. MON signal from the mainframe is also brought out through the 002 Option board. A 0 to full scale current-monitor output is available between pins J3-3 (I. MON) and J3-1 (D COMMON). Output impedance is 10 k ohms; the monitoring device input impedance should be at least 1 M ohm to limit error to 1% + basic accuracy.

A-32 In some applications it may be desirable to install a noise-suppression capacitor on these monitor outputs to lessen the effects of noise induced in the monitor leads. The capacitors should be ceramic or tantalum type, from 0.1 to 1 uf. The capacitor is installed directly across the monitor device input terminals.

A-33 Status Indicators

A-34 Six optically isolated lines provide open collector digital outputs which indicate certain modes and conditions of power supply operation. For proper supply operation of the opto-isolators, the user must supply the bias voltage, (ISOLATOR BIAS). This voltage can be from +4.75 V to +16 V depending upon the user's interface circuits, refer to the specifications Table A-1. Connect the bias voltage (+) between J3-37, (ISOLATOR BIAS) and J3-34 (ISOLATOR COMMON). The status indicator outputs are open collector (referenced to ISOLATOR COMMON); therefore, it is necessary to connect a pull-up resistor from each output to ISOLATOR BIAS. When choosing the resistor value observe the current sink capabilities of these lines as decribed in the Specifications Table A-1.

A-35 Because of the relatively slow rise and fall times of opto-isolators, Schmitt-triggered devices should be used to interface these output lines to logic circuits.

A-36 The following signals are in active low-form:

a. CV MODE , J3-36, indicates that the power supply is in constant voltage operation.

b. CC MODE , J3-35, indicates that the power supply is in constant current operation.

c. OUTPUT UNREGULATED , J3-18, indicates that the power supply is in neither constant voltage nor constant current operation and cannot be guaranteed to meet specifications.

d. OVERVOLTAGE , J3-17, Indicates power supply shutdown because of: the voltage output exceeding the OV trip point set at the front panel; or, a system-initiated shutdown as decribed in Section A-60.

e. OVERTEMPERATURE , J3-16, indicates power supply shutdown due to an excessive temperature rise on the FET or output diode heatsink.

A-37 The Low Bias AC DROPOUT signal, J3-19, is in active high form. This signal indicates: loss of primary power, momentary AC dropout, or "brownout" conditions where the AC line voltage drops below approximately 70% nominal.

A-38 Remote Control

A-39 For operation of the opto-isolators, the user must supply the bias voltage (CONTROL ISOLATOR BIAS). This voltage can be from +4.75 V to +16 V depending on the requirements of the driving circuits. The type of driving logic and bias voltage will determine the amplitude of the high and low logic levels, refer to the Specification Table A-1 under Remote Control.

A-40 Connect the bias voltage (+) to J3-10 CONTROL ISOLATOR BIAS, and reference the input signals to this bias supply's negative terminal.

A-41 Two optically isolated methods of remote control are available. They are described in the following paragraphs.

A-42 Remote Trip. A negative-going edge applied to terminal J3-30 (REMOTE TRIP) will shut down the power supply, reducing the output voltage to near zero. For minimum pulse duration and timing considerations with respect to REMOTE RESET , see Table A-1. The following paragraph provides a brief circuit description (see schematic diagram and Figure A-8).

A-43 A negative going edge at REMOTE TRIP coupled through opto-isolator (U9) causes one-shot U13B to set the TRIP/RESET latch (U5A) low. This sets terminal J1-13 (INHIBIT) low, thus inhibiting the Pulse Width Modulator of the power supply. It also lights the unregulated indicator on the front panel and generates an unregulated signal from the opto-isolator U3.

A-44 The low signal generated by the Trip/Reset Latch is also coupled through opto-isolator U2 and appears at J3-17 as an OVERVOLTAGE status signal. This signal does not affect The state of the power supply's OVP circuit.

A-45 Remote Reset. A negative-going edge applied to terminal J3-29 (REMOTE RESET) will return the supply to its initial state following a system-initiated shutdown or an OVP shutdown caused by a temporary over voltage condition. For minimum pulse duration and timing considerations with respect to REMOTE TRIP see Table A-1 under Remote Control. The following paragraphs provide a brief discription of this circuit (see schematic diagram and Figure A-8).

A-46 A negative-going pulse applied to terminal J3-29 (REMOTE RESET) is coupled through opto-isolator U10. One-Shot U13A then triggers and resets the TRIP/RESET latch output high. This sets terminal J1-13 (INHIBIT) high, thus enabling the power supply's Pulse Width Modulator.

A-47 The REMOTE RESET signal will also reset the power supply OVP circuit in the event that an overvoltage condition has shut down the supply. When a REMOTE RESET signal is present, ONE SHOT U13A goes low, this will produce an OV CLEAR pulse at terminal J1-12. The OV CLEAR pulse will cause the output of A2U2 to go low thus, resetting the OV FLIP FLOP. When this occurs the output of A2U24D goes high and simultaneously causes the front panel OV LED to turn off and the OV signal (J1-6) to go high. The OVERVOLTAGE signal to U4B also goes high and enables the PWM of the power supply.

NOTE

By observing the OVERVOLTAGE status indicator or the power supply's output while applying a reset pulse to REMOTE RESET, the user can determine the cause of shutdown. If the output returns and OVERVOLTAGE goes high immediately, this indicates a controller-initiated shutdown. If the output takes about one second to return, this indicates that the output voltage had exceeded the OVP trip point. If the OVP circuit trips continually, check the load and/or the trip point setting.

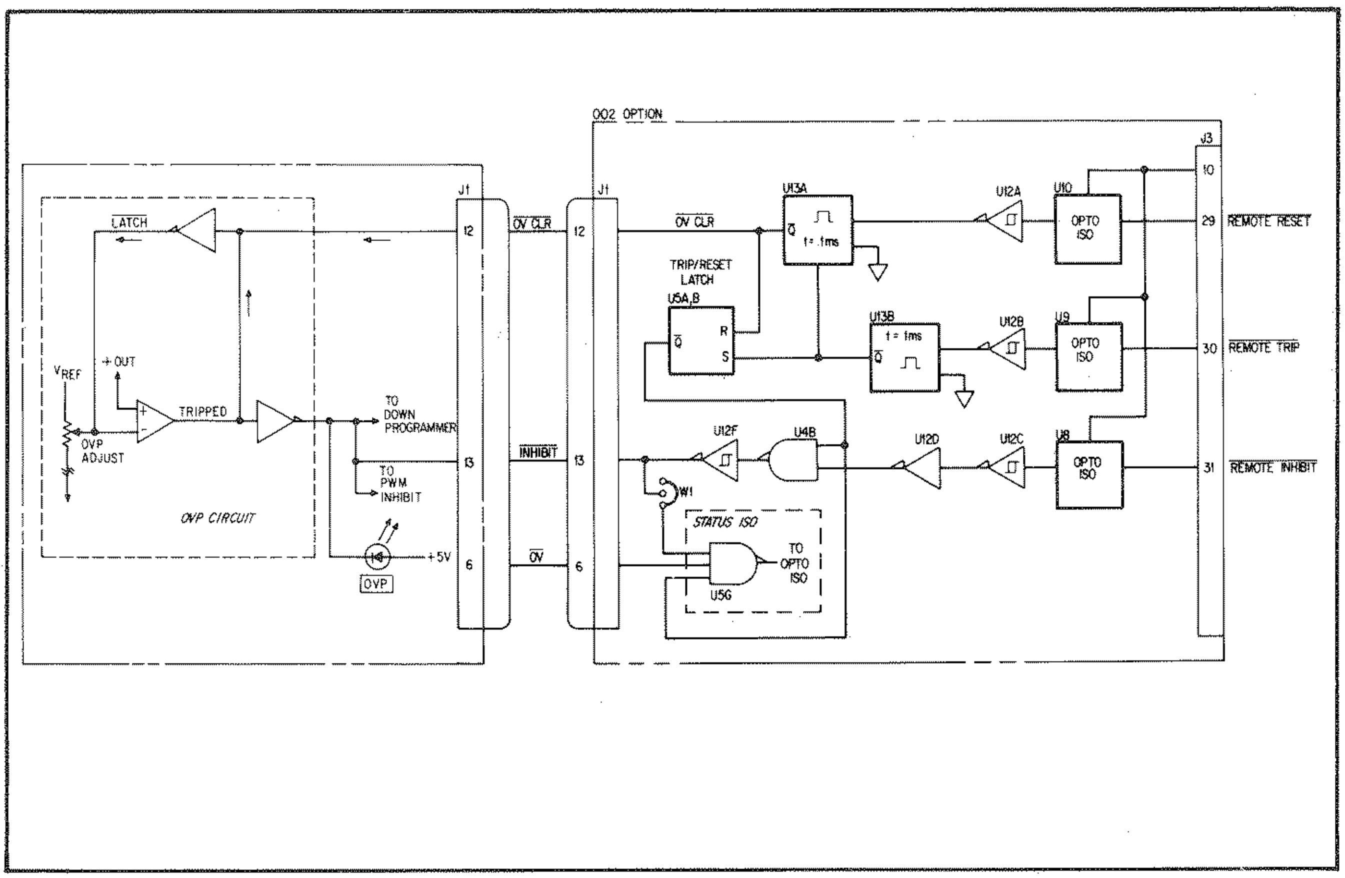


Figure A-8. Remote Control

A-48 Alternate Method of Remote Control. The REMOTE INHIBIT input, J3-31, provides an alternate method of remote shutdown. By maintaining a low logic level at this input, the supply's output will be inhibited until REMOTE INHIBIT is returned to its initial high state. The following paragraph provides a brief description of this circuit (see schematic diagram and Figure A-8).

A-49 A low logic level applied to terminal J3-31 (REMOTE (INHIBIT) is coupled through opto-isolator U8 and causes U4B to inhibit the power supply's (PWM) Pulse Width Modulator. If jumper W1 is used (see Figure A-8) while a REMOTE INHIBIT signal is applied, an OVERVOLTAGE signal will appear at terminal J3-17 OVERVOLTAGE thus, indicating the power supply shut down.

A-50 POWER-ON PRESET

A-51 This open collector output line J3-6, provides a logic low pulse (Power-On-Preset) to the user that can be used to initialize or delay a system's operation until +5 V Reg. supply has stabilized. The pulse s generated after primary power is turned on and also after resumption of power following momentary ac dropout or conditions in which line voltage drops below approximately 70% of the nominal. See Table A1 for Power-On Preset signal specifications.

A-52 The Power-On-Preset circuit also ensures that terminal J3-17 (OVERVOLTAGE) will be high when the supply is turned on. This protects against unwanted Multiple Supply System Shutdowns when using J3-17 (OVERVOLTAGE) to remote trip additional power supplies.

A-53 The following paragraphs provide a brief description of the power-on preset circuit, refer to schematic diagram

A-54 Circuits on the Power Supply's A2 Control Board produce a power-clear signal, (PCLR), when the supply is turned on. These circuits hold PCLR low until the unregulated input to the A2 Board's +5 Vdc bias supply is greater than about 11Vdc, an input voltage sufficient to assure +5 Vdc bias output.

A-55 This PCLR signal is coupled through terminal J1-15 to the 002 Option board's power-on preset circuit. When the power-on preset circuit receives the PCLR signal, transistors U14A and U14C turn off.

A-56 Turning U14A off causes a DROPOUT signal to appear at terminal J3-19 (DROPOUT). Turning U14C off causes U14B and U14D to turn on. When U14B is on, it holds output J3-17 (OVERVOLTAGE) high. Holding J3-17 high will prevents any unwanted Multiple Supply Shutdown's from occurring when the supply is wired for such an application. When U10D is on, it causes J3-6 (Power-On-Preset) to be low thus, if used, can initialize or delay a customer's system operation.

A-57 AC Dropout Buffer Circuit

A-58 This circuit couples, inverts and isolates the DROPOUT signal (received from the A2 Control Board) of status output terminal J3-19 (DROPOUT). The dropout signal indicates loss of primary power, momentary AC dropout, or "brownout" conditions where the AC line voltage drops below approximately 70% normal. The following paragraph provides a brief description of the AC Dropout Buffer circuit, refer to the Schematic Diagram.

A-59 The AC Dropout Buffer Circuit receives a DROPOUT signal from the 6012B A2 Control Board. This causes the bias voltage supplied to the Dropout Buffer U14A to be pulled down through diode CR4 thus, turning U14A off. This in turn will cause Opto-Isolator U3 to turn off. Since external pull up resistors are used, terminal J3-19 (DROPOUT) will go high and remain high until the DROPOUT signal from the A2 Control Board is removed.

A-60 Multiple Supply System Shutdown

A-61 When using more than one 002 Option equipped power supply in a system, it may be desirable to implement a system shutdown. In this configuration, an OVP trip or remote shutdown of a single unit will cause all of the supplies to shut down.

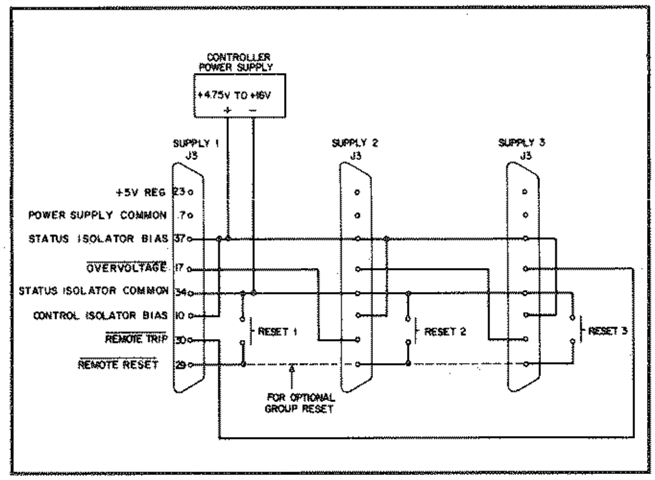


Figure A-9. System Shutdown using Controller Power Supply

A-62 Figure A-9 shows one method of system shutdown. The advantages of this method are that one common is used for all status and control lines (useful for controller-operated systems), and the capability of system reset. As shown in Figure A-9, one supply's OVERVOLTAGE line is connected to the next supply's REMOTE TRIP line, and so on in a continuous chain.

NOTE

+5 V REG/POWER SUPPLY COMMON from Supply 1 can be used instead of the bias voltage from the controller. However, because of current limits of the +5 V REG, no more than four units can be connected together in this configuration. To prevent ground loops, do not parallel connect +5 V REG from more than one supply.

A-63 The note following paragraph A-47 tells how to determine if a shutdown was inititated through the remote trip line or by a supply's OVP. This allows the controller to determine which supply initiated the shutdown.

A-64 Following a multiple supply shutdown, each unit can be reset individually or all the REMOTE RESET lines can be tied together for a system reset.

A-65 If it is necessary to have all the supplies come up simultaneously after a system shutdown, follow this procedure:

a. First bring the REMOTE INHIBIT line low.
b. Provide a negative-going pulse to the REMOTE RESET
c. After at least one second, return REMOTE INHIBIT to a high level.

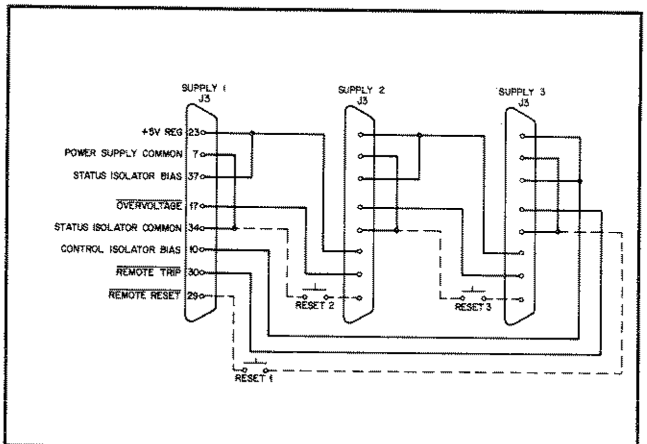


Figure A-10. System Shutdown the Units Brass Supply Outputs

A-66 Figure A-10 shows a second method of system shutdown. This method is appropriate in systems which are not controller-operated and in which more than four supplies must be shutdown simultaneously. Because each supply derives its CONTROL ISOLATOR BIAS from the previous supply's +5 V REG, there is no limit to the number of supplies that can be shutdown. Each supply must be reset individually.

A-67 Using either method of system shutdown, PCLR inhibits the OVERVOLTAGE indicator from going low and shutting down succeeding supplies upon initial turn-on. After the supplies have stabilized, PCLR returns to a high state.

A-68 Bias Supplies

A-69 The outputs of three current-limited bias supplies are available for user-supplied circuitry. These are +15 V @ 75mA at J3-4, −15 V @ 75 mA at J3-20, and +5 V @ 100 mA at J3-23; all with respect to J3-7, L Common.

A-70 It may be desirable to install noise-suppression capacitors on the bias supply outputs near the load circuits. The capacitors should be ceramic or tantalum type, approximately 0.1 μf to 10μf.

A-71 MAINTENANCE

A-72 The following paragraphs provide procedures and setups to aid in checking and troubleshooting the 002 Option Board. This information, used in conjunction with the schematic drawing and the Operation section of this Appendix, will help in the isolation and repair of faulty circuits.

A-73 When testing the option, use of the test connector of paragraph A-17 will allow easier access to the J3 contacts.

A-74 Troubleshooting

A-75 Before attempting to troubleshoot the 002 Option Board, ensure that the fault is with the option itself and not with the main power supply. This can be accomplished by removing the top cover, inside cover and disconnecting the two ribbon cables from the A2 Control board and checking the operation of the main supply. Otherwise troubleshoot the option board as described in the following paragraphs.

A-76 Removal of the Option Board. To facilitate troubleshooting the 002 Option the board can be removed from the power supply and electrically connected via the ribbon cables from Service Kit's 06033-60005 or 5060-2665. To remove the circuit board proceed as follows:

a. Turn off power supply and disconnect line cord.
b. Disconnect option I/O cable from J3 on rear panel and remove the two screws that secure option board to rear panel.
c. Disconnect the ribbon cables from the A2 Control board.
d. Remove option board by lifting the board by the front edge and sliding the board toward the front of the power supply.
e. Reconnect the option board to the A2 Control board using the extended ribbon cables from the Service Kit, and place the option board on an insulated surface next to the power supply.
f. Be careful that the option board lies securely on insulating material and does not touch any part of the main power supply.

A-77 Isolating Faulty Circuit. It is apparent which function is not operating properly, proceed to the appropriate paragraph. If the problem involves more than one function check the bias voltages from connectors J1 and J2 and the ±11.8 V on the option board.

A-78 Troubleshooting Resistance and Voltage Programming

a. Confirm that the problem is on the option board by disconnecting the ribbon cables from the A2 Control Board and attempting to program the supply via the rear panel terminal strip.
b. Check ±15 V and ±11.8 V supplies.
c. Check for a problem in the programming protection circuit. This circuit should draw about 2μA from the programming lines.

d. Check that W3 and W4 are installed and S1 is in proper position.

A-79 Troubleshooting Current Programming

a. Check ±15 V and ±11.8 V supplies.
b. Proceed to test set-up shown in Figure A-11 and/or A-12.
c. Put S1 in V, R position and see if varying the 0-20 V voltage source produces a 0-5 volt DC level across R44 or R39. If not, check op-amps and associated circuitry.
d. Put S1 in I position and see if varying voltage source from 0 to 20 volts produces a 0-5 VDC level at W3 or W4. If not check relay and programming protection circuit.

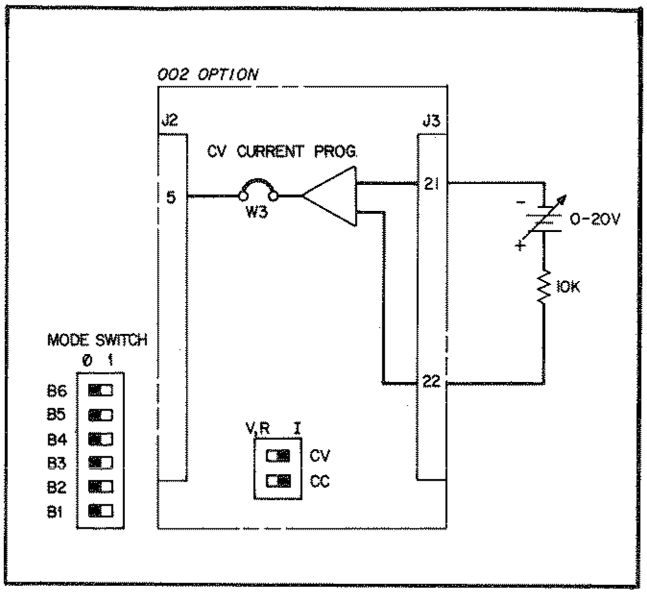


Figure A-11. Troubleshooting Current Programming of CV Mode

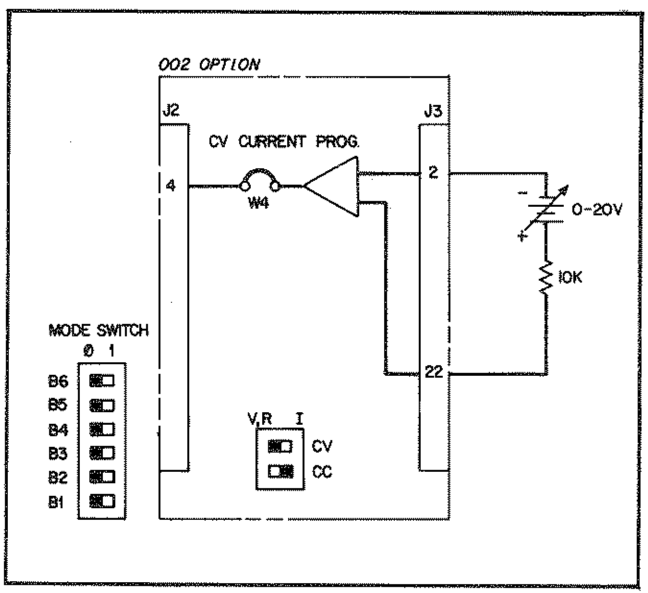


Figure A-12. Troubleshooting Current Programming of CC Mode

A-80 Troubleshooting Status Indicators. The test set-up shown in Figure A-13 can be used to check each of the six status indicators. This set-up will temporarily defeat the isolation of the status lines. Before attempting to troubleshoot a status indicator, check for +5 V Bias for proper operation of the opto-couplers.

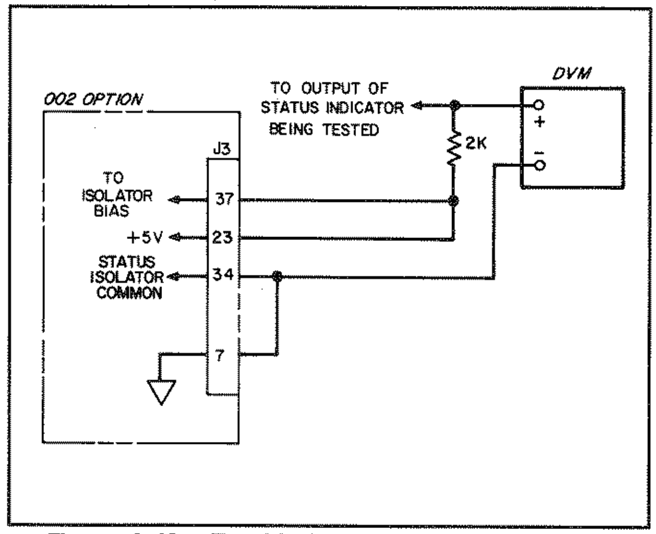


Figure A-13. Troubleshooting Status Indicators

A-81 To check CV Mode proceed as follows:
a. Using test set-up, Figure A-13, connect to end of 2 kΩ resistor to J3-36.
b. Turn on power supply.
c. Using "Display Setting" set voltage and current or power supply for 1 volt and 1 amp.
d. DVM should read between 0 to 0.4 volts.
e. Turn off power supply and short to output terminals.
f. Turn on power supply.
g. DVM should read appoximately 5 Vdc.

A-82 To check CC Mode proceed as follows:
a. Using test set-up, Figure A-13, connect top end of 2 kΩ resistor to J3-35.
b. Turn on power supply.
c. Using "Display Settings" set voltage for 1 volt and current for 1 Amp.
d. DVM should read ≈ 5 Vdc.
e. Turn off power supply and short the output terminals.
f. Turn on power supply.
g. DVM should read between 0 to 0.4 volts DC.

A-83 To check OVERVOLTAGE proceed as follows:
a. Using test set-up, Figure A-13, connect top end of 2 kΩ resistor to J3-17.
b. Turn "OVP Adjust" fully clockwise and voltage control fully counter clockwise.
c. Open power supply output terminals and turn on power.
d. DVM should read approximately 5 Vdc.
e. Press 'Display Settings" and increase voltage control for 15 Vdc output.

f. Turn OVP Adjust" counterclockwise until supply goes into overvoltage.
g. DVM should read between 0 and 0.4 Vdc.
h. Turn "OVP Adjust" fully clockwise and turn off input power for 5 seconds.
i. Turn on input power and DVM should read approximately 5 Vdc.

A-84 To check OUTPUT UNREGULATED proceed as follows:

a. Using test set-up, Figure A-13, connect to end of 2 kΩ to J3-18.
b. Connect output terminals of power supply to an electronic load capable of exceed the power supplies output power rating by 50%.
c. Turn on power supply.
d. DVM should read approximately 5 Vdc.
e. Set voltage and current controls of power supply to maximum.
f. Decrease resistance of electronic load until "UNREGULATED" LED on front panel lights.
g. DVM should now read between 0 to 0.4 VDC.

A-85 To check LOW BIAS or AC Dropout proceed as follows:

a. Using test set-up, Figure A-13, connect top end of 2 KΩ resistor to J3-19.
b. Substitute an oscilloscope in place of DVM. Set vertical deflection for 1 volt/div on the DC input.
c. Turn power on and observe oscilloscope trace. Voltage should increase to 5 V at power-on and drop to between 0 to 0.4 Vac approximately 3 sec.
d. Turn power off. Voltage should go to about 5 Vdc before decaying back to 0 V.

NOTE

In this test, the LOW BIAS or AC Dropout signal decays to 0 V only because of loss of power to the +5 V REG Bias Supply used in the test set-up. If in doubt, use an external +5 V supply for this test.

A-86 To check OVERTEMPERATURE proceed as follows:

a. Turn off power supply and disconnect line cord.
b. Wait at least two minutes for input capacitors to discharge.
c. Remove top cover and inside cover.
d. Using test set-up, Figure A-13, connect top end of 2 kΩ resistor to J3-16.
e. Turn on power supply.
f. DVM should read approximately 5 VAC.
g. Turn off power and wait two mintues.
h. Remove the A4 FET Assembly from the unit.
i. Turn on power supply.
j. DVM should read between 0 to 0.4 VDC.

NOTE

The FET heatsinks are connected to the primary circuit and hazardous voltage (up to between 300 to 400 V) exists between the heatsinks and the heatsink and the chassis. These potentials remain for up to 2 minutes if the power supply is turned off. Do not touch the heatsinks or any components on the heatsink assemlies while the power supply is turned on or for at least two minutes after primary power is removed.. Do not place any of the heatsink assemblies on extender boards.

A-87 Troubleshooting Remote Shutdown. The following procedures check the Remote Shutdown features of 002 Option. Troubleshooting can be accomplished by using a logic probe and referring to the schematic and the circuit description in paragraph A-60. Before attempting to troubleshoot the Remote Shutdown section of the option, check for +5 Vdc internal bias. This voltage must be present for proper operation of these circuits.

A-88 To check the REMOTE TRIP and REMOTE RESET proceed as follows:

a. Connect +5 V (J3-23) to Control Isolator bias (J3-10).
b. Turn unit on and short REMOTE TRIP (J3-30) to +5 V common (J3-7) momentarily. Output should go into unregulated condition with output off.
c. Short REMOTE RESET (J3-29) to +5 V common (J3-7) momentarily and OUTPUT should return to its initial state.

A-89 To check REMOTE INHIBIT proceed as follows:

a. Connect +5 V (J3-23) to control isolator bias (J3-10).
b. Turn unit on and short REMOTE INHIBIT (J3-31) to +5 V common (J3-7). Ouptut should go to an unregulated output off condition.
c. Remove short between REMOTE INHIBIT (J3-31) and +5 V common (J3-7) and output should return to its initial state.

Table A-3. Replaceable Parts

REF. DESG.	HP PART NO.	TQ.	DESCRIPTION	MFR. CODE	MFR. PART NO.
A7	5060-2854	1	Opt. 002 Interface Board	28480	
C1,2	0180-0230	6	fxd elect. 1uf 20% 50V	56289	150D105X0050A2
C3	0180-2825	3	fxd elect. 22uf 50V	28480	
C4	0160-4835	2	fxd cer. 0.1uf 10% 50V	28480	
C5	0160-4554	2	fxd cer. 0.01uf 20% 50V	28480	
C6	0160-4835		fxd cer. 0.1uf 10% 50V	28480	
C7	0160-4554		fxd cer. 0.01uf 20% 50V	28480	
C8,9	0180-0230		fxd elect. 1uf 20% 50V	56289	150D105X0050A2
C10	0180-2825		fxd elect. 22uf 50V	28480	
C11	0160-4801	2	fxd cer. 100pf 5% 100V	28480	
C12,13	0160-5422	4	fxd cer. 0.047uf 20% 50V	28480	
C14	0160-4801		fxd cer. 100pf 5% 100V	28480	
C15	0160-5422		fxd cer. 0.047uf 20% 50V	28480	
C16	0160-5422		fxd cer. 0.047uf 20% 50V	28480	
C17,18	0180-0230		fxd elect. 1uf 20% 50V	28480	
C19	0180-2825		fxd elect. 22uf 50V	28480	
C20-22	0160-0128	3	fxd cer. 2.2uf 20% 50V		
CR1-4	1901-0050	10	switching 80V 200ma	28480	
CR5-10	1901-0327	8	pwr. rect. 300V 40A	05277	1N1187AR
CR11-14	1901-0033	10	gen. prp. 180V 200ma	12969	1N645
CR15	1901-0327	2	zener 9.09V 10% PD=1.5W	28480	
CR16,17			NOT USED		
CR18,19	1901-0050		switching 80V 200ma	28480	
CR20	1901-0033		gen. prp. 180V 200ma	12969	1N645
CR21,22	1901-0050		switching 80V 200ma	28480	
CR23	1901-0033		gen. prp. 180V 200ma	12969	1N645
CR24,25	1901-0050		switching 80V 200ma	28480	
CR26-29	1901-0033		gen. prp. 180V 200ma	12969	1N645
CR30	1901-0327		zenar 9.09V 10% PD=1.5W	28480	
K1,2	0490-1418	2	relay 250ma 28V,5V-coil 3VA	28480	
L1-3	9170-1223	3	core shielding bead	28480	
Q1,2	1854-0823	2	NPN SI PD=300mW FT=200MHZ	28480	
R1-3	0683-2015	3	fxd. film 200 5% 1/4W	01121	CB2015
R4	0683-3925	1	fxd. film 3.9K 5% 1/4W	01121	CB3925
R5	0683-2035	3	fxd. film 20K 5% 1/4W	01121	CB2035
R6	0683-3035	1	fxd. film 30K 5% 1/4W	01121	CB3035
R7	0683-6225		fxd. film 6.2K 5% 1/4W	01121	CB6225
R8,9	0683-2035		fxd. film 20K 5% 1/4W	01121	CB2035
R10	0683-1035	3	fxd. film 10K 5% 1/4W	01121	CB1035
R11	0683-5125	3	fxd. film 5.1K 5% 1/4W	01121	CB5125
R12	0757-0984	1	fxd. film 10 1% 1/2W	28480	
R13	0683-1615	1	fxd. film 160 5% 1/4W	01121	CB1615
R14	0683-4715	7	fxd. film 470 5% 1/4W	01121	CB4715
R15,16	0683-1235	6	fxd. film 12K 5% 1/4W	01121	CB1235
R17	0686-1525	3	fxd. film 1.5K 5% 1/4W	01121	CB1525
R18	0683-1535	3	fxd. film 15K 5% 1/4W	01121	CB1535
R19	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R20,21	0683-1235		fxd. film 12K 5% 1/4W	01121	CB1235
R22	0686-1525		fxd. film 1.5K 5% 1/4W	01121	CB1525
R23	0683-1535		fxd. film 15K 5% 1/4W	01121	CB1535
R24	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R25,26	0683-1235		fxd. film 12K 5% 1/4W	01121	CB1235
R27	0686-1525		fxd. film 1.5K 5% 1/4W	01121	CB1525
R28	0683-1535		fxd. film 15K 5% 1/4W	01121	CB1535

Table A-3. Replaceable Parts (cont.)

REF. DESG.	HP PART NO.	TQ.	DESCRIPTION	MFR. CODE	MFR. PART NO.
R29,30	0698-4479	2	fxd. film 14K 1% 1/8W	24546	CT4-1/8-T0-1402-F
R31	0686-5125	2	fxd. comp. 5.1K 5% 1/2W	01121	EB5125
R32	0683-5125		fxd. film 5.1K 5% 1/4W	01121	CB5125
R33	0686-5125		fxd. comp. 5.1K 5% 1/4W	01121	EB5125
R34	0683-5125		fxd. film 5.1K 5% 1/4W	01121	CB5125
R35	0757-0986	2	fxd. film 12.1K 1% 1/2W	28480	
R36	0757-0269	2	fxd. film 270 1% 1/8W	24546	CT4-1/8-T0-271-F
R37	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R38	0683-1035		fxd. film 10K 5% 1/4W	01121	CB1035
R39	0698-6631	2	fxd. film 2.5K .1% 1/8W	28480	
R40	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R41	0813-0001	2	fxd. ww. 1K 5% 3W	28480	
R42	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R43	0683-1035		fxd. film 10K 5% 1/4W	01121	CB1035
R44	0698-6631	1	fxd. film 2.5K .1% 1/8W	28480	
R45	0683-4715		fxd. film 470 5% 1/4W	01121	CB4715
R46	0813-0001		fxd. ww. 1K 5% 3W	28480	
R47	0683-1525	1	fxd. film 1.5K 5% 1/4W	01121	CB1525
R48	0683-3325	1	fxd. film 3.3K 5% 1/4W	01121	CB3325
R49	0683-2225	1	fxd. film 2.2K 5% 1/4W	01121	CB2225
R50,51	0683-3355	2	fxd. film 3.3M 5% 1/4W	01121	CB3335
R52,53	0683-1055	1	fxd. film 1M 5% 1/4W	01121	CB1055
R54	0757-0441	1	fxd. film 8.25K 1% 1/8W	24546	CT4-1/8-T0-8251-F
R55	0757-0986		fxd. film 12.1K 1% 1/2W	28480	
R56	0757-0269		fxd. film 270 1% 1/8W	24546	CT4-1/8-T0-271-F
S1	3101-2715	1	Switch-Slide 2-1A .1A 50V	28480	
U1-3	1990-0732	3	Opto-Isolator IF=20mA max.	28480	
U4	1820-1197	1	IC NAND gate TTL LS quad	01295	SN74LS00N
U5	1820-1202	1	IC NAND gate TTL LS	01295	SN74LS10N
U6	1826-0393	2	IC Voltage Reg.	01295	LM317KC
U7	1826-0551	1	IC Voltage Reg.	01255	TL7805ACKC
U8-10	1990-0494	3	Opto-Isolator IF=20mA max.	28480	
U11	1820-1491	1	IC Buffer TTL LS, hex	01295	SN74LS367AN
U12	1820-1416	1	IC Schmitt-Trig. TTL LS, hex	01295	SN74LS14N
U13	1820-1437	1	IC Multi. Vib. TTL LS	01295	SN74LS221N
U14	1858-0023	1	Trans. Array 16-pin	28480	
U15	1826-0527	2	IC Voltage Reg.	27014	LM337T
U16	1826-0277	1	IC Voltage Reg.	01295	LM317KC
U17,18	1826-0493	2	IC Op Amp Low-bias-High-Impd.	04713	LM308AN
U19	1826-0393		IC Voltage Reg.	27014	LM3337
U20	1826-0607	1	IC Voltage Reg.	27014	LM340AT-15
VR1-8	1902-0556	10	zener 20V 5% PD=1W IR=5uA	28480	
VR9	1902-3185	1	zener 12.4V 5% PD=.4W	28480	
VR10	1902-0556		zener 20V 5% PD=1W IR=5uA	28480	
VR11	1902-3256	2	zener 23.7V 5% PD=.4W	28480	
VR12	1902-0779	1	zener 11.8V 5% PD=.4W	28480	
VR13	1902-3180	1	zener 11.8V 2% PD=.4W	28480	
VR14	1902-3110	1	zener 5.9V 2% PD=.4W	28480	
VR15	1902-0575	1	zener 6.5V 2% PD=.4W	28480	
VR16	1902-0556		zener 20V 5% PD=.4W IR=5uA	28480	
VR17	1902-3256		zener 23.7V 5% PD=.4W	28480	
Z1	1810-0276	1	network res. 1.5K x 9	01121	210A152

Table A-3. Replaceable Parts (cont.)

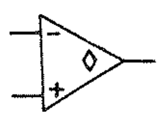
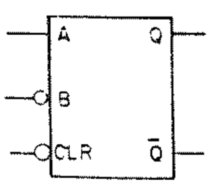
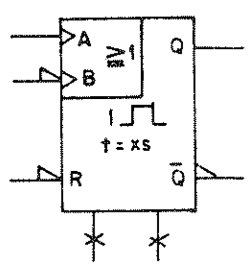
REF. DESG.	HP PART NO.	TQ.	DESCRIPTION	MFR. CODE	MFR. PART NO.
			Mechanical		
	06023-00013	1	plate (ref. A7J3)	28480	
A7J3	1251-6075	1	connector 37-pin	28480	
	1205-0282	6	heatsink (ref. U6,7,15, 16,19,20)	28480	
W1	1258-0189	1	jumper	28480	
W2			NOT USED		
W3,4	7175-0057	2	jumper,solid tinned copper	28480	
W5,6	8120-4356	2	ribbon cable, 16 cond.	28480	
	1251-8417	2	post type header(ref. J1, J2)	28480	

Definitions

High = more positive
Low = less positive

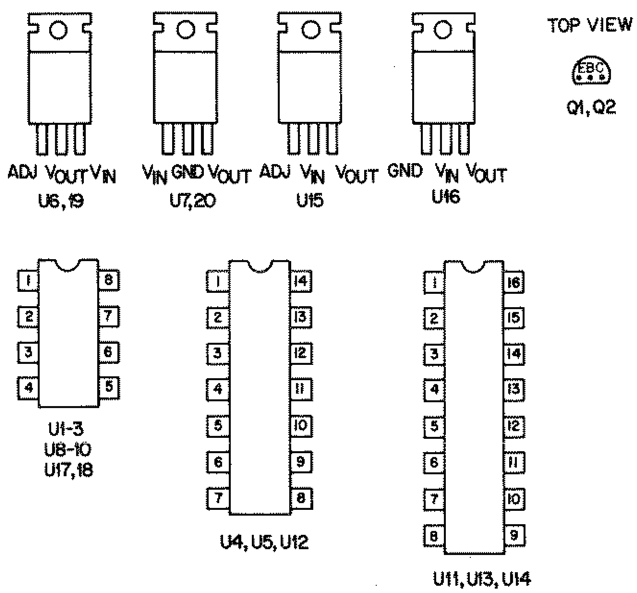
Indicator and Qualifier Symbols

≧	OR function
⊿	(polarity indicator, shown outside logic symbol) Any marked input or output is active low; any unmarked input or output is active high.
▷	(dynamic indicator) Any market input is edge-triggered, ie, active during transition between states; any unmarked input is level sensitive.
⎍	(Schmitt trigger) indicates that hysteresis exists in device.
✱	(non-logic indicator) Any marked input or output does not carry logic information.
◊	open-collector or open emitter output
1⎍	monostable (one-shot) multivibrator
t=xSec	indicates pulse width (usually determined by external RC network)
G	gate input (a number following G indicates which inputs are gated)
C	control input (clock)
R	reset (clear)
S	set

OLD SYMBOL	*NEW SYMBOL*	*NOTES*
		
		Output requires external components to achieve logic state
		A positive-going transition at A or a negative-going transition at B triggers the one-shot. External timing components connect to non-logic inputs.
		Output changes state rapidly regardless of input rate of change.

SCHEMATIC NOTES:

1. ALL RESISTORS ARE IN OHMS, ±5%, 1/4W, UNLESS OTHERWISE INDICATED.
2. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
3. WHITE SILKSCREENED DOTS ON P.C. BOARDS INDICATE ONE OF THE FOLLOWING:
   A. PIN 1 OF AN I.C. (EXCEPT FOR U18, SEE NOTE 4).
   B. POSITIVE END OF A POLARIZED CAPACITOR.
   C. CATHODE OF A DIODE OR THE EMITTER OF A TRANSISTOR.
4. PIN LOCATIONS FOR SEMICONDUCTORS ARE SHOWN BELOW:



5. ON VOLTAGE REGULATOR DEVICES,
   REF SUPPLY = BIAS FOR REGULATOR'S INTERNAL REFERENCE.
   REF = OUTPUT FROM REGULATOR'S INTERNAL REFERENCE.
   BOOST OUTPUT = CONTROL FOR EXTERNAL PASS TRANSISTOR.
   C_S = CURRENT SENSE
   C_L = CURRENT LIMIT
   INV = INVERTING INPUT TO REGULATOR'S ERROR AMPLIFIER.
   NI = NON-INVERTING INPUT TO REGULATOR'S ERROR AMPLIFIER.
   COMP = FREQUENCY COMPENSATION.

Schematic Diagram Notes

Schematic Notes

1. W1 in normally open position.
2. W3 & W4 jumpered.
3. Relays K1, K2 normally closed.
4. S1A and S1B are located at the rear panel.

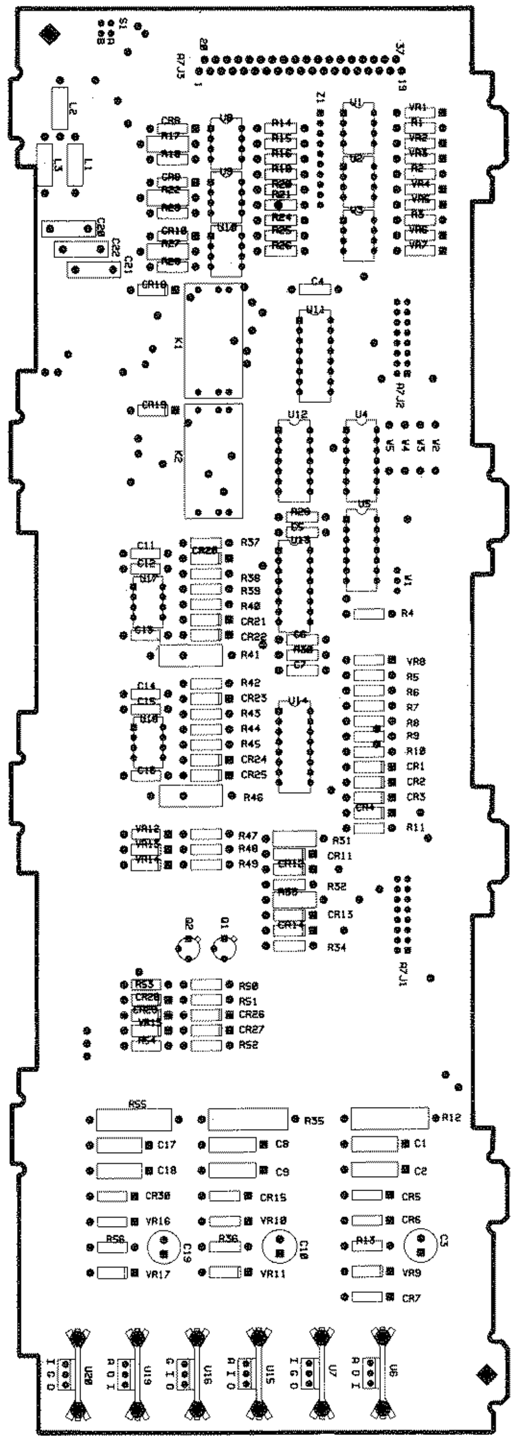


Figure A-15. Option 002 Board. Component Location

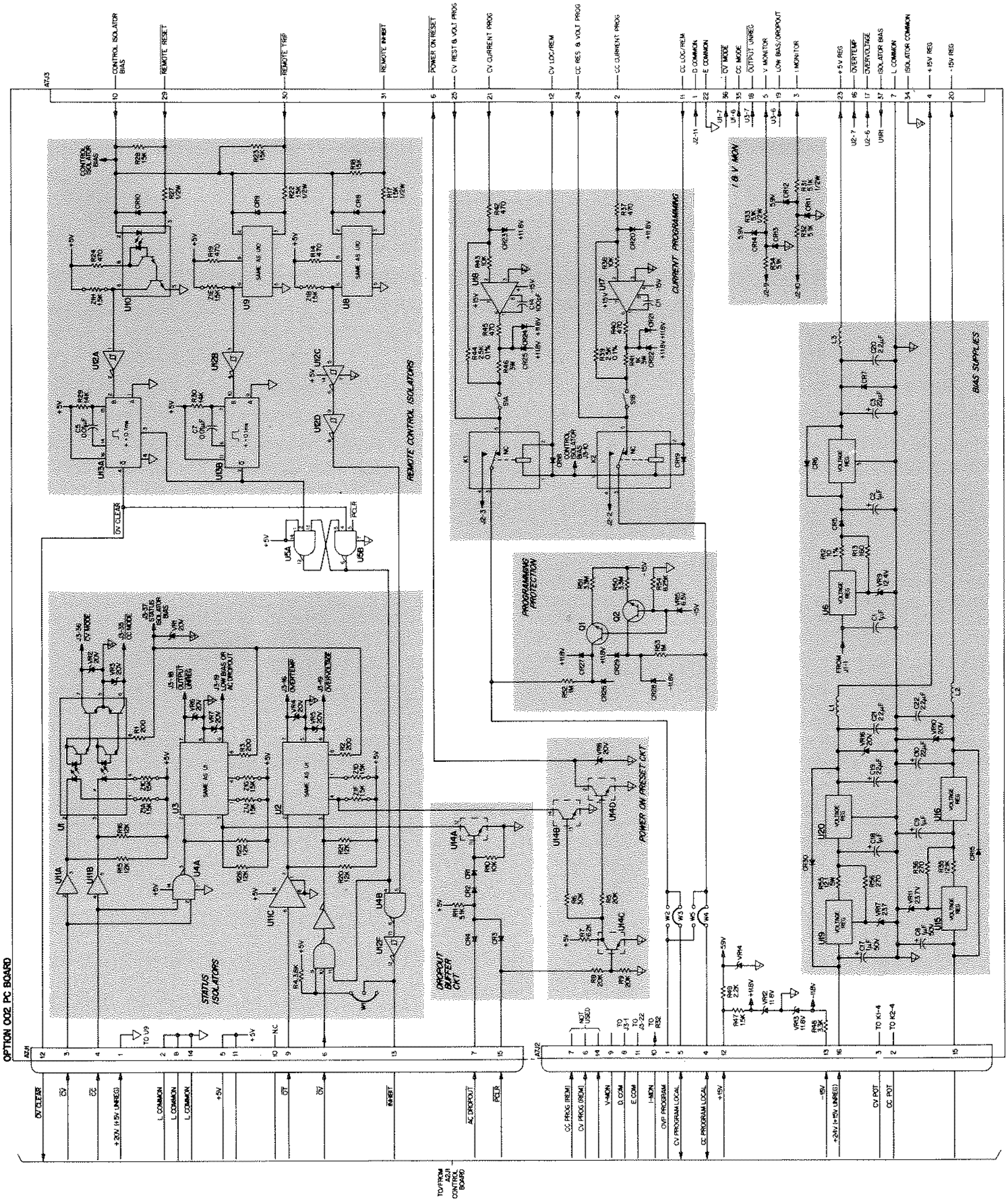


Figure A-16. Option 002 Board Schematic Diagram