Sorensen

SORENSEN HPD SERIES
DC POWER SUPPLY

INSTRUCTION MANUAL

SORENSEN
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SORENSEN LIMITED WARRANTY

All HPD Series power supplies manufactured by Sorensen are guaranteed for five (5) years from the date of delivery against defects in material and workmanship. This does not apply to products damaged through accident, abuse, misuse, or unauthorized repair. Sorensen shall not be liable for any special or consequential damage of any nature.

The manufacturer will repair or replace the non-conforming product or issue credit, at its option, provided the manufacturer's inspection establishes the existence of a defect. Packing, freight, insurance and other charges incurred in returning the defective products to the manufacturer will be paid by the purchaser. If any questions arise concerning the warranty, check with Sorensen prior to taking any action.

When requesting information, assistance, or authorization please refer to the model and serial number on the unit's rear panel. Use the spaces below to record this information so that it is readily available.

Model: _____

Serial Number: _____

NOTE

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause interference to radio communication. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

Agency Approvals: This unit is CE marked according to the requirements of European Council Directive 89/336/EEC. Conforms to the following standards: EN5011 (Group 1 Class B): 1991, EN50081-1: 1992, EN50082-1: 1992.

(96/03/20)

About This Manual

This manual contains operation and maintenance instructions for the HPD Series, high performance, switching laboratory power supplies. It provides information about features and specifications, installation procedures, and basic functions testing, as well as operating procedures for using both standard and multiple supply functions. It also includes a complete set of schematics, circuit descriptions, and parts lists for the assemblies used in the supply.

This manual is designed for the user who is familiar with basic electrical laws especially as they apply to the operation of power supplies. This implies a recognition of Constant Voltage and Constant Current operating modes and the control of input and output power, as well as the observance of safe techniques while effecting supply connections and any changes in configuration. The more knowledgeable user will find that the detailed schematics and circuit descriptions supplied will enable a greater flexibility in troubleshooting and in configuring new applications.

Section 1. Features and Specifications	Describes the power supply, lists its features, and provides tables of specifications.
Section 2. Installation	Reviews safety and inspection procedures, then goes through the basic setup. Also includes directions for the testing of basic functions.
Section 3. Load Connection and Operation	Provides procedures for connecting the load, grounding, remote sensing, and for standard operation (Constant Voltage and Constant Current). Series, parallel, and split supply operation is also covered.
Section 4. Theory of Operation	Provides an explanation of the functions within each of the power supply's assemblies.
Section 5. Maintenance	Covers troubleshooting, servicing, and calibration. Lists replacement parts.
Appendix A	Contains the schematics for the supply's component assemblies. Includes an interconnection diagram.

Warnings, Cautions, and Notes

Warnings, cautions, and notes are defined and formatted as presented below.

WARNING
Describes a potential hazard which could result in injury or death, or, a procedure which, if not performed correctly, could result in injury or death.

CAUTION
Describes a procedure which, if not performed correctly, could result in damage to data, equipment, or systems.

Note: Describes additional operating information which may affect the performance of the equipment.

MANUAL CORRECTIONS

(95/12/29)

Page 5-5: The A2 PCB calibration resistors are potentiometers which you adjust to conform to specification.

(96/01/31)

Section 1 and Section 5: Revised multiple unit status.

(96/03/20)

Agency Approvals: This unit is CE marked according to the requirements of European Council Directive 89/336/EEC. Conforms to the following standards: EN5011 (Group 1 Class B) 1991, EN50081-1 1992, EN50082-1 1992.

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1. FEATURES AND SPECIFICATIONS

1.1 Introduction

We designed the HPD Series DC power supplies to provide highly stable, variable output voltage and current for a broad range of development and system requirements. These power supplies employ high frequency switching regulator technology to achieve high power density and small package size, as well as a linear post-regulator circuit for low output noise. We added a wide variety of options including both analog and IEEE-488 controlled programming to make HPD Series supplies the first choice in flexible power system design.

TABLE 1.1-1 HPD SERIES MODELS

Model	Output Voltage	Output Current
HPD 15-20	0-15V	0-20A
HPD 30-10	0-30V	0-10A
HPD 60-5	0-60V	0-5A

1.2 Features

- High frequency switching technology allows high power density, providing increased power output in a small, light package.
- Simultaneous digital displays for both voltage and current. Bar graph displays for monitoring transient changes.
- Ten-turn voltage control permits high resolution setting of the output voltage. Current limit is fully adjustable from zero to the rated output with a single turn control.
- Automatic mode crossover into current or voltage mode.
- Impedance-switched remote sensing permits the voltage at the load to be displayed with no switch ambiguity.
- Connect multiple units in parallel or series. Short-circuit proof outputs.
- Combine with XT Series power supplies to form mixed units for high precision applications.

1.3 Options and Accessories

- Internal Analog Programming (APG) Interface for analog signal control of voltage and current, overvoltage protection (OVP), master/slave output tracking, and remote ON/OFF.
- Internal RS232 Interface for serial instrument programming using RS232 protocol.
- Internal GPIB Interface for complete remote digital programming. IEEE-488 standard.
- Single Address Multichannel (SAMI) Interface to serial link up to 31 supplies at one IEEE-488 address. Complete GPIB programming.
- Optional 200-250V AC input (AC200). Standard is 115V. AC input cords for use in different countries.
- Ten-turn current potentiometer (Option M11). Rack mount kit (Option RM).

1.4 Specifications

1.4.1 Electrical Specifications[1]

TABLE 1.4-1 ELECTRICAL SPECIFICATIONS			
Models	**HPD 15-20**	**HPD 30-10**	**HPD 60-5**
Output Ratings:			
Output Voltage	0-15V	0-30V	0-60V
Output Current	0-20A	0-10A	0-5A
Output Power	300W	300W	300W
Line Regulation: [2]			
Voltage (0.01% of V max + 2mV)	3.5mV	5mV	8mV
Current (0.01% of I max + 1mA)	3mA	2mA	1.5mA
Load Regulation: [3]			
Voltage (0.01% of V max + 2mV)	3.5mV	5mV	8mV
Current (0.01% of I max + 1mA)	3mA	2mA	1.5mA
Meter Accuracy:			
Voltage (1% of V max + 1 count)	0.25V	0.4V	0.7V
Current (1% of I max + 1 count)	0.3A	0.2A	0.06A
Output Noise and Ripple at rear output: (20Hz-20MHz)	5mVrms 100mVp-p	5mVrms 100mVp-p	5mVrms 100mVp-p

[1] Specifications are warranted over a temperature range of 0 - 30°C with default local sensing. Above 30°C, derate output linearly to zero at 70°C.

[2] For input voltage variation over the AC input voltage range, with constant rated load.

[3] For 0-100% load variation, with constant nominal line voltage.

AC Input	Default:	104-127 Vac at 6Arms
	AC 200 Option:	200-250 Vac at 3Arms
Maximum Voltage Differential from output to safety ground	400Vdc	

1.4 Specifications

1.4.2 Additional Characteristics

TABLE 1.4-2 ADDITIONAL CHARACTERISTICS			
Models	**HPD 15-20**	**HPD 30-10**	**HPD 60-5**
Stability [4]			
Voltage (0.02% of V max)	3mV	6mV	12mV
Current (0.03% of I max)	6mA	3mA	1.5mA
Temperature Coefficient [5]			
Voltage (0.015% of V max/°C)	2.25mV	4.5mV	9mV
Current (0.02% of I max/°C)	4mA	2mA	1mA
Front Panel Voltage Control Resolution (0.02% of V max)	3mV	6mV	12mV

[4] Drift over 8 hours after 60 minute warmup.

[5] Change in output per °C change in ambient temperature, with constant line and load.

Operating Ambient Temperature	0-30°C with default local sensing. Above 30°C, derate output linearly to zero at 70°C
Storage Temperature Range	-55° to +85°C
Humidity Range	0-80% RH Non-condensing
Voltage Mode Transient Response Time	<500µS recovery to 50mV band for ±50% load change in the range of 25% to 100% of the rated load
Switching Frequency	100kHz (nominal)
Front Panel Control	10-turn voltage and 1-turn current potentiometers (10-turn current control optional)
Front Panel Voltage Control Resolution	0.02% of Vmax
Agency Approvals	CSA, FCC Part 15, Subpart J, Class A standards for radiated and conducted emissions

1.4.3 Mechanical Specifications

TABLE 1.4-3 MECHANICAL SPECIFICATIONS				
Unit	**Height**	**Width**	**Depth**	**Weight**
Single	132mm 5.25in	109mm 4.25in	297mm 11.7in	3.5kg 7.7lbs

2. INSTALLATION

2.1 Introduction

This section provides recommendations and procedures for inspecting, installing, and testing your new power supply. Refer to the front and rear panel diagrams in **Figure 2.1-1 and 2.1-2** as needed.

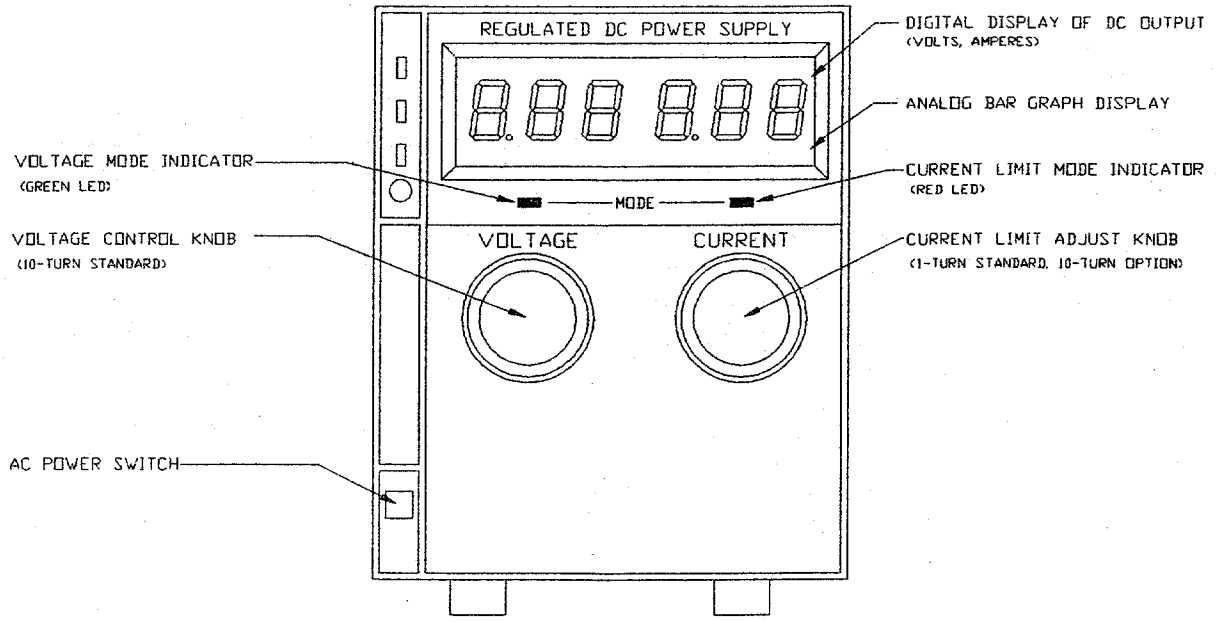


Figure 2.1-1 HPD Series Supply Front Panel

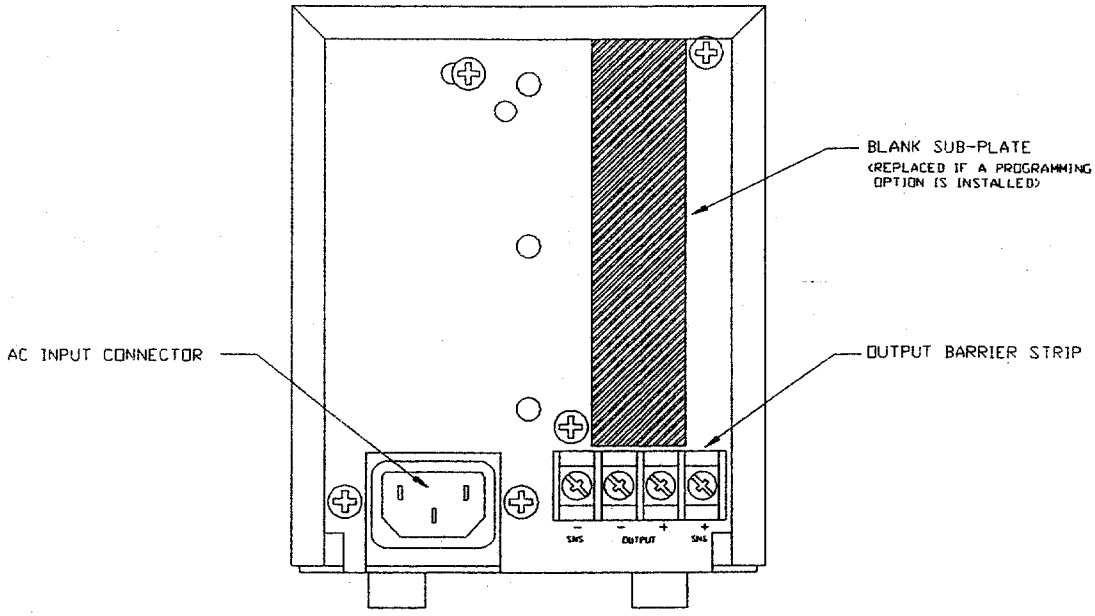


Figure 2.1-2 HPD Series Supply Rear Panel

2.2 Safety

Exercise caution when using and servicing power supplies. The output voltage terminals on all power supplies in normal operation can store potentially destructive energy levels. In addition, any single model or series configuration which results in output of 40 Volts or greater presents a potential personal hazard.

Use extra caution when biasing the output relative to the chassis due to potential high voltage levels at the output terminals.

2.3 Initial Inspection

The power supply comes complete with an IEC power cord set and a technical manual. Inspect the equipment for damage as follows:

1. Inspect panel and chassis for dents, and other signs of obvious damage.
2. Turn front panel controls from stop to stop. Rotation should be smooth.
3. Test the action of the power switch. Switching action should be positive.
4. If you suspect any internal damage, remove the cover and check the components and printed circuit boards for damage. Reinstall the cover.

If you find any damage, save all packing materials and notify the carrier immediately. Refer to the terms of the warranty. Direct any repair problems to the manufacturer.

2.4 Indicators, Controls, and Outputs

A voltage control mode indicator (green) is located above the voltage control knob. A current limit mode indicator (red) is located above the current limit adjust knob. The front panel voltmeter and ammeter readouts are digital. Load connection is at the output barrier strip on the supply's rear panel. See **Figures 2.1-1** and **2.1-2**

2.5 Ventilation Requirement

Whether installing the HPD Series power supply on a bench or in a rack, allow a 1U (1.75") space between units. This allows cooling air to reach the top and bottom of each supply.

2.6 Power On Procedure

1. Before connecting the unit to an AC outlet, make sure that the front panel power switch is in the extended (OFF) position and the voltage and current controls are in their fully counter clockwise positions.
2. Ensure the AC line voltage is 115V (nominal). (Use 220V (nominal) AC line voltage if your power supply has AC input option AC200 for 200-250Vac.)
3. Plug the line cord into a grounded AC outlet.
4. Push the power switch to turn on the power supply.

The red current mode LED will light and the meter reading should remain at zero.

See **Section 3.5** for information about **Standard Operation**.

2.7 Output Biasing

When biasing the output voltage relative to ground, you may bias the power supply outputs up to a maximum of 400Vdc with respect to the chassis.

2.8 Initial Functional Tests

2.8.1 Voltage Mode

To check voltage mode operation, proceed as follows:

1. Rotate VOLTAGE and CURRENT controls fully counterclockwise.
2. Connect a DVM, rated better than 0.5% accuracy, to the front panel binding posts (+ and -).
3. Connect the IEC power cord set to the unit, then to the specified power source, and set the POWER switch to ON.
4. Rotate the CURRENT control a 1/2 turn clockwise. Slowly rotate the VOLTAGE control clockwise and observe the digital meters. Minimum control range should be from 0 to maximum rated output. Compare the test meter with the front panel voltage meter on the left. Observe the bar graph meter to see that it tracks as the voltage rises. Verify that the voltage mode indicator light is ON.
5. Set the POWER switch to OFF.

2.8.2 Current Mode

To check current mode operation, proceed as follows:

1. Rotate VOLTAGE and CURRENT controls fully counterclockwise.
2. Rotate the VOLTAGE control a 1/2 turn clockwise.
3. Connect a DC ammeter across the front panel binding posts (+ and -). Select leads of sufficient current carrying capacity and an ammeter range compatible with the unit's rated current output. The ammeter should have an accuracy of better than 0.5%.
4. Set the POWER switch to ON.
5. Rotate the CURRENT control slowly clockwise. The control range should be from zero to the maximum rated output. Compare the test meter reading with the reading on the front panel current meter. Also check that the current bar graph meter follows the rise in current and that the current mode indicator light is ON.
6. Set the POWER switch to OFF.

3. LOAD CONNECTION AND OPERATION

3.1 Introduction

This section covers single and multiple load connection, Constant Voltage and Constant Current operating modes, and alternate power supply configurations such as series and parallel connections.

3.2 Load Connection

You can obtain reliable performance from your power supply if you take certain basic precautions when connecting it for use on the lab bench or installing it in a system.

To obtain a stable, low noise output, pay careful attention to factors such as conductor ratings, system grounding techniques, and the way you make the AC input, DC output, and remote sensing connections. Use a conductor size that satisfies the current rating requirements. To overcome impedance and coupling effects, however, we recommend larger gauge wire and shorter leads.

Where positive load transients such as back EMF from a motor may occur, connect a transorb or a varistor across the output to protect the power supply.

Connecting Multiple Loads

Proper connection of distributed loads is an important aspect of power supply use. A common mistake is to connect leads from the power supply to one load and then from that load to other loads. In this **parallel power distribution method**, the voltage at each load depends on the current drawn by the other loads and DC ground loops are developed. Except for low current applications, we recommend that you not use this method.

The preferred way to distribute power is by the **radial distribution** method in which power is connected individually to each load. In the radial method, a single pair of terminals are designated as the positive and negative distribution terminals. This pair of terminals may be the power supply output terminals, the load terminals, or a distinct set of terminals specially established for distribution. In this scheme, there are no ground loops and the effect of one load upon the other is minimized.

3.3 Grounding

Make proper grounding connections to avoid developing paths between separate ground points. To avoid ground loops, there must be only one ground return point in a power system. If the load itself is not grounded, ground the positive or negative output to the supply's chassis via a rear panel screw.

3.4 Remote Sensing

Remote sensing permits you to shift the regulation point of the power supply from the output terminals to the load or other distribution terminals. It compensates for voltage losses of up to a total of 0.5 volts in the power leads supplying the load.

To compensate for losses in power leads connected to the output, your power supply provides sense connections beside the output terminals. With remote sense leads in place, the supply regulates the displayed voltage at the point where the sense lines are connected to the output leads (provided the sum of these lead losses does not exceed 0.5 volts). With the sense lines disconnected, the supply regulates the voltage at the output terminals.

Notes:

1. Do not operate the supply with sense lines connected without also connecting the normal power leads to the output terminals. Avoid reversing positive and negative lead connections.

2. Always use shielded twisted pair wiring for sense lines to minimize noise effects.

3.5 Standard Operation

Your power supply has two basic operating modes: Constant Voltage Mode and Constant Current Mode. The mode in which the power supply operates at any given time depends on the combination of the output voltage setting, the output current limit setting, and the resistance of the attached load.

Figure 3.5-1 Operating Modes provides a graphical representation of the relationships between these variables.

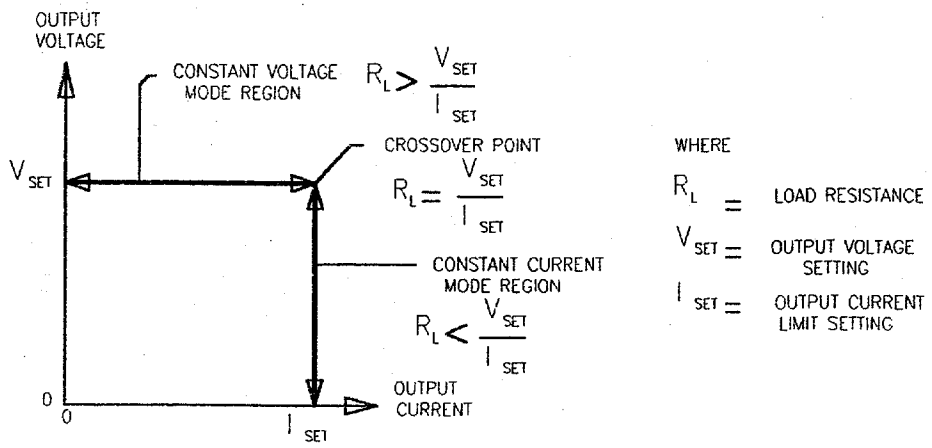


Figure 3.5-1 Operating Modes

3.5. Standard Operation

3.5.1 Constant Voltage Mode Operation

The power supply will operate in constant voltage mode whenever the load current I_L **is less** the current limit setting I_{SET}, or: $\mathbf{I_L < I_{SET}}$ (Note: $I_L = V_{SET} / R_L$). In constant voltage mode, the power supply maintains the output voltage at the selected value (V_{SET}) while the load current I_L varies with the load requirements.

To use the power supply in Constant Voltage mode, either turn the current control to its extreme clockwise position or take the precaution of setting a desired maximum current, then set the voltage control to the desired voltage.

3.5.2 Constant Current Mode Operation

The power supply will operate in constant current mode whenever the load resistance is low enough that the load current I_L **is greater than** the current limit setting I_{SET}, or: $\mathbf{I_L > I_{SET}}$. In constant current mode, the power supply maintains the output current at the selected value (I_{SET}) while the load voltage varies with the load requirements.

To set the Current Limit, connect a shorting lead across the output terminals, turn the voltage control a half-turn clockwise, and set the desired maximum value of current limit by turning the current control slowly clockwise to the desired level. Then disconnect the shorting lead from the output terminals. The power supply will now automatically switch into current limiting mode (current regulation) as soon as the preset current level is reached. **To operate the supply in Constant Current mode, set the Current Limit as described above, then set the voltage control fully clockwise or to the compliance voltage of the circuit.** As soon as the supply starts operating in current mode, the red current mode LED will turn on.

3.5.3 Automatic Mode Crossover

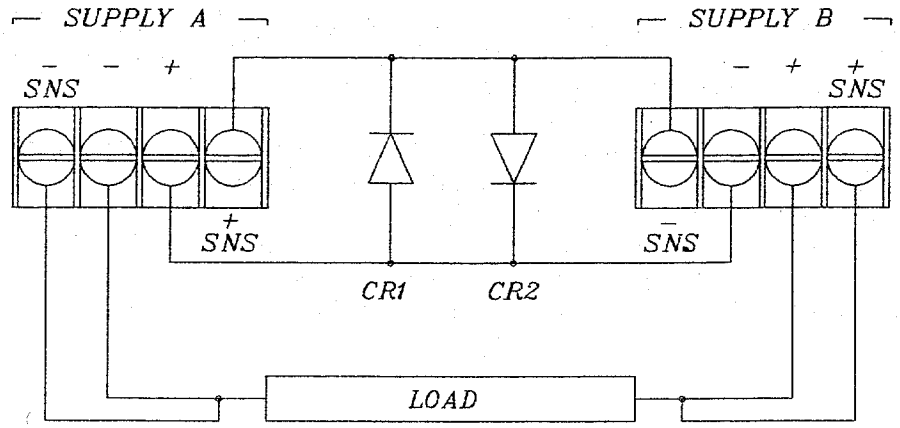
The automatic crossover system allows the power supply to automatically switch operating modes in response to changing load requirements. For example, if the load current attempts to increase above the setting of the current adjust control, the unit will switch automatically from Constant Voltage to Constant Current mode. If you lower the load requirements, the supply will automatically return to Constant Voltage mode.

3.6 Series, Parallel, and Split Supply Operation

You can operate two or more power supplies with outputs in series or in parallel to obtain increased load voltage or current. A split supply configuration allows you to obtain two positive outputs or a positive and a negative output.

3.6.1 Series Operation (Voltage Mode Only)

Connect power supplies in series to obtain a higher voltage single output supply. Connect the negative (-) terminal of one supply to the positive (+) terminal of the next supply. The total voltage available is the sum of the maximum voltages of each supply (add voltmeter readings).



CR1, CR2 : 1N4004 (REQUIRED ONLY IF REMOTE SENSE USED)

Figure 3.6-1 Series Operation with and without OVP

Notes:

1. The maximum allowable sum of the output voltages is 400V. This is limited by the output to ground isolation specification.
2. The maximum current available to the load is equal to the current of the lowest rated supply in the string.
3. You do not need to use remote sensing for series operation. If you do, refer to **Section 3.4 Remote Sensing**.
4. CR1 and CR2 protect sense circuits during transient events such as momentary current limit events which may cause supply outputs to collapse.

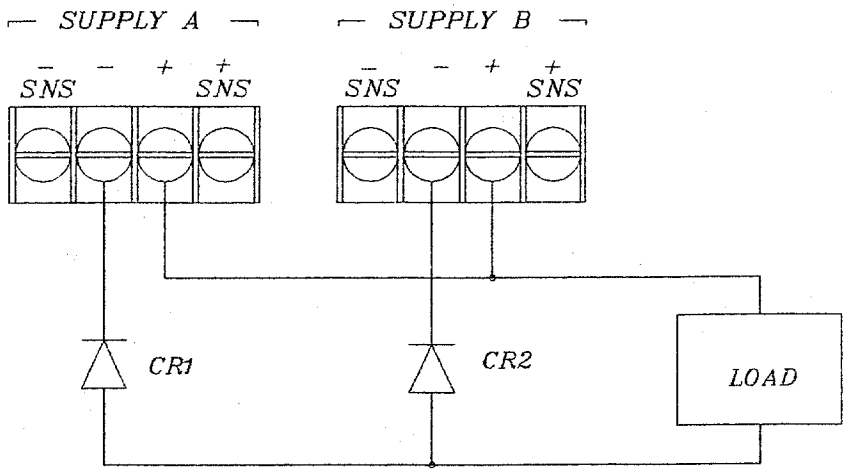
3.6 Series, Parallel, and Split Supply Operation

3.6.2 Parallel Operation

Connect power supplies in parallel to obtain a higher current single output supply. Set all of the outputs to the same voltage before connecting the positive (+) and negative (-) terminals in parallel. The total current available is the sum of the maximum currents of each supply. The maximum voltage available at the load is equal to the voltage of the lowest rated supply. When you connect two supplies in parallel, the supply with the higher voltage setting will be in the current limiting mode, while the other supply controls the output voltage.

CAUTION

For parallel operation with OVP-equipped supplies, set all OVP trip points higher than the maximum output voltage. To prevent the internal OVP fuse from blowing during OVP trip events, add external blocking diodes as illustrated in **Figure 3.6-2**.



CR1, CR2 (TYPICAL)	15–20	30–10	60–5
	1N1184	1N1200	1N1200
P(max)/DIODE	20W	10W	5W

Figure 3.6-2 Parallel Operation with OVP-equipped Units

3.6 Series, Parallel, and Split Supply Operation

3.6.3 Split Supply Operation

Use split connection to obtain two positive voltages with a common ground, or a positive-negative supply.

To obtain **two positive voltages**, connect the negative terminals of both supplies together. The positive terminals will supply the required voltages with respect to the common connection.

To obtain a **positive-negative supply**, connect the negative terminal of one supply to the positive terminal of the second supply. The positive terminal of the first supply then provides a positive voltage relative to the common connection while the negative terminal of the second supply provides a negative voltage. The current limits can be set independently. The maximum current available in split operation is equal to the rated output of the supplies used.

Note: The optional Analog Programming Interface (APG) has a Master/Slave Tracking feature which will allow one knob control of both supplies in a split supply configuration

4. THEORY OF OPERATION

4.1 Introduction

This section explains the operation of your power supply's power circuit (A2 assembly) and meter circuit (A1 assembly). It starts with a description of the two-transistor forward converter on the A2 assembly. Detailed circuit descriptions then complete the power circuit theory. The final subsection briefly describes the front panel meter circuit.

4.2 Power Circuit (A2 Assembly)

4.2.1 Simplified Two-Transistor Forward Converter Theory

The AC line voltage is first rectified to a DC voltage by rectifier CR23 (**Figure 4.2-1**). A surge limiter circuit formed by K1 and R84 prevents excessive power-on current surges to the main filter capacitors. This DC voltage is applied to power-FET transistors Q5-8 which are gated on and off simultaneously at a 100kHz switching rate by the pulse width modulator U8 through totem-pole drivers Q12 and Q13 and drive transformer T2. This allows current to begin flowing through the primary of T3 for the duration of the drive pulse waveform from U8, causing a current ramp in the T3 primary, which develops a voltage ramp across the primary shunt resistor. This voltage level is fed back to the pulse width modulator U8 which terminates the on-time drive pulse when the ramp crosses an internal threshold voltage (corresponding to a peak primary current in T3). In this way, the current feedback to the PWM forms a cycle-by-cycle current mode control loop limiting the maximum output on the T3 secondary.

During the on-time of the switching transistors and the T3 primary, current flows through CR5A and inductor L2 to the output. When the T3 primary is turned off, the stored energy in inductor L2 causes current to continue to flow to the output through CR5B. (CR5 is a fast recovery switching rectifier.) A current shunt resistor in the output return line develops a voltage dependent on the output current. The current control circuit (U3C, U3D) compares this current information to the setting of the current limit control. The voltage control circuit (U3A) monitirs the output voltage in the same way and compares it to the voltage adjust control. The outputs of both of these (voltage and current) control circuits are ORed to drive power-FET Q3 to precisely regulate the output voltage or current to the level set by the voltage adjust control or the current limit control. As the output load requirements change, the voltage and current control circuits change the drive to Q3 to maintain the desired output level.

The output from T3 is pre-regulated to the level required by the linear post-regulator circuit (described in the preceding paragraph). This is accomplished by a negative feedback path through opto-isolator U5, which controls PWM U8, and sets the on-time of the switching drive waveform. As post-regulator Q3 requires more output, the negative reference provided by U2B biases error amplifier U3A positive, biasing the opto-isolator on, and lengthening the on-time pulse from the PWM until the output increases to the required level (at which the error amplifier output returns to zero). As the post-regulator requires more input at lower voltage and current levels, the outputs of the current and voltage control circuits also control the negative reference level.

The current and voltage control circuits feed the output voltage and current information to the A1 assembly (front panel) where the voltage and current digital readouts and bar graphs display it. An auxiliary switching power supply of the flyback type, operating at 200kHz, provides the necessary supply voltage for the PWM circuit as well as isolated supply voltages for the voltage and current control circuits, any option boards, and the A1 metering board. A 10 volt reference circuit supplies the necessary reference level for the current and voltage monitoring circuits.

The isolation of transformer T3 and opto-isolator U5 provide output isolation from the line potentials in the primary circuit, PWM, and auxiliary switching supply (which also has an isolating transformer).

4.2 Power Circuit (A2 Assembly)

4.2.1 Simplified Two-Transistor Forward Converter Theory (continued)

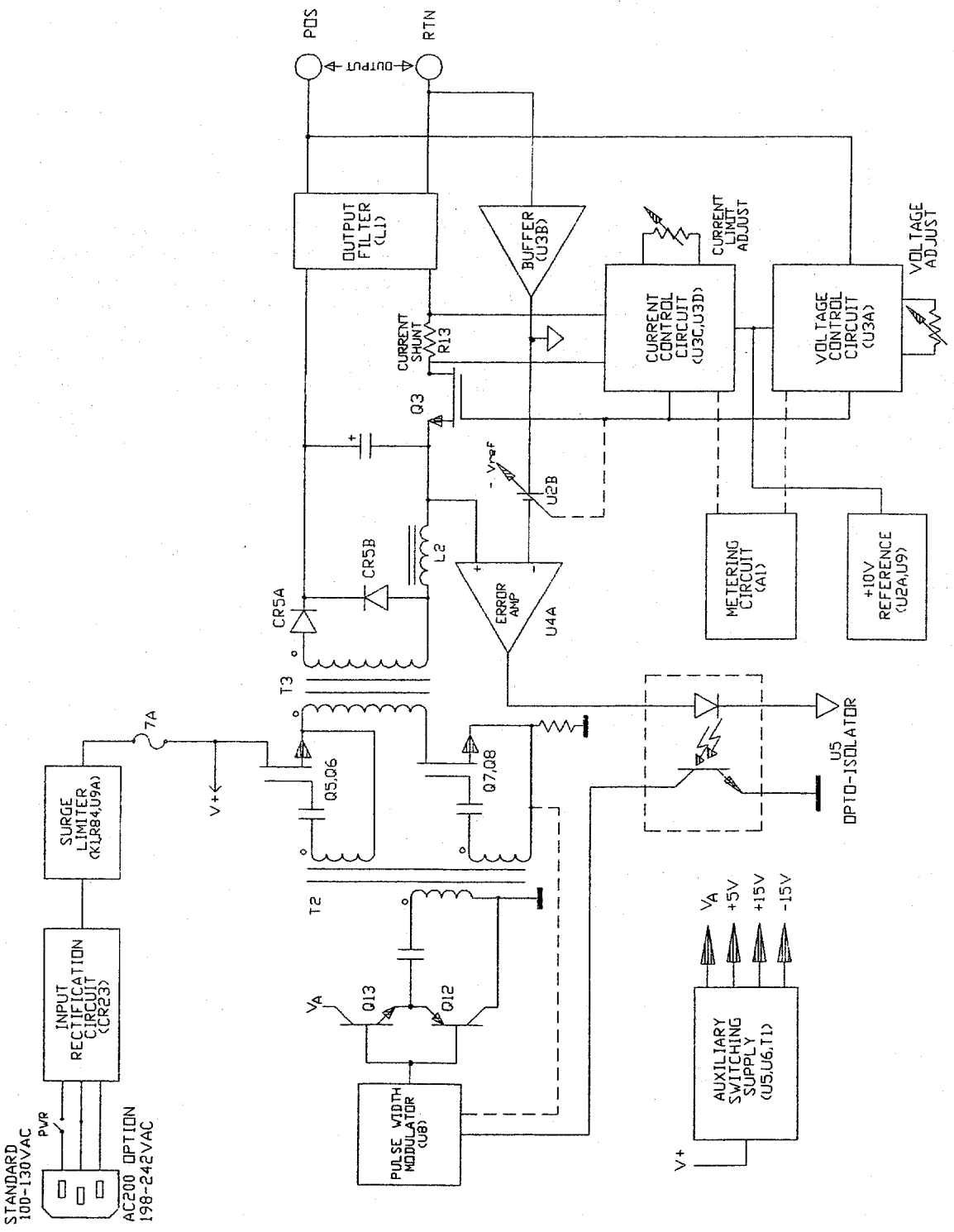


Figure 4.2-1 Simplified Two-Transistor Forward Converter With Linear Post-Regulator

4.2 Power Circuit (A2 Assembly)

4.2.2 Detailed Circuit Descriptions

> **WARNING**
> Potentially lethal voltages exist on the A2 circuit board on the primary side of the isolation barrier. Troubleshoot with care, preferably with power off and recognizing that filter capacitors store potentially lethal and destructive energy even for some time after power is removed. Always use an isolation transformer connected only to the power supply input when making test measurements on the primary side circuits.

This section provides more in-depth information for troubleshooting purposes. Refer to the detailed A2 assembly schematic in **Appendix A.**

Input Rectifier, Surge Limiter, and Voltage Doubler

F1 channels power to the input RFI filter which consists of C56-58, and inductors L3 and L4. Recifier CR23 provides input rectification. The main energy storage capacitors C53 and C54 charge through current limiting resistor R84. When the V+ bus reaches approximately 190Vdc, op-amp U9A drives relay K1, shorting out R84, and op-amp U9B enables the main converter.

When the 115V jumper is installed, CR23, C53, and C54 act as a line frequency voltage doubler to provide the same V+ bus voltage as with the 200V input configuration (Option AC200).

Pulse Width Modulator

Pulse width modulator U8 acts as a current mode controller, driving switching transistors Q5-8 through drive transistors Q12 and Q13, and transformer T2. Zeners CR10, CR11, CR18, and CR19 provide gate protection while components R50, CR13, C31, R63, CR20, and C38 act as snubbers, limiting switching transients on the primary of T3. U8 monitors the voltage ramp provided by current shunt R64 and compares it to an internal threshold voltage, thus controlling the output pulse duration on U8 pin 14, depending on the T3 primary current. R62 and C50 provide filtering for this current feedback signal. U7 and associated components form a 200kHz stable oscillator from which C44 relays a 200kHz pulse to U8 pin 10 (sync input). This sets the output of U8 to a 100kHz frequency. The PWM IC generates a +5.1 volt reference at pin 2. R75, R76, and C51 provide a soft-start function by holding pin 1 low on power-up. U5 and R70 divide the reference voltage and, with R71 and R72, control the internal threshold voltage which is compared to the peak T3 primary current. The degree to which U5 is biased on thus controls the on-time of the pulse at U8 pin 14, and consequently the output level at the secondary of T3.

Output Rectifier Circuit

CR5A and CR5B rectify the output on the T3 secondary as previously described. R44, R45, C25, and C26 are snubber components which further limit switching transients. C5-7 and L2 provide filtering of the pre-regulated output at this point, and Q1 can rapidly discharge C5-7 whenever power-on/off or output load changes occur. Q1 maintains the voltage across Q3 at a maximum of -10 volts (set by CR29 and associated components).

4.2 Power Circuit (A2 Assembly)

4.2.2 Detailed Circuit Description (continued)

Output Pre-Regulator Circuit

The circuit formed by U3B and Q15 buffers the output return sense level to provide a control ground level used by the reference and output regulating circuits. U2B is used to generate a -10 volt reference from the +10 volt reference level provided by U2A. R33, R34, and R37 divide down this negative reference to provide the appropriate negative reference level at the U4A error amplifier input pin 2. R37 and R34 are referenced to the current control output (U3C pin 8) and the output voltage respectively, thus making the negative reference proportional to the output current and voltage levels. The other error amplifier input (U4A pin 3) is referenced to the source of Q3. As the voltage across Q3 (source to drain) varies between -10 volts and zero, the output of U4A also varies, controlling the drive to opto-coupler U5, which in turn controls the output of the PWM and the level at the T3 secondary. This forms a negative feedback path which pre-regulates the voltage across Q3 at typically -4 volts (set by the negative reference level at U4A pin 2). In this way, enough output is supplied to Q3 for all output conditions.

Output Filter Circuit

C4, C4A, L1 and C120-122 form the output filter. R27A provides an output pre-load and allows the output circuits to operate under low output current conditions.

Auxiliary Switching Supply

U6, U7, T1, and associated components form a multiple output flyback type switching supply operating at 200kHz. U7 (a CMOS timer IC) generates a 200kHz frequency used to drive the oscillator input of pulse width modulator U6 which generates a variable pulse width 200kHz signal to Q4. Q4 switches the primary of transformer T1, generating a current ramp monitored by U6 at pin 3 from current shunt resistor R55. R53, R54, and C41 condition this current feedback signal. R56 and R57 limit the gate drive to Q4 below 20 volts. R51, CR15, and C32 act as a snubber, limiting switching transients on the T1 primary. A flyback winding provides power to U6 through CR16 and C34, and provides negative feedback to pin 2 through R66 and R67 where internal comparison to a 2.5 volt reference shortens the output pulse width for increasing flyback voltage (thus providing voltage regulation). The resulting regulation provides regulated outputs on the T1 secondaries which are rectified and filtered to provide supply voltages for the control, A1 metering, and any option circuits. The flyback winding is also used to power the main PWM circuit (U8) via CR17 and filter capacitors C35 and C45. R12 and CR2 provide a -6.2 volt supply to the A1 circuit.

+10 Volt Reference

U2A, U9, and associated components form a well-regulated +10 volt reference circuit used in the voltage and current control circuits as well as the A1 metering circuit. Trimming R16 sets the output of U2A to the +10 volt reference level. C2 and C11 filter any noise present on the reference.

Voltage Control Circuit

U3A monitors the output voltage at pin 2 through the positive sense line (J2-8) and the resistor divider string R7-10. The voltage adjust control (via analog gate U1C) applies a zero to 10 volt reference at pin 3 of U3A to compare to this output voltage. As the output voltage rises, pin 2 goes high with respect to pin 3 of U3A, the U3A output goes low, and the drive to Q3 is decreased through CR3. (In the voltage control mode, U3D pin 14 is high.) This decreases the output current through Q3 so that voltage regulation of the output is achieved at a voltage proportional to the set point of the voltage adjust control. The R7 to R10 divider is scaled such that 10 volts at pin 3 of U3A generates maximum output voltage. Thus, the output tracks the voltage adjust control linearly from zero to maximum output voltage.

4.2 Power Circuit (A2 Assembly)

4.2.2 Detailed Circuit Description (continued)

Current Control Circuit

U3C monitors the output current from current sense resistor R13. U3C and associated components form a differential amplifier scaled such that full scale output current corresponds to +5 volts at U3C pin 8. This level is compared to the current limit control at U3D. The current limit control supplies an adjustable zero to 10 volt signal to U1A, after which it is scaled to zero to 5 volts at U3D pin 12. As U3D pin 13 exceeds U3D pin 12 (when the output current increases above the current limit set-point), the output of U3D goes low, decreasing the drive to Q3. This limits the output current as a result, until the voltage at U3D pin 13 becomes equal to that of U3D pin 12, and precise current regulation is achieved. In this way, the output current tracks the current limit control linearly from zero to maximum rated current, provided the output load is sufficient to draw such current. If the output current falls below the current limit set-point, U3D pin 14 will go high and U3A will be able to control the output in the voltage control mode by sinking current through R35 and CR3, and thus controlling the drive to Q3.

Mode Indication

U4B takes advantage of the fact that CR3 is forward-biased in voltage control mode and reverse-biased in current control mode to provide a mode indication signal at U4B pin 7. This is used to drive two back-to-back LED indicators on the front panel. In the voltage control mode, U4B pin 7 is high and the green (voltage) LED lights. In the current control mode, U4B pin 7 is low and the red (current) LED lights.

Remote Programming

You can use the option connector lines P2-9 and P2-8 to turn off analog gates U1C and U1A, switching out of circuit the zero to 10 volt signals from the current and voltage controls. The option boards can then use lines P2-1 and P2-2 to remotely program the voltage and current control circuits with appropriate zero to 10 volt programming levels.

Shutdown Circuit

You can use a high level on the option connector line P1-9 to turn off the power circuit. This turns on Q2, which turns off U1D, and removes drive current to the opto-coupler U5, turning off the power supply. When U1D turns off, U1B turns on, preventing positive saturation of U3A which would result in an output overshoot when the shutdown level is removed. A control ground or return sense line fault, causing the buffered control ground from U3B to go high, will cause a similar shutdown function through CR3A.

Metering Output

The R7 to R10 divider string provides two outputs proportional to the output voltage for metering purposes: a zero to 5 volt output to the option board (P2-4), and an appropriately-scaled output to the A1 metering circuit (J2-7). Similarly, the resistor divider string R28, R25A, and R11 provides two outputs proportional to the output current: a zero to 5 volt output to the option board (P3-1), and an appropriately-scaled output to the A1 metering circuit (J2-6).

Model Identification

The A2 board also provides model information required by the option board at connector lines P3-4, P3-5, P3-6, and P3-7. A coded combination of shorted links at points A, B, and C identifies each model. This is decoded by logic circuitry on the option boards.

4.3 Meter Circuit (A1 Assembly)

Refer to the schematic diagram in **Appendix A** for the following discussion.

4.3.1 Voltage Meter

The analog input signal from the A2 power board is divided down so that 1mV between P102-7 to P102-5 represents 1 volt at the output of the power supply. R128 and C114 filter this reduced voltage to remove any noise and then input the voltage to U104, a 3 1/2 digit analog-to-digital converter. U104 converts the input voltage to a three digit readout of up to 999mV on the seven segment LED displays DS104 through DS106. The conversion is performed approximately 3 times each second at a rate determined by the value of C106. The reference voltage from pin 35 to pin 36 of U104 determines the full scale accuracy of the meter.

The reference voltage of 1.0 volts is derived from the 10 volt reference on the A2 board via the divider R132, R133, and R134. Note that the display shows any negative input as a positive reading as there is no negative sign in the display.

The bar graph driver IC (U103) and LEDs DS117 through DS126 display changes in the output voltage. R104 and R113 determine the full scale reference voltage which corresponds to all 10 LEDs being lit

4.3.2 Current Meter

The current meter circuit functions like the voltage meter circuit discussed in **Section 4.3.1**. U102 performs the analog-to-digital conversion which DS101 through DS103 then display. The U101-driven current bar graph LEDs DS107 through DS116 display the output current.

4.3.3 Output and Sense Lines

R122 and R125 internally connect the remote sense lines to the main output terminals. Should you incorrectly connect the sense lines to the output, for example, in reverse, Q101 is biased on and raises the return sense potential. This performs a shutdown function via U3B, CR3A, and Q2 on the A2 power assembly.

5. MAINTENANCE

5.1 Introduction

This section provides troubleshooting, servicing, and calibration procedures as well as the parts lists. Use the troubleshooting data in conjunction with the schematics in **Appendix A** and with the circuit descriptions in **Section 4**. Refer to the specifications in **Section 1** when calibrating your power supply.

5.2 Units under Warranty

Return units requiring repair during their warranty period to the manufacturer for service. Unauthorized repairs performed by any one other than the manufacturer during the warranty period may void the warranty. Direct any questions regarding the warranty or any repairs to the manufacturer.

5.3 Periodic Servicing

Whenever you remove a unit from service, clean it by using naphtha or an equivalent solvent on metal surfaces and a weak solution of soap and warm water on the front panel. Use compressed air (at 5 psi) to blow dust from in and around components.

5.4 Servicing Precautions

Always disconnect power and discharge circuits before replacing components. Ensure only experienced technical personnel make any repairs.

Use proper static control techniques to avoid damage to front panel display drivers and other static-sensitive parts.

Be sure to isolate the power supply from the input line with an isolation transformer when using grounded test equipment, such as an oscilloscope, in the primary circuit.

5.5 Test Equipment Required

You may need the following test equipment when servicing or calibrating your power supply:

1. Oscilloscope, dual trace, 20-200MHz bandwidth.
2. Digital multimeter, 4 1/2 digit accuracy.
3. True RMS voltmeter (Hewlett Packard HP-3403C or Fluke 8840-09).
4. Line isolation transformer, 500VA.

5.6 Troubleshooting

WARNING

Potentially lethal voltages exist in the power circuit (on the A2 Assembly PCB). Troubleshoot with care after familiarizing yourself with circuit operation and use appropriate high voltage testing techniques. Assign service and repair to experienced technical personnel only. Remember that filter capacitors can store potentially dangerous energy for some time after you turn off the power. Discharge large filter capacitors with suitable resistors for your personal safety and for the protection of components during repair work. Line potentials are present throughout the A2 circuit. Isolate the power supply from the line with an isolation transformer when using grounded test equipment in the power circuit.

5.6.1 Blown Fuses

Always replace fuses with the same type and rating as those originally installed. A blown fuse almost invariably indicates other faulty components which you should identify and replace before you install a new fuse. If possible, troubleshoot and identify faulty components **with power removed**. Look particularly for isolation faults in inductors and transformers, and drain-source shorts in the power-FET devices.

A blown F2 fuse indicates likely failure of switching transistors Q4 to Q8 and/or output devices, while a blown F1 fuse indicates likely bridge rectifier (CR23) failure and/or failure of transistors Q9, Q10, and Q14.

Replace power transistors with similar parts, not with substitutes.

5.6.2 Main Assembly Troubleshooting Chart

Follow the procedures in this section to service the A1 Front Panel Assembly and the A2 Power Assembly.

1. Check for burnt components, poor solder connections, and loose connectors.

2. Disconnect any attached option board (internal interfaces such as Analog Programming or GPIB). If the problem is corrected once the board is removed, refer to the technical manual for that interface.

3. Observe the high voltage precautions listed at the beginning of this section when troubleshooting the A2 assembly. Be sure to power the unit from an isolation transformer when using grounded test equipment (such as an oscilloscope) in the primary side of the circuit. **Failure to observe these precautions could cause serious injury** or could damage test equipment.

4. Make all measurements with reference to P2-6 unless otherwise noted.

5. All parts and test points are located on the A2 assembly unless otherwise noted.

6. In the **Possible Defective Component** column, we list parts in order of decreasing probability of failure.

5.6 Troubleshooting

5.6.2 Main Assembly Troubleshooting Chart

TABLE 5.6-1 MAIN ASSEMBLY TROUBLESHOOTING CHART

Symptom	Check	Possible Defective Component and Causes
No output and the display is blank	1. That F1 is not open	1. Check Q9, Q10, CR24, CR23, Q14, CR22 and CR21 before replacing fuse
	2. That F2 is not open	2. Check Q5 to Q8, Q4, CR12, CR14, CR5, and insulating washers on Q5 to Q10 before replacing fuse
	3. DC auxiliary voltages are present and within range: P2-5=+15V +/- 1V P2-7=-15V +/- 1V P3-3= +5V +/- 1V	3. If not: U6, U7, Q4, T1, CR7 to CR9
	4. Reference voltage at P1-7 is 10V +/- 0.1V	4. If not: U2, U9 Otherwise: Replace the front panel and proceed to next troubleshooting section
No output but the display functions	1. Fast-on cable connectors to the A1 assembly are properly seated	1. Fast-on connectors
	2. DC auxiliary voltages are as listed in step #3 of previous section	2. If not: CR7, CR8, U6, T1
	3. Reference voltage is as in step #4 of previous section	3. If not: U2, U9
	4. With voltage and current controls fully clockwise, voltage at anode of CR3 is greater than 5V	4. If not: U3, U1, Q2, Q3, Q1 or R122, R125 and A1 assembly
	5. Voltage across Q3 is less than 3 volts	5. If not: Q1, Q2, Q3, U1
	6. Voltage at R70, R71 junction is less than 2V with reference to P4-2	6. If not: U2B, U4A, coaxial jumper W1, U5
	7. With an oscilloscope, check for 15Vp-p square wave at emitters of Q12 or Q13 at 100kHz +/- 5kHz with reference to P4-2	7. If not: U18, Q12, Q13
	8. With an oscilloscope, check for square wave on T3 secondary pins 7 to 12	8. If not: T2, Q5 to Q8 otherwise: CR5
Output is above the normal maximum output voltage and is not adjustable	1. Turn off the power supply immediately and remove U8 from its socket to prevent further damage to output components	1. Replace over-stressed output capacitors C5, C6 and C7
	2. Q3 is functional	2. If not: Q3
	3. With power ON and the voltage control fully counterclockwise, U3 pin 1 is less than 0 volts	3. If not: Connect +SNS to + output. If voltage is then correct, replace R122 and R125 on A1. If still incorrect, check U3B, U2, U9, U1.
	4. With power OFF, check that resistance across W1 is greater than 1k Ohm	4. If not: U5, W1 Otherwise: U4, U2, U8

Continued on next page.

5.6 Troubleshooting

5.6.2 Main Assembly Troubleshooting Chart

TABLE 5.6-1 MAIN ASSEMBLY TROUBLESHOOTING CHART (CONTINUED)

Symptom	Check	Possible Defective Component and Causes
Display erratic or blank but output is functional	1. Ribbon cable connectors to A1 assembly are properly seated	1. Ribbon cable connectors
	2. DC voltage at P3-3 is 5V +/- 0.5V and at CR2 anode is -6.2V +/- 0.5V	2. If not: CR9, CR2, CR8
	3. DC reference voltage at P1-7 is 10V +/- 0.1V	3. If not: U2, U9 otherwise: (A1 assembly) - Voltage display: U104 - Voltage bar graph: U103, R113 - Current display: U3 on A2 assembly, U102 - Current bar graph: U3 on A2 assembly, U101
Output regulation poor or output not adjustable over full range	1. DC auxiliary voltages are present as previously described (Table section 1, step #3)	1. If not: U6, U7, Q4, T1, CR7 to CR9
	2. DC reference voltage is as previously described (Table section 1, step #4)	2. If not: U2, U9
	3. Control ground voltage at P2-3 referenced to the negative output is less than +/- 50mV	3. If not: R125 on A1 assembly or U3, Q15
	4. DC voltage at U3 pin 3 is adjustable from 0V to 9.5V with front panel voltage control	4. If not: U1, U3, ribbon cable connectors
	5. With NO load on output, DC voltage at Q3 source is between -2V and -10V	5. If not: Q1, U4A, U2B, CR29, U3
	6. CR5 and Q3 case are isolated from heatsink	6. Insulating washers on Q3 and Q5
	7. DC raw supply voltage at T1 pin 4 referenced to P4-2 is greater than 140V	7. If not: CR23, Q9, Q10, Q14 otherwise: U3, U1, U8

5.7 Calibration

You will not normally need to recalibrate your power supply unless you replace entire assemblies while repairing the supply. But when necessary, you will calibrate your power supply using selected resistors on the printed circuit boards for the A1 Front Panel and A2 Power Assembly. These calibration resistors allow you to trim such critical parameters as the reference voltage and front panel display accuracy. Refer to the specifications in **Section 1** when calibrating.

The calibration resistors on the A1 PCB are mounted in component lead sockets on 0.5" centers and you can replace them easily, using needle nose pliers. Some are 1% metal film resistors to ensure low temperature drift of the related parameter, so you should not replace them with standard 5% ¼W resistors. The A2 PCB calibration resistors are potentiometers which you adjust to conform to specification. We have listed these calibration resistors and other calibration components by assembly in the following sections.

5.7.1 A1 Assembly (Front Panel) Calibration

TABLE 5.7-1 FRONT PANEL ASSEMBLY (A1) CALIBRATION	
A1 Calibration Resistor	**Parameter Affected**
R103	Current bar graph full scale level
R104	Voltage bar graph full scale level
R130	Voltage display accuracy.

5.7.2 A2 Assembly (Power Circuit) Calibration

TABLE 5.7-2 POWER CIRCUIT ASSEMBLY (A2) CALIBRATION	
A2 Calibration Resistor	**Parameter Affected**
RV3	Maximum output current. Set for 5% above rated output current.
RV28	Current display accuracy
RV24	Current display offset. Set for "0" reading with output current at zero.
RV16	+10 volt reference level. Set for most accurate voltage display.

5.8 Replacement Parts

This section provides parts lists for the following assemblies:

- Front Panel Assembly (A1)
- Power Circuit Assembly (A2)
- Rear Output Assembly
- Baseplate and Cover Assembly

In **Appendix A, Figure A-1 Power Supply Interconnection Diagram** shows the connections between each assembly. **Figures A-2 and A-3** are schematic diagrams for the A1 and A2 Assemblies and are used as references for customizing your system configuration and for troubleshooting.

Most assemblies consist of parts common to all model assemblies as well as parts which are model-specific, or differential. You can order each of the parts and assemblies listed, whether complete, common, or differential.

5.8.1 Parts Replacement and Modifications

Do not use substitute parts or make any unauthorized modifications to the power supply to ensure that its safety features are not degraded. For service and repair help, contact the factory.

5.8.2 Ordering Parts

Order parts from the factory using the parts numbers given in the specific assembly parts lists in this section.

Please include the following information with your order: the power supply's model number and serial number as well as the PCB assembly number and revision level.

5.8.3 Front Panel Assembly (A1) Replacement Parts

TABLE 5.8-1 FRONT PANEL ASSEMBLY (A1) COMMON PARTS

Designation	Description	Part Number
Complete Assembly	A1 Front Panel Assembly (Specify model.)	X2-3xxx-FP
C101,102	10µF 50V 2mm Electrolytic Radial Capacitor 5x11	CL-100C-50
C103,105,107-109,112, 118,119	0.1µF 50V Z5U +80% to -20% 2.5mm Ceramic Radial Capacitor	CC-104D-09
C104,106	100pF 100V X7R 10% 2.5mm Ceramic Radial Capacitor	CB-101D-16
C110,111,114,115	47nF 50V Z5U +80% to -20% 2.5mm Ceramic Radial Capacitor	CC-473D-09
C113,116,117	0.1µF 100V MF 10% 10mm Radial Capacitor	CD-104J-16
C120,122	10nF 400Vdc MF 10% 10mm Radial Capacitor	CD-103J-46
C121	0.47µF 100V MF 10% 7.5mm Radial Capacitor	CD-474H-16
C123,124	0.33µF 50V Z5U +80% to -20% 5mm Ceramic Radial Capacitor	CC-334F-09
DS101-106	7 segment Green Display 13.5mm Char HT	DS-0161-G7
DS107-126,129,131	Green Rectangular LED 2.5 x 5mm	DS-0394-G6
DS127,130	Red Rectangular LED 2.5 x 5mm	DS-5556-R6
DS128	Yellow Rectangular LED 2.5 x 5mm	DS-0384-Y6
P101,102,104	9 pin Male 0.1" Friction Lock	MC-0903-MC
PCB	A1 Printed Circuit Board Rev. H	PC-6001-H
Q101	MPS-A92 PB 300V 500mA 625mW	QN-MPSA-92
R105,110	5.11k 1/4W 1% MF Resistor	R-5111-41
R106,107,111,112	2.74k 1/4W 1% Resistor	R-2741-41
R108,113,130	Select and Install in Test	R-TEST
For R108,113,130	Socket .025" Comp. Lead 0.052" Mtn Hole	MC-5315-MS

Continued on next page.

5.8 Replacement Parts

5.8.3 Front Panel Assembly (A1) Replacement Parts

TABLE 5.8-1 FRONT PANEL ASSEMBLY (A1) COMMON PARTS (CONTINUED)		
Designation	**Description**	**Part Number**
R109,116,126,128	100k 1% 1/4W MF Resistor	R-1003-41
R119 (current control)	5k 1-turn 1/2W 20% Panel Mount Potentiometer 1/4" Shaft	RP-5001-18
R120,127	475k 1/4W 1% MF Resistor	R-4753-41
R121 (voltage control)	5k 10-turn 2W 5% Panel Mount Potentiometer 1/4" Shaft	RP-5001-0
R122	301Ω 1% 1/4W	R-3010-41
R123,124	22.1k 1/4W 1% Resistor	R-2212-41
R125	44.2K 1/4W 1% MF	R-4422-41
R129	8.25k 1/4W 1% Resistor	R-8251-41
R131	1.00kΩ 1% 1/4W MF Resistor	R-1001-41
U101,103	18 pin DIP LM3914N Bargraph Driver	UD-3914-N
U102,104	7107 CMOS 3.5 Digit A/D LED Driver	UD-7107-C
For U102,104	4 pin DIL IC Socket .1 x 0.6"	MC-0040-IC
Knob	Black Control Knob	MK-4094-SB
Front Panel	Flat Black Molded Plastic Panel	SP-6001-02FB
For Front Panel	Front Panel Label Set (Specify model.)	LA-30FP-xxxx
Filter	Grey Filter 1.145" x 3.33"	SP-6002-04
	Brass Eyelet SE610 3/16"D x 5/16"	MC-0610-SE
Secure PCB to F/P	#6-32 x 1/4" Taptite Pan Zinc Screw	MS-6P15-04
For BP103	#6 x 1/4" Internal Lockwasher	MW-6108
Knob	Black Control Knob	MK-4094-SB

TABLE 5.8-2 FRONT PANEL ASSEMBLY (A1) DIFFERENTIAL PARTS FOR 15V MODELS		
Designation	**Description**	**Part Number**
R101A,102	365Ω 1/4W 1% Resistor	R-3650-41
R103 (calibration)	392Ω 1/4W 1% Resistor	R-3920-41
R104 (calibration)	270Ω 1/4W 5% Resistor	R-2700
R114	16.2k 1/4W 1% Resistor	R-1622-41
R115	100k 1-turn 1/4W 10% Cermet Trimpot	RC-1003-49

TABLE 5.8-3 FRONT PANEL ASSEMBLY (A1) DIFFERENTIAL PARTS FOR 30V MODELS		
Designation	**Description**	**Part Number**
R101A,102	365Ω 1/4W 1% Resistor	R-3650-41
R103 (calibration)	180Ω 1/4W 5% Resistor	R-1800
R104 (calibration)	619Ω 1/4W 1% Resistor	R-6190-41
R114	7.5k 1/4W 5% CF Resistor	R-7501
R115	100k 1-turn 1/4W 10% Cermet Trimpot	RC-1003-49

TABLE 5.8-4 FRONT PANEL ASSEMBLY (A1) DIFFERENTIAL PARTS FOR 60V MODELS		
Designation	**Description**	**Part Number**
R101A,102	365Ω 1/4W 1% Resistor	R-3650-41
R103 (calibration)	1.1k 1/4W 1% MF Resistor	R-1101-41
R104 (calibration)	1.5k 1/4W 1% Resistor	R-1501-41
R114	36kΩ 1/4W 5% CF Resistor	R-3602
R115	1MΩ 1- turn 1/4W 10% Cermet Trimpot	RC-1004-49

Note: Check **Section 5.8.6 Baseplate and Cover Assembly** for front panel hardware not listed here.

5.8 Replacement Parts

5.8.4 Power Circuit Assembly (A2) Replacement Parts

TABLE 5.8-5 POWER CIRCUIT ASSEMBLY (A2) COMMON PARTS

Designation	Description	Part Number
Complete Assembly	A2 PCB Assembly (Specify model.)	X2-3xxx-A2
C1,2,12,12A,13,16,22, 23,30,36,39,45-49, 52,55,62,64	0.1µF 50V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-104F-06
C2A	10nF 100V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-103F-16
C3,11,18,19,35,63	10µF 50V 2.0mm Electrolytic Radial Capacitor	CL-100C-50
C4	1µF 100V MF 10% 15mm Radial Capacitor	CD-105L-16
C10	2.2nF 100V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-222F-16
C10A, 32A	100pF 1kV 10% 6.5mm Ceramic Radial Capacitor	CB-102G-66
C14A,15,24,40,60	100pF 100V Z5F 10% 5.0mm Ceramic Radial Capacitor	CB-101F-16
C15A	10µF 25V Tantalum 20% 2.5mm	CJ-100D-25
C17,20	220µF 16V 5mm 20% Electrolytic Radial Capacitor	CL-221F-16
C21	470µF 16V 10x20, 5.0mm 20% Electrolytic Radial Capacitor	CL-471F-16
C27,28,29	10nF 400Vdc MF 10% 10mm Radial Capacitor	CD-103J-46
C28A	0.33µF 400V MF 10% 22.5mm Radial Capacitor	CD-334N-46
C31,38	220pF 1kV 10% Z5F 6.5mm Ceramic Radial Capacitor	CB-221G-66
C32A	1.0nF 1kV X7R 10% 6.5mm Ceramic Radial Capacitor	CB-101G-66
C33, 37	50nF 1kV Z5U +80%/-20% 10mm Ceramic Radial Capacitor	CC-503J-69
C34	33µF 25V 2.5mm 20% Electrolytic Radial Capacitor	CL-330D-25
C41,50	470pF 100V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-471F-16
C42	390pF 100V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-391F-16
C44	68pF 100V X7R 10% 5.0mm Ceramic Radial Capacitor	CB-680F-16
C51	0.33µF 50V Z5U 20% 5.0mm Ceramic Radial Capacitor	CC-334F-09
C53,54	1000µF 200V 10mm 20% 35D x 45L	CL-102J-80
C56,57	10nF 250Vac Y 10% MF Radial Capacitor	CD-103L-36
C58	0.33µF 250Vac 10% MFRD 22.5mm "X" Capacitor	CD-334N-36
C65	0.10µF 250Vac 10% 15.0mm MF Capacitor	CD-104L-36
C67	1nF 3kV Z5U +80%/-20% 6.5mm Ceramic Radial Capacitor	CC-102G-99
CR1,1A,3,3A,4,21,25, 25A,25B,26,28,29A, 30,32,33,35	IN4148 UR DO35 75V 300mA Diode	CR-4148
CR2,10,19	1N4735A DO41 6.2V 1W Zener Diode	CR-4735-A
CR2A	400V 15A TO-220 Rectifier	CR-1540-UF
CR6-8,16,17,34	MUR140 UR D05 400V 1A Rectifier Diode	CR-0140-UR
CR9	1N5819 1AMP 40V Schotky Rectifier	CR-5819
CR9A	1N825A VZ DO35 6.2V 400mW	CR-0825-A
CR11,18	1N4746A Z D04 18V 500mW Zener Diode	CR-4746-A
CR12-15,15A,20	MUR160 UR 600V 1A DO41 Rectifier Diode	CR-0160-UR
CR29, 31	1N5231B Z DO204 5.1V 5% .5W Zener Diode	CR-5231-B
F2	4A Picofuse	F1-0400-F2
F3	3A PC TRON Fuse	F2-0300-F6
F4	1A 125V Picofuse Fast Axial	F1-0100-F2
J1,J2	9 pin Male 0.1" Friction Lock Spacing Header	MC-0903-MC
K1	12Vdc 10A SPDT PC Mount Relay	K3-012D-10AP
L1	0.5" x 0.25" Torroid (Ferrite)	FT-0525
For L1	#14 Bus Wire Tinned	WB-0014-0010

Continued on next page.

5.8 Replacement Parts

5.8.4 Power Circuit Assembly (A2) Replacement Parts

TABLE 5.8-5 POWER CIRCUIT ASSEMBLY (A2) COMMON PARTS (CONTINUED)		
Designation	**Description**	**Part Number**
L3	213mH 6A Input Inductor	L2-3130-6
L4	AC Input Common Mode Inductor	L2-3001-6
P1,2,3	9 pin Male 0.1" Friction Lock Spacing Header	MC-0903-MC
P5	4 pin PC Type Mate-N-Lock Header	MC-3502-ML
P6	2 Pole Mate-N-Lok PCB Header	MC-0209-ML
PCB	Rev I PCB Bare Board	PC-3002-I
For Bracket, PCB	#6-32 X 5/16" Philips Pan Zinc Screws	MS-6P00-05
For PCB, T1, Gnd Strip	#6-32 X 3/8"PPM Type A Zinc Screws	MS-6P09-06
For Rear PCB	1/2" Right Angle Bracket 6-32 1S	MB-1295-30
Q1	IRF640 NM 200V .18Ω 18A T0220	QF-0640-IR
Q2,11,13,16	PN2222A NB 40V 500mA 500mW TO92	QM-2222-A
Q4	MTP4N90 NM 900V 4Ω 75W TO220	QF-P04N-90
Q5-8	IRF740R NM 400V 55mΩ 125W	QF-F740-R
For Q5-8	#4-40 x 1/4" KEP Nut Steel/Cad	MN-440K-08
For Q5-8, Heatsink	#4-40 x 1/4" PPM Zinc	MS-4P00-04
For Q5-8	#4 Nylon Shoulder Washer	MI-0412-SW
For Q5-8	Insulating Washer, T0-220	MI-T220-IW
Q12,14	XX2907A PB 60V .5mA 400mW TO92	QN-2907-A
Q15	2N4033 P 80V 5A 7W TO39	QJ-4033
R1,14,19,22,32,43,71, 73-75,88,89	10kΩ 1/4W 1%	R-1002-41
R2,4,25,30,33,38,40	100kΩ 1/4W 1% CF	R-1003-41
R5,7,11,29A,39,42, 54,62,70	1.00kΩ 1/4W 1% MF	R-1001-41
R6,57	20kΩ 1/4W 1%	R-2002-41
R11A	2.7MΩ 1/4W 1%	R-2744-41
R12,17	511Ω 1/4W 1%	R-5110-41
R12A	825Ω 1/4W 1%	R-8250-41
R15	4.99kΩ 1/4W 1% MF	R-4991-41
R18	6.65kΩ 1/4W 1% MF	R-6651-41
R23,29,87	47.5kΩ 1/4W 1%	R-4752-41
R26,27	3.57k 1/4W 1% MF	R-3571-41
R31	5.6Ω 2W 5% MF	R-5R60-2
R35,47,53,59	2.21k 1/4W 1% MF	R-2211-41
R42A,82	100Ω 1/4W 1% MF	R-1000-41
R46,80,90	475kΩ 1/4W 1% MF	R-4753-41
R48,49,60,61	2.21W 1/4W 1% CF	R-2R21-41
R50,63	1k 2W 5%	R-1001-2
R51	1.2kΩ 1W 5%	R-1201-1
R52,77,83	120kΩ 2W 5%	R-1203-2
R55	2Ω 1/4W 1% MF	R-2R00-41
R56	27.4Ω 1/4W 1% MF	R-27R4-41
R64	0.2W 2W 5% Low Inductance	RN-0R20-2
R65	150kΩ 1/4W 5%	R-1503
R66	16.9kΩ 1/4W 1%	R-1692-41
R67	3.16k 1/4W 1%	R-3161-41

Continued on next page.

5.8 Replacement Parts

5.8.4 Power Circuit Assembly (A2) Replacement Parts

TABLE 5.8-5 POWER CIRCUIT ASSEMBLY (A2) COMMON PARTS (CONTINUED)		
Designation	**Description**	**Part Number**
R68	1.62kΩ 1/4W 1%	R-1621-41
R69	4.75k 1/4W 1% MF	R-4751-41
R72	8.2kΩ 1/4W 5% CF	R-8201
R76	18.2kΩ 1/4W 1%	R-1822-41
R78	953kΩ 1/4W 1% MF	R-9533-41
R79	21kΩ 1/4W 1% MF	R-2102-41
R81	30.1k 1/4W 1% MF	R-3012-41
R84	39Ω 5W 5% WW	RW-39R0-5
R85	1MΩ 1/4W 1% CF	R-1004-41
RV3,16,28 (calibration)	Trimpot 5K "Y" 20 Turn 10%	RC-5001-Y9
RV24 (calibration)	Trimpot 500W "Y" 20 Turn 10%	RC-5000-Y9
T1	200kHz 20VA Transformer	T-3001-12
T2	Toroidal Pulse Drive Transformer	T2-3002
U1	4066B Quad Analog Gate 14 Pin	UC-4066-BN
For U1,3	IC Socket, DIL 14 Pin	MC-0014-IC
U2,4,9	LM358 Dual Op Amp 8 Pin DIP	UA-0358-N
For U2,4,6,7	IC Socket, DIL 8 Pin	MC-0008-IC
U3	LF347N Q JFT Op Amp 14 Pin DIP	UA-0347-N
U5	4N37 Opto-coupler 6 Pin DIP	UP-4N37
U6	3842 IMODE PWM 8 Pin DIP	UR-3842-N
U7	7555 CMOS Timer 8 Pin DIP	UC-7555-P
U8	3846 IMODE PWM 16 Pin DIP	UR-3846-N
For U8	IC Socket DIL 16 Pin	MC-0016-IC

TABLE 5.8-6 POWER CIRCUIT ASSEMBLY (A2) DIFFERENTIAL PARTS FOR 15V MODELS		
Designation	**Description**	**Part Number**
C4A	470µF 16V Electrolytic Radial Capacitor 5mm	CL-471F-16
C5,6,7	1000µF 35V Electrolytic Radial Capacitor 5mm	CL-102F-35
C8	2.2nF 100V X7R 10% 5mm Ceramic Radial Capacitor	CB-222F-16
C9	100pF 100V Z5F 10% 5mm Ceramic Radial Capacitor	CB-101F-16
C25,26	1nF 100V X7R 10% 5mm Ceramic Radial Capacitor	CB-102F-16
CR5	200V 30A Dual UFast Rectifier TO-3	CR-3220-UD
For CR5	TO-3 Insulating Washer	MI-0TO3-IW
For CR5, Q3	T03 Transistor Socket	MC-0T03-QS
For CR5, Q3	#6-32 x 5/8" PPM Type B Zinc Screws	MS-6P12-10
	#6 x 1/4" Lockwasher	MW-6108
For CR5, PCB A2, Q3	Heatsink Anodized 6.925x4.75" 2x10-3	HS-6000-A2
For CR23 to H/S	#6-32 X 1/2"Philips Pan Zinc Screws	MS-6P00-08
CR26A	0Ω Jumper 1/4W Resistor Size	R-0000
L2	15V 21µH 20A Output Inductor	L2-3015
Q3	RFG50N05N FET 50V 50A .28Ω TO247	QF-P50N-05
For Q3	#6 Nylon Shoulder Washer	MI-0625-SW
For Q3	TO247 Insulating Washer	MI-T247-IW
For Q3	#8 Ring Tongue, 18-14 AWG	MC-8305-RT
R8	32.4k 1/4W 1% MF Resistor	R-3242-41
R9	30.1k 1/4W 1% MF Resistor	R-3012-41

Continued on next page.

5.8 Replacement Parts

5.8.4 Power Circuit Assembly (A2) Replacement Parts

TABLE 5.8-6 POWER CIRCUIT ASSEMBLY (A2) DIFFERENTIAL PARTS FOR 15V MODELS (CONTINUED)		
Designation	**Description**	**Part Number**
R10	36.5k 1/4W 1% MF Resistor	R-3652-41
R13	#20 Manganin Resistance Wire 23.6mΩ/inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
R20	10k 1/4W 1% Resistor	R-1002-41
R21	4.3kΩ 1/4W 5% CF Resistor	R-4301
R25A	24.3k 1/4W 1% Resistor	R-2432-41
R27A	270Ω 2W 5% Resistor	R-2700-2
R34	Resistor Empty Position	R-EMPT
R36	100k 1/4W 1% MF Resistor	R-1003-41
R37	75k 1/4W 1% MF Resistor	R-7502-41
R44,45,45B	10Ω 1/2W 5% CF Resistor	R-10R0-3
T3	15-20 Transformer	T2-3015
T3 (model dependent)	Transformer for 230Vac Input Option - 15V Model	T2-3015-12

TABLE 5.8-7 POWER CIRCUIT ASSEMBLY (A2) DIFFERENTIAL PARTS FOR 30V MODELS		
Designation	**Description**	**Part Number**
C4A	100µF 63V 20% Electrolytic Radial Capacitor 5mm	CL-101F-63
C5,6,7	470µF 63V 20% Electrolytic Radial Capacitor 7.5mm	CL-471H-63
C8	1nF 100V X7R 10% 5mm Ceramic Radial Capacitor	CB-102F-16
C9	100pF 100V Z5F 10% 5mm Ceramic Radial Capacitor	CB-101F-16
C25,26	2.2nF 100V X7R 10% 5mm Ceramic Radial Capacitor	CB-222F-16
CR5	200V 30A Dual UFast Rectifier TO3	CR-3220-UD
For CR5, Q3	TO-3 Insulating Washer	MI-0TO3-IW
For CR5, Q3	T03 Transistor Socket	MC-0T03-QS
For CR5, Q3	#6-32 x 5/8" PPM Type B Zinc Screws	MS-6P12-10
	#6 x 1/4" Lockwasher	MW-6108
For CR5, PCB A2, Q3	Heatsink Anodized 6.925x4.75" 2x10-3	HS-6000-A2
For CR23 to H/S	#6-32 X 1/2"Philips Pan Zinc Screws	MS-6P00-08
CR26A	0Ω Jumper 1/4W Resistor Size	R-0000
L2	30V 85µH 10A Output Inductor	L2-3030
Q3	MTM25N10 NM 100V .075Ω 150W TO-3	QF-M25N-10
R8	15.8k 1/4W 1% MF Resistor	R-1582-41
R9	15k 1/4W 1% MF Resistor	R-1502-41
R10	68.1kΩ 1/4W 1% MF Resistor	R-6812-41
R13	#20 Manganin Resistance Wire 23.6mΩ/inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
R20	10k 1/4W 1% Resistor	R-1002-41
R21	1.5k 1/4W 1% Resistor	R-1501-41
R25A	49.9k 1/4W 1% MF Resistor	R-4992-41
R27A	1k 2W 5% Resistor	R-1001-2
R34	Resistor Empty Position	R-EMPT
R36	100k 1/4W 1% MF Resistor	R-1003-41
R37	121k 1/4W 1% MF Resistor	R-1213-41
R44,45,45B	33Ω 3W 5% MF Resistor	RA-33R0-6
T3	30-10 Transformer	T2-3030
	Transformer for 230Vac Input Option - 30V Model	T2-3030-12

5.8 Replacement Parts

5.8.4 Power Circuit Assembly (A2) Replacement Parts

TABLE 5.8-8 POWER CIRCUIT ASSEMBLY (A2) DIFFERENTIAL PARTS FOR 60V MODELS		
Designation	**Description**	**Part Number**
C4A	47µF 100V 20% Electrolytic Radial Capacitor 5mm	CL-470F-76
C5,6,7	220µF 100V 20% Electrolytic Radial Capacitor 7.5mm	CL-221H-76
C8	1nF 100V X7R 10% 5mm Ceramic Radial Capacitor	CB-102F-16
C9	100pF 100V Z5F 10% 5mm Ceramic Radial Capacitor	CB-101F-16
C25	470pF 1kV X7R 10% 6.5mm Ceramic Radial Capacitor	CB-471G-66
C26	1nF 250V X7R 10% 5mm Ceramic Radial Capacitor	CB-102F-26
C66	0.33µF 50V Z5U +80 to -20% 5mm Ceramic Radial Capacitor	CC-334F-09
CR5	500V 30A Dual UFast Rectifier TO218	CR-3050-UD
For CR5	TO-247 Transistor Insulating Washer 6mil	MI-T247-IW
For CR5, Q3	T03 Transistor Socket	MC-0T03-QS
For CR5, Q3	#6-32 x 5/8" PPM Type B Zinc Screws	MS-6P12-10
	#6 x 1/4" Lockwasher	MW-6108
For CR5, PCB A2, Q3	Heatsink Anodized 6.925x4.75" 2x10-3	HS-6000-A2
For CR23 to H/S	#6-32 X 1/2"Philips Pan Zinc Screws	MS-6P00-08
CR26A	1N5240A Z DO-35 10V 10% 500mW	CR-5240-A
L2	60V 342µH 5A Output Inductor	L2-3060
Q3	MTM15N20 NM 200V .16Ω 150W TO3	QF-M15N-20
For Q3	TO-3 Insulating Washer	MI-0TO3-IW
R8	7.32k 1/4W 1% MF Resistor	R-7321-41
R9	7.5kΩ 1/4W 1% MF Resistor	R-7501-41
R10	84.5k 1/4W 1% MF Resistor	R-8452-41
R13	#20 Manganin Resistance Wire 23.6mΩ/inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
R20	10k 1/4W 1% Resistor	R-1002-41
R21	1.3k 1/4W 1% MF Resistor	R-1301-41
R25A	9.09k 1/4W 1% Resistor	R-9091-41
R27A	3.9kΩ 2W 5% Resistor	R-3901-2
R34	2.2MΩ 1/4W 5% CF Resistor	R-2204
R36	100k 1/4W 1% MF Resistor	R-1003-41
R37	47.5k 1/4W 1% MF Resistor	R-4752-41
R44	330Ω 3W 5% MF Resistor	RA-3300-6
R45,45A,45B	249Ω 1% 5W Non-Inductive	RN-2490-51
T3	60-5 Transformer	T2-3060
	Transformer for 230Vac Input Option - 60V Model	T2-3060-12

5.8 Replacement Parts

5.8.5 Rear Output Assembly Replacement Parts

TABLE 5.8-9 REAR OUTPUT ASSEMBLY REPLACEMENT PARTS		
Designation	**Description**	**Part Number**
C1,2	10nF 400Vdc MF 10% 10mm Radial Capacitor	CD-103J-46
C3 (For 15V)	470µF 16V 10 x 20, 5mm 20% Electrolytic Radial Capacitor	CL-471F-16
C3 (For 30V)	220µF 35V 5mm Electrolytic Radial Capacitor	CL-221F-35
C3 (For 60V)	100µF 63V 10 x 20, 5mm 20% Electrolytic Radial Capacitor	CL-101F-63
C4	0.47µF 100V MF 10% 7.5mm Radial Capacitor	CD-474H-16
	.5" x 0.25" Torroid (Ferrite)	FT-0525
Rear Panel DC Output	#6-32 20A 3/8" x 4 position Barrier Strip	MC-0406-BS
Mount Barrier Strip	Speed Nut for 0.312 shaft	MN-31SN-12
For Barrier Strip	Sense Label	LA-6300-SNS
PCB	Rear Output Filter Printed Circuit Board	PC-30RC-A
R1	150Ω 1/4W 5% CF Resistor	R-1500
R2	22.1k 1/4W 1% Resistor	R-2212-41
For +/- Connections to A2 PCB	Female Fast-on 1/4" x 0.032" AWG 14-16	MC-0250-FO
	Female Fast-on 1/4" x 0.032" AWG 18-22	MC-0251-FO
For Fast-on	0.25" Female Fast-on Nylon Insulator	MI-4804-FO
For Output End of Wiring Harness	3/8" ID Heatshrink	IS-0024-HS
For Chassis Ground	#18 TEW Stranded Green	WT-0118-GN
For Chassis Ground	#8 Ring Tongue, 18-14AWG	MC-8305-RT
For "-" Output	#14 TEW Stranded Black	WT-0114-BK
For "+" Output	#14 TEW Stranded Red	WT-0114-RD
For "-" Sense	#22 TEW Stranded Blue	WT-0122-BL
For "+" Sense	#22 TEW Stranded Orange	WT-0122-OR

5.8.6 Baseplate and Cover Assembly

TABLE 5.8-10 BASEPLATE AND COVER ASSEMBLY		
Designation	**Description**	**Part Number**
CR23	8A 600V Bridge Rectifier PC Block 0.71" Square	CR-B086
For CR23	Heatsink - Fabricated	SM-3023-HS
On Rear Panel	Model and Rating Label, CSA Approved	LA-6HMD-OP
In Indent on Base	Label, Power Cord Warning	LA-6300-CPxx
AC Wire on Rear Panel	1/4" Nylon Cable Clamp, #6 mounting hole	MI-N4W6-CC
For Nylon Cable Clamp and Ground Stud	#6-32 x 1/4" Kep Nut	MN-632K-08
For AC Connector	Mate'n'Lock Socket Pin	MC-6191-ML
	4 pin Mate'n'Lock Socket Housing	MI-4824-ML
Power Switch	SPST 15A 125V Pushbutton Switch	SW-1116-BN1M
	Molded Switch Push Rod	SP-6001-03FB
For Power Switch	Power Switch Bracket	SM-60SB-CA
Mount Switch to Bracket	$4-40 x 1/4" Type F Philips Pan Zinc Screw	MS-4P06-04
For PCB	Nylon Grommet #6 Screw 0.25" Square Hole	MI-4026-00
Foil Tabs for H/S	Adhesive Copper Foil 3milx0.43" Wide	WC-0430-A3
For Cover and Switch	#4-40 x 1/4" Phillips Flathead Zinc Screw	MS-4P18-04

Continued on next page.

5.8 Replacement Parts

5.8.6 Baseplate and Cover Assembly

TABLE 5.8-10 BASEPLATE AND COVER ASSEMBLY (CONTINUED)		
Designation	**Description**	**Part Number**
Switch and AC Housing	#4-40 x 1/4" Kep Nut Steel/Cad	MN-440K-08
AC Hot Line	#18 TEW Stranded Black	WT-0118-BK
Safety Ground	#18 TEW Stranded Green	WT-0118-GN
For Ground Wire	#8 Ring Tongue, 18-14AWG	MC-8305-RT
Neutral	#18 TEW Stranded Orange	WT-0118-OR
For Switch	#18 TEW Stranded White	WT-0118-WT
Power Cord	125V 10A NA Plug to IEC 320 Power Cord 7.5'	WP-1725-00
For Ventilation Holes	Alumunium Screening 14 wire/inch	SC-1418-AL
Fasten Screen	3/16" Pop Rivets	MP-0202
Use with Pop Rivets	#6 x 3/8" Flat Washer Cad/Zinc	MW-6412
	Rubber Foot with Recess 1/2"D x 5/16"H	MF-RD08-05R
For A2 to Rear Panel, Rubber Feet, Option Subplate, and Handle	#6-32 x 1/4" Phillips Pan Zinc Screw	MS-6P00-04
	#8 x 1/2" Type A Zinc Flathead Screw	MS-8P32-08
	Single Baseplate	SM-6HBS-S
	Single Cover	SM-6HCR-S
	Subplate with Barrier Strip, No Option	SM-60CC-FA
Op Subplate & Handle	#8 x 1/2" Type A Phil Flathead Black Oxide Screw	MS-8P31-08
Handle	1" Black Nylon Webbing Material	SP-6HND-BK
For Handle	Handle Clamp	SM-60HC-AA

APPENDIX A

ASSEMBLY SCHEMATICS

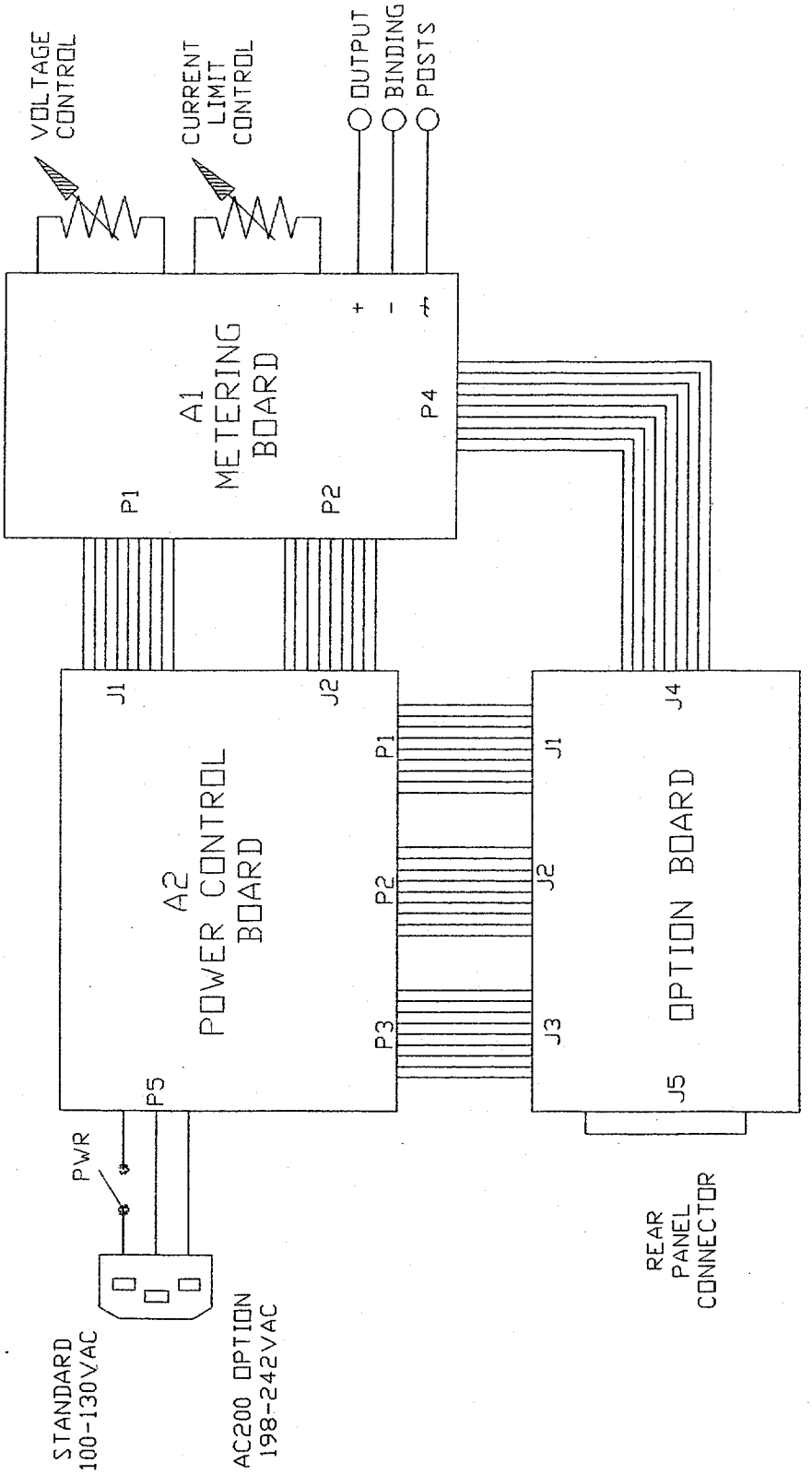
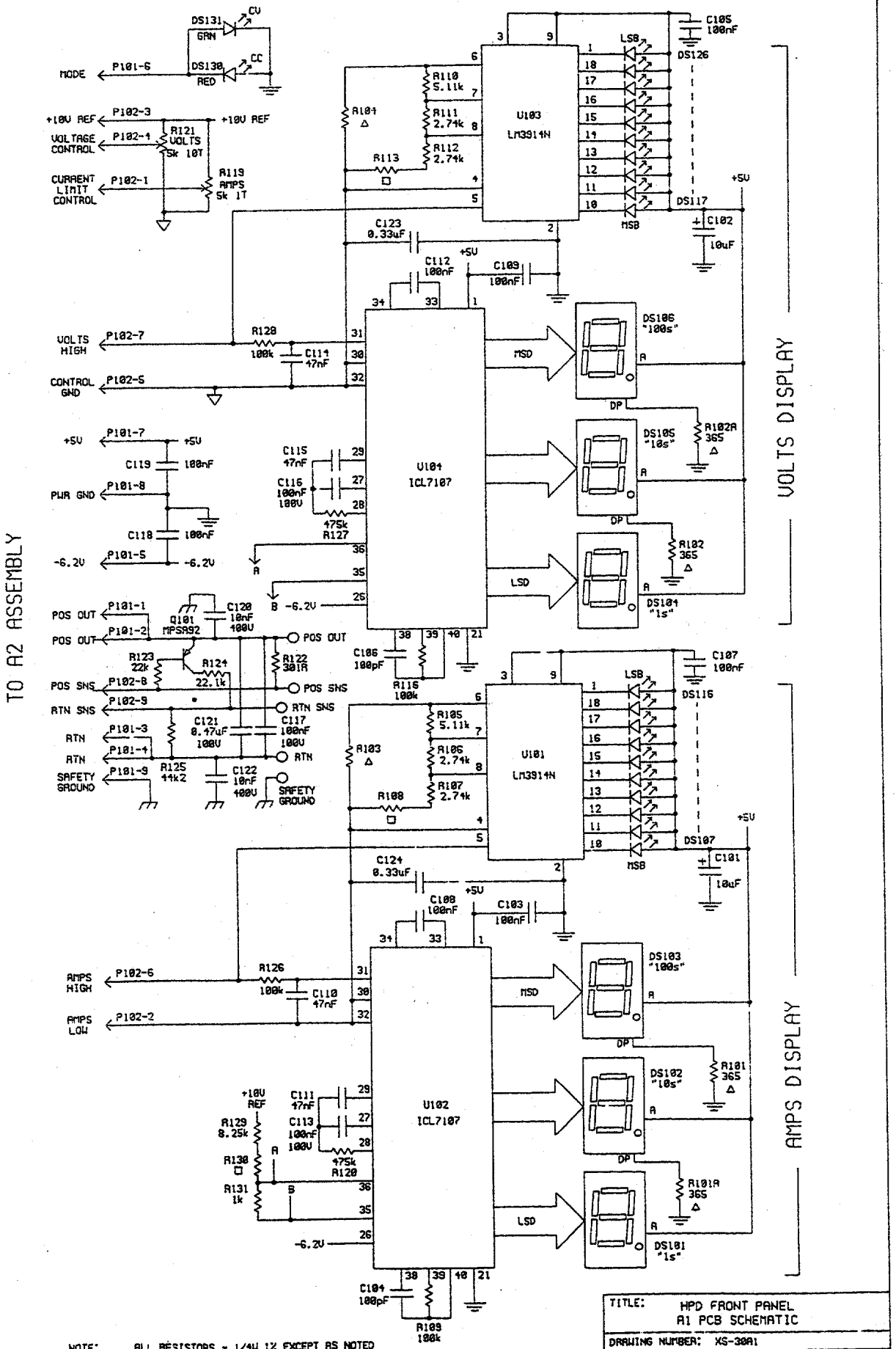


Figure A-1 Power Supply Interconnection Diagram

A1 ASSEMBLY



NOTE: ALL RESISTORS - 1/4W 1% EXCEPT AS NOTED
ALL CAPACITORS - uF/Vdc EXCEPT AS NOTED
Δ - DENOTES MODEL DEPENDENT PART
□ - DENOTES SELECTED TRIM VALUE

TITLE:	HPD FRONT PANEL A1 PCB SCHEMATIC
DRAWING NUMBER:	XS-30A1
DESIGN: KR	REV: F ECN: R3000/01
DRAWN BY: KR	LAST REV: 95/10/13/DC
CHECKED:	RELEASE DATE:
APPROVED:	

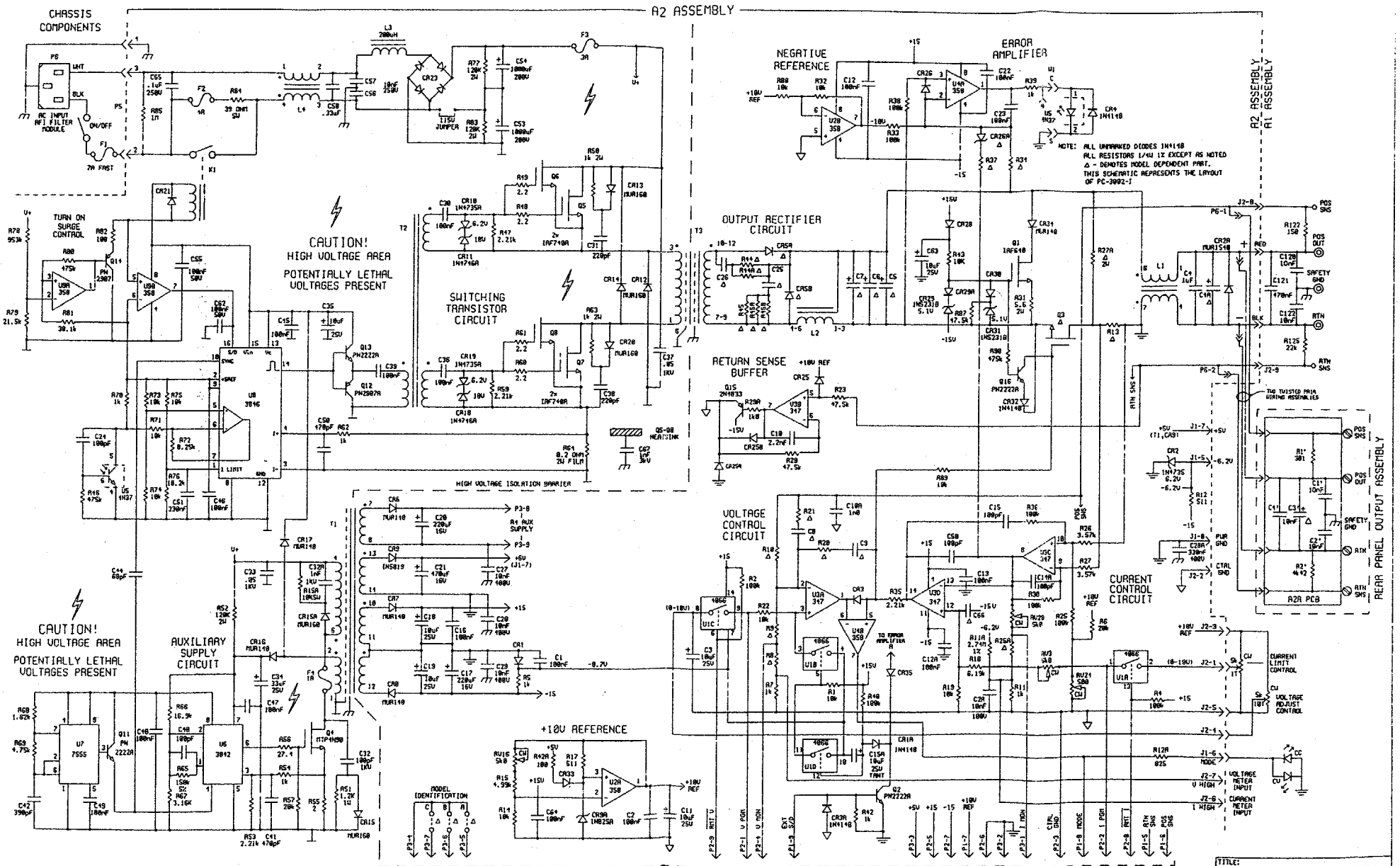


Figure A-3 115/220Vac Input A2 PCB Schematic (Power Assembly)