

XANTREX HPD Series DC Power Supply
INSTRUCTION MANUAL

Release 3.2

TM-3000-XN

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SECTION 1

FEATURES AND SPECIFICATIONS

1.1 PURPOSE

This manual contains operation and maintenance instructions for the HPD Series of high performance switching laboratory power supplies. Its purpose is to provide sufficient maintenance data to ensure long operating life.

Five major sections form the manual divisions:

- Section 1 - Description of series features and specifications.
- Section 2 - Installation and operating instructions.
- Section 3 - Theory of operation.
- Section 4 - Maintenance and service procedures.
- Section 5 - Drawings, schematics, and parts lists.

1.2 DESCRIPTION

The HPD Series laboratory power supplies are designed to provide highly stable continuously variable output voltage and current for a broad range of development and system requirements. The HPD Series employs high frequency switching regulator technology to achieve high power density and small package size, and a linear post-regulator circuit for low output noise. A wide variety of available options including both analog and IEEE 488 controlled programming makes the HPD Series the first choice in flexible power system design.

The series consists of 3 basic models. The basic models are designated by the HPD prefix, followed by the voltage and current rating. For example, the HPD 60-5 model number signifies that this is a single unit rated at 0 to 60 Vdc output at a maximum of 5 Amps while the HPD 15-20 is a single unit rated at 0 to 15 Vdc at 20 Amps.

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

1.3 OPERATING MODES

The HPD Series 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 V_{SET}
- the output current limit setting I_{SET} , and
- the resistance of the attached load R_L

Figure 1.3-1 Operating Modes provides a graphical representation of the relationships between these variables.

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: $I_L < I_{SET}$ (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.

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: $I_L > I_{SET}$

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.

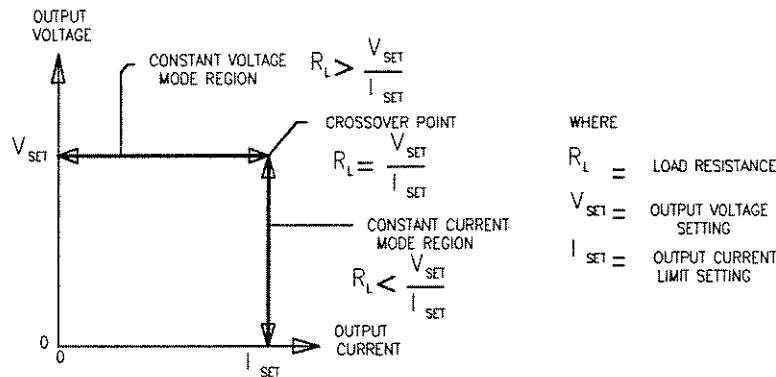


Figure 1.3-1 Operating Modes

1.3.1 Automatic Crossover

The automatic crossover system enables the unit to transfer operating modes as a function of 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 the voltage to the current mode. If the load requirements are lowered, return to the voltage mode will occur automatically.

1.3.2 Sense Connections

To compensate for losses in power leads connected to the output, sense connections are provided beside the output terminals. With remote sense leads in place, the voltage is regulated at the point where the sense lines are connected to the output leads (provided the sum of these losses do not exceed 0.5 volts). With the sense lines disconnected, the voltage is regulated at the output terminals. Do not use the sense connections without the normal power lead connections to the output terminals, and avoid positive and negative lead connections.

1.4 EQUIPMENT FEATURES

- Simultaneous digital display of both voltage and current.
- Unique analog bar graphs display both voltage and current for ease of monitoring transient changes under varying loads.
- Ten turn potentiometer voltage control permits high resolution setting of the output voltage.
- Current adjust potentiometer permits current limiting which is fully adjustable from zero to the rated output.
- 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.
- Output connections are via a four terminal barrier strip on the back panel.
- Flexible output configuration: Multiple units can be connected in parallel or series without damage and are short circuit proof.
- The modular design provides for easy replacement or repair of plug connected sub-assemblies.
- High frequency switching technology allows high power density, providing increased power output in a smaller, very light package.
- A broad range of optional functions are readily available,
 - Over-Voltage Protection (OVP)
 - External TTL Shutdown
 - Remote Voltage & Current Programming
 - Audible Mode Indicator
 - Rear Access Connector
 - IEEE 488 Interface
 - Output Tracking

1.5 SPECIFICATIONS

1.5.1 Electrical Specifications¹

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 Regulations ² :			
Voltage	3.5mV	5mV	8mV
Current	3mA	2mA	1.5mA
Load Regulation ³ :			
Voltage	3.5mV	5mV	8mV
Current	3mA	2mA	1.5mA
Meter Accuracy:			
Voltage	0.25V	0.4V	0.7V
Current	0.3A	0.2A	0.006A
Output Noise and Ripple rms at rear output: p-p (20Hz-20MHz)	5mVrms 50mVp-p	5mVrms 50mVp-p	5mVrms 50mVp-p

¹ Specifications are warranted over a temperature range of 0-30°C, derate output linearly to zero at 70°C.

² For input voltage variation from 104 to 127Vac, with constant rated load.

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

AC Input: 104-127Vac at 6Arms, 47-63Hz

Maximum Voltage Differential from output to safety ground: 400Vdc

Additional Characteristic

MODELS	HPD 15-20	HPD 30-10	HPD 60-5
Stability ⁴ :			
Voltage (0.02%)	3mV	6mV	12mV
Current (0.03%)	6mA	3mA	1.5mA
Temperature Coefficient ⁵ :			
Voltage	2.25mV	4.5mV	9mV
Current	4mA	2mA	1mA
Front Panel Voltage Control Resolution	3mV	6mV	12mV

⁴ Drift over 8 hours after 60 minutes warm up

⁵ Change in output per°C change in ambient temperature, with constant line and load
Operating Ambient Temperature: 0-30°C for full rated output. 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 0.05% band, for ±50% load change in the range of 25% to 100% of the rated load

Switching frequency: 100kHz (nominal)

1.5.2 Mechanical Specifications

	Height	Width	Depth	Weight
Single unit	132mm 5.2in	109mm 4.3in	297mm 11.7in	2.5kg 5.5lbs
Dual unit	132mm 5.2in	216mm 8.5in	297mm 11.7in	4.8kg 10.5lbs
Triple unit	132mm 5.2in	325mm 12.8in	297mm 11.7in	7.0kg 15.5lbs
Quad unit	132mm 5.2in	436mm 17.0in	297mm 11.7in	11.5kg 25.0lbs

Agency approval: CSA, meets FCC Part 15, Subpart J, Class A standard for radiated and conducted emissions

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SECTION 2

INSTALLATION AND OPERATING INSTRUCTIONS

2.1 GENERAL

After unpacking, an initial inspection should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the

Service Department,
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Customer Service: 1-800-667-8422

2.2 INITIAL INSPECTION

The power supply comes complete with an IEC power cord set and technical manual. The equipment should be inspected for damage as follows:

- a. Inspect for obvious signs of physical damage.
- b. Turn front panel controls from stop to stop. Rotation should be smooth.
- c. Test the action of the power switch. Switching action should be positive.
- d. If internal damage is suspected, remove the cover and check the components and printed circuit board for damage. Reinstall cover.

2.3 INSTALLATION

Before connecting the unit to an AC outlet, make sure that the power switch is in the extended (OFF) position and the voltage and current controls are in their fully counter clockwise positions. The AC line voltage should be 115V (nominal).

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 power supply outputs are located on the back panel terminal block.

If the output voltage is to be biased relative to ground, the power supply outputs may be biased up to a maximum of 400Vdc with respect to the chassis.

Plug the line cord into a grounded AC outlet. Push the power switch to turn on the power supply. The red current LED should light and the meter reading should remain zero.

2.4 ELECTRICAL CHECK

2.4.1 Voltage Mode

To check voltage mode operation, proceed as follows:

- a. Rotate VOLTAGE and CURRENT controls fully counterclockwise.
- b. Connect a DVM, rated better than .5% accuracy, to the front panel binding posts (+ and -).
- c. Connect the IEC power cord set to the unit, then to an appropriate power source and set the POWER switch to ON.
- d. Rotate the CURRENT control 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 panel voltage meter on the left (green). Observe the bar graph meter to see that it tracks as the voltage rises and that the voltage mode indicator lamp is ON.
- e. Set the POWER switch to OFF.

2.4.2 Current Mode

To check current mode operation, proceed as follows:

- a. Rotate VOLTAGE and CURRENT controls fully counterclockwise.
- b. Rotate the VOLTAGE control 1/2 turn clockwise.
- c. 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 .5%.
- d. Set the POWER switch to ON.
- e. 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 panel current meter (red). Also check that the current bar graph meter follows the rise in current and that the current mode indicator light is ON.
- f. Set the POWER switch to OFF.

2.5 STANDARD OPERATION

Reliable performance of the power supply can be obtained if certain basic precautions are taken when connecting it for use on the lab bench or installing it in a system.

To obtain a stable, low noise output, careful attention should be paid to factors such as conductor ratings, system grounding techniques, and the particular way the AC input, DC output, and remote sensing connections are made.

A conductor size that satisfies the current rating requirements should be used. To overcome impedance and coupling effects, however, larger wire and shorter leads are recommended.

To use the power supply in the Constant Voltage mode, turn the current control to its extreme clockwise position and set the voltage control to the desired voltage. To operate the supply in the Constant Current mode, turn the voltage control 1/2 turn clockwise and the current control fully counter clockwise. Connect a shorting lead across the output terminals and set the desired maximum value of current limit by turning the control slowly clockwise. Then disconnect the shorting lead from the output terminals. The power supply will now automatically switch into the current limiting mode (current regulation) as soon as the set current level is reached and will not exceed this level at any output voltage. As soon as the supply starts operating in current mode, the red current mode LED will turn on.

2.5.1 Grounding

Proper grounding connections should be made to avoid paths between separate ground points. To avoid ground loop problems, there must be only one ground return point in a power system.

2.5.2 Load Connection

Proper connection of distributed loads is an important aspect of power supply application. A most 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, voltage at each load depends on the current drawn by the other loads and DC ground loops are developed. Except for low current applications, this method should not be used.

A preferred way to distribute power is by the radial distribution method in which power is connected individually to each load from a single pair of terminals designated as the positive and negative distribution terminals. The pair of terminals may be the power supply output terminals, the load terminals, or a distinct set of terminals specially established for distribution. Connecting the sense leads to these terminals will compensate for losses and minimize the effect of one load upon another.

2.5.3 Multiple Supplies

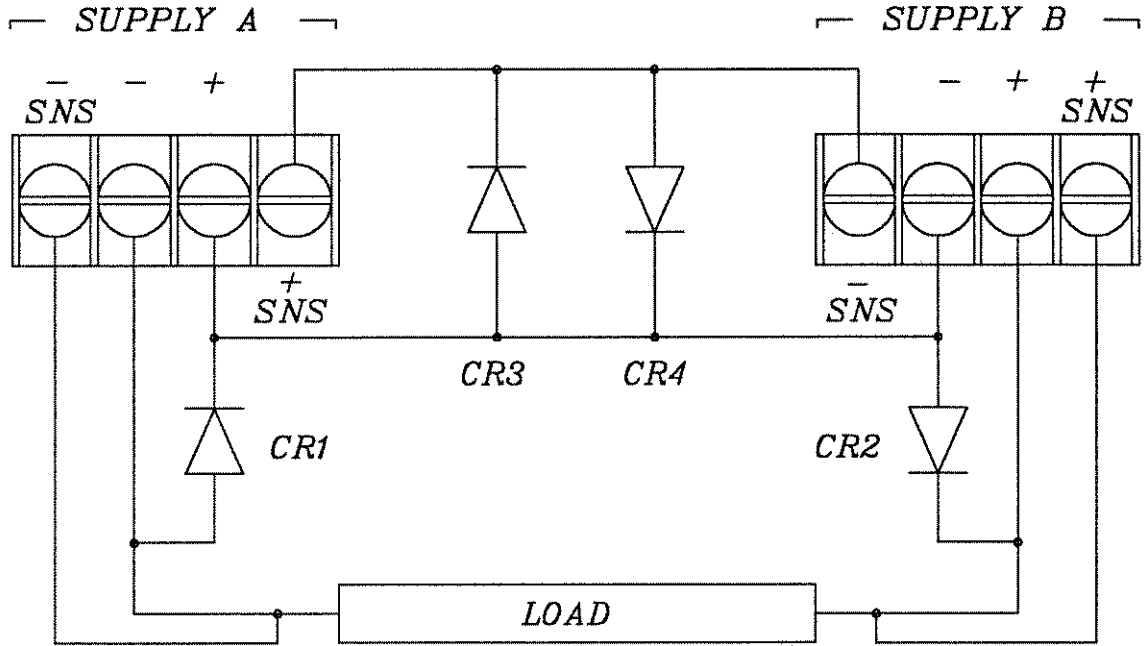
The HPD Series power supplies may be operated with outputs in series or parallel. For independent operation of each supply, the procedure as previously outlined applies.

2.5.4 Series Operation (Voltage Mode Only)

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

Figure 2-1

Series Operation With and Without OVP



CR3, CR4 : 1N4004 (REQUIRED ONLY IF REMOTE SENSE USED)

	15-20	30-10	60-5
CR1, CR2 (TYPICAL)	1N1184	1N1200	1N1200

Notes:

Maximum allowable sum of the output voltages is 400V. This is limited by the output to ground isolation specification.

The maximum allowable current for a series string of power supplies is the lowest output current of any supply in the string.

Use of remote sense is not essential for series connection. Where used, refer to notes on remote sensing.

CR3 and CR4 protect sense circuits during transient events which may cause supply outputs to collapse (such as momentary current limit events).

2.5.5 Parallel Operation

The parallel connection is used to obtain a higher current single output supply. Set all of the outputs to the same voltage before connecting the (+) terminals and (-) 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 two supplies are paralleled, the supply with the higher voltage setting will be in the current limiting mode, while the other supply controls the output voltage.

2.5.6 Split Supply Operation

The split connection is used 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 the left section to the positive terminal of the right section. The left section (positive terminal) then provides a positive voltage relative to the common connection and the right section (negative terminal) provides a negative voltage. The current limits (current controls) can be set independently. The maximum current available in split operation is equal to the lowest individual rating of the supplies.

2.5.7 Remote Sensing

Remote sensing permits regulation with respect to the point of load connection, rather than at the output terminals of the power supply. Connecting the positive and negative sense lines to the point where the metered output voltage is desired will automatically compensate for the voltage losses in the main power leads (provided these losses do not exceed .5v/line). With the voltmeter reading 10.0 volts, for example, and having the sense lines connected directly to the load, the load voltage will stay at exactly 10.0 volts regardless of the voltage drops in the power leads, no matter how much current is drawn. NEVER use the sense connections without the normal power lead connections to the output terminals, and avoid reversing positive and negative lead connections. Always use twisted pair or teisted pair for sense line to minimize noise effects.

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BASIC SWITCHING REGULATOR SCHEME

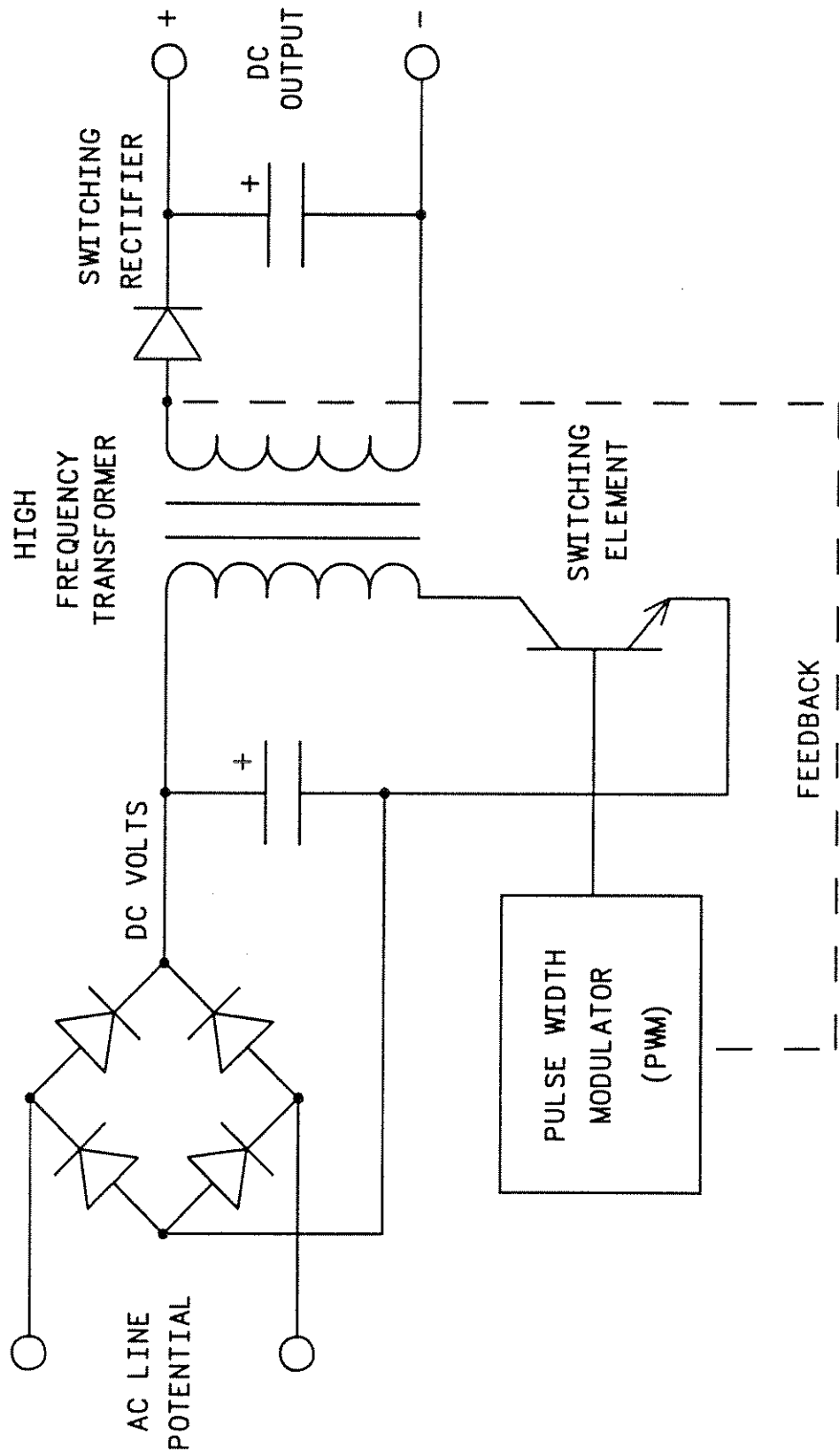


Figure 3-1

SECTION 3

THEORY OF OPERATION

3.1 POWER CIRCUIT (A2)

This section explains the operation of the A2 assembly switching regulator power circuit including basic switching regulator theory, basic features of the Xantrex two-transistor forward converter, and a more detailed circuit description.

3.1.1 Basic Off-Line Switching Regulator Theory

An off-line switching power supply converts AC line voltage to high voltage DC by diode rectification and then chops the DC at a high frequency. This DC switching waveform is then applied to a high frequency transformer which provides a step-down in voltage and electrical isolation on its secondary. The switching waveform on the secondary is then rectified and filtered, giving a smooth DC output voltage. Feedback from the secondary circuit is used to control the switching waveform to the primary so that output regulation is obtained. This feedback is applied to a pulse width modulator (PWM) control circuit which controls the on-time of the primary circuit, thus increasing or decreasing the voltage on the secondary. See Figure 3-1.

The use of high frequency transformers in switching power supplies has the advantage of requiring less volume, less weight, and dissipating less heat than the lower frequency transformers in conventional linear power supplies.

SIMPLIFIED TWO-TRANSISTOR FORWARD CONVERTOR WITH LINEAR POST-REGULATOR

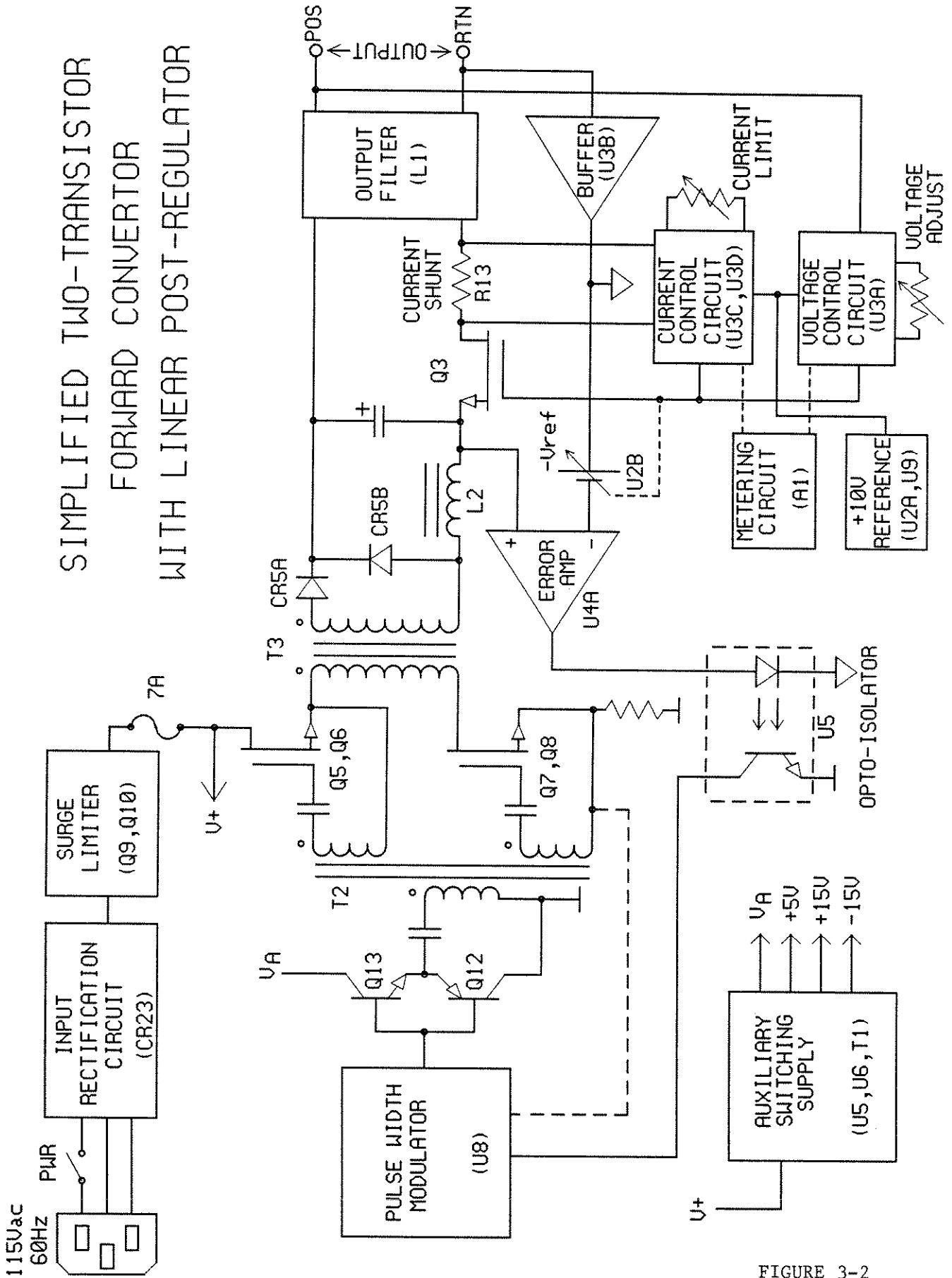


FIGURE 3-2

3.1.2 Simplified Two-Transistor Forward Converter Theory

As in the basic switching regulator scheme of Figure 3-1, the AC line voltage is first rectified to a DC voltage (Figure 3-2). Following this, an active circuit provides surge current limiting, preventing excessive power-on current surges to the main filter capacitors in the input rectification circuit. This DC voltage is applied to power-FET transistors 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. This current information is compared to the setting of the current limit control in the current control circuit (U3C, U3D). The output voltage is similarly monitored and compared to the voltage adjust control in the voltage control circuit (U3A). 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 more output is required by Q3, 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 negative reference level is also controlled by the outputs of the current and voltage control circuits.

The output voltage and current information from the current and voltage control circuits is also fed to the A1 assembly (front panel) where it is displayed on voltage and current digital readouts and bar graphs. 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, A3 or A4 option boards, and 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).

CAUTION: 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.

3.1.3 Detailed Circuit Description

This section is intended to provide further detail for troubleshooting purposes. Please read the previous section and then refer to the detailed A2 assembly schematic in Section 5 (Figure 5-3).

Input Rectifier and Surge Limiter

Power is applied through F1 to the input RFI filter consisting of C56-C58, L3, and L4. CR23 provides input rectification. The input surge limiter consists of transistors Q9, Q10, Q14 and associated components. As the main filter capacitors (C53 and C54) begin to charge, current flows through Q9, Q10 and R77. Above a nominal 20 Amps (peak) the voltage across R77 turns on Q14. This turns down the gate drive to Q9 and Q10 provided by R81, limiting the peak current to a nominal 20 Amps. As the voltage across Q9 and Q10 increases above a nominal 5 volts, Q14 is similarly turned on and Q9 and Q10 are turned off. In this way Q9 and Q10 remain within their safe operating regions as capacitors C53 and C54 charge.

CR22 clamps the gate voltage to below 18 volts and C55 charges and holds Q9 and Q10 on after the charging of C53 and C54 is completed. CR24 protects Q9 and Q10 against line transient events exceeding 160 volts, and CR24A, R83 and C52 dissipate transient energy when Q9 and Q10 turn off.

Pulse Width Modulator

Pulse width modulator U8 acts as a current mode controller driving switching transistors Q5-Q8 through drive transistors Q12 and Q13 and transformer T2. Zeners CR10, CR11, CR18 and CR19 provide gate protection while components R50, CR13, C31 and R63, CR20, C38 act as snubbers limiting switching transients on the primary of T3. Current shunt R64 provides a voltage ramp which is monitored by U8 and compared 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 astable oscillator from which a 200kHz pulse is taken to U8 pin 10 (sync input) via C44. 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 to which the peak T3 primary current is compared. 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 further limiting switching transients. C5-C7 and L2 provide filtering of the pre-regulated output at this point, and C5-C7 can be rapidly discharged by Q1 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).

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. This negative reference is divided down by R33, R34, and R37 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-C122 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 A3/A4 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. U9 is a temperature-stabilized zener diode reference. 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

The output voltage is monitored by U3A at pin 2 through the positive sense line (J2-8) and the resistor divider string R7-R10. A zero to 10 volt reference is applied in comparison to this output voltage at pin 3 of U3A from the voltage adjust control (via analog gate U1C). 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.

Current Control Circuit

The output current is monitored by U3C 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

The zero to 10 volt signals from the current and voltage controls may be switched out of circuit by analog gates U1C and U1A being turned off via the option connector lines P2-9 and P2-8. Lines P2-1 and P2-2 can then be used by the option boards to remotely program the voltage and current control circuits with appropriate zero to 10 volt programming levels.

Shutdown Circuit

The power circuit may be turned off with a high level on the option connector line P1-9. 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. Each model is identified by a coded combination of shorted links at points A, B and C. This is decoded by logic circuitry on the option boards.

3.2 METER CIRCUIT (A1)

Refer to the schematic diagram (Figure 5-2) in section 5 for the following discussion.

3.2.1 Voltage Meter

The analog input signal from the A2 power board is divided down so that 1 mV between P102-7 to P102-5 represents 1 volt at the output of the power supply. This reduced voltage is filtered by R128 and C114 to remove any noise and then input to U104, a 3 1/2 digit analog to digital converter. U104 converts the input voltage to a three digit readout of up to 999 mV 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 full scale accuracy of the meter is determined by the reference voltage from pin 35 to pin 36 of U104.

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

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

3.2.2 Current Meter

The current meter circuit functions like the voltage meter circuit discussed in paragraph 3.2.1. The analog to digital conversion is performed by U102 and displayed by DS101 through DS103. The output current is displayed on the current bar graph LEDs DS107 through DS116 which are driven by U101.

3.2.3 Output and Sense Lines

The remote sense lines are internally connected to the main output terminals by R122 and R125. Should the sense lines be incorrectly connected to the output (eg. reversed), 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.

SECTION 4**MAINTENANCE****4.1 GENERAL**

This section provides troubleshooting data, and periodic servicing, calibration, and performance testing procedures. The troubleshooting data should be used in conjunction with the schematic diagrams in section 5 and with section 3 which outlines the theory of operation. Any questions pertaining to repair should be directed to

Xantrex Technology Inc,
1584 Fell Avenue, North Vancouver, B.C, V7P 3E7,
Tel: (604) 984-4268, Fax: (604) 984-9758.
Customer Service: 1-800-667-8422

Include the model and serial numbers in any correspondence. Should it be necessary to return a unit to the factory for repair, prior authorization from Xantrex Technology Inc must be obtained.

4.2 PERIODIC SERVICING

Whenever a unit is removed from service, it should be cleaned, using naphtha or an equivalent solvent on painted metal surfaces, and a weak solution of soap and warm water for the front panel. Compressed air (at 5 psi) may be used to blow dust from in and around components.

4.3 TEST EQUIPMENT REQUIRED

The following test equipment may be required to service the 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.

4.4 TROUBLESHOOTING

CAUTION!! POTENTIALLY LETHAL VOLTAGES EXIST IN THE POWER CIRCUIT (A2). Troubleshoot with care after familiarization with circuit operation and using appropriate high voltage testing techniques. Refer servicing to experienced technical personnel only. Remember - **FILTER CAPACITORS STORE POTENTIALLY DANGEROUS ENERGY EVEN FOR SOME TIME AFTER POWER IS REMOVED.** Discharging of large filter capacitors with suitable resistors is necessary for safety and 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.**

Fuses should always be replaced with the same type and rating as originally installed. A blown fuse almost invariably indicates other faulty components which should be identified and replaced before a new fuse is installed. 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 the same type; not substitutes.

4.4.1 Main Assembly Troubleshooting Chart
(A1 Front Panel Assembly, and A2 Power Assembly)

- Check for burnt components, poor solder connections, and loose connectors.
- Disconnect any attached option board (A3 or A4 assembly). If the problem is corrected when the board is removed, refer to the appropriate option board troubleshooting chart.
- Observe the high voltage precautions listed in section 4.4 when troubleshooting the A2 assembly. Be sure the unit is powered 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 damage to test equipment.**
- All measurements are to be made with reference to P2-6 unless otherwise noted.
- All parts and test points are located on the A2 assembly unless otherwise noted.
- Under the **POSSIBLE DEFECTIVE COMPONENTS** column, parts are listed in order of decreasing probability of failure.

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
Continued on next page.		

4.4.1 Main Assembly Troubleshooting Chart (continued)

SYMPTOM	CHECK	POSSIBLE DEFECTIVE COMPONENT AND CAUSES
	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 regulation poor or output not adjustable over full range	1) DC auxiliary voltages are present as previously described (section 1, step #3)	1) If not: U6, U7, Q4, T1, CR7 to CR9
	2) DC reference voltage is as previously described (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
Display erratic or blank but output is functional	1) Ribbon cable connectors to A1 assembly are properly seated	1) Ribbon cable connectors
Continued on next page.		

4.4.1 Main Assembly Troubleshooting Chart (continued)

SYMPTOM	CHECK	POSSIBLE DEFECTIVE COMPONENT AND CAUSES
	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 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
	4) With power OFF, check that resistance across W1 is greater than 1k Ohm	4) If not: U5, W1 Otherwise: U4, U2, U8

4.5 CALIBRATION

The HPD Series power supply is calibrated primarily with selected resistors which trim such critical parameters as the reference voltage and front panel display accuracy. These resistors are mounted in component lead sockets on 0.5" centers and are readily replaceable with the use of needle nose pliers. Some are 1% metal film resistors to ensure low temperature drift of the related parameter, and should not be replaced with standard 1/4W 5% resistors. These calibration resistors and other calibration components are listed by assembly in the following sections. Recalibration is not normally required unless entire assemblies are replaced when repairing the supply.

4.5.1 A1 Assembly Calibration Chart

CALIBRATION RESISTOR	PARAMETER AFFECTED
R103	Current bar graph full scale level
R104	Voltage bar graph full scale level
R130 or R133 (Only 1 used)	Voltage and current display accuracy-adjust both displays simultaneously

4.5.2 A2 Assembly Calibration Chart

CALIBRATION RESISTOR	PARAMETER AFFECTED
R3	Maximum output current - Set for 5% above rated output current
R28	Current display accuracy
R24	Current display offset - Set for "0" reading with output current at zero
R16	+10 volt reference level - Set for most accurate voltage display
C43	Switching frequency - Set for frequency of 200kHz +/- 5kHz at Q11 emitter referenced to P4-2 (Be sure to use an isolation transformer to power the supply when using grounded test equipment)



SECTION 5

DRAWINGS AND PARTS LISTS

5.1 GENERAL

This section provides schematic drawings and parts lists for the following assemblies:

- A1 - Front panel assembly
- A2 - Power assembly
- - Base plate Assembly, Cover, Power cord set

5.2 PARTS ORDERING

Parts may be ordered from the factory by the Xantrex part numbers listed in the following parts lists. Order parts from:

XANTREX TECHNOLOGY INC
1584 Fell Avenue
North Vancouver, B.C
V7P 3E7
Tel: (604) 984-4268
Fax: (604) 984-9758
Customer Service: 1-800-667-8422

POWER SUPPLY INTERCONNECTION DIAGRAM

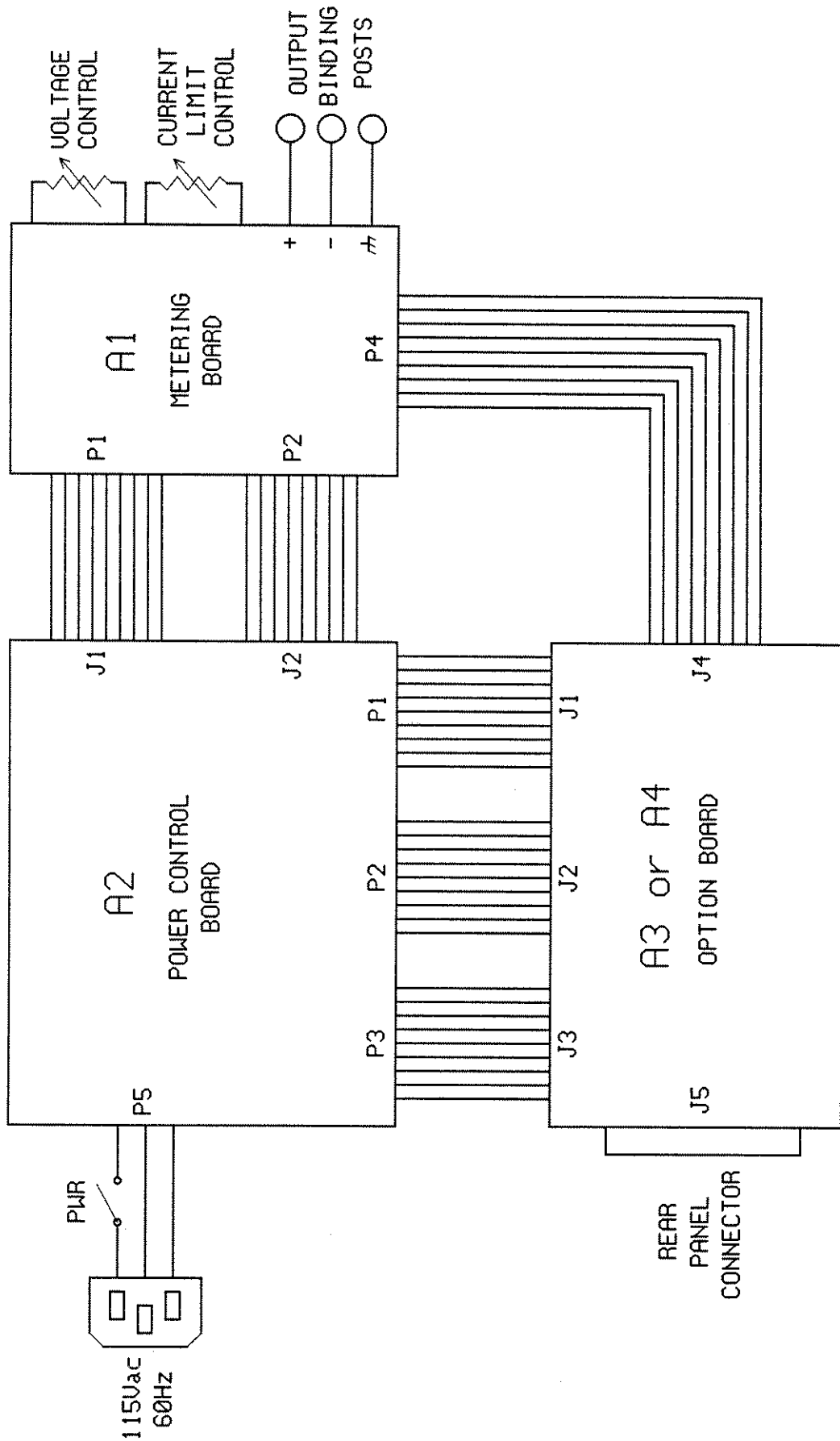
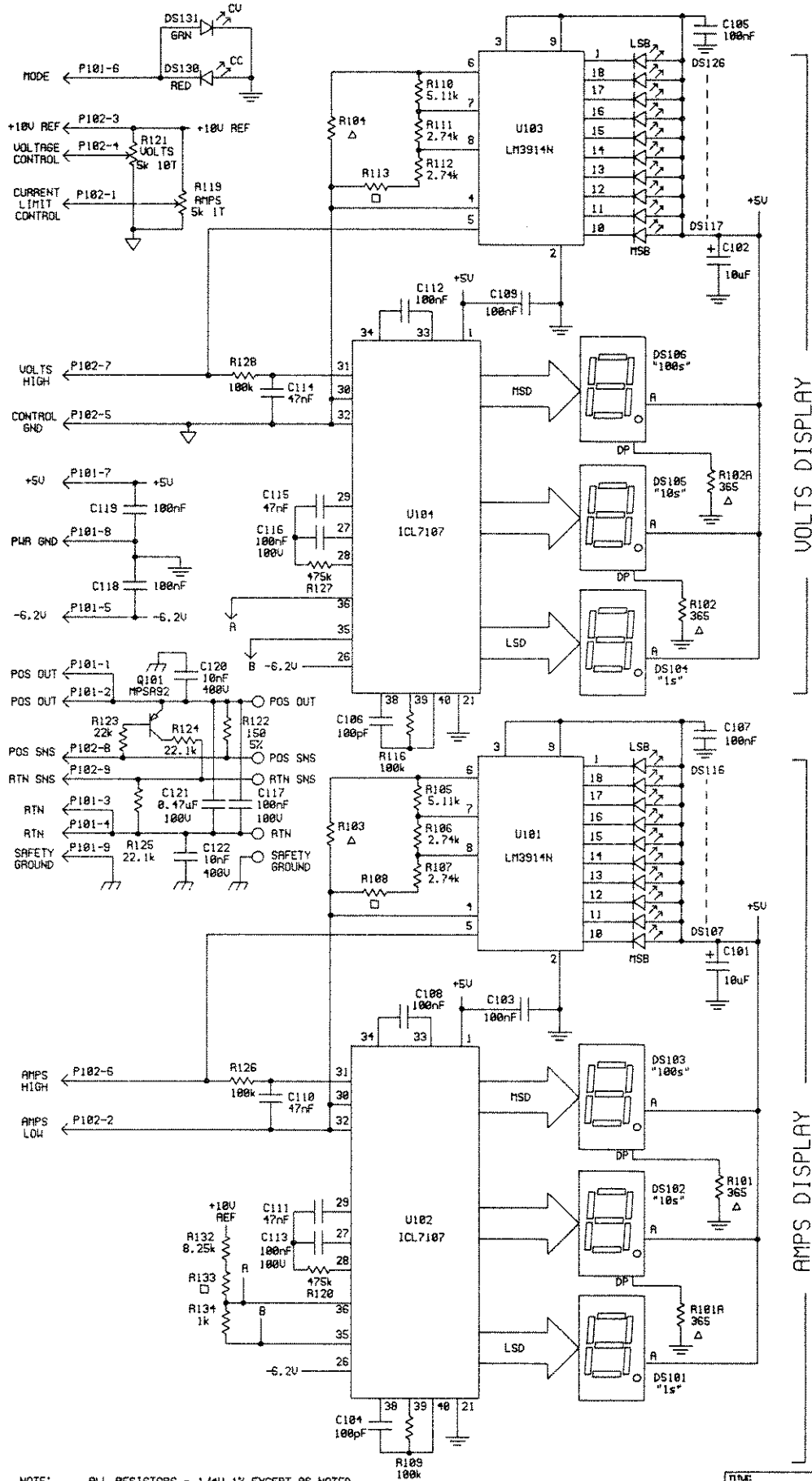


FIG. 5-1

A1 ASSEMBLY

TO A2 ASSEMBLY



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

TITLE: MPD FRONT PANEL A1 PCB SCHEMATIC	
DRAWING NUMBER: XS-30A1	REV: A
DESIGNED BY: JN	REV: A
DRAWN BY: JN	LAST REV: 04/06/12/JN
APPROVED: JN	ISSUE DATE:

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5.3 A1 ASSEMBLY REPLACEMENT PARTS

Designation	Description	Part Number
C101,102	10uF 50V 2mm EL RAD 5x11	CL-100C-50
C103,105,107-109,112, C118,119,123,124	0.1uF 50V Z5U +80% to -20% 2.5mm Cer Radial	CC-104D-09
C104,106	100pF 100V X7R 10% 2.5mm Cer Radial	CB-101D-16
C110,111,114,115	47nF 50V Z5U +80% to -20% 2.5mm Cer Rad	CC-473D-09
C113,116,117	0.1uF 100V MF 10% 10mm Radial	CD-104J-16
C120,122	10nF 400VDC MF 10% 10mm Radial	CD-103J-46
DS101-106	7 SEG DISP GRN 13.5mm CHAR HT	DS-0161-G7
DS107-126,129,131	LED, Green Rect. 2.5 x 5mm	DS-0394-G6
DS127,130	LED, Red Rect. 2.5 x 5mm	DS-5556-R6
DS128	LED, Yellow Rect. 2.5 x 5mm	DS-0384-Y6
P101,102,104	* 9PIN MALE 0.1inch Friction Lock XT/6000 A1 PCB Rev. H	MC-0903-MC PC-6001-H
Q101	MPS-A92 PB 300V 500mA 625mW	QN-MPSA-92
R105,110	5.11k 1/4W 1% MF	R-5111-41
R106,107,111,112	2.74k 1/4W 1%	R-2741-41
R108,113,133	Select and Install in Test	R-TEST
R119	5k 1T 1/2W 20% Panel Mount 1/4" Shaft	RP-5001-18
R120,127	475k 1/4W 1% MF	R-4753-41
R121	5k 1OT 2W 5% Panel Mount 1/4" Shaft	RP-5001-0
R123-125	22.1k 1/4W 1%	R-2212-41
R132	8.25k 1/4W 1%	R-8251-41
R134	1k 1% 1/4W MF	R-1001-41
U101,103	LM3914N Bargraph Drvr 18pin Dip	UD-3914-N
U102,104	7107 CMOS 3.5 Digit A/D LED Driver	UD-7107-C
	Eyelet Brass SE610 3/16D x 5/16	MC-0610-SE
For U102,104	IC Socket DIL 40 PIN .1 x .6in	MC-0040-IC
For R108,113,133	Socket .025" Comp. Lead , 0.052" Mtn Hole	MC-5315-MS
For R121	Internal Lockwasher (.6x415x.022)	MW-1220-08
For BP103	#6 x 1/4in Internal Lockwasher	MW-6108
To Secure PCB to F/P	#6-32 x 1/4in Taptite Pan Zinc	MS-6P15-04
BP103 Safety Ground Terminal, one nut each side of PCB	* Binding Post Green #6-32 15A	MC-BP21-GN

5.3.1 A1 DIFFERENTIAL REPLACEMENT PARTS FOR 15V

Designation	Description	Part Number
BP101	5 Way Binding Post, 30A Red	MC-BP31-R
BP102	5 Way Binding Post, 30A Black	MC-BP31-B
R101A,102	365Ω 1/4W 1%	R-3650-41
R103	392Ω 1/4W 1%	R-3920-41
R104	270Ω 5% 1/4W	R-2700
R114	16.2k 1/4W 1%	R-1622-41
R115	Trimpot 100k 1T 1/4W 10% Cermet	RC-1003-49
	HPD 15-20 Front Panel Label Set	LA-30FP-X015
	Control Knob, Black, Set 0.23" From Bottom	MK-4112-SB
	Flat Black Mld Plastic Front Panel	SP-6001-02FB
	Filter Grey 1.145in x 3.33in	SP-6002-04

5.3.2 A1 DIFFERENTIAL REPLACEMENT PARTS FOR 30V

Designation	Description	Part Number
BP101	5 Way Binding Post, 30A Red	MC-BP31-R
BP102	5 Way Binding Post, 30A Black	MC-BP31-B
R101A,102	365Ω 1/4W 1%	R-3650-41
R103	180Ω 1/4W 1%	R-1800-41
R104	619Ω 5% 1/4W	R-6190-41
R114	7.5k 1/4W 1%	R-7501-41
R115	Trimpot 100k 1T 1/4W 10% Cermet	RC-1003-49
	HPD 30-10 Front Panel Label Set	LA-30FP-X030
	Control Knob, Black, Set 0.23" From Bottom	MK-4112-SB
	Flat Black Mld Plastic Front Panel	SP-6001-02FB
	Filter Grey 1.145in x 3.33in	SP-6002-04

5.3.3 A1 DIFFERENTIAL REPLACEMENT PARTS FOR 60V

Designation	Description	Part Number
BP101	5 Way Binding Post, 30A Red	MC-BP31-R
BP102	5 Way Binding Post, 30A Black	MC-BP31-B
R101A,102	365Ω 1/4W 1%	R-3650-41
R103	1.1k 1/4W 1%	R-1101-41
R104	1.5k 5% 1/4W	R-1501-41
R114	36k 1/4W 1%	R-3602
R115	Trimpot 1M 1T 1/4W 10% Cermet	RC-1004-49
	HPD 60-5 Front Panel Label Set	LA-30FP-X060
	Control Knob, Black, Set 0.23" From Bottom	MK-4112-SB
	Flat Black Mld Plastic Front Panel	SP-6001-02FB
	Filter Grey 1.145in x 3.33in	SP-6002-04

5.4 A2 ASSEMBLY REPLACEMENT PARTS

Designation	Description	Part Number
C1,2,12,12A,13,16,17,22 C23,30,36,39,45-49,64	0.1uF 50V X7R 10% 5.0mm Cer	CB-104F-06
C2A,55	10nF 100V X7R 10% 5.0mm Cer Radial	CB-103F-16
C3,11,18,19,35,63	10uF 50V 2.0mm EL Radial	CL-100C-50
C4	1uF 100V MF 10% 15mm Radial	CD-105L-16
C10	2.2nF 100V X7R 10% 5.0mm Cer Radial	CB-222F-16
C14A,15,24,40,44,60	100pF 100V Z5F 10% 5.0mm Cer Radial	CB-101F-16
C20	220uF 16V 5mm 20% EL Radial	CL-221F-16
C21	470uF 16V 10 x 20, 5.0mm 20% EL Radial	CL-471F-16
C27-29	10nF 400VDC MF 10% 10mm Radial	CD-103L-36
C28A	0.33uF 400V MF 10% 22.5mm Radial	CD-334N-36
C31,38	1nF 250V X7R 10% 5.0mm Cer Rad	CB-102F-26
C32	470pF 1kV X7R 10% 6.5mm Cer Rad	CB-471G-66
C33,37	0.1uF 250V MF 10% 15.0mm	CD-104J-26
C34	33uF 25V 2.5mm 20% EL Radial	CL-330D-25
C41,50	470pF 100V X7R 10% 5.0mm Cer Rad	CB-471F-16
C42	390pF 100V X7R 10% 5.0mm Cer Rad	CB-391F-16
C51	0.33uF 50V Z5U +80 to -20% 5.0mm Cer	CC-334F-09
C52	2.2uF 200V 5.0mm EL Rad	CL-2U2F-80
C53,54	1000uF 200V 10mm 20% 35D x 45mm	CL-102J-80
C56,57	10nF 250Vac 10% MF Rad 15.0mm	CD-103L-36
C58	0.33uF 250Vac 10% MFRD 22.5mm "X" Capacitor	CD-334N-36
C65	0.1uF 250Vac 10% 15mm MF Cer Rad	CD-104L-36
C67	1nF 3KV Z5U +80% 6.5mm Cer Rad	CC-102G-99
CR1,1A,3,3A,3B,4,25, CR25A,25B,26,28,29A, CR30,32,33,35	1N4148 UR D035 75V 300mA	CR-4148
CR2,10,19	1N4735A ZENER D041 6.2V 1W	CR-4735-A
CR6-9,12-17,20,24A,34	MUR140 UR D05 400V 1A	CR-0140-UR
CR9A	1N825A VZ D0-35 6.2V 400mW	CR-0825-A
CR11,18,22,31	1N4746A Z D04 18V 500mW	CR-4746-A
CR21	1N4731A Z D04 4.3V 1W	CR-4731-A
CR23	KBPC804 BR KBPC8 400V 8A	CR-B084
CR24	1.5KE 160 TS D041 160V 1500W	CR-T160-15
CR29	1N5231B Z D0204 5.1V 5% .5W	CR-5231-B
F1,2	7A 125V Pico Fuse	F1-0700-F2
F3	3/8A 125v Pico Fuse Fast Axial	F1-0036-F2
J1	#22 x 9, 3.5in Flat Cable Assembly	WA-0922-07
J2	#22 x 9, 4.5in Flat Cable Assembly	WA-0922-09
	Continued on next page.	

5.4 A2 ASSEMBLY REPLACEMENT PARTS (Continued)

Designation	Description	Part Number
L1	.5in x .25in Torroid (Ferrite)	FT-0525
L3	HPD L3 213uH 6A I/P Inductor	L2-3130-6
L4	HPD L4 AC Input Common Mode Inductor	L2-3001-6
P1,2,3	9Pin Male 0.1in Friction Lock	MC-0903-MC
P5	Header, 4Pin PC Type Mate-N-Lock	MC-3502-ML
	HPD A2 PCBoard Rev. E	PC-300W-E
Q1,5-10	IRF640 NM 200V .18Ohm 18A TO220	QF-0640-IR
Q2,11,13,14,16	PN2222A NB 40V 500mA 500mW TO92	QM-2222-A
Q4	MTP2N45 NM 450V 2A 75W TO220	QF-P02N-45
Q12	XX2907A PB 60V .5mA 400mW TO92	QN-2907-A
Q15	2N4033 P 80V 5A 7W TO39	QJ-4033
R1,2,4,25,30,33,38,40,81	100k 1% 1/4W MF	R-1003-41
R3,16,24,28	Select and Install in Test	R-TEST
R5,7,11,29A,39,42,54, R62,70,78	1k 1% 1/4W MF	R-1001-41
R6,57	20k 1/4W 1%	R-2002-41
R11A	3.3M 5% 1/4W CF	R-3304
R12,17	511 Ω 1/4W 1%	R-5110-41
R14,19,22,32,43,71, R73-75,80,88,89	10k 1/4W 1%	R-1002-41
R15	4.99k 1% 1/4W MF	R-4991-41
R18	6.65k 1% 1/4W MF	R-6651-41
R23,29,87	47.5k 1/4W 1%	R-4752-41
R26,27	3.57k 1/4W 1% MF	R-3571-41
R31	2.7 Ω 1W 5% MF	R-2R70-1
R35,47,53,59	2.21k 1% 1/4W MF	R-2211-41
R42A,79	100 Ω 1% 1/4W MF	R-1000-41
R46,86,90	475k 1/4W 1% MF	R-4753-41
R48,49,60,61	2.2 Ω 1/4W 1%	R-2R20-41
R50,63	1k 2W 5%	R-1001-2
R51	1.2k 1W 5%	R-1201-41
R52	62k 1W 5% MF	R-6202-1
R55	1 Ω 1/4W 1% MF	R-1R00-41
R56,76A,77A	27.4 Ω 1/4W 1% MF	R-27R4-41
R64	0.1 Ω 2W 5% MF	RA-R100-2
R65	150k 1/4W 1% MF	R-1503-41
R66	15.8k 1/4W 1% MF	R-1582-41
R67	3.16k 1/4W 1% MF	R-3161-41
R68	1.62k 1/4W 1% MF	R-1621-41
R69	4.75k 1/4W 1% MF	R-4751-41
R72	8.25k 1/4W 1%	R-8251-41
R76	18.2k 1/4W 1%	R-1822-41
	Continued on next page.	

5.4 A2 ASSEMBLY REPLACEMENT PARTS (Continued)

Designation	Description	Part Number
R77	#20 Manganin Resistance Wire 23.6m ² /inch	WR-0020-MN
R82	1M 1/4W 1%	R-1004-41
R83	100Ω 1/4W 1% MF	R-1000-2
T1	HPD 200kHz 20VA Flyback Aux.	T2-3001-A
T2	HPD 20/20/20 Toroidal Pulse Driver	T2-3002-A
U1	4066B Quad Analog Gate 14pin	UC-4066-BN
U2,4	LM358 Dual OP Amp 8pin Dip	UA-0358-N
U3	LF347N Q JFT OP Amp 14pin Dip	UA-0347-N
U5	4N37 Opto-Coupler 6pin Dip	UP-4N37
U6	3842 Imode PWM 8pin Dip	UR-3842-N
U7	7555 CMOS Timer 8pin Dip	UC-7555-P
U8	3846 Imode PWM 8pin Dip	UR-3846-N
W1	RG 174U Coaxial Cable, 5in	WZ-174U-RG
For CR5, Q3	Heatsink Anodized 6.925x4.75in 2xTO-3	HS-6000-A2
For CR5, Q3	TO3 Transistor Socket	MC-0TO3-QS
For CR5, Q3	#6-32 x 5/8" PPM Type B Zinc	MS-6P12-10
For CR5, Q3	#6 x 1/4in Internal Lockwasher	MW-6108
For CR23	Heatsink - Fabricated	SM-3023-HS
For Mounting CR23	#6-32 x 1/4in Kep Nut	MN-632K-08
For Mntg CR23 to H/S	#6-32 x 1/2in PPM Zinc	MS-6P00-08
For C 53,54	RTV Silicone Rubber Clr/Wht Non-Slf Level	AS-108R-TV
For (+) and (-) Output Connectors	Fast-On .25in Male Vertical PC Mount	MC-025M-FO
Output Wire Harness	Fast-On Fm 1/4 x .32" AWG 14-16	MC-0250-FO
For L1	# 14 Bus Wire Tinned Cu	WS-0014-0010
For Rear PCB Mount	1/2in Right Angle Bracket 6-32 1S	MB-1295-30
For U1,3	IC Socket, Dil 14pin	MC-0014-IC
For U2,4,6,7	IC Socket, Dil 8pin	MC-0008-IC
For U8	IC Socket, Dil 16pin	MC-0016-IC
For Q3	TO3 Insulation Washer	MI-0TO3-IW
For Q5-10	#4 Nylon Shoulder Washer 0.12"SD x 0.22"	MI-0412-SW
For Q5-10	Washer, TO-220 Insulation Greaseless	MI-T220-IW
For Q5-10	Heatsink 6 x TO-220 HPD	SM-30HS-A
For Mounting Q5-10	#4-40 x 1/4in Kep Nut Steel/Cad	MN-440K-08
For Mounting Q5-10 & H/S to PCB	#4-40 x 1/4" Phillips Pan Zinc	MS-4P00-04
For Mntg RT Angle Bracket to PCB	#6-32 x 5/16in Phillips Pan Zinc	MS-6P00-05
For R3,16,24,28	Socket .025" Comp. Lead 0.052 Mtn Hole	MC-5315-MS
	10 mil x 1.73" Nomex Insulation	IN-1730-10
	Nylon Grommet, Heatsink Mounting	MI-4026-00
For R77	#18 Teflon Sleeving	IS-T200-18

5.4.1 A2 DIFFERENTIAL REPLACEMENT PARTS FOR 15V

Designation	Description	Part Number
C4A	220uF 35V EI Radial 5mm	CL-221F-35
C5,6,7	1000uF 35V EI Radial 5mm	CL-102F-35
C8	2.2nF 100V X7R 10% 5mm Cer Radial	CB-222F-16
C9	100pF 100V Z5F 10% 5mm Cer Radial	CB-101F-16
C25,26	1nF 100V X7R 10% 5mm Cer Radial	CB-102F-16
CR5	200V 30A Dual UFast Rect TO3	CR-3220-UD
CR26A	#24 Bus Wire Tinned Cu	WB-0024-0010
L2	HPD L2 15V 21uH 20A O/P Inductor	L2-3015
Q3	MTM50N05E NM 50V 50A .35Ω 125W TO3	QF-M50N-05
For Q3	TO3 Insulation Washer	MI-0TO3-IW
R8	32.4k 1/4W 1% MF	R-3242-41
R9	30.1k 1/4W 1% MF	R-3012-41
R10	36.5k 1/4W 1% MF	R-3652-41
R13(4 x 1.8" pieces)	#20 Manganin Resistance Wire 23.6m [^] /inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
R20	10k 1/4W 1%	R-1002-41
R21	4.3k 1/4W 5% CF	R-4301
R25A	24.3k 1/4W 1%	R-2432-41
R27A	270Ω 2W 5%	R-2700-2
R34	Resistor Empty Position	R-EMPT
R36	100k 1/4W 1% MF	R-1003-41
R37	75k 1/4W 1% MF	R-7502-41
R44,45(2x10Ω)	10Ω 1/2W 5% CF	R-10R0-3
T3	HPD T3 15-20 Transformer	T2-3015

5.4.2 A2 DIFFERENTIAL REPLACEMENT PARTS FOR 30V

Designation	Description	Part Number
C4A	100uF 63V EI Radial 5mm	CL-101F-63
C5,6,7	470uF 63V EI Radial 5mm	CL-471H-63
C8	1nF 100V X7R 10% 5mm Cer Radial	CB-102F-16
C9	100pF 100V Z5F 10% 5mm Cer Radial	CB-101F-16
C25,26	2.2nF 100V X7R 10% 5mm Cer Radial	CB-222F-16
CR5	200V 30A Dual UFast Rect TO3	CR-3220-UD
CR26A	#24 Bus Wire Tinned Cu	WB-0024-0010
L2	HPD L2 30V 85uH 20A O/P Inductor	L2-3015
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5.4.2 A2 DIFFERENTIAL REPLACEMENT PARTS FOR 30V

Designation	Description	Part Number
Q3	MTM25N10 NM 100V .075Ω 150W TO3	QF-M25N-10
For CR5	TO3 Insulation Washer	MI-0TO3-IW
R8	15.8k 1/4W 1% MF	R-1582-41
R9	15k 1/4W 1% MF	R-1502-41
R10	68.1k 1/4W 1% MF	R-6812-41
R13(2 x 1.8" pieces)	#20 Manganin Resistance Wire 23.6m [^] /inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
R20	10k 1/4W 1%	R-1002-41
R21	1.5k 1/4W 1% CF	R-1501-41
R25A	49.9k 1/4W 1%	R-4992-41
R27A	1k 2W 5%	R-1001-2
R34	Resistor Empty Position	R-EMPT
R36	100k 1/4W 1% MF	R-1003-41
R37	121k 1/4W 1% MF	R-1213-41
R44,45(2x33Ω)	33Ω 3W 5% MF	RA-33R0-6
T3	HPD T3 30-10 Transformer	T2-3015

5.4.3 A2 DIFFERENTIAL REPLACEMENT PARTS FOR 60V

Designation	Description	Part Number
C4A	470uF 35V El Radial 5mm	CL-470F-76
C5,6,7	1000uF 35V El Radial 5mm	CL-221H-76
C8	2.2nF 100V X7R 10% 5mm Cer Radial	CB-102F-16
C9	100pF 100V Z5F 10% 5mm Cer Radial	CB-101F-16
C25	1nF 100V X7R 10% 5mm Cer Radial	CB-471G-66
C26	1nF 250V X7R 10% 5mm Cer Radial	CB-102F-26
C66	0.33uF 50V Z5U +80 to -20% 5mm Cer Rad	CC-334F-09
CR5	500V 30A Dual UFast Rect TO218	CR-3050-UD
CR26A	1N5240A Z DO-35 10V 10% 500mW	CR-5240-A
L2	HPD L2 60V 342uH 5A O/P Inductor	L2-3015
Q3	MTM15N20 NM 200V .16Ω 150W TO3	QF-M15N-20
For CR5	TO-247 Transistor Insulating Washer 6mil	MI-T247-IW
R8	7.32k 1/4W 1% MF	R-7321-41
R9	7.5k 1/4W 1% MF	R-7501-41
R10	84.5k 1/4W 1% MF	R-8452-41
R13(1 x 1.8" pieces)	#20 Manganin Resistance Wire 23.6m [^] /inch	WR-0020-MN
For R13	#18 Teflon Sleeving	IS-T200-18
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5.4.3 A2 DIFFERENTIAL REPLACEMENT PARTS FOR 60V

Designation	Description	Part Number
R20	10k 1/4W 1%	R-1002-41
R21	1.3k 1/4W 1% MF	R-1301-41
R25A	9.09k 1/4W 1%	R-9091-41
R27A	3.9k 2W 5%	R-3901-2
R34	2.2M 5% 1/4W CF	R-2204
R36	100k 1/4W 1% MF	R-1003-41
R37	47.5k 1/4W 1% MF	R-4752-41
R44	330Ω 1/2W 5% CF	RA-3300-6
R45(3 x 249Ω)	249Ω 1% 5W Non-Inductive	RN-2490-51
T3	HPD T3 60-5 Transformer	T2-3015

HPD REAR OUTPUT REPLACEMENT PARTS

Designation	Description	Part Number
C1,2	10nF 400VDC MF 10% 10mm Radial	CD-103J-46
C3 (For 15V)	470uF 16V 10 x 20, 5mm 20% El Radial	CL-471F-16
C3 (For 30V)	220uF 35V 5mm El Radial	CL-221F-35
C3 (For 60V)	100uF 63V 10 x 20, 5mm 20% El Radial	CI-101F-63
	0.47uF 100V MF 10% 7.5mm Radial	CD-474H-16
	.5in x .25in Torroid (Ferrite)	FT-0525
Install on Top of Barrier Strip	Label, Sense 6000/HPD	LA-6300-SNS
	HPD Rear Output Filter PCB	PC-30RC
R1	150Ω 1/4W 5% CF	R-1500
R2	22.1k 1/4W 1%	R-2212-41
For Connections	Fast On Female 1/4 x .032" AWG 14-16	MC-0250-FO
For Chassis Ground	#8 Ring Tongue, 18-14AWG	MC-8305-RT
For Chassis Ground	#18 TEW Stranded Green	WT-0118-GN
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

5.5 BASEPLATE AND COVER ASSEMBLY REPLACEMENT PARTS

Description	Part Number
Label, Serial# Imprintable CSA Approved	LA-6000-B1
Label, Power Cord Warning XT/HPD Billing	LA-6300-CPXN
Power Receptacle,RFI Filter	FL-2100-06
4 Pin Connector Housing	MC-1602-CP
Connector Socket Pin	MC-6191-ML
Rubber Foot W/Recess 1/2D x 5/16HT	MF-RD08-05R
Rubber Foot W/Recess 13/16D x 15/32HT	MF-RD13-08R
#6-32 x 1/4in Kep Nut	MN-632K-08
#8-32 x 3/4" Type U Spring Nut	MN-832S-24
3/16in Pop Rivets	MP-0202
#8-32 x 5/16 Phillips Pan Stainless Steel	MS-8P28-05
#4-40 x 1/4" Phillips Black Oxide Flathead	MS-4P31-04
#6-32 x 1/4" Phillips Pan Zinc	MS-6P00-04
#6-32 x 1/4" PPM Black Oxide	MS-6P02-04
#8 x 1/2 in Type A Phil Flathead Black Oxide	MS-8P31-08
#8 x 1/2 in Type A Zinc Flathead	MS-8P32-08
#4-40 x 1/4in Phillips Flathead Zinc	MS-4P18-04
#6 x 3/8in Flat Washer Cad/Zinc	MW-6412
Base Plate, Single	SM-6HBS-S
Base Plate, Dual	SM-32BS
Base Plate, Triple	SM-63BS-SO
Base Plate, Quad	SM-64BS-SO
Cover, Single	SM-6HCR-S
Cover, Dual	SM-32CR
Cover, Triple	SM-63CR-SO
Cover, Quad	SM-64CR-SO
Side Panel, Quad	SM-64SP-AC
HPD Dual Stiffener	SM-62ST-AB
HPD Triple Stiffener	SM-63ST-AB
HPD Quad Stiffener	SM-64ST-AB
HPD Handle Clamp	SM-60HC-AA
Rear Sub-plate, No Option	SM-60CC-EA
Sub-plate with Barr Strip, No Option	SM-60CC-FA
Power Switch Bracket	SM-60SB-CA
Power Switch Rod	SP-6001-03
Handle Webbing Material	SP-6001-05
Alumunium Screening Base	SC-1418-AL
Power Switch	SW-1116-BNIM
Power Cord	WP-1725-00

