

POWER *TEN*

4500 Series
2.5kW
DC Power Supply

Operation and Maintenance
Manual

*** REFERENCE ONLY ***

**** OBSOLETE SERIES, NO LONGER SUPPORTED ****

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WARNING

Hazardous voltages (greater than 50 volts) may be present when cover is removed and could cause injury to personnel. Wear safety glasses with cover removed. Authorized personnel only should remove cover.

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CHAPTER 1

DESCRIPTION OF EQUIPMENT

1-1. PURPOSE AND CAPABILITIES

The Power Ten, Inc. Series 4500, 2.5 kilowatt power supplies are general purpose power supplies designed specifically for laboratory test and systems applications requiring variable DC sources with good ripple and regulation characteristics. The Series 4500 power supplies are constant current/constant voltage power supplies with an automatic crossover feature. They provide up to 2500 watts of DC power over a wide range of voltage and current levels.

1-2. TECHNICAL CHARACTERISTICS

The physical, electrical and environmental characteristics for Series 4500 are listed in Tables 1-1 and 1-2.

Table 1-1. Series 4500 Technical Characteristics

PARAMETERS	SPECIFICATIONS
<p>PHYSICAL CHARACTERISTICS:</p> <p>Width Depth Height Weight</p> <p>ELECTRICAL CHARACTERISTICS:</p> <p>Input Power</p> <p>Voltage Frequency Phases</p> <p>Regulation (Line or Load)</p> <p>Voltage</p> <p>Current</p> <p>Transient Response</p> <p>Stability</p> <p>Remote Control</p>	<p>19 in. 22 in. 5 1/4 in. 55 lbs. max.</p> <p>190-253 VAC 47 to 63 Hz One, 2 wire plus gnd</p> <p>0.1% of max. output voltage.</p> <p>0.1% of max. output current.</p> <p>A 30% step load will recover to within 2% of final value within 10 ms.</p> <p>+/-0.05% if set point per 8 hrs. after warm-up and at a fixed line, load and temperature.</p> <p>On/Off control via contact closure, 6-120 VDC or 12-240 VAC.</p>

Table 1-1. Series 4500 Technical Characteristics - Continued

PARAMETERS	SPECIFICATIONS
<p>ELECTRICAL CHARACTERISTICS:</p> <p>Remote Programming</p> <p> Resistive:</p> <p> Constant Voltage(0-100%)</p> <p> Constant Current(0-100%)</p> <p> Voltage:</p> <p> Constant Voltage(0-100%)</p> <p> Constant Current(0-100%)</p> <p> Current:</p> <p> Constant Voltage(0-100%)</p> <p> Constant Current(0-100%)</p> <p>Remote Sensing</p> <p>ENVIRONMENTAL CHARACTERISTICS:</p> <p>Temperature Coefficient</p> <p>Ambient Temperature</p> <p> Operating</p> <p> Storage</p> <p>Cooling</p>	<p>0 - 5K ohms</p> <p>0 - 100 ohms</p> <p>0 - 5 VDC</p> <p>0 - 100 mV</p> <p>0 - 1 mA</p> <p>0 - 1 mA</p> <p>Terminals are provided to sense output voltage at point of load.</p> <p>0.02%/deg. C of max. output voltage rating for voltage set point.</p> <p>0.03%/deg. C of max. output current rating for current set point.</p> <p>0 to 50 Degrees C</p> <p>-40 to 75 Degrees C</p> <p>Internal Blowers</p>

Table 1-2. 4500 Technical Characteristics

MODEL NO.	OUTPUT DC		OUTPUT RIPPLE (RMS)
	VOLTS	AMPS	
7.5300	0-7.5	0-300	10 mV
10250	0-10	0-250	10 mV
15160	0-15	0-160	10 mV
20125	0-20	0-125	10 mV
3080	0-30	0-80	30 mV
4060	0-40	0-60	10 mV
6040	0-60	0-40	20 mV
8030	0-80	0-30	20 mV
10025	0-100	0-25	50 mV
15016	0-150	0-16	75 mV
25010	0-250	0-10	100 mV
3008	0-300	0-8	100 mV
4505	0-450	0-5	150 mV
6004	0-600	0-4	200 mV

CHAPTER 2

INSTALLATION

2-1. INSPECTION

Inspect the shipping carton for possible damage before unpacking the unit. Carefully unpack the equipment. Save all packing materials until inspection is complete. Verify that all items listed on the packing slips have been received. Visually inspect all exterior surfaces for broken knobs, connectors or meters. Inspect for dented or damaged exterior surfaces. External damage may be an indication of internal damage. If any damage is evident, immediately contact the carrier that delivered the unit and submit a damage report. Failure to do so could invalidate future claims.

2-2. INPUT/OUTPUT CONNECTORS

Table 2-1 lists all external connectors for Series 4500.

2-3. LOCATION AND MOUNTING

The Series 4500 is intended for mounting in a standard 19-inch equipment rack. Four captive screws, two on each side of the front panel, are used to secure the unit in place. Optional slide mounting is available. The unit is also suitable for workbench applications.

2-4. CHECKOUT AND PRELIMINARY ADJUSTMENTS

Follow the instructions in paragraph 3-2 for setup and operation of the equipment.

Table 2-1. Series 4500 Input/Output Connectors

CONNECTOR	FUNCTION	CONNECTS TO
TB3 - AC TB3 - AC GND Pos. Bus Bar Neg. Bus Bar GND Stud TB1/TB2	[Prime Power Input Chassis GND Output Power Control Interface	190-253 VAC 47-63 Hz Power Source User Load(s) See Table 3-2 For Description

CHAPTER 3

OPERATING INSTRUCTIONS

3-1. CONTROLS AND INDICATORS

Front panel controls and indicators for the Series 4500 are identified in Figure 3-1 with index numbers keyed to Table 3-1. Table 3-1 provides a description of all operator controls and indicators.

3-2 SETUP AND OPERATING INSTRUCTIONS

The following paragraphs provide setup and operating procedures for the Series 4500.

The power supply may be configured via TB1/TB2 for different operating configurations: local and remote current programming, local and remote voltage programming, normal parallel, auto-parallel, normal series, auto-series, and auto-tracking. The use and operating requirements of each configuration are provided in the following paragraphs. Reference Table 3-2 for barrier strip TB1/TB2 reference designators and functions.

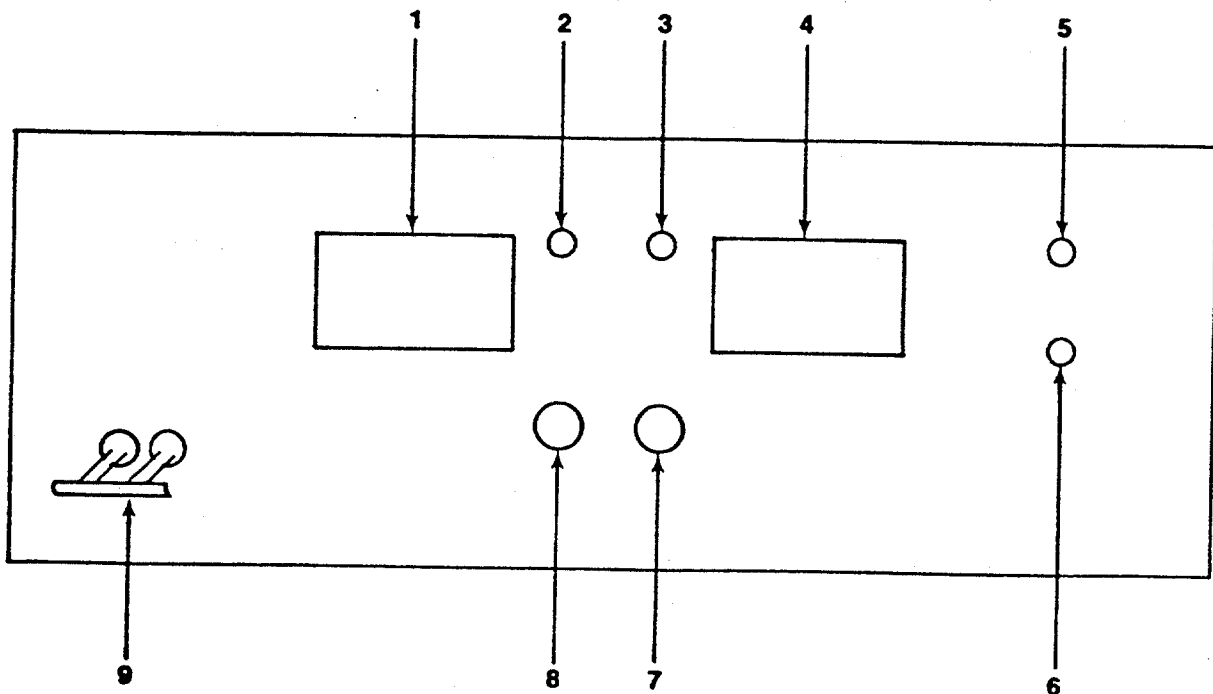


Figure 3-1. Series 4500 Controls and Indicators

Table 3-1. Series 4500 Controls and Indicators

FIGURE & INDEX NO	CONTROL/ INDICATOR	FUNCTION
3-1		
-1	VOLTAGE Meter	Measures voltage output.
-2	Voltage Mode Indicator	Indicates the power supply is operating in the voltage mode.
-3	Current Mode Indicator	Indicates the power supply is operating in the current mode.
-4	CURRENT Meter	Measures current output.
-5	OVERVOLTAGE Indicator	Indicates output voltage has exceeded preset level, and power supply output is turned off.
-6	Overvoltage Potentiometer	Adjusts overvoltage trip level
-7	Output Current Control	Adjusts current output to a desired level.
-8	Output Voltage Control	Adjusts voltage output to a desired level.
-9	Circuit Breaker	Applies AC power to the power supply.

Table 3-2. Barrier Strip Designators and Functions

TB1/TB2 DESIGNATOR	SCHEMATIC SYMBOL	FUNCTIONAL DESCRIPTION
1	V+	Positive output voltage for local voltage sensing.
2	VS+	Positive voltage sensing terminal.
3	VPRO	1 milliamp current source for either local or remote voltage programming using resistance.
4	VCON	Voltage control input terminal.
5	VSET	Front panel voltage control potentiometers for local control.
6	VS-	Negative voltage sensing terminal.
7	V-	Negative output voltage for local voltage sensing.
8	COM	Control Circuit Common. Used with TB2-12 for current monitor and/or TB2-14 for remote on/off control return.
9	I PROG	1 milliamp current source for either local or remote current programming using resistance.
10	ICONT	Current control input terminal.
11	ISET	Front panel current control potentiometers for local control.
12	IMON +	0-5 VDC = 0-100% rated current. User positive current monitor terminal or 0-1 milliamp auto-tracking control output terminal. Referenced to TB2-13.
13	COM	Control Circuit Common. Used with TB2-12 for current monitor and/or TB2-14 for remote on/off control return.
14	CONTACT CONTROL	Remote on/off control using contacts of switch of relay.

Table 3-2. Barrier Strip Designator and Functions - continued

TB1/TB2 DESIGNATOR	SCHEMATIC SYMBOL	FUNCTIONAL DESCRIPTION
15	AC/DC RTN	Return for AC/DC voltage source used for remote on/off control.
16	AC/DC CONTROL	Externally supplied AC/DC voltage source for on/off output voltage control. This is a positive (+) terminal for DC voltage. This control is Opto-Isolated from the power supply circuits for voltages up to 500 volts AC or DC.

a. Local Operation. Units are shipped from the factory configured for local voltage/current control and local voltage sensing. This configuration is used for applications where the IR drop of the load wires is insufficient to degrade performance at the load. The strapping pattern is provided in Figure 3-2. Prior to turning the unit on, rotate the voltage and current potentiometers fully counterclockwise (minimum output). Then switch the circuit breaker to the ON position and adjust the voltage and current to the desired output.

b. Remote Current Programming. The remote current programming configuration is used for applications that require the output current be programmed (controlled) from a remote source. An external resistance or external floating voltage source may be used for a programming device. When using remote current programming, a shielded, twisted pair hookup wire is recommended to prevent noise interference with programming signals.

(1) External Current Programming Using Resistance. The resistance coefficient for remote current programming is 100 ohms/100% rated output. The programming current from the current control programming terminal TB2-9 is factory set for 1 milliamperes. This yields a coefficient of 1% of rated output current per ohm (1%/ohm). If multiple switches or relays are used to program different levels, make-before-break contacts are recommended. See Figure 3-3 for strapping requirements.

(2) External Current Programming Using a Voltage Source. The voltage coefficient for remote current programming 1 millivolt = 1% of rated output, i.e., for a 500 amp model each millivolt of programming voltage would equal 5 amps of output current. See Figure 3-4 for strapping requirements.

c. Remote Voltage Programming. The remote voltage programming configuration is used for applications that require the output voltage be programmed (controlled) from a remote source. An external resistance or external floating voltage source may be used as a programming device. When using remote voltage programming, a shielded twisted pair hookup wire is recommended to prevent noise interference with programming signals.

(1) External Voltage Programming Using Resistance. The resistance coefficient for remote voltage programming is 5k ohms = 100% of rated output voltage. The programming current from terminal 3 is factory set to 1.000 mA. If multiple switches or relays are used to program different levels, make-before-break contacts are recommended. See Figure 3-5 for strapping requirements.

(2) External Voltage Programming. The voltage coefficient for external voltage programming is 5 volts = 100% of rated output voltage. To program voltage slightly above the rated output will not damage the unit, but degraded performance may result. See Figure 3-6 for strapping requirements.

d. Remote Sensing. In applications where the load is located some distance from the power supply or the voltage drop of the power output leads significantly interferes with load regulation, remote voltage sensing may be used. When remote sensing is used, voltage is regulated at the load versus the power supply output terminals. To connect the power supply for remote voltage sensing (see Figure 3-7 for strapping requirements):

CAUTION

If the power supply is operated with load power lines disconnected and sensing line connected, internal power supply damage may occur. (Output current then flows through sensing terminals.)

- (1) Remove jumper between the positive sense terminal (TB1-2) and the positive output monitor terminal (TB1-1).
- (2) Remove jumper between the negative sense terminal (TB1-6) and the negative output monitor terminal TB1-7.
- (3) Connect sensing leads from the load positive to TB1-2 and the load negative to TB1-6. A shielded, twisted pair is recommended to avoid potential noise interference.

e. Remote Output On/Off Control. Remote on/off control may be accomplished by contact closure or by an external AC/DC voltage source.

- (1) Remote on/off by contact closure. See Figure 3-8 for strapping requirements. Output is on when contacts are closed.
- (2) Remote on/off control may be accomplished by an external AC voltage of 12 to 240 VAC or an external DC voltage of 6 to 120 VDC. See Figure 3-9 for strapping requirements. Application of AC or DC voltage will turn on the power supply.

NOTE

The following modes of operation are used for applications requiring greater output current or voltage than is available from a single power supply. To meet the requirements for greater output voltage or current, two or more supplies may be connected in series or parallel.

f. Auto-Parallel Operation. In the auto-parallel mode of operation, a master/slave configuration is established.

CAUTION

When using two or more supplies in parallel, damage may occur to slave(s) crowbar circuits if slave overvoltage level set is not higher than the master overvoltage level set. To prevent damage, set all slave units overvoltage-set potentiometers fully clockwise and the master unit to the desired trip level. If overvoltage protection is not desired, set to trip at maximum rated voltage (less than fully clockwise).

To set-up the auto-parallel mode of operation, connect all outputs in parallel to load. Connect jumper from master TB2-12 to slave TB2-10 and TB2-11. Remove jumper between slave TB2-9 and TB2-10. Rotate slave voltage control potentiometers to maximum and adjust current control potentiometers for balanced output currents during operation. Once adjusted, output currents will track automatically. If tracking is not close, perform the calibration procedures listed in Chapter 5. See Figure 3-10 for strapping requirements.

g. Auto-Series Operation. In the auto-series mode of operation, a master/slave configuration is established. With two or more supplies connected in series, one is established a master and the remaining units as slaves. The master supply must always be the most positive unit. When operating in the auto-series mode, voltage control potentiometer settings determine the percentage of total load voltage contribution by slave units. Current control potentiometers of the slave units are active and should be set to maximum clockwise position. See Figure 3-11 for the strapping requirements.

h. Auto-Tracking Operation. In the auto-tracking mode of operation, a master/slave configuration is established. In this configuration, two or more supplies may be connected with common negative outputs.

The slave(s) output voltage is a percentage of the master as controlled by the slaves(s) voltage control potentiometers. Individual current controls on both master and slave(s) remain active. See Figure 3-12 for strapping requirements.

TB1

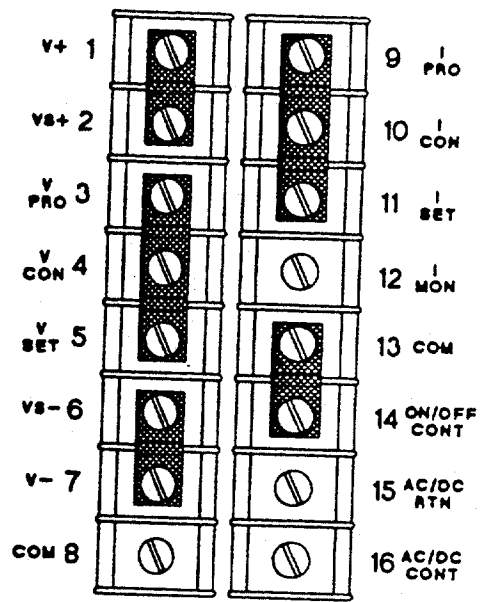


FIGURE 3-2
NORMAL STRAPPING PATTERN

TB1

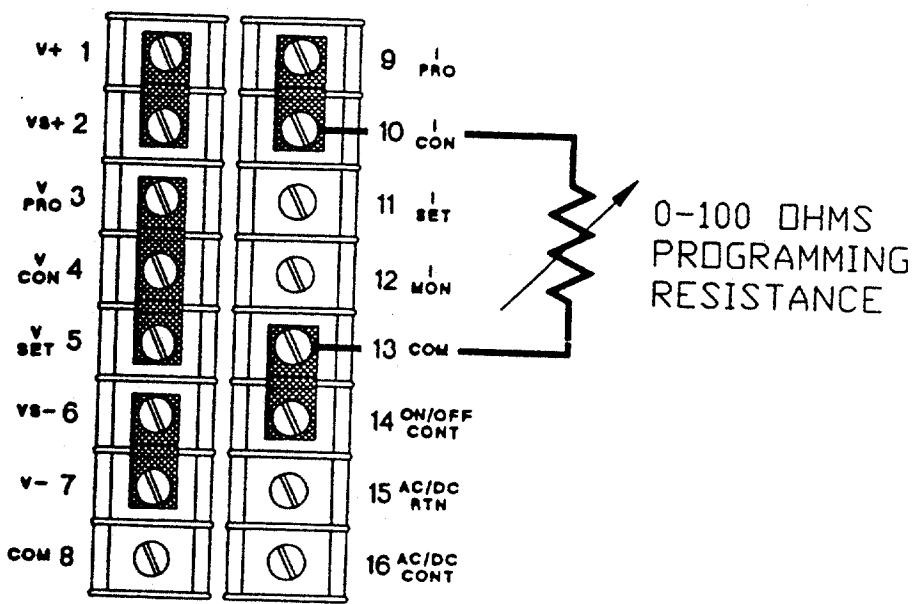


FIGURE 3-3
REMOTE RESISTANCE PROGRAMMING OF OUTPUT CURRENT

TB1

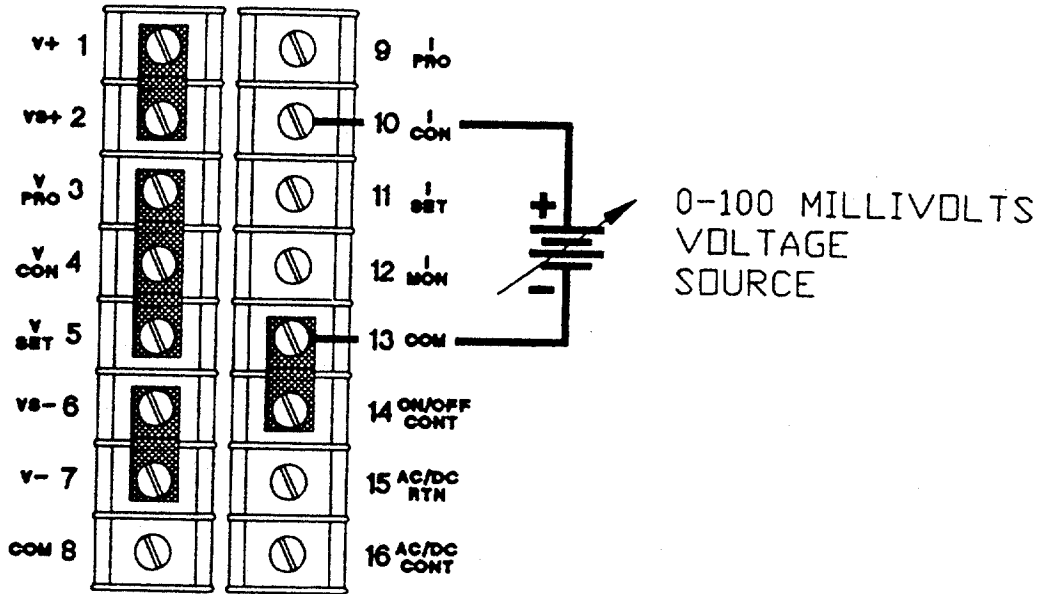


FIGURE 3-4
REMOTE VOLTAGE PROGRAMMING OF OUTPUT CURRENT

TB1

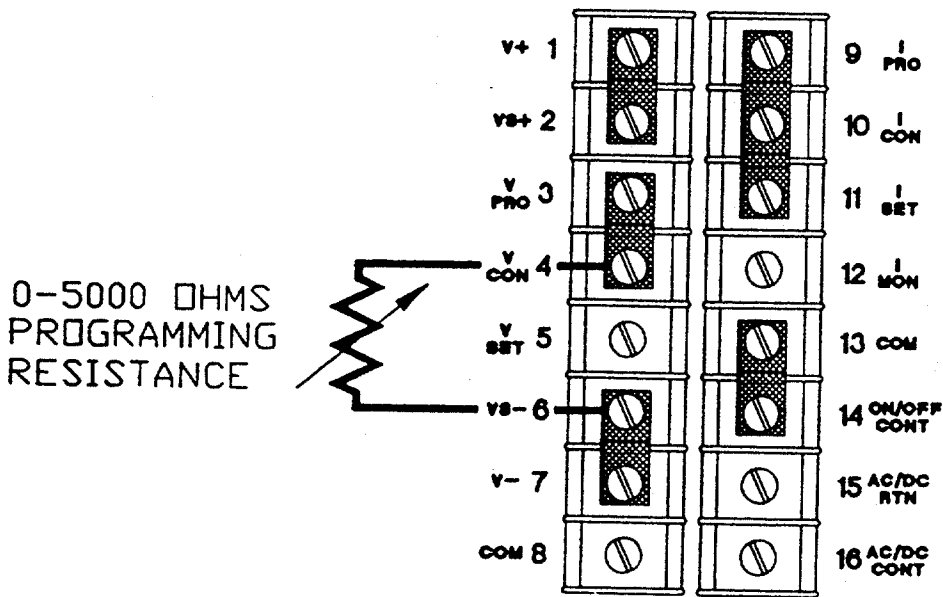


FIGURE 3-5
REMOTE RESISTANCE PROGRAMMING OF OUTPUT VOLTAGE

TB1

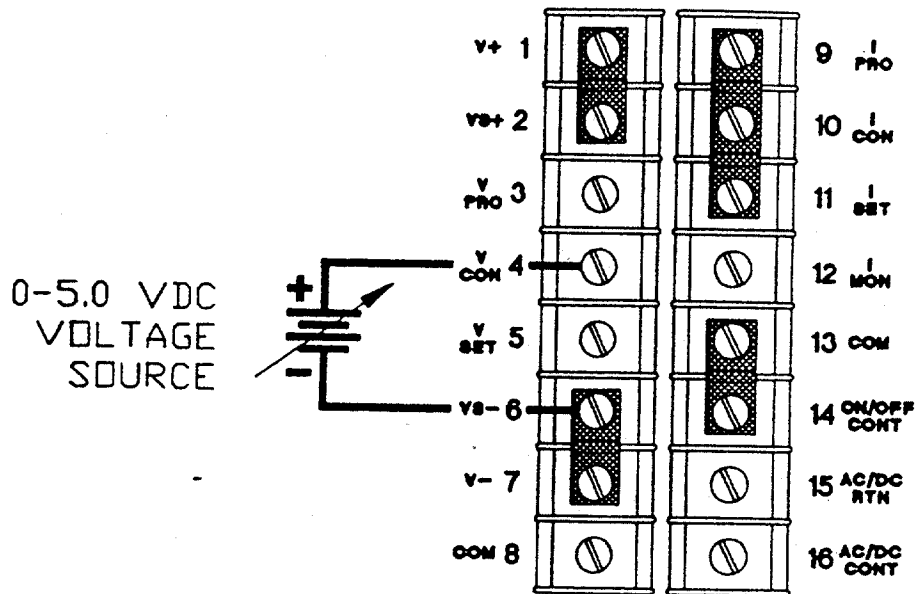


FIGURE 3-6
REMOTE VOLTAGE PROGRAMMING OF OUTPUT VOLTAGE

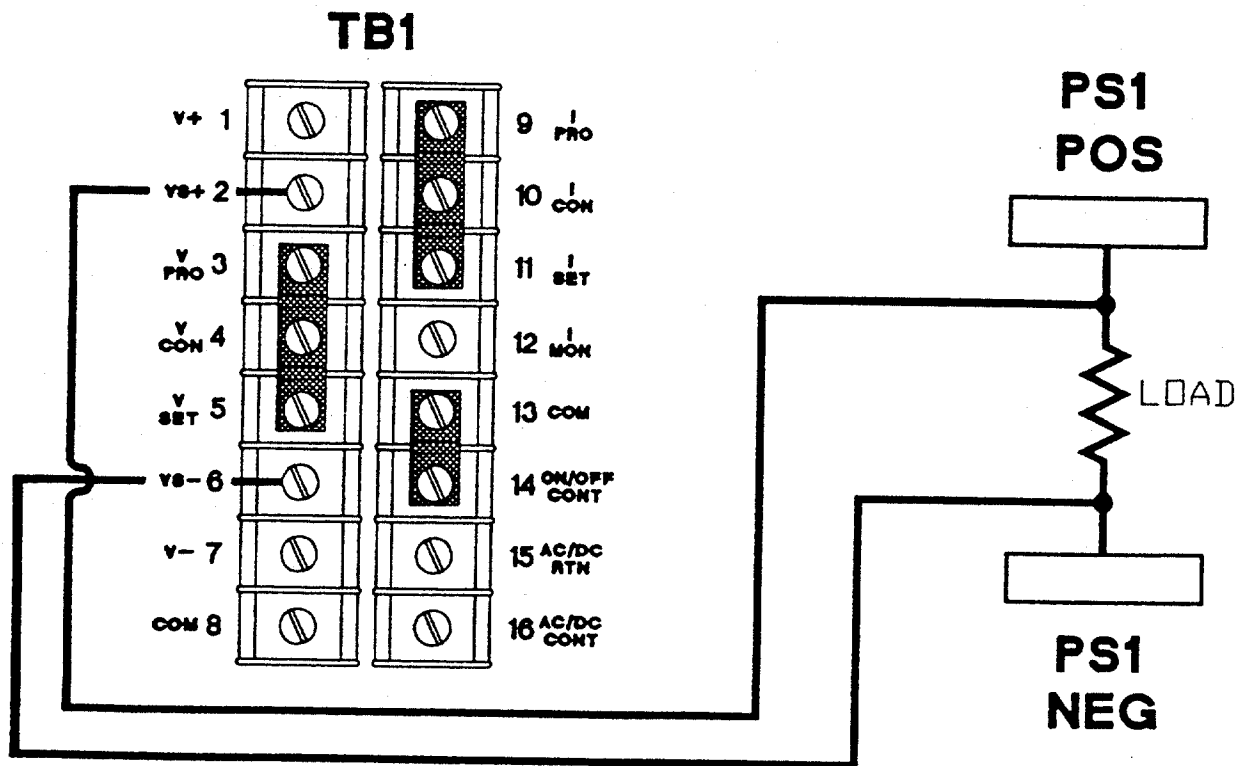


FIGURE 3-7
REMOTE SENSING OPERATION

TB1

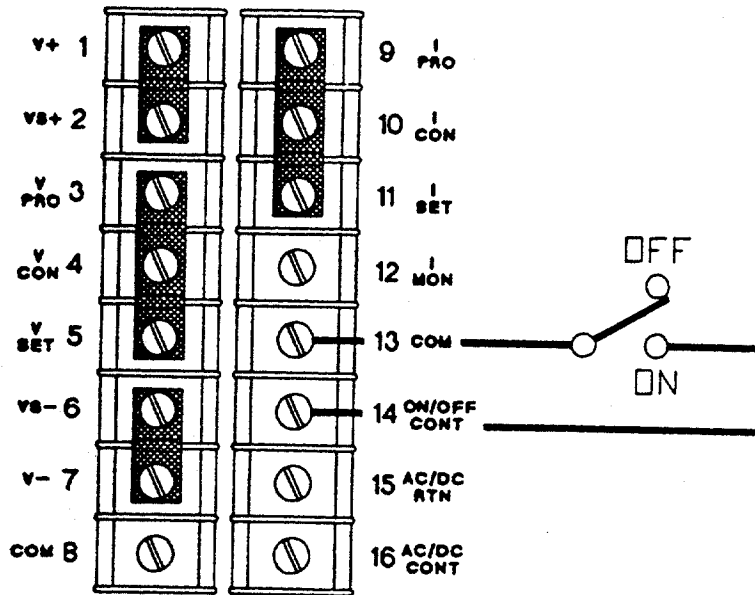


FIGURE 3-8
REMOTE ON/OFF CONTROL BY CONTACT CLOSURE

TB1

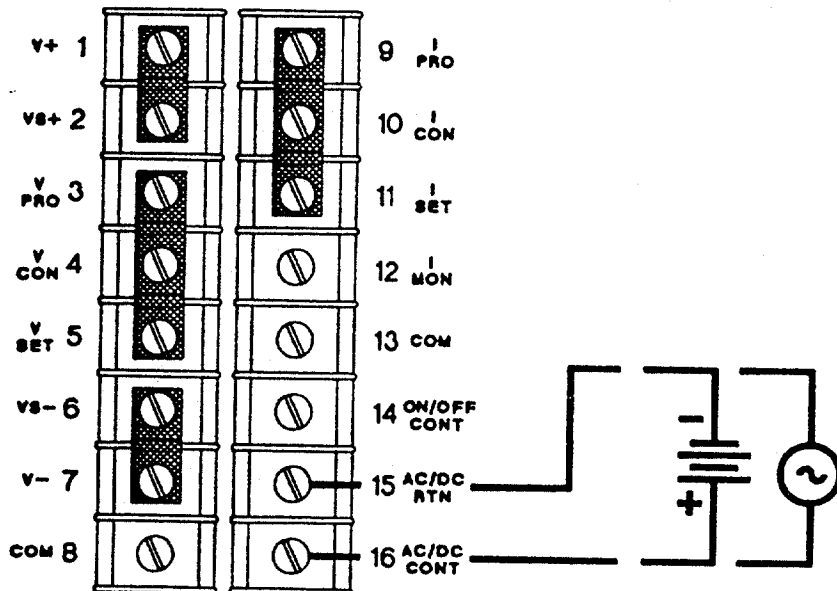


FIGURE 3-9
REMOTE ON/OFF USING AC OR DC VOLTAGE SOURCE

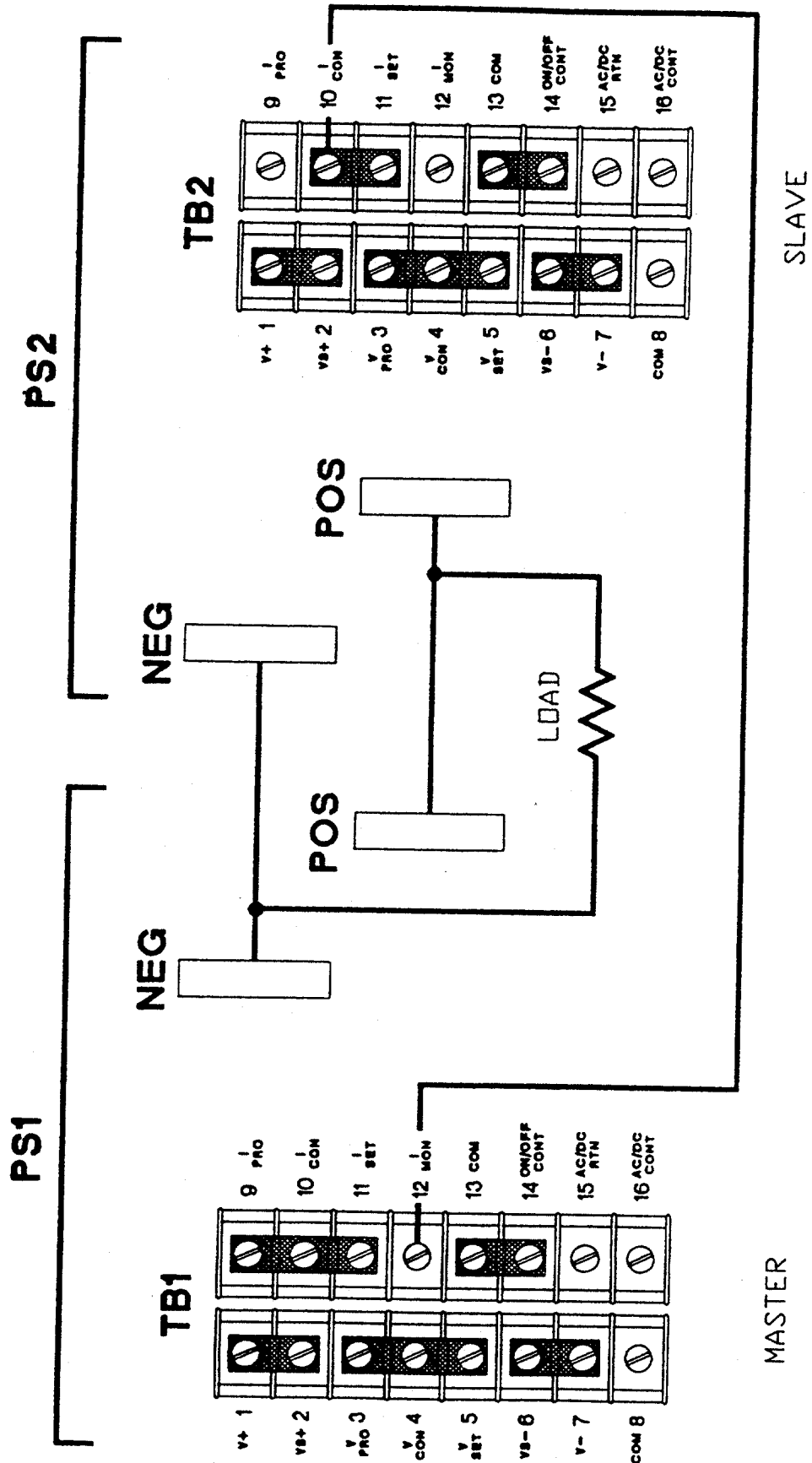
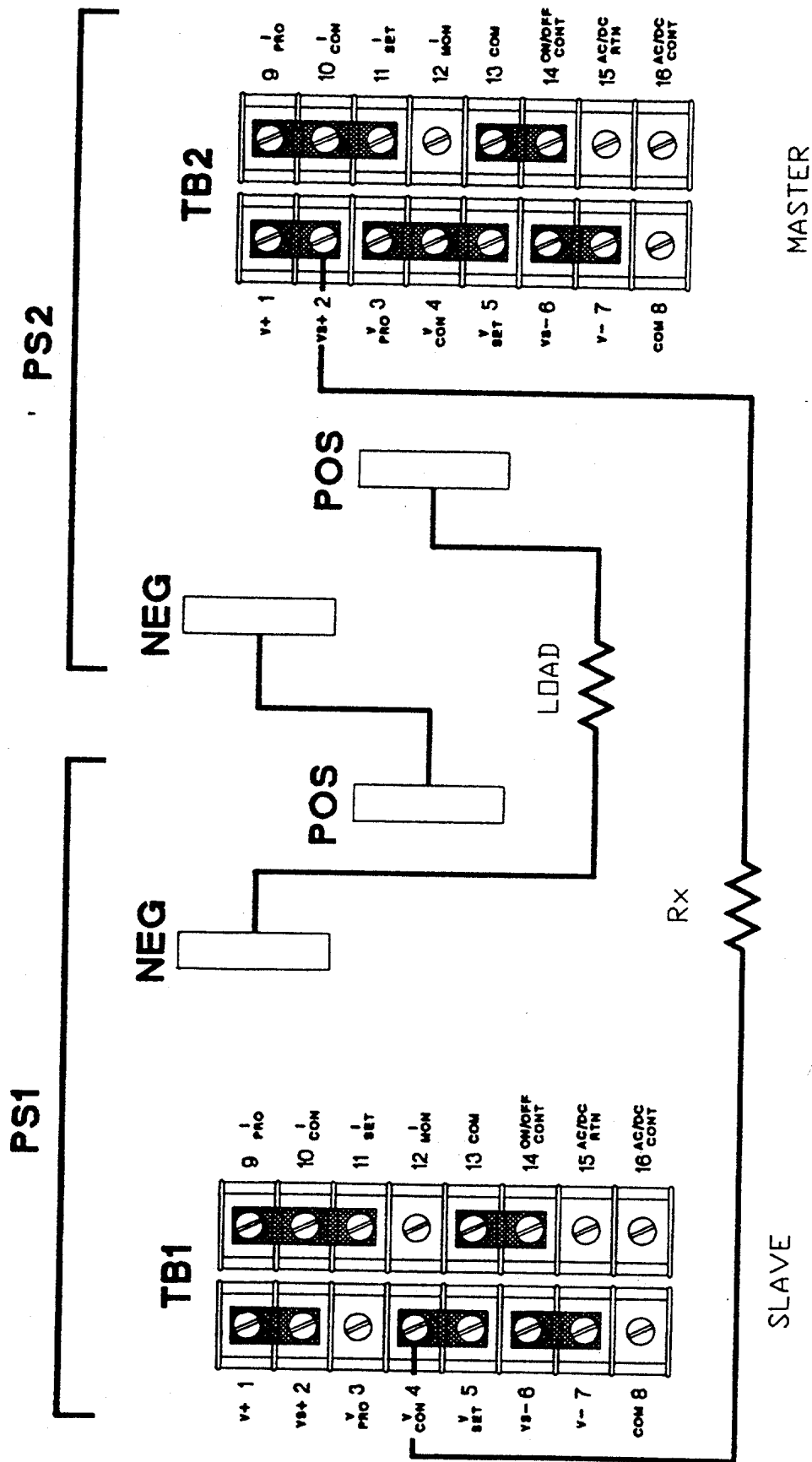
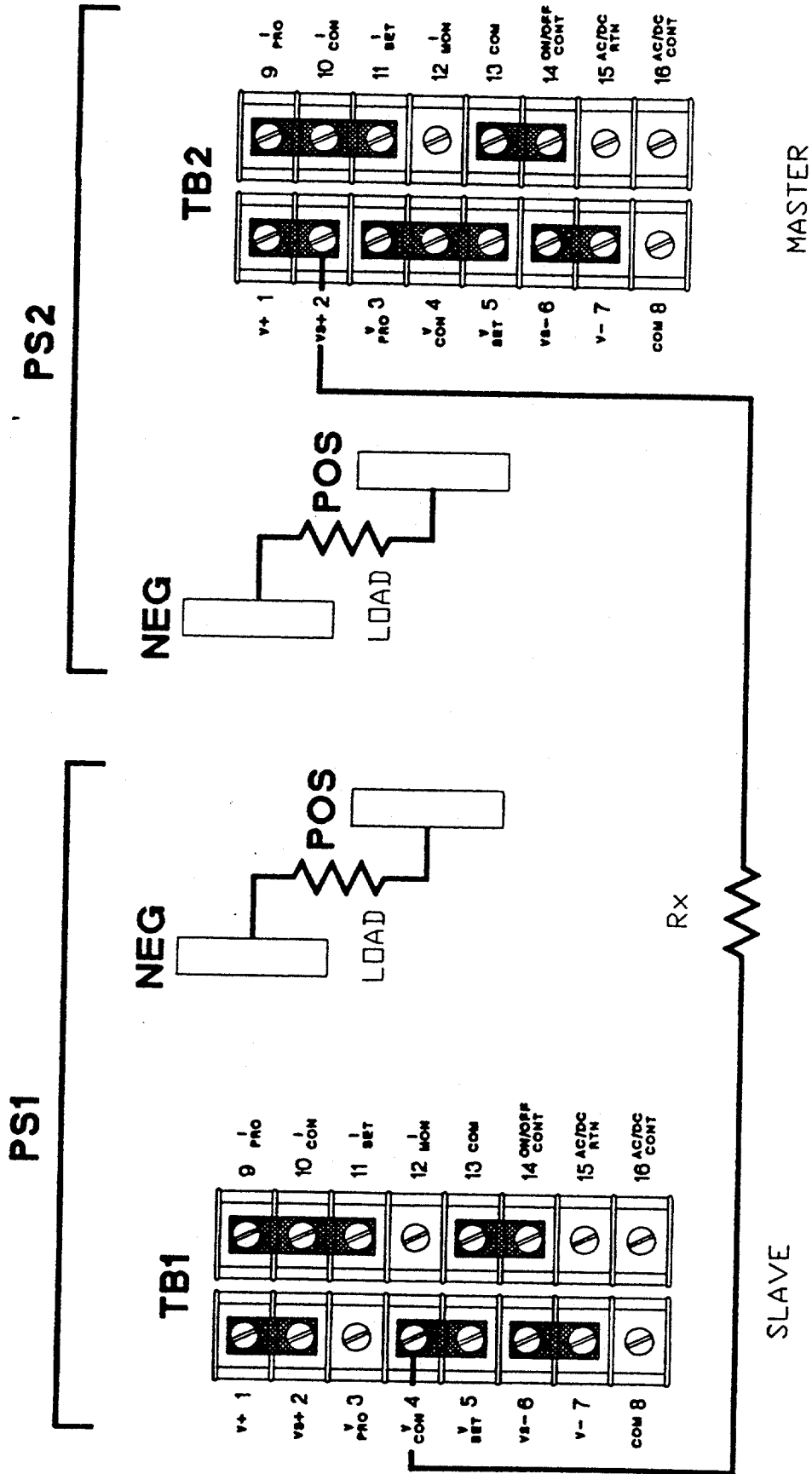


FIGURE 3-10
AUTO-PARALLEL OPERATION



Rx (Kohms) = Rated Vout - 5
 Example: For 20V Rated Vout
 Rx = 20 - 5 = 15Kohms.

FIGURE 3-11
 AUTO-SERIES OPERATION



Rx (Kohms) = Rated Vout - 5
 Example: For 20V Rated Vout
 Rx = 20 - 5 = 15Kohms.

FIGURE 3-12
 AUTO-TRACKING OPERATION

CHAPTER 4

PRINCIPLES OF OPERATION

4-1. INTRODUCTION

This chapter provides a circuit description of the Series 4500, 2.5 kW Power Supplies. Reference schematics 4500-91, 10-010-140-90 (A1), 10-010-093-90 (A3 and A5) and 10-010-086-90 (A6).

4-2. GENERAL DESCRIPTION

The Series 4500 power supplies are on-line switching power supplies operating at a frequency of approximately 60 kHz per converter. The multiple power converters utilize staggered synchronization resulting in input/output ripple frequency of 240 kHz for the 2.5 kW models. Regulation is attained via pulse-width modulation. There are six major subassemblies in each power supply.

a. Control Assembly A1 - is the central control for the power supply including local/remote controls, indicators, monitors, meters, sensing, and protection circuits.

b. Converter Assembly A3 and A5 - is a full-bridge converter that converts the input unregulated DC voltage to a regulated DC output voltage. Converters A3 and A5 are connected in parallel to provide the required output power. The 2.5 kW models use two converters.

c. Display Assembly A6 - is mounted behind the front panel and contains the digital meters, operating mode indicators, overvoltage indicator and overvoltage set potentiometer.

4-3. DETAILED CIRCUIT DESCRIPTION

a. Input Power Distribution - 190-253 Input Models (Reference schematic 4500-91). The input 190-253 VAC, 1 phase, 2 wire plus ground is routed from TB3 (located on the back panel) through the EMI filter FL1 and the power switch/circuit breaker CB1 to the input rectifier bridge BR1 and the control assembly A1.

The nominal 300 VDC output of BR1 is routed through R3/K1 (which provides input current surge limiting) to C1 and subsequently distributed to all converter assemblies as primary input power.

b. Control Assembly A1. (Reference schematic 10-010-140-90).

(1) Bias Supplies. Input 190-253 VAC is routed through J2 to the primary of bias transformer T1. T1 secondary is rectified and capacitively filtered to provide a nominal ± 18 VDC unregulated input to the bias and blower regulators. Internal bias power is regulated by U3 (+12 VDC) and U4 (-12 VDC). The bias voltages are distributed to the converter assemblies through J2 and to the display assembly through J3.

(2) 5 VDC Reference Amplifier. Reference amplifier consists of a precision 5 volt reference, VR1, and an operational amplifier, U4-D, connected in a voltage follower configuration to provide buffering of the +5 volt reference voltage.

The primary purpose of the =5 volt reference voltage is to provide a stable input for the bias enable circuit U11-B and the overvoltage set potentiometer (located on the Display Assembly A6). The reference voltage is also used in the AC/DC on/off control U6-A, the indicator driver, U12, the crowbar control, U6-C, the restart holdoff circuit, U6-B, and the surge relay driver, U11-A.

(3) Bias Enable. The bias enable prevents power supply operation should bias voltages become marginal. This would occur during a brownout condition or due to a malfunction of the bias supply. Operational amplifier U11-B senses the unregulated input voltage through resistor divider R45 and R46 and compares it to the +5 volt reference. At any time the unregulated input voltage is below a safe operating level, the output of U11-B is driven high and provides a converter shutdown signal. This signal is or'ed via CR15 with other shutdown sources. Resistor divider R48 and R49 provide a circuit hysteresis to prevent oscillatory output.

Resistor R47, capacitor C38 and diode CR14 provide a turn-on delay for the surge relay driver U11-A and Q7 which enables the input filter capacitor (Top Assembly) to charge prior to enabling the surge limit relay K1 (Top Assembly).

(4) Overvoltage Detector. The purpose of the overvoltage detector circuit is to provide protection for user loads that may be damaged by excessive voltages. The overvoltage detector circuit consists of U6-B and associated components. The 0 to 110% (of rated voltage) trip threshold is provided by the overvoltage set potentiometer on the Display Assembly A6 and is routed through J3-7 and R86 to the inverting input of U6-B, pin 13. C55 provides noise suppression for this signal. The output voltage sensing is provided via the voltage feedback scaler U13-C, which converts the output voltage to a 0-5 VDC signal equating to 0-100% of rated output voltage. This 0-5 VDC feedback signal is routed through resistor divider R87 and R88 to the non-inverting input of U6-B, pin 12.

When the 0-5 volt divided feedback signal exceeds the overvoltage set point, the output of U6-B, pin 14, goes high (approximately +12 volt). The output is latched via CR29. The output provides drive to the overvoltage indicator through R90 and a converter shutdown signal via CR30. The overvoltage detector circuit latch is reset by removing and re-applying AC power to the power supply. This is accomplished via CR28 from the bias enable circuit U11-B.

(5) Crowbar. The function of the crowbar circuit is to provide discharge of the output filter capacitors at any time the power supply output is shut down. This condition exists when any power supply fault (low bias voltage, output overvoltage, or converter overtemperature) occurs or the external ON/OFF command is commanded OFF.

This function is provided by gate drive amplifier U6-C, silicon controlled rectifier SCR1, restart holdoff amplifier U6-B and associated components. When a power supply shutdown signal is activated, the gate drive amplifier output drives high which provides drive to SCR1 through resistor divider R93 and R94. C57 provides noise suppression. Once the gate of SCR1 goes positive, crowbar SCR1 fires, discharging the output filter capacitors through R95.

While the output capacitors are being discharged, a voltage is developed by R96 and clamped by diode CR31. This voltage is applied to the restart holdoff amplifier U6-B, pin 5, which compares it to a 450 millivolt reference provided by resistor divider R97 and R98. The restart holdoff amplifier keeps the shutdown signal present through CR32, as long as current is flowing through the crowbar SCR1.

(6) Remote On/Off Output Control. Remote on/off control may be accomplished by two methods:

- (a) Switch or contact closure. A switch, set of relay contacts, or a semiconductor switch, may be used to provide contact between TB2-13(-) and TB2-14(+). When using a semiconductor switch, it must be capable of sinking approximately 1 mA of current from TB2-14(+) to TB2-13(-) return.
- (b) AC/DC Voltage Source. An isolated (floating) input at TB2-15 and TB2-16 is available for either 12 to 240 VAC or 6 to 120 VDC source on/off control. When DC voltage used for control the (+) positive input is TB2-16 with reference to TB2-15 return.

Both methods of using remote on/off output control require that the jumper between TB2-13 and TB2-14 be removed.

An AC or (+) DC voltage input to TB2-16 provides current flow through CR10, R17, R16 and Q3 opto-coupler back to TB2-15 return.

Q3 transistor output is activated, thereby providing drive to U6-A, pin 3. Pin 3 of U6-A is normally at +12 VDC through resistor R13. When Q3 activates, U6-A, pin 3, is pulled below the 5 volt reference input at pin 2, and the output at pin 1 is active low permitting the shutdown signal and the converter assemblies A3 and A5 to operate, if there are no other faults providing a shutdown signal.

(7) Voltage Reference Circuit. The voltage reference circuit is an adjustable current source which is factory set for one milliamperere. This reference is routed to TB1-3 (VPROG) for either local or remote voltage control via resistance. The circuits consists of Q4 and associated components and a reference voltage source provided by VR3 and temperature compensation transistor Q5.

(8) Current Reference Circuit. The current reference circuit is identical to the voltage reference circuit described above. It consists of Q6 and associated components and is routed to TB2-9 (IPROG) for local or remote current control via resistance.

(9) Voltage Control. Voltage control is accomplished by U13 and associated components. Voltage control circuits consists of: (a) input control scaler, (b) voltage feedback scaler, (c) voltage slow-start circuit, (d) voltage error amplifier.

(a) Input Control Scaler. The function of the input control scaler is to provide an input capability either 0-5 VDC or 0-10 VDC voltage control, while providing only 0-5 VDC control signal to the voltage error amplifier. This function is provided by U13-B buffer stage and resistor divider R67 and R69.

When a 0-5 VDC input control is desired, R69 is removed and the input 0-5 VDC voltage control signal is routed through U13-B buffer and resistor R67 directly to the voltage error amplifier U13-B, pin 5. When a 0-10 VDC voltage control signal is desired, the output of U13-B buffer is divided 2:1 by resistor divider R67 and R69. This provides a 0-5 VDC to the voltage error amplifier U13-B, pin 5. Trimpot R76 and resistor R77 provide zero offset nulling for input control scaler U13-B.

(b) Voltage Feedback Scaler. The function of the voltage feedback scaler is to provide a 0-5 VDC feedback signal to the voltage error amplifier U13-B and the overvoltage detector U6-B, when the output voltage varies from 0-100% of rated output voltage.

Feedback scaling is accomplished via resistor divider R79 through R83 and the voltage feedback buffer U13-C. Trimpot R80 provides full-scale calibration, and trimpot R73 with resistor R74 provide zero calibration for the feedback scaler circuit.

(c) Voltage Slow-Start Circuit. The function of the voltage slow-start circuit is to minimize voltage overshoot at

turn-on of the output voltage. This function is accomplished by U13-A and associated components.

At any time the power supply output is disabled by protection circuitry or an external ON/OFF command, the inverting input to U13-A, pin 2, is approximately +12 VDC. The non-inverting input is tied to the +5 VDC reference. During this shutdown period, the output of U13-A, pin 1, is driven to approximately -12 VDC. The -12 VDC output is coupled through diodes CR25 and CR26 to the voltage error amplifier U13-B, control input, which tries to drive the output voltage to less than zero volts output.

Once the shutdown command signal at U13-A, pin 2, goes below the 5 VDC reference, the output at U13-A, pin 1, goes positive which reverse biases diode CR25 and allows capacitor C48 to charge through R66. This R-C charge signal is coupled through diode CR26, thereby allowing the control voltage at the voltage error amplifier U13-B, pin 5, to slowly increase to the preset level. The slow-start ramp will continue to charge to the +5 VDC and reverse bias diode CR26. This disconnects the slow-start input once the control voltage reaches the preset control voltage level.

(d) Voltage Error Amplifier. The function of the voltage error amplifier is to provide voltage regulation, which is provided by U13-B and associated components.

Operation is such that the 0-5 VDC control input is compared to the 0-5 VDC feedback input, and the error signal is amplified at the output of U13-B, pin 7, which is coupled through diode CR20 to the control +. This controls the multiple converter outputs. Capacitors C43, C44, C45 and resistors R62 and R63 provide loop compensation. Transistor Q8, capacitor C46, diodes CR22 and CR23, and resistor R65 minimizes crossover distortion when changing from current to the voltage mode of operation.

(10) Current Control. Current control is accomplished by U7 and associated components. Current control circuits consist of: (a) current control scaler, (b) current feedback differential amplifier, (c) current error amplifier.

(a) Current Control Scaler. The function of the current control scaler is to convert the input current control signal of 0-100 millivolts, 0-5 VDC or 0-10 VDC to a 0-5 VDC signal for the current amplifier input. this function is provided by U7-B and associated components.

With a 0-100 millivolt input signal, the output of U7-B is scaled by the resistance ratio of resistors R36 and R37 to provide a 0-5 volt output at U7-B, pin 7. Resistor R34 is not installed, so the 0-5 volt signal is fed directly to the control input of the current error amplifier U7-D.

With a 0-5 VDC input signal, resistors R34 and R37 are not installed, so the input 0-5 VDC signal is routed through U7-B (connected as a voltage follower) and resistor R35 to the control input of the current error amplifier U7-D.

With a 0-10 VDC input signal, the current control scaler U7-B is connected as a voltage follower by not installing resistor R37 and the 0-10 VDC output is divided 2:1 by resistor divider R34 and R35 to provide 0-5 VDC to the control input of current error amplifier U7-D.

In all modes of scaling, zero offset null is accomplished by trimpot R38 through resistor R39.

(b) Current Feedback Differential Amplifier. The high current outputs of the converter assemblies through the output wiring may cause a varying offset voltage to appear on the feedback current level signal. To overcome this offset voltage level, a differential amplifier is used to shift the level back to the control assembly reference (common). The current differential amplifier U7-C has a gain of unity which is set by resistors R19 (+) and R20 (-) along with the output impedance of the converter assemblies A3 and A5 connected in parallel. C15, C16, C17 and C18 provide noise suppression.

(c) Current Error Amplifier. The purpose of the current error amplifier is to provide control to the converter assemblies when in the constant current mode of operation. This is accomplished by comparing the feedback signal to the control input and amplifying the error signal which then controls the converter assemblies.

The current error amplifier consists of U7-D and associated components. The control (+) non-inverting input is provided by U7-B, the current control scaler, described in paragraph (a) above. The feedback error (-) inverting input is provided by U8-C, the current differential amplifier, described in paragraph (b) above. The output error signal from U8-D, pin 14, is coupled through CR9 to the converter control (+) output at J2, pin 1. C42 provides noise suppression, while C21, C22, C23, R32 and R33 provide loop compensation.

(11) Voltage/Current Mode Indicator Drivers. The primary purpose of the indicator drivers is to provide power for the front panel indicators and thus allow the operator to know whether the operating mode of the power supply is voltage, current, or fault. There is no fault indicator, but the absence of both voltage and current mode indicators is an indication of internal fault or external output on/off control being switched off. Internal faults that will cause both mode indicators to be OFF are:

- (a) Overvoltage fault
- (b) Overcurrent fault

- (c) Thermal fault (any converter module)
- (d) Low input voltage fault.

Inputs to the indicator drivers are provided by the voltage error amp U13-B and the current error amp U7-D which is coupled through CR13 and CR21, respectively. U12-B compares these input levels and provides approximately 10 mA to the current mode indicator via R55 when the current error amplifier output is more negative (controlling error amp) than the current error amplifier output. When the opposite condition exists (the voltage error amp output is more negative), U12-B, pin 7, output is driven negative, causing U12-B, pin 14, to go positive. This provides approximately 10 mA drive to the voltage mode indicator through R54.

In the event of an internal fault protection circuit activation or the remote on/off control being in the OFF condition, both voltage and current error amplifier go to approximately 10 VDC output. CR19 (through R57) limits the voltage at U12-B, pin 5, to 5.6 volts; this turns off the voltage mode indicator. At the same time, the input signal to U12-C, pin 10, goes more positive than the +5 volt reference on pin 9 and causes the output of U12-C, pin 8, to go positive. This is coupled through CR18 to the (-) inverting input to U12-B, pin 13, thereby turning off the current mode indicator.

In the event that both voltage and current error amplifiers are at less than zero volts positive, R59 provides a small offset voltage at the input of U12-B, pin 6, which keeps the current mode indicator OFF and the voltage mode indicator ON. This eliminates potential partial illumination of both indicators as well as random voltage of current mode indicator during this condition.

(11) Synchronizer. The purpose of the synchronizer is to provide synchronization to the power converters A3 and A5. The two outputs provide a bi-phased switching frequency on both input and output. For the input, this results in lower switching current peaks from the input filter as well as a higher effective switching frequency. This makes EMI filtering for conducted emissions more effective. For the output, the resultant switching ripple is approximately 240 kHz, thereby reducing the output ripple.

The synchronizer consists of three sections: a clock (U8), an octal counter (U9) and a pulse shaper/driver (U10).

(a) Clock. The clock is simple R-C coupled squarewave generator operating at approximately 1 MHz. The clock consists of two stages of U8 (buffer/inverter) and associated components. Frequency of operation is set by R23 and C21. R22 limits overdrive current into U8, pin 3.

(b) Octal Counter. The octal counter U6 simply divides the input frequency by 8 and provides 8 equally spaced output phases of approximately 125 kHz. Only two phases (3 and 7) are used for this 2.5 kW application. A reset input for initialization is provided by C23, R24, and CR11 and buffered by one stage of U8.

(c) The Pulse Shaper/Driver. The pulse shaper/driver U10 is a quad, 2 input AND gate. The output frequency of 125 kHz is determined by the input from the octal counter U9 and the output pulse-width of 0.5 microsecond is set by the clock (+) positive pulse-width. The two outputs of U10 are routed through J2 to the power converter assemblies to provide staggered synchronization.

(13) Remote Interface. The remote interface is simply the barrier strips TB1/TB2 and appropriate jumpers to permit user selection of local/remote voltage or current controls and local/remote voltage sensing. The barrier strip is mounted directly on the control board, and is accessible at the back panel. See Chapter 3 of this manual for local/remote control and sensing connections.

c. Converter Assemblies A3 and A5 (Reference schematic 10-010-093-90). There are two converter assemblies in each power supply for 2.5 kW models. Each converter contains power conversion, control and protection circuits. All converter assemblies for each series model are interchangeable. The following circuit descriptions apply for a single converter as utilized in the Series 4500 power supply.

The primary purpose of the converter assembly is to convert the input unregulated DC line voltage to a regulated output DC voltage or current. Inputs to the converter are a nominal 300 VDC prime power, ± 12 VDC bias power, control, synchronization and shutdown signals.

Outputs are the regulated DC power, a current monitor and a shutdown signal. In normal circuit operation, the converter operates in a current mode. The current mode of operation may be controlled by either voltage or current via the control assembly A1 described in paragraph 4.3.b.

(1) Power Converter. The Series 4500 power supply utilizes a full-bridge converter consisting of MOSFET transistors Q1-Q4 with associated gate and snubber circuits. Q1 and Q4 alternate ON cycles with Q2 and Q3. The output from the converter switch transistors is a 60 kHz, pulse-width modulated AC drive to power Transformer T2.

(2) Power Rectifier/Filter. The secondary of the power transformer T2 is full wave rectified by CR1 and CR2. Filtering is provided by L1, C10, C11, C12 and C13. On some models L2 (an

RF choke) is included. Snubbing for the transformer secondary and the rectifiers is provided by R7, R8, R9, R62, C5, C6 and C8. (On some models these components are a separate assembly mounted directly on the output rectifier assembly CR1/CR2.) R11 is a bleed resistor for discharge of the output capacitors. R12 is a current shunt for current sensing. C14 and C15 provide high frequency bypass to chassis from the DC outputs.

(3) Current Sensing Amplifier. The purpose of the current sensing amplifier is to amplify the low level current sensing voltage (0-100 mV) across R12 to a higher voltage (0-5 VDC) for use in current regulation.

The output from the current sensing amplifier U1-D is used for both converter control loop regulation as well as overall power supply regulation whether operated in the voltage or current mode. The converter assembly control loop only controls output current. The level of power supply output current or voltage is determined by the error amplifiers located on the control assembly A-1 described in paragraph 4.3.b.

The current sensing amplifier consists of U1-D and associated components. In operation it is a fixed gain amplifier. The voltage gain is set by the ratio of R25 and R26 to R30. R25 is used for full-scale calibration. R27 is used for zero current calibration. C21, C22 and R61 are loop compensation components.

C37 is used for noise suppression.

(4) Control Differential Amplifier. This amplifier is used to compensate for any difference of potential that may occur between the power supply circuit common and the converter circuit common. This small difference of potential may occur as a result of the high current output of the converters causing a voltage drop across the output bus bars.

The control differential amplifier consists of U1-B and R43 thru R46. It has a gain of unity set by the ratio of R43 and R44 to R45 and R46, respectively.

(5) Current Error Amplifier. The purpose of the current error amplifier is to compare the scaled output current from the converter assembly (U1-D output) to the input control signal from the control differential amplifier and provide the analog control input to the pulse-width modulator (U2) which provides the pulsewidth regulation for the converter assembly.

The current error amplifier consists of U1-C and associated components. C27, C28 and R48 provide loop compensation. CR10 is a signal disconnect diode to prevent negative drive to the input of the pulse-width modulator U2.

(6) Pulse-Width Modulator. The pulse-width modulator (PWM) U2 and its associated components are the primary controlling

circuit in the converter assembly. For a detailed description of the internal circuit operation, reference manufacturer's data sheets and application notes for the SG3525A. The primary function in the converter assembly is to convert the input analog error signal from U1-C output to pulse-width modulated signals to drive the gate-drive amplifier and subsequently the power converter switch transistors.

A shutdown input at pin 10 provides a means to protect the converter from internal power supply faults as well as an on/off control for output power.

Soft-start protection is provided by C32 to pin 8.

Synchronization of the converter to other power supply converters is accomplished by an input to pin 3. Initial free-running frequency is determined by R52 and C31 with minimum dead time for the PWM outputs controlled by R53.

C30 provides loop compensation and C40 is for noise suppression.

In addition to all these inputs and controls, the PWM also provides a 5-volt reference output which is used in the gatedrive amplifier, thermal detector, current sensing amplifier and current limit circuits of the converter assembly.

(7) Gatedrive Amplifier. The purpose of the gatedrive amplifier is to amplify pulse-width modulation signal from U2 and condition it to drive the gatedrive transformers T1 and T2. Both sides of the gatedrive amplifier are identical, so only one will be described to provide the theory of operation.

The pulse-width modulator output of U2 consists of a totem-pole transistor driver on pins 11 and 14. The output from U2, pin 11, provides emitter drive to Q11 and Q12 through R24. Both Q11 and Q12 bases are connected to the 5-volt reference from the U2, pin 16. When U2, pin 11, is high (approximately 11 VDC), Q12 is turned on through R24 providing basedrive to Q10; this results in negative drive to T1 and T2 right end. When U2, pin 11, is low (approximately 1 VDC), Q11 is turned on providing basedrive to Q9; this results in positive drive to T1 and T2 right end. The left side of the basedrive amplifier, Q5, Q6, Q7 and Q8 operate similar to Q9, Q10, Q11 and Q12, but with opposite polarity drive.

(8) Thermal Detector Circuit. The purpose of the thermal detector circuit is to provide protection for the bridge converter in the case that the cooling is inadequate or the power supply is subjected to temperatures above the normal specified operating range.

The thermal detector circuit consists of U1-A, U4 (thermal sensor) and associated components. The reference input for U1-A, pin 2, is provided by the 5-volt reference from U2 through R32,

R35 voltage divider. The input temperature is sensed by U4 which provides a linear ramp of 10 mV per degree C at the input (pin 3). When the temperature of the power supply exceeds a safe operating level, pin 3, exceeds the reference of pin 2, thereby activating U1-A and shutting down the pulse-width modulator via CR9.

The shutdown signal is also routed to all other converter assemblies in the power supply resulting in power supply output being turned OFF for an overtemperature condition in any converter assembly.

(9) Current Limit. The current limit circuit is a fast-response current limiter to provide overcurrent protection for each converter in the event of external overcurrent programming or control circuit failure. It also provides the fast response necessary to protect the power converter switch transistors during an instantaneous short circuit or current overload at the power supply output.

The current limit circuit consists of U3 and associated components. In the event of an overcurrent condition sensed by current shunt R12, the negative going signal from the left side of R12 is coupled through R58 to the (-) inverting input of U3-B, pin 6. This causes the output of U3-B, pin 7, to turn off (open collector output) permitting C35 to charge through R54. C35 and R54 provide a time delay to avoid inadvertent noise tripping of U3-A.

When the output from pin 7 (and the input at pin 2) exceeds the 5-volt reference at U3-A, pin 3, the output of U3-A, pin 1, is driven negative which pulls down the compensation terminal of the PWM (U2, pin 9) reducing the PWM output. Under normal conditions this will only occur for a period of 2 to 3 milliseconds until the current control loop has time to respond and take control of the PWM.

(10) Fuse Protection. Because of the high current required to operate multiple converters, the power supply input circuit breaker does not provide adequate protection in the event of power converter failure. A fuse is incorporated in the 300 volt return line to provide this protection.

d. Display Assembly A6 (Reference schematic 10-010-086-90). The primary purpose of the display assembly is to provide voltage and current meter displays at the front panel. Bias power for the display assembly is provided by the control assembly A1. The +/-12 V inputs are regulated by U1(+) and U2(-) to provide +/-5 V power to the A/D converters U3 and U4.

The A/D converters with associated components provide all necessary functions to convert analog input signals to digital driver outputs for the 3 1/2" displays LCD1 and LCD2. Analog inputs are provided by the control assembly A1.

The A/D converters U3 and U4 zero automatically. Full scale calibration is provided by R8 for the ammeter and R11 for the voltmeter. Fixed decimal point location for the LCD displays is factory set via a solder bridge connection.

Other functions provided are simply a convenient means of mounting for front panel access or viewing. These functions include the overvoltage adjustment potentiometer R1, the overvoltage indicator LED1, the current mode indicator LED2 and the voltage mode indicator LED3.

CHAPTER 5

MAINTENANCE AND CALIBRATION

5-1. INTRODUCTION

This chapter contains preventive and corrective maintenance information for the Series 4500. To isolate defective components, use standard troubleshooting procedures in conjunction with the principles of operation in Chapter 4, the list of materials information in Chapter 6 and the illustrations in Chapter 7.

5-2. EQUIPMENT REQUIRED

Table 5-1 lists the test equipment required to perform maintenance on the Series 4500. The recommended model or an equivalent may be used.

5-3. PREVENTIVE MAINTENANCE

Preventive maintenance for the Series 4500 consists of scheduled inspection and cleaning.

a. Schedule. Table 5-2 lists the preventive maintenance routines and the recommended performance intervals.

b. Inspection. Table 5-3 lists the visual inspection checks to be performed. It also indicates the corrective action to be taken.

c. Cleaning. Cleaning requirements are based on the need established during inspection. If cleaning is required, follow the instruction listed in the corrective action column of Table 5-3.

5-4. REPAIR

Repair of the Series 4500 is performed by removing and replacing failed parts and components. Information required to order replacements is contained in Chapter 6, List of Materials.

Table 5-1. Test Equipment Required

COMMON NAME	REQUIRED CAPABILITIES	RECOMMENDED MODEL
Digital Multimeters	AC and DC Ranges	Hewlett-Packard Model 3468A
Oscilloscope	Signal and Waveform Measurement	Tektronix 2215
Resistive Load	For Full Rated Output Voltage and Current of P.S. Model Type.	
Current Shunt	For Full Rated Output Current	EMPRO Type HA or Equipment

Table 5-2. Preventive Maintenance Schedule

PREVENTIVE MAINTENANCE ROUTINE	RECOMMENDED PERFORMANCE INTERVAL
Inspection	Annual
Cleaning	As Required

Table 5-3. Inspection and Corrective Action

ITEM	INSPECT FOR	CORRECTIVE ACTION
Connector plugs and jacks	Looseness, bent or corroded contacts, damage or improper seating in mating connector	Clean contacts with solvent moistened cloth, soft bristle brush, small vacuum or low compressed air. Replace connectors damaged, deeply corroded, or im- properly seated in mating connector.
Chassis, blower & extruded heatsinks	Dirt and Corrosion	Clean with cloth moistened with soapy water.
Electrical Wiring	Broken, burned or pinched wire; frayed, worn or missing insulation	Repair or replace defective wires.
Soldering connections	Corrosion, loose, cracked, or dirty connections	Clean and resolder connections.
Dirt and moisture buildup	Short circuits, arcing, corrosion, overheating	Clean as required.
Front panel controls and meters	Dirt and corrosion	Clean with cloth moistened with soapy water. Use a Kimwipe tissue and GTC glass cleaning compound to clean the meter faces.

5-5. CALIBRATION AND ADJUSTMENTS

To perform the following calibration and adjustment procedures, the cover must be removed from the power supply. Because removal of the cover allows access to potentially hazardous power voltages (up to 253 VAC or 360 VDC) and because of the importance of accurate readings to performance, only technically trained personnel should perform calibration procedures.

WARNING

Hazardous voltages (up to 253 VAC or 360 VDC) during equipment operations. Press switch to OFF position and disconnect power cord from power source. Allow a minimum of 3 minutes for discharge of storage capacitance before removing the cover or performing any maintenance function.

The calibration Test Setup procedures require the following: With prime power removed, connect the power supply to a resistive load capable of full rated voltage and current. Connect a precision current shunt in series with either the positive or negative output between the power supply and the resistive load. Two digital multimeters are required to perform the calibration procedures.

a. Converter Assemblies A3, A5 Calibration. Reference assembly 10-010-093-90 while performing calibration. The converter assemblies A3 and A5 must be calibrated prior to the control assembly A1 calibration for proper results.

- (1) Current Sense Amplifier Zero Calibration.
 - (a) Remove jumper between TB2-13 and TB2-14 (rear panel).
 - (b) Connect digital multimeter (DMM) between top of R60 and bottom of R37 (on A3 converter assembly).
 - (c) Apply prime power to power supply.
 - (d) Adjust R27 for zero null (minimum voltage on DMM).
 - (e) Remove prime power from the power supply and wait three minutes for capacitor discharge.
 - (f) Repeat steps (b) thru (5) on A5 converter assembly.
 - (g) Replace jumper between TB2-13 and TB2-14.

(2) Current Sense Amplifier Full-Scale Calibration.

- (a) With prime power removed, unplug jumper P4 on all converter assemblies not being calibrated. Leave jumper installed on assembly to be calibrated.
- (b) Connect DMM between top of R60 and bottom of R37. Set DC voltage scale to read 5.0 volts.
- (c) Connect a second DMM across the external current shunt. (Test setup)
- (d) Rotate front panel voltage control fully clockwise.
- (e) Rotate front panel current control fully counterclockwise.
- (f) Apply prime power to power supply.
- (g) Rotate front panel current control clockwise until DMM between top of R60 and bottom of R37 indicates 5.000 VDC.
- (h) Adjust R25 of converter assembly being calibrated (A3 and A5) until DMM across external current shunt indicates one-half the rated output current for 2.5 kW power supply models.
- (i) Remove prime power from power supply and wait 3-minutes (minimum) for filter capacitors to discharge.
- (j) Repeat steps (a) thru (i) for balance of converter assemblies A3 and A5.

(3) Current Limit Calibration.

- (a) With prime power removed, unplug jumper P4 on all converter assemblies not being calibrated. Leave jumper installed on assembly to be calibrated.
- (b) Connect a DMM across external current shunt.
- (c) Rotate front panel voltage control fully clockwise.
- (d) Rotate front panel current control fully counterclockwise.
- (e) Apply prime power to power supply.
- (f) Rotate front panel current control clockwise until DMM across external current shunt indicates 5% above the converter assembly rated output.

(The converter assembly rated output = the power supply rated output divided by the number of converter assemblies.) For 2.5 kW models, there are two converter assemblies.

EXAMPLE: For a 2.5 kW model 4500-10250, the power supply output current is rated at 250 amps. There are two converter assemblies in the 2.5 kW models, so each converter is rated at:

$$\frac{250 \text{ AMPS}}{2 \text{ ASSEMBLIES}} = 125 \text{ amps/assembly}$$

If the converter assembly is rated for 125 amps, as in the example above, the current limit should be set at 125 amps X 1.05 = 131.3 amps.

NOTE

If the front panel control will not adjust the output current up to the 5% above rated current, then adjust R56 clockwise until it will.

- (g) Once the converter is delivering 105% of rated current and the current mode indicator on the front is illuminated, rotate R56 counterclockwise until the current mode indicator extinguishes. Do not adjust beyond this point.
- (h) Remove prime power from the power supply and wait three minutes (minimum) for the filter capacitors to discharge.
- (i) Repeat steps (a) thru (h) for the balance of the converter assemblies A2 thru A5.

b. Control Assembly Calibration. Reference assembly 10-010-140-90 while performing calibration the converter assemblies A3 and A5 should be calibrated prior to the control assembly A1.

(1) Voltage Reference. The voltage reference is provided by an adjustable current regulator Q4 and associated components. To calibrate for the 1 mA programming coefficient (constant voltage) the following sequence is recommended.

- (a) Remove all jumpers and external connections to TB1-3.
- (b) Set front panel current control fully counter clockwise.

- (c) Connect a precision digital multimeter (DMM) to TB1-3(+) with reference to TB1-7 (-). Set DMM to DC milliamps and 2 milliamps range.
- (d) Apply power to power supply.
- (e) Adjust R26 for 1.000 milliamps on DMM.
- (f) Remove power from power supply.
- (g) Reconnect all jumpers/connections to TB1-3 as required for local or remote voltage control.

(2) Current Reference. The current reference is a precision current source consisting of Q6 and associated components. Calibration is accomplished through adjustment of R30. The following sequence is recommended.

- (a) Remove all jumpers and external connections to TB2-9.
- (b) Set front panel voltage control fully clockwise.
- (c) Connect a precision DMM to TB2-9(+) with reference to TB2-13(-). Set DMM to dc milliamps and 2 mA range.
- (d) Apply power to power supply.
- (e) Adjust R30 for 1.000 milliamps on DMM.
- (f) Remove power from power supply.
- (g) Remove DMM and reconnect jumpers/connections for TB2-9 as required for local or remote current control.

(3) Feedback Voltage Zero Calibration. The voltage feedback zero is adjusted by R73,. The following sequence is recommended.

- (a) Remove jumper between TB2-13 and TB2-14.
- (b) Connect jumper (short circuit) between TB1-6 and TB1-2.
- (c) Unplug connector P3 from control assembly.
- (d) Connect DMM between J3-13 and J3-14 on control assembly.
- (e) Apply power to power supply.
- (f) Adjust R73 for zero null on DMM.
- (g) Remove power from power supply.

- (h) Remove jumper between TB1-6 and TB1-2.
- (i) Disconnect DMM.
- (j) Reconnect connector P3.
- (k) Reinstall jumper between TB2-13 and TB2-14.

(4) Voltage Zero Calibration. The voltage control circuit (U13-D) zero is adjusted by R76. The following sequence is recommended.

- (a) Connect jumper (short circuit) between TB1-4 and TB1-6.
- (b) Connect DMM across output terminals of power supply. Set DMM to read DC volts and approximately 200 millivolt range.
- (c) Set front panel current control fully clockwise.
- (d) Apply power to power supply.
- (e) Adjust R76 until the power supply output voltage starts to increase in the normal polarity. Reverse adjustment direction of R76 until output voltage decreases to zero reading on the DMM, Do not continue adjustment once the output reads zero millivolts.
- (f) Remove power from power supply.
- (g) Remove DMM from power supply output terminals.
- (h) Remove jumper from TB1-4 and TB1-6.

(4) Current Zero Calibration. The current control amplifier circuit (U7-A) zero is adjusted with R38. The following sequence is recommended.

- (a) Connect a jumper (short circuit) between TB2-10 and TB2-13.
- (b) Connect a resistive load and DMM across the output terminals of the power supply. Set DMM to read DC volts and approximately 200 millivolt range.
- (c) Set front panel voltage control fully clockwise.
- (d) Apply power to power supply.
- (e) Adjust R38 until the power supply output voltage starts to increase in the normal polarity. Reverse

adjustment direction of R38 until output voltage decreases to zero reading on the DMM. Do not continue adjustment when output reads zero volts.

- (f) Remove power from power supply.
- (g) Remove DMM from power supply output terminals.
- (h) Remove jumper between TB1-10 and TB1-13.

(5) Voltage Full-Scale Calibration. Full-scale voltage calibration is adjusted with R80. The following sequence is recommended.

- (a) Connect a DMM between TB1-2 and TB1-6. Set DMM to DC volts and scale to read maximum rated power supply output voltage.
- (b) Connect a second DMM between TB1-4(+) and TB1-7(-). Set DMM to DC volts and scale to read 5.00 volts.
- (c) Rotate front panel current control fully clockwise.
- (d) Apply power to power supply.
- (e) Rotate front panel voltage control for 5.00 volt reading on DMM attached to TB1-4 and TB1-7.
- (f) Adjust R80 until output voltage reading is 100% of rated output voltage DC between TB1-2 and TB1-7.
- (g) Remove power from power supply.
- (h) Remove DMM from power supply terminals.

c. Display Assembly Calibration. Reference assembly 10-010-086-90 while performing calibration.

(1) Meter Zero Calibration. The zero set for both voltage and current front panel meters is automatic.

(2) Meter Full-Scale Calibration. The full-scale adjustment for the digital panel meters M1 and M2 is adjusted by R8 and R11, respectively, of the display assembly 10-010-086-00. R8 is for full-scale current meter calibration and R11 is for full-scale scale voltage meter calibration. Both resistors are accessible from inside the power supply with the cover removed.

To calibrate for full-scale voltage or current, adjust the power supply to maximum rated output voltage (or current) using external calibrated meters and adjust the appropriate meter to correspond to the rated output voltage or current.

CHAPTER 6

LIST OF MATERIALS

6-1. INTRODUCTION

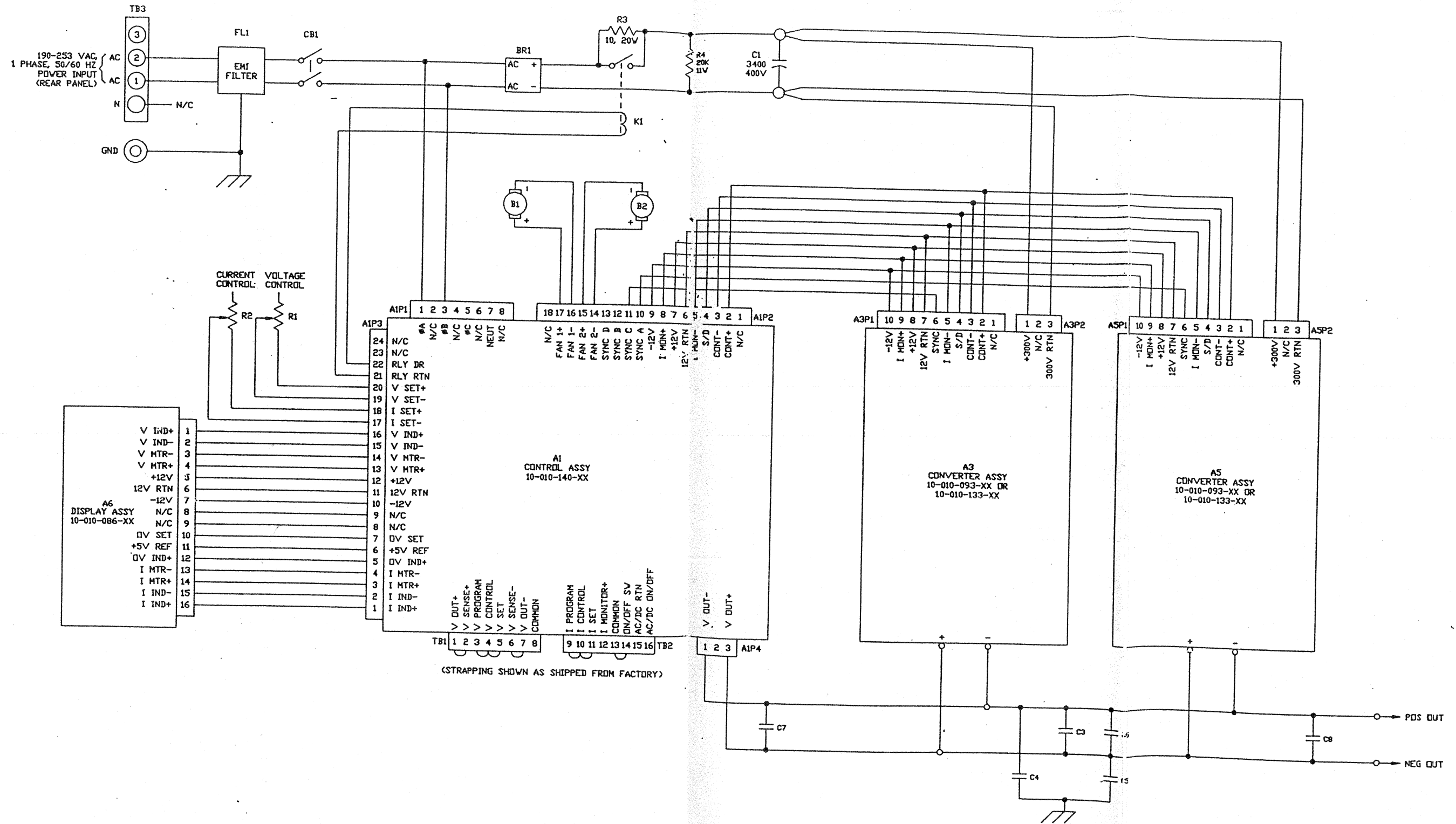
The repair parts list contains the major parts required to maintain the Series 4500. To ensure accurate procurement of replacement parts, the information contained in the parts list columns must be used effectively. The following paragraphs describe the parts list format and include an explanation of the information presented in each of the columns.

The SEQ column contains the sequence number in ascending order. The REFERENCE column contains the reference designations of the electrical components. The DESCRIPTION column contains the standard identifying noun or item name. The ITEM column contains the part number Power Ten has assigned to items both purchased and Power Ten manufactured. The QUANTITY column contains the quantity for a unique configuration which is identified by a dash number.

CHAPTER 7
ILLUSTRATIONS

7-1. INTRODUCTION

This chapter contains the appropriate schematic drawings for your model of the Series 4500.

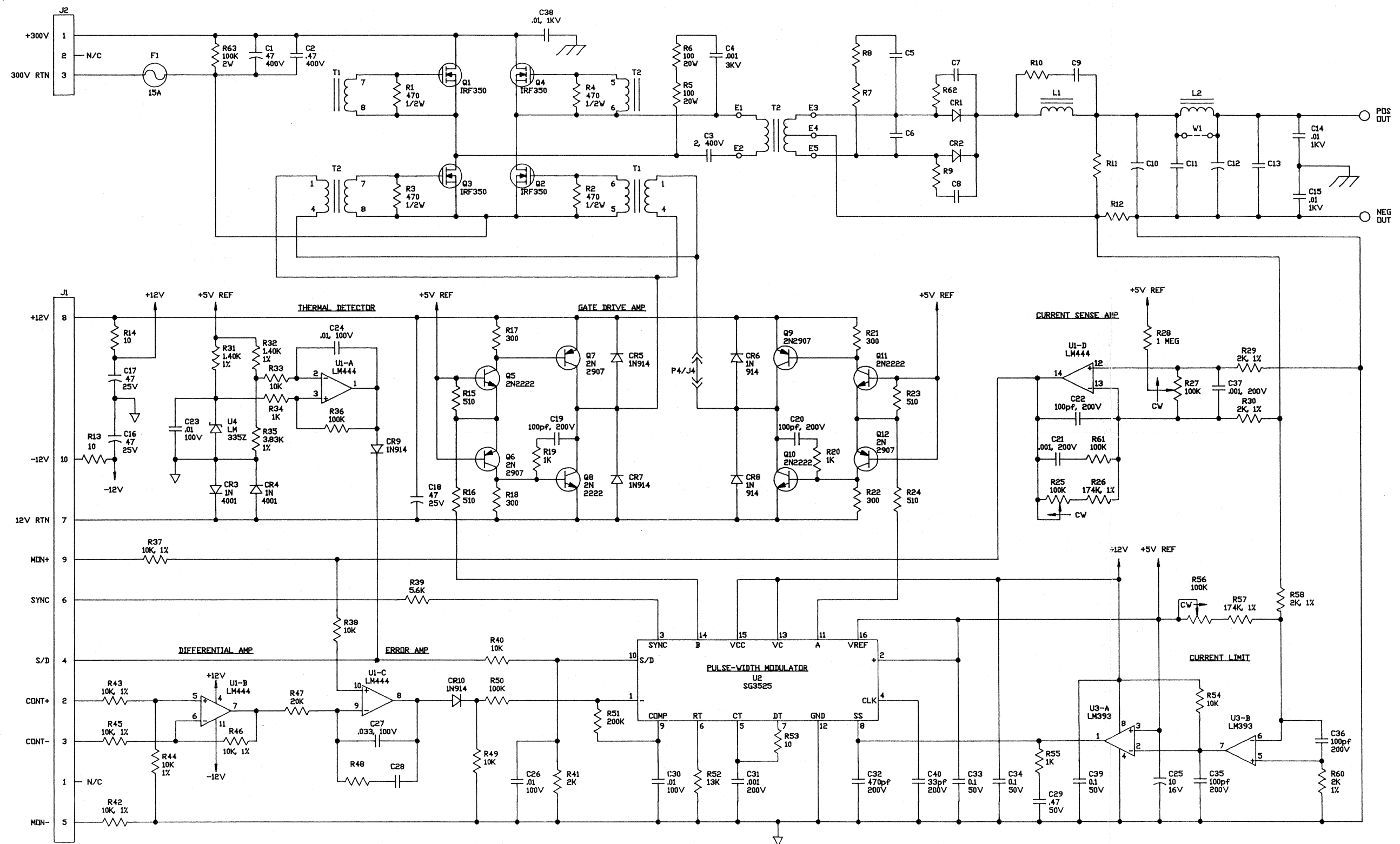


(STRAPPING SHOWN AS SHIPPED FROM FACTORY)

REV	DATE	BY	DESCRIPTION

4500 SERIES	REV D	61987	4500-91

POWER TEN INC.	SUNNYVALE CA, 94086
SCHEMATIC, 2.5 KW P. S.	
4500 SERIES	
REVISED FOR -140 ASSEMBLY	
SCALE	CODE 4501TASC



NOTES: UNLESS OTHERWISE SPECIFIED
 1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 5%.
 2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
 3. SEE LIST OF MATERIALS FOR NON-SPECIFIED VALUES.

LAST DESIGNATOR USED
 C40 Q12
 CR10 R63
 E7 T2
 J4 U4
 P4 W1
 L2 F1

NOT USED
 P1,2,3
 C37
 J3

REV	DATE	BY	CHKD	DESCRIPTION
4700				
4600				
4500				

REV	DATE	BY	CHKD	DESCRIPTION
4700				
4600				
4500				

REV	DATE	BY	CHKD	DESCRIPTION
4700				
4600				
4500				

REV	DATE	BY	CHKD	DESCRIPTION
4700				
4600				
4500				

POWER TEN INC.
 SUNNYVALE CA, 94086
 SCHEMATIC CONVERTER
 1.2 KW MODULE
 SCALE: 4600CVSC
 SHEET 1 OF 1

