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INSTRUCTION MANUAL FOR

10KW - 15KW

ESS POWER SUPPLY

83-481-004 Revision Z

LAMBDA EMI

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MANUFACTURER'S PRODUCT DECLARATION

INTENDED PURPOSE (USE)

The Power Supplies described by this manual are defined by Lambda EMI as a component for use in the composition of an apparatus as defined in Article 1 (1) of the EMC Directive (89/336/EEC). These products, as individual components, do not perform in themselves a direct function for the user of the end product. They are not intended to be placed on the market with a direct function to a final user! As such, the products described by this manual are not subject to the provisions of the EMC Directive (89/336/EEC, with amendment 92/31/EEC). The products described by this manual are intended for incorporation into a final product by a professional assembler. It is the responsibility of the assembler to ensure that the final apparatus or system incorporating our products complies with all relevant EMC standards for that final product.

OPERATING ENVIRONMENT

The operating environment as defined by Lambda EMI, for the products described by this manual is stated as follows:

The Power Supplies described by this manual are intended for use in a protected industrial environment or in proximity to industrial power installations. These locations are often referred to as industrial locations containing establishments that are not connected to the low voltage public mains network.

Industrial locations are characterized by the existence of one or more of the following conditions:

1) industrial, scientific and medical (ISM) apparatus are present;
2) heavy inductive or capacitive loads are frequently switched;
3) currents and associated magnetic fields are high;
4) location supplied by their own transformer.

These components are not intended for connection to a public mains network, but are intended to be connected to a power network supplied from a high or medium-voltage transformer dedicated for the supply of an installation feeding manufacturing or similar operations. They are suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

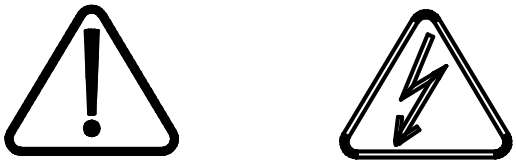
Description of symbols used in product labeling.

SYMBOL	PUBLICATION	DESCRIPTION
	EC Council directive 93/68/EEC	European Community Conformity Assessment Product Mark
	IEC 348	Attention, consult accompanying documents
	IEC 60417-1-5036	Dangerous voltage
	IEC 60417-1-5019	Protective earth (e.g. power line earth ground)
	IEC 60417-1-5017	Functional earth (e.g. chassis ground)
	IEC 60417-1-5134	Electrostatic Discharge (ESD) Sensitive Device

1 GENERAL INFORMATION

1.1 INTRODUCTION

This series of high frequency switching power supplies is designed to operate as a source of constant current/constant voltage power with automatic crossover. The ESS series exhibits excellent transient response, excellent regulation, high efficiency, low ripple and low noise.



NOTE: This manual contains information, instructions and diagrams which apply to a variety of standard constructions. If special features or modifications have been installed, the specific instructions peculiar to that special are contained in addenda and take precedence where conflicts exist. Take care to refer to the correct information for your unit.

1.2 SAFETY PRECAUTIONS

All EMI power supplies are designed to minimize risk of fire or shock hazards. This instrument received comprehensive mechanical and electrical inspection prior to shipment. Nevertheless, certain safety precautions must be observed. Only technically competent personnel familiar with the principles of electrical safety should operate this supply. To prevent fire or shock hazard, the power supply should not be exposed to water or moisture. Electrical safety should be maintained at all times.

Lethal voltages are developed within the power supply's enclosure. Therefore, the power supply must always be unplugged prior to removing the cover. If the input to the power supply is hard-wired, the circuit breaker must be secured and the line fuses removed.

Of course, dangers are inherent in high voltage equipment. However, a power supply with a low voltage output is also potentially dangerous considering the amount of energy (current) the supply is capable of delivering. **In addition to the steady state energy available, power supplies are typically terminated by very large capacitors, which can deliver huge surge currents capable of vaporizing metallic objects such as screwdrivers or jewelry. This could result in molten metal being sprayed. Proper care and judgment must always be observed.**

1) Ensure all covers are in place and securely fastened and the required grounding is connected before supplying input AC power.

2) Proper grounding from the input AC power is required to reduce the risk of electric shock. Insure that the ground connection has at least the same gauge as the supply leads.

3) Use extreme caution when connecting input AC power and never apply the incorrect input voltage. Refer to ratings label.

4) Use extreme caution when connecting the high voltage output cable including the separate ground connecting the supply to the load.

5) **Ensure all load capacitors are completely discharged prior to connection. Never handle the output cable when the power supply is operating.**

6) Always replace fuses with the same type and Volt/Amp ratings.

7) Never attempt to operate the power supply in any manner not described in this manual.

8) Never remove DANGER or WARNING labels from the power supply, and replace lost or damaged labels immediately.

9) The power supply should only be serviced by Lambda-EMI factory qualified personnel, or authorized service centers.

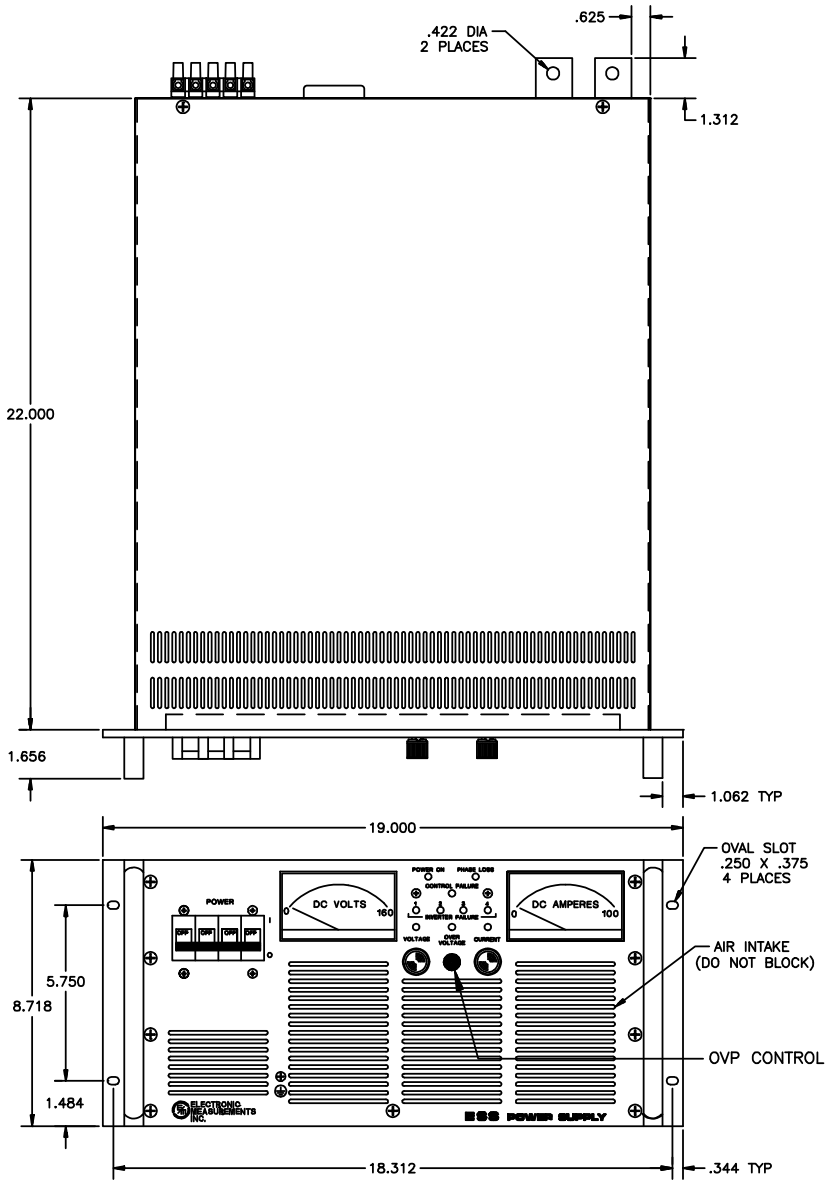


Figure A Outline Drawing

1.3 SPECIFICATIONS

This series of high frequency switching power supplies is designed to operate as a source of constant current/constant voltage power with automatic crossover. All ESS power supplies are fully remote programmable via our RSTL-488 interface, allowing for systems integration to meet the customer's specific requirements.

AC Input

THREE PHASE INPUT AC VOLTAGE	10KW NOMINAL INPUT CURRENT	CIRCUIT BREAKER
190-250 (220)	35	3ϕ 3 Pole, 40 Amps
342-418 (380)	20	3ϕ 4 Pole, 40 Amps
375-456 (415)	19	3ϕ 4 Pole, 40 Amps
396-484 (440)	17.5	3ϕ 4 Pole, 30 Amps
432-528 (480)	16	3ϕ 4 Pole, 30 Amps
360-440 (400)	18.7	3ϕ 4 Pole, 40 Amps

Table 1.1: Nominal Input Current/Circuit Breaker for the 10 KW Series

THREE PHASE INPUT AC VOLTAGE	15KW NOMINAL INPUT CURRENT	CIRCUIT BREAKER
190-250 (220)	52	3 Pole, 60 Amps
342-418 (380)	28	4 Pole, 40 Amps
375-456 (415)	27	4 Pole, 40 Amps
396-484 (440)	26	4 Pole, 30 Amps
432-528 (480)	23	4 Pole, 30 Amps
360-440 (400)	26.7	4 Pole, 40 Amps

Table 1.2: Nominal Input Current/Circuit Breaker for the 15 KW Series

GENERAL:

Power Factor:

.9 Passive

Efficiency:

85-91%

Dielectric withstanding voltage:

Primary to Secondary: 2500 VDC

Primary to Case: 2500 VDC

Secondary to Case: 1500 VDC*

(Sensing removed)

Operating Temperature:

All ESS power supplies are capable of continuous duty performance within their specifications in ambient temperature between 0 ºC and 50 ºC. Units may be safely stored at temperatures of -55 ºC to 85 ºC.

Humidity:

95% non-condensing

Transient Response

For a 30% load step below 20V, the transient response is 650 µS. For units above 20V, use Vmax/20 for transient response.

Dimensions:

Rack mount standard - 19 inches (see Figure A)

Weight:

105 lbs (48 kg)

Stability:

Maximum deviation in either voltage or current mode for an eight (8) hour period is up to 0.05% under conditions of constant line, load and temperature.

Temperature Coefficient:

The output voltage temperature coefficient is 0.02% per 1ºC of rated output voltage. The output current temperature coefficient is 0.03% per 1ºC of the rated output current.

Regulation:

Constant Voltage Mode :

An output current load change of 100% will cause an output voltage variation of less than 0.1%.

Constant Current Mode :

An output voltage load change of 100% will cause an output current change variation of less than 0.1%.

VOLTS	AMPS	LINE	LOAD	RIPPLE$_{P-P}$	MODEL
10	1,000	0.1%	0.1%	50mV	ESS10-1000
20	500	0.1%	0.1%	60mV	ESS 20-500
30	330	0.1%	0.1%	60 mV	ESS 30-330
40	250	0.1%	0.1%	75 mV	ESS 40-250
60	165	0.1%	0.1%	75 mV	ESS 60-165
80	125	0.1%	0.1%	75 mV	ESS 80-125
100	100	0.1%	0.1%	75 mV	ESS100-100
160	62	0.1%	0.1%	75 mV	ESS 160-62
300	33	0.1%	0.1%	125 mV	ESS 300-33
500	20	0.1%	0.1%	250 mV	ESS 500-20
600	16	0.1%	0.1%	300 mV	ESS 600-16

Table 1.3: Regulation 10 KW

10	1,500	0.1%	0.1%	60mV	ESS 10-1500
20	750	0.1%	0.1%	60mV	ESS 20-750
30	500	0.1%	0.1%	60 mV	ESS 30-500
40	375	0.1%	0.1%	75 mV	ESS 40-375
60	250	0.1%	0.1%	75 mV	ESS 60-250
80	185	0.1%	0.1%	75 mV	ESS 80-185
100	150	0.1%	0.1%	75 mV	ESS100-150
160	93	0.1%	0.1%	75 mV	ESS 160-93
300	50	0.1%	0.1%	125 mV	ESS 300-50
500	30	0.1%	0.1%	300 mV	ESS 500 30
600	25	0.1%	0.1%	300 mV	ESS 600-25

Table 1.4: Regulation 15 KW

1.4 DESCRIPTION

Remote Start/Stop Interlock:

All ESS models are capable of being remotely started or stopped by means of an external AC or DC voltage source. NOTE: When remote is OFF or interlock is open, control failure LED will be ON, this is normal.

Programming:

The ESS series of power supplies will respond either to the setting of the front panel controls or to an external control signal. This control signal may be in the form of either a resistance, a current, or a voltage. Full scale output is signaled by 5000 ohms, by 5 Vdc, or 1mA.

Proper ESD precautions must be taken when taking off the cover and making connections to J1, RS-232 and IEEE connection when used.

Remote Sensing:

Separate sense and power terminals are provided to enable specified regulation directly at the terminals of the load. This feature provides automatic compensation for the voltage drop in the power distribution system. Voltage drop of sensing lead should be no more than 5V total. Over 10 ft. of Remote Sensing, contact Lambda-EMI.

Controls:

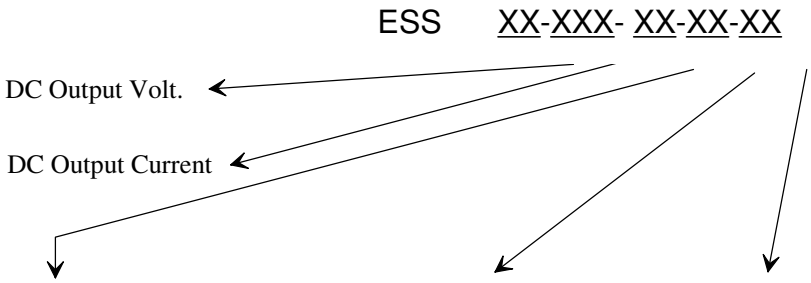
All ESS models are provided with a UL listed circuit breaker which provides primary circuit protection and serves as a power on/off control. Output voltage and current are adjusted by the 10 turn, front panel mounted, controls. Simultaneous indication of output current and voltage is provided by front panel meters. The voltmeter is connected across the sense terminals so that the meter will read either the voltage at the load or the voltage at the power supply terminals, depending on whether local or remote sense is selected.

Overvoltage:

Overvoltage protection, adjustable from the front panel, is standard on all ESS models. This circuit will soft discharge the power supply output to protect the load when the output voltage reaches the OVP set value. The adjustment is from 0% to 105% of Full Vout. This protection is effective regardless of the cause of the overvoltage. Events which will trigger the OVP include, but are not limited to the OVP knob being turned inadvertently, broken remote sense lead, voltage applied from external source, and servo failure in the power supply.

1.5 SETTING INPUT VOLTAGE

The following chart explains the model number for the ESS power supply series.



AC INPUT VOLTS		PANEL METERS		FEATURES		1950	CE
2	220 Vac 50/60 Hz 3 PHASE, 4 WIRE	OMIT	ANALOG METERS	LB	LOCK BUSHING	X	
3	190-253 Vac 400 Hz 3 PHASE, 4 WIRE						
8	380 Vac 50/60 Hz 3 PHASE, 5 WIRE	D	DIGITAL METERS			X	
0	415 Vac 50/60 Hz 3 PHASE, 5 WIRE			TP	TEST POINTS		
10	400 Vac 50/60 Hz 3 PHASE, 5 WIRE					X	X
11	480 Vac 50/60 Hz 3 PHASE, 5 WIRE			TL	PROGRAMMING		
12	440 Vac 50/60 Hz 3 PHASE, 5 WIRE						

Table 1.5: Model Number

The input voltage for the ESS is determined by the option number. The options are:

- 2 = 190-250 Vac Three Phase 4 Wires 50/60 Hz.
- 3 = 190-250 Vac Three Phase 4 Wires 400 Hz.
- 4 = 190-250 Vac Three Phase 4 Wires 60/400 Hz.
- 7 = 180-220 Vac Three Phase 4 Wires 50/60 Hz.
- 8 = 348-418 Vac Three Phase 5 Wires 50/60 Hz.
- 9 = 374-452 Vac Three Phase 5 Wires 50/60 Hz.
- 10 = 360-440 Vac Three Phase 5 Wires 50/60 Hz.
- 11 = 432-528 Vac Three Phase 5 Wires 50/60 Hz.
- 12 = 396-484 Vac Three Phase 5 Wires 50/60 Hz.
- 13 = 380-460 Vac Three Phase 5 Wires 50/60 Hz.
- 14 = 380, 415, 440 Vac Three Phase 5 Wires 50 Hz.
- 15 = 190-253 Vac One Phase 6 Wires 47/64 Hz.
- 16 = 380 Vac Three Phase 4 Wires
- 17 = 415 Vac Three Phase 4 Wires
- 18 = 480 Vac Three Phase 4 Wires
- 19 = 400 Vac Three Phase 4 Wires
- 20 = 440 Vac Three Phase 4 Wires
- 21 = 460 Vac Three Phase 4 Wires

The Power Supply must be properly connected to an approved AC distribution box with the correctly rated over current protection. Input voltages above 230VAC should be supplied from a grounded neutral Wye connected AC power source. For nominal input voltages of 380 Vac and higher, a Wye connection of the input is required in order to provide a neutral connection. Refer to the following diagram below. Lambda-EMI provides two auto transformers (28-004-890-2 set type or 28-004-952-1 set type) for delta to Wye conversion.

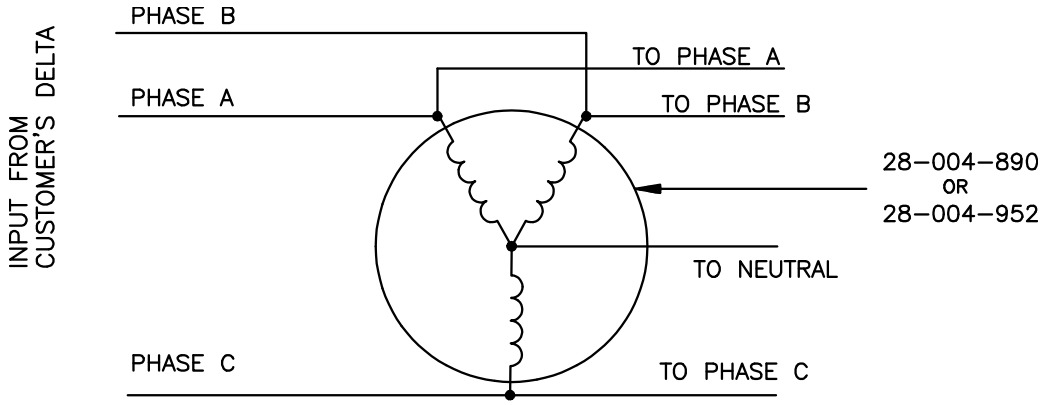


Figure 1.1: Delta to Wye Conversion

Phase rotation sequence need not be observed when connecting the power lines to the input terminals of the power supply. A neutral connection (marked N) is required for the 380, 400, 415 and 480 VAC rated units. For safety, the chassis ground terminal should be connected to earth ground. The input wires must be of the proper gauge size to minimize impedance. The wiring of the AC input connector is dependent upon the rated input voltage of the power supply. Refer to the below table for the appropriate connections.

PIN	195-253 Vac CONNECTIONS	342-418, 373-456, 432-528, 360-440, 400-480 Vac CONNECTIONS
L1	PHASE A	PHASE A
L2	PHASE B	PHASE B
L3	PHASE C	PHASE C
N	NO CONNECTION	NEUTRAL
G	GROUND	GROUND

Table 1.6: AC Input Configuration

Both POS and NEG output terminals are floating (not connected to ground). Either may be grounded or operated at any voltage less than 600 VDC with respect to chassis ground.

RSTL Controller Board:

This is an optional board that can be installed at the customer's request. The board is designed for remote computer control, functionally duplicating the controls on the front panel of the power supply. These controls select the programming levels (Voltage and Current), and provide metering of the supply's output. The RSTL, when set in the REMOTE mode, disables the front panel control pots (but the meters still read), and asserts control of the power supply. For detailed information, refer to Section 4.

1.6 RETURNING EQUIPMENT

Before returning any equipment to the factory, the following steps should be taken.

1) Notify Lambda-EMI, at telephone number (732)-922-9300. Give a full description of the difficulty, including the model and serial number of the unit in question. Upon receipt of this information, Lambda-EMI will assign a Return Material Authorization number (RMA) and provide shipping instructions.

2) Equipment returned to Lambda-EMI must be packed in such a manner as to arrive without incurring any damage. The shipping container must be marked with the RMA number in legible numbers near the shipping label. Any returned unit must have its RMA number clearly displayed on the outside of the container in order to be accepted.

3) For non-warranty repairs, Lambda-EMI will submit a cost estimate for the customer's approval prior to proceeding.

1.7 CLAIM FOR DAMAGE IN SHIPMENT

This instrument received comprehensive mechanical and electrical inspection before shipment. Immediately upon receipt from the carrier, and prior to operation, this instrument should be visually inspected for any damage that may have been incurred during shipment.

If such inspection reveals internal or external damage in any way, a claim should be filed with the carrier. A full report of the damage should be furnished to the claim agent and forwarded to Lambda-EMI noting the model and serial number of the equipment. Lambda-EMI will determine the proper course of action and arrange for repair or replacement.

2 INSPECTION AND INSTALLATION

2.1 UNPACKING

Carefully open the top of the box and remove the packing material. The supply can then be lifted from the box. This power supply is intended for rack mounting. The blades of the forklift must extend fully under the base of the power supply. Both sides must be supported. The power supply may be hoisted with a suitable sling, using the specially provided side lifting plates. If the plates interfere with the application installation, they may be removed. The holding screws should be reinstalled into power supply.

2.2 VISUAL INSPECTION

Immediately inspect the power supply for any shipping damage. Verify the following:

A) Check the operation (knobs should rotate smoothly) of the front panel controls.

B) Verify that the circuit breaker latches in the ON and OFF positions.

C) Confirm that there are no dents or scratches on the panel surfaces.

D) Check front panel meters and LEDs for any broken or cracked glass.

If any damage is found, follow the "Claim for Damage in Shipment" instructions in Section 1.7.

2.3 LOCATION

Make sure that adjacent equipment does not block air intake or exhaust openings of the power supply. Air enters at the front panel and is forced out of the rear panel. This power supply is intended for rack mounting. A conventional 19-inch rack panel can be used.

2.4 ELECTRICAL INSTALLATION

This power supply should not be operated with covers removed. Please refer to safety precautions detailed in section 1.2. After the supply has been installed in a location with sufficient space for ventilation, the appropriate AC input can be applied. Refer to Section 1.5 (Option) for the required AC input voltage and wiring configuration of the AC input connector.

2.5 ELECTRICAL INSPECTION

To ensure that no internal damage was incurred during shipment, a preliminary test should be performed as follows:

A) Rotate Voltage and Current knobs completely counter clockwise.

B) Apply appropriate AC input power to the supply. With no load connected to the output terminals, flip ON the circuit breaker of the supply. The internal fans should start immediately. The power supply should turn on after an approximate ten second delay. The status of the indicators is as follows:

Power On indicator is glowing.
Phase Loss indicator is off
Control Failure indicator is on (Will turn off as control is achieved)
Inverter Failure indicators are off
Overvoltage indicator is off

C) Rotate the current knob clockwise.

D) Rotate the voltage knob completely clockwise. The front panel's voltmeter should display the maximum output voltage of the supply. The voltage indicator should glow.

E) Rotate the current knob completely counter clockwise; the output voltage should drop to zero.

F) Rotate the current knob clockwise. The output voltage should rise to its original value. Rotate the OVP potentiometer counter clockwise. The output voltage should drop to zero volts.

G) Since the OVP circuitry latches on itself, rotate the OVP potentiometer completely clockwise. Flip the circuit breaker OFF and then ON to disable the OVP. The voltmeter should display the output voltage.

H) Rotate the voltage knob completely counter clockwise and monitor the front panel voltmeter. The output voltage should gradually decrease to zero. Flip OFF the circuit breaker of the supply.

I) Apply a short wire, that can sustain the maximum output current, across the output terminals of the supply.

J) Flip ON the circuit breaker of the supply. Rotate the voltage knob clockwise. Rotate the current knob completely clockwise. The front panel ammeter should display the maximum output current of the supply. The current indicator should glow.

K) Rotate Current knob completely counter clockwise. The output current should drop to zero.

Flip OFF circuit breaker.

If any inconsistency from the above test procedure is noted, please do not hesitate to call Lambda-EMI for assistance.

3 OPERATING INSTRUCTIONS

3.1 CONTROLS, INDICATORS (LEDS) AND CONNECTORS

This section gives a brief description of the controls and indicators and also describes the different operational methods of the ESS power supply. Refer to figures 3.1 and 3.2.

REFERENCE NUMBER	FRONT PANEL CONTROL/INDICATOR	FUNCTION
1	Power On LED	When glowing, indicates that the supply is on and in the Normal Operation Mode.
2	Phase Loss LED	When glowing, indicates that the supply is off and not in Operation Mode.
3	Inverter Failure LEDs	Four LEDs corresponding to four inverters. The number of the LED that glows indicates which inverter has failed.
4	Current LED	Indicates constant current mode.
5	Overvoltage LED	Indicates supply has exceeded the voltage that was set by the OVP Control.
6	Voltage LED	Indicates that the supply is in the constant Voltage mode.
7	Circuit Breaker	Connects and disconnects AC input to supply.
8	Voltmeter	Displays output voltage of power supply.
9	Ammeter	Displays output current of power supply.
10	Control Failure LED	Indicates system failure in the supply. NOTE: will go out when supply has soft started and is on when remote is turned off.
11	Voltage control	Adjusts the output voltage from zero to full scale.
12	Current Control	Adjust the output current from zero to full scale.
13	OVP Voltage Adjust	Adjust Overvoltage from Zero to 105% of Vout

Table 3.1: Front Panel Controls and LEDs

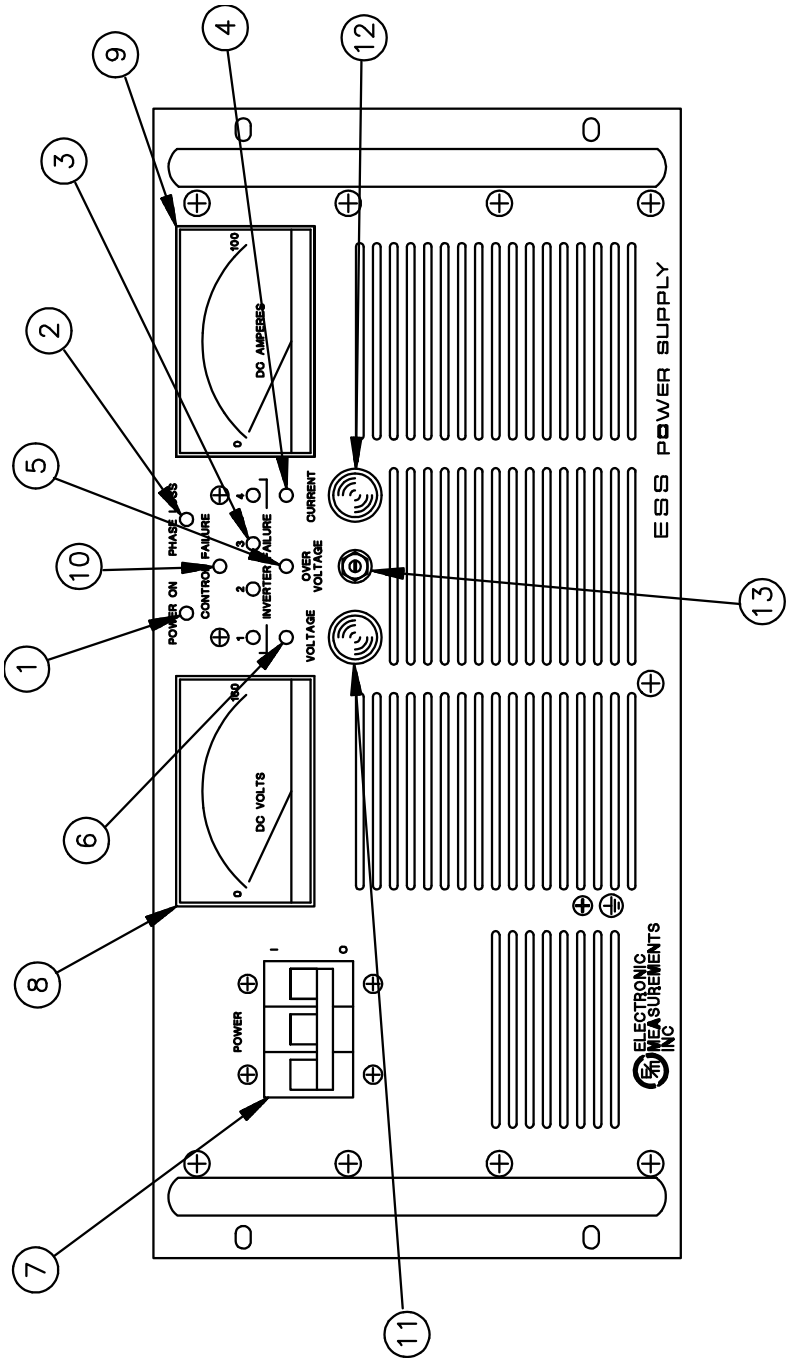


Figure 3.1: Front Panel

REFERENCE NUMBER	CONTROL/ CONNECTOR	FUNCTION
1	J1 Connector	Programming Connector
2	TB1 Terminal Strip	AC Input
3	IEEE 488	Provides interfacing between a computer and the power supply.
4	Address Switch	Selects the IEEE488 address.
5	Ground Stud	Allows the panel to be conveniently connected to ground.
6	Output Terminals	The load is connected to these 2 terminals. The output terminals supply power to the load.
7	RS232	Provides interfacing between computer and the power supply.

Table 3.2: Rear Panel Controls and Connections

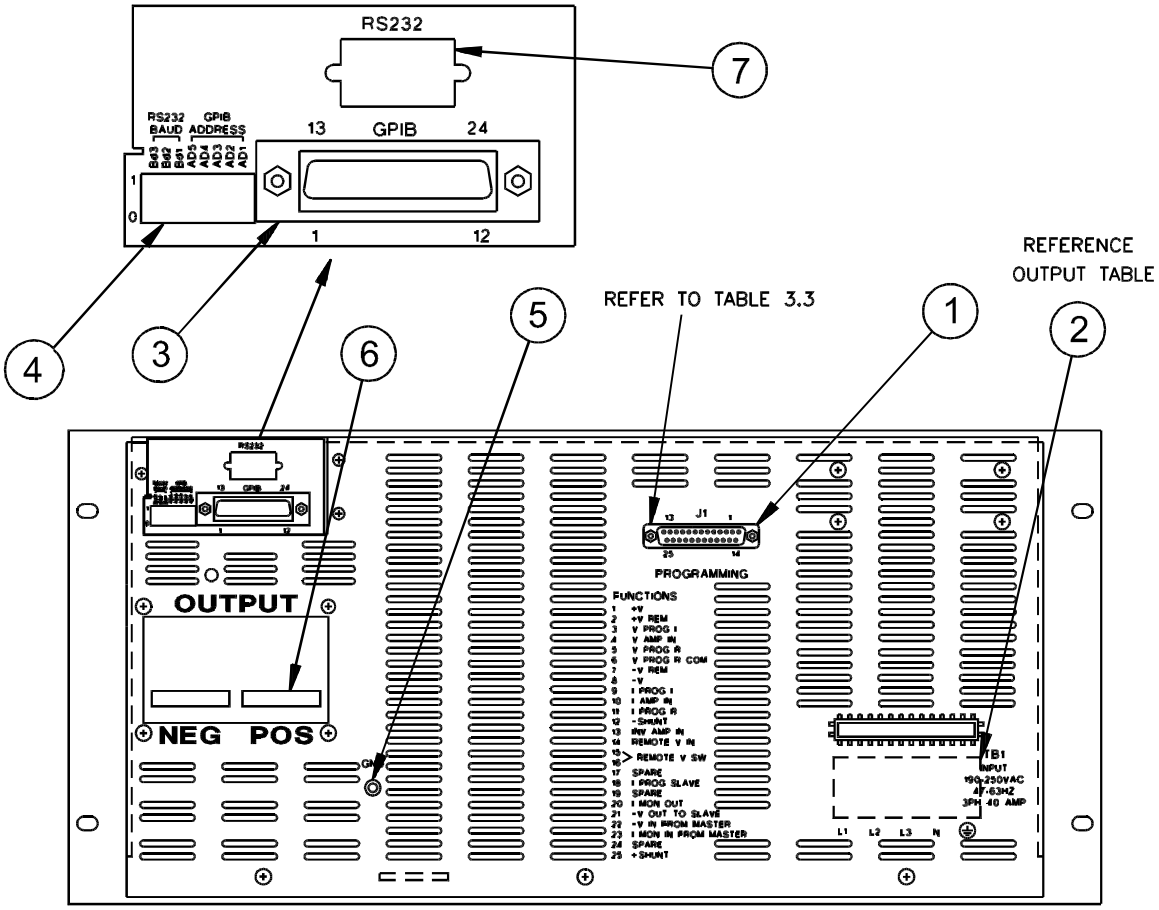


Figure 3.2 Rear Panel

3.2 GENERAL OPERATION

When shipped from the factory, each supply is configured for constant voltage, constant current and local sensing operation. This is the default or typical operating mode of the supply. All performance specifications, unless otherwise stated, are defined in this configuration. The voltage and current controls set the boundary limits for the load voltage and current respectively. The relationship between the control settings and the load resistance determines whether the power supply operates in constant voltage or constant current mode. Automatic crossover between modes depends on the following:

- The load connected to the output terminals of the power supply RL .
- The front panel voltage control setting Vset .
- The front panel current control setting Iset .

Constant Voltage Mode: The power supply will operate in this mode whenever the current demanded by the load is less than that defined by front panel current control. In this mode, the output voltage of the power supply is set by the front panel voltage control. The output current is determined by the load and the Vset .

Constant Current Mode: The power supply will operate in this mode whenever the current demanded by the load is greater than that defined by front panel current control. In this mode, the output current of the power supply is set by the front panel current control. The output voltage is determined by the load and Iset.

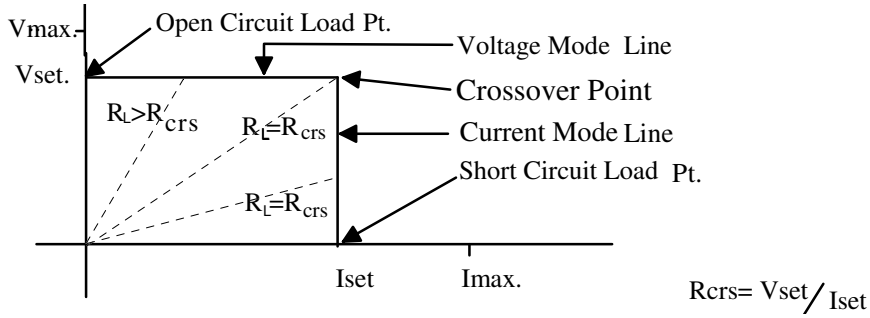


Figure 3.3: Operating Modes

The front panel provides all controls and indicators necessary to operate the power supply.

3.3 OVERVOLTAGE PROTECTION

An adjustable internal overvoltage protection (OVP) circuit trips between 0% and 105% of output. When the circuit is tripped, the front panel Overvoltage LED will glow, and the OVP circuitry will latch on. To reset the OVP circuit, rotate the OVP potentiometer completely clockwise, and flip the circuit breaker to the OFF and then to the ON position.

3.4 CONNECTING THE LOAD

Ensure that the power supply is off and disconnected from the input power and that all load capacitors are discharged and shorted to ground before making any connections. Never handle the output cable during operation.

Each resistive load must be connected to the power supply output terminals using separate pairs of connecting wires. Make sure that the connecting wires are of suitable gauge to sustain maximum rated current. Separate pairs of wires minimize mutual coupling effects between loads and maintain the low output impedance of the power supply. Each pair of connecting wires must be as short as possible. If strong AC or RF fields are present, the connecting wires should be twisted or shielded. If a shield is used, connect the supply end of the shield to earth ground. Do not terminate the shield at the load end.



ESD precautions must be taken when taking off the J1 cover and making connections to J1, RS-232, IEEE connectors when used.

3.5 MODES OF OPERATION

A 25 pin Sub-D female Connector (J1) is used for configuring the operating mode of the power supply. Depending on the configuration of the J1 programming connector, an external resistance, voltage or current can be used to control the power supply in the remote operation mode. Remote programming can be applied to either voltage channel (voltage regulation circuit) or current channel (current regulation circuit). If strong AC or RF fields are present, use a twisted pair or shielded cable to connect the remote terminals of J1 to the programming source. The following table provides a description of the J1 connector and J18 connector.

J18 PIN	**PIN DESCRIPTION**
1	+V
2	+V REMOTE SENSE
J1 PIN	**PIN DESCRIPTION**
1	+V (+ Buss Bar of Power Supply up to 300V)
2	+V REMOTE (+ sense of control board up to 300V)
3	V PROG I (Current source for voltage channel)
4	V AMP IN (Voltage programming input)
5	V PROG R (Front panel voltage pot +)
6	V PROG R COM (Front panel voltage pot -)
7	-V REMOTE (-Sense of control board)
8	-V (Output of Power Supply and common of A100)
9	I PROG I (Current source of current channel)
10	I AMP IN (Current programming input)
11	I PROG R (Front panel current pot +)
12	- SHUNT
13	I MON REMOTE (Buffered current monitor)
14	REMOTE V IN (Internal VAC for interlock)
15	REMOTE V SW (Return connection, internal VAC)
16	REMOTE V SW (Interlock contact)
17	OVP M/S IN (Logic port in for OVP)
18	I PROG SLAVE (Output of Difference Amp.)
19	V MONITOR (Voltage monitor)
20	I MON OUT TO SLAVE ESS (50X internal shunt Amp)
21	-V OUT TO SLAVE (common of A100 control Bd)
22	-V IN FROM MASTER (-Input of Difference Amp)

23	I MON IN FROM MASTER (+ input of Difference Amp)
24	OVP M/S OUT (logic output of OVP)
25	+ SHUNT

Table 3.3: Programming J1 ConnectorNormal operation mode

In the Normal Operation mode, the power supply is controlled by the front panel potentiometers. The supply is configured for constant voltage, constant current and local sensing. When shipped from the factory, the supply is configured for this mode. Figure 3.4 illustrates the configuration of J1 for the Normal Operation mode. When using RSTL program, voltage and current programming are not applicable.

NOTE: If the unit has the "RSTL" option, you cannot perform any remote analog programming in the voltage or current mode.

NOTE: If the unit has a 0-10Volt Programming option, you cannot perform external resistive or external current programming in the voltage or current mode.

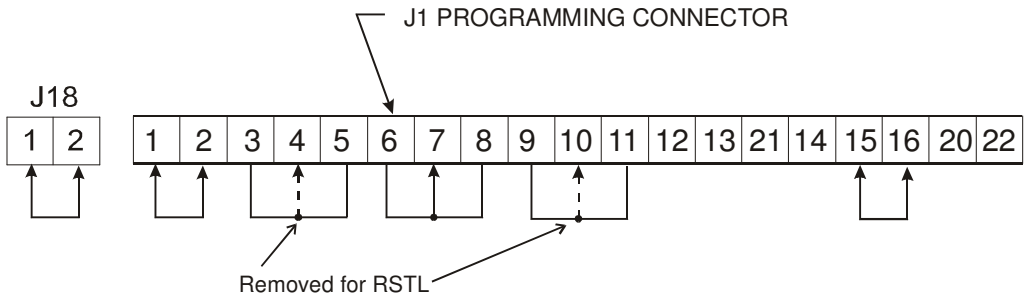


Figure 3.4: Normal Operation Mode

CAUTION: IF THE REMOTE PROGRAMMING RESISTOR OPENS, THE LOAD VOLTAGE OR LOAD CURRENT CAN INCREASE TO THE MAXIMUM RATING OF THE POWER SUPPLY. THEREFORE, USE MAKE-BEFORE- BREAK SWITCH CONTACTS BETWEEN EXTERNAL PROGRAMMING SOURCE AND THE PROGRAMMING J1 CONNECTOR.

3.5.1 REMOTE PROGRAMMING BY EXTERNAL RESISTANCE

Voltage Channel

A 5000 ohm potentiometer programs the supply output voltage from zero to full rated voltage. Front panel Voltage control is disabled. Front panel Current control remains active.

$$= \frac{\textit{Desired Output Voltage}}{\textit{Full Rated Output Voltage}} \times 5000\ \textit{ohms}$$

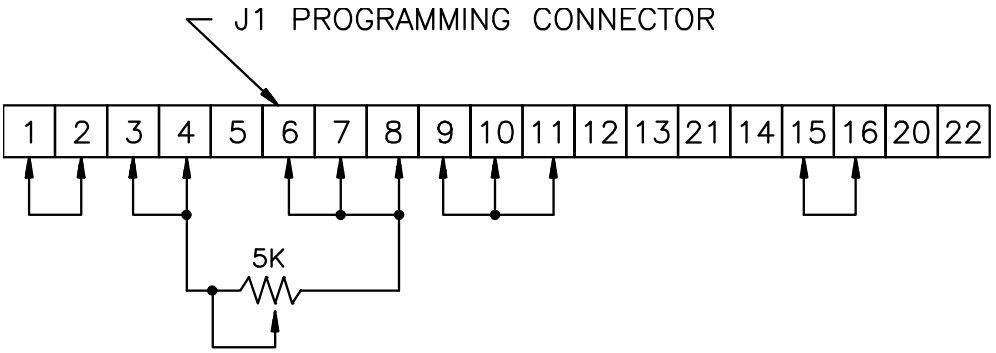


Figure 3.5: Remote Programming By External Resistance for Constant Voltage

Current Channel

A 5000 ohm potentiometer programs the supply output current from zero to full rated current. Front panel Current control is disabled. Front panel Voltage control remains active.

$$= \frac{\textit{Desired Output Current}}{\textit{Full Rated Output Current}} \times 5000\ \textit{ohms}$$

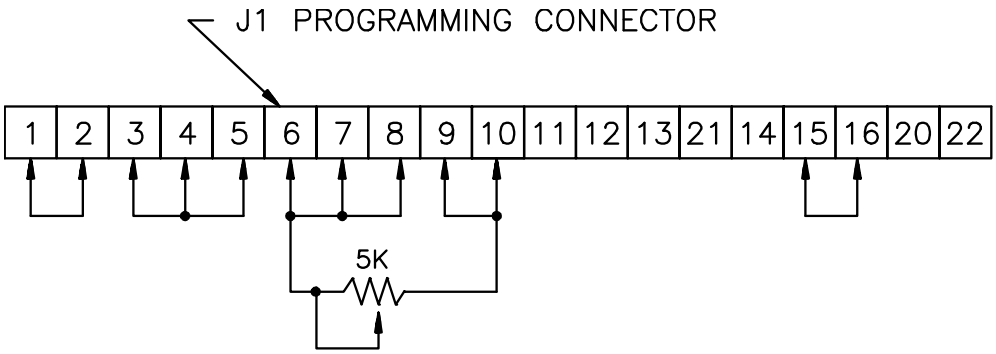
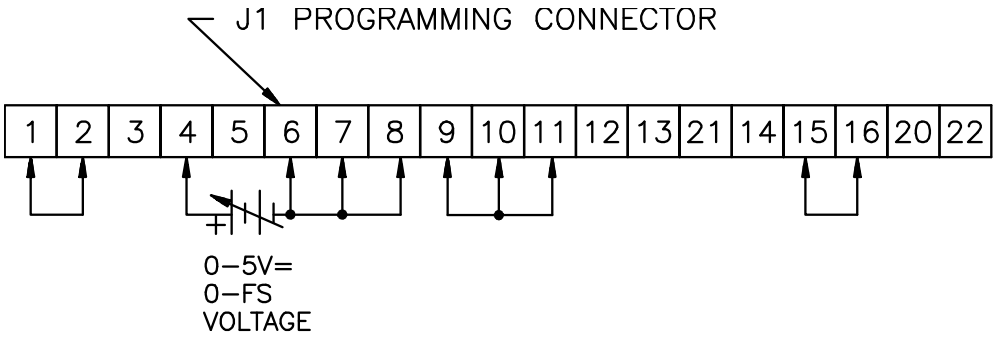


Figure 3.6: Remote Programming by External Resistance for Constant Current

3.5.2 REMOTE PROGRAMMING BY EXTERNAL VOLTAGE

Voltage Channel

A 0 to 5 Vdc variable power supply programs the supply output from zero to full rated voltage. Front panel Voltage control is disabled. Front panel Current control remains active.



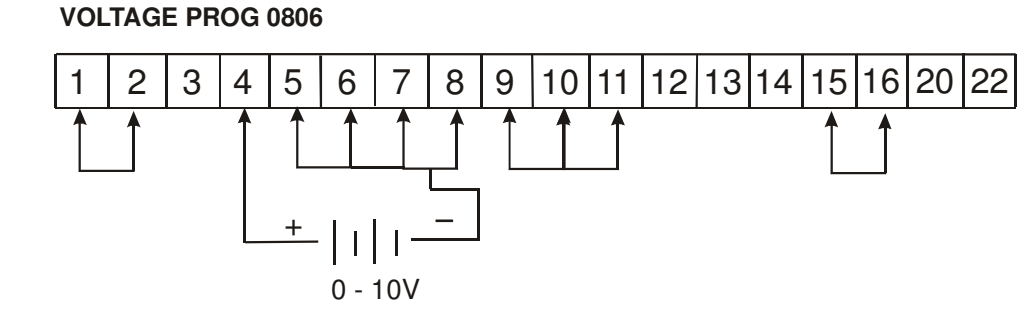
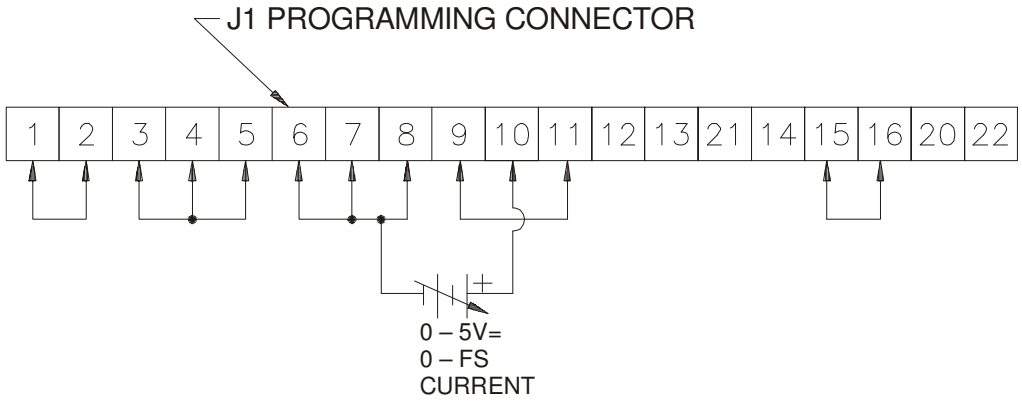


Figure 3.7.1: Voltage Prog 0806

Current Channel

A 0 to 5 Vdc variable power supply programs the supply output from zero to full rated current. Front panel Current control is disabled. Front panel Voltage control remains active



0806 Option 0-10V Program

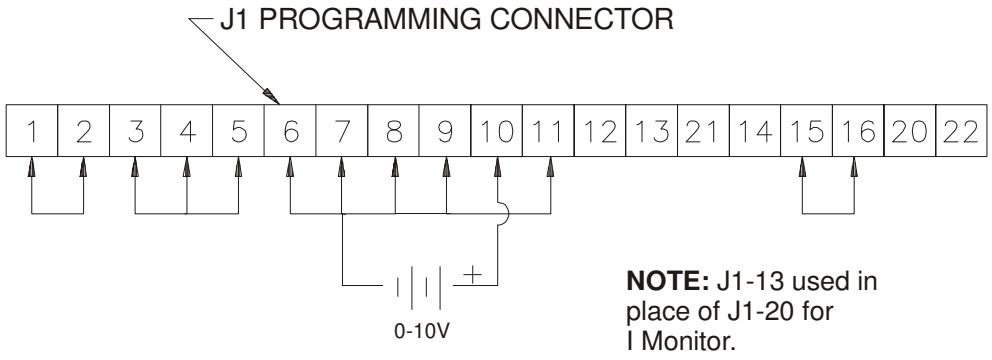


Figure 3.8: Remote Programming by External Voltage for Constant Current

3.5.3 REMOTE PROGRAMMING BY EXTERNAL CURRENT

Voltage Channel

A 0 to 1 mA Variable Current Source programs the supply output from zero to full rated voltage. The current source is placed in parallel with a 5000 ohm variable resistor. Front panel Voltage control is disabled. Front panel Current control remains active.

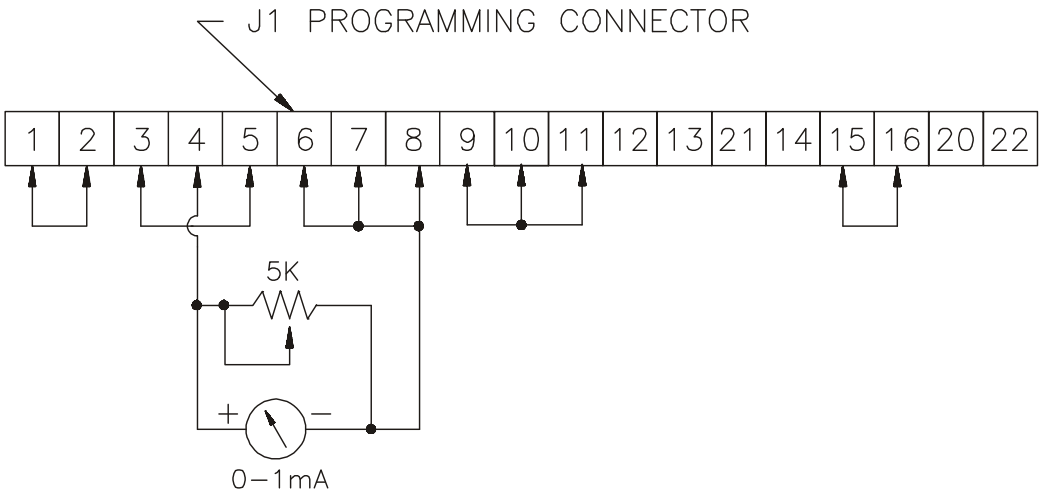


Figure 3.9: Remote Programming by External Current for Constant Voltage

Current Channel

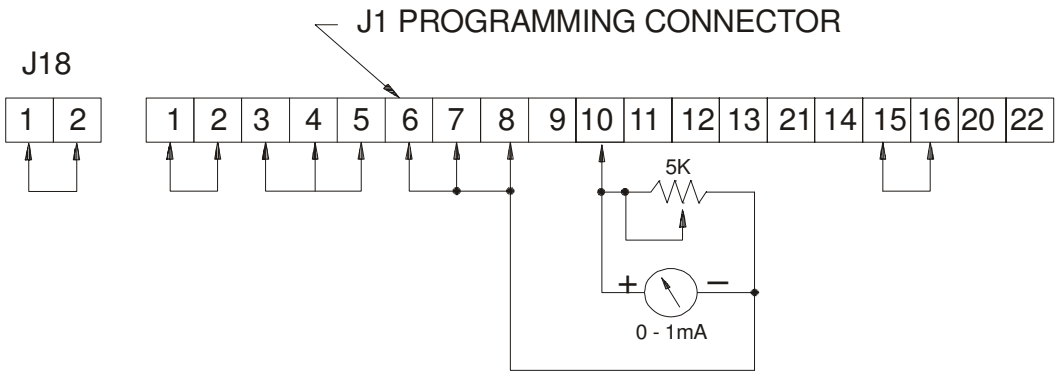


Figure 3.10: Remote Programming by External Current for Constant Current

A 0 to 1 mA variable current source programs the supply output from zero to full rated current. The current source is placed in parallel with a 5000 ohm variable resistor. Front panel current control is disabled. Front panel Voltage control remains active.

3.6 REMOTE SENSING

In applications where the voltage drop across the wires connecting the load cannot be ignored, the output voltage can be sensed directly across the load. The front panel voltmeter indicates the voltage directly at the power supply. Remote sensing minimizes the effect of the power distribution system on load voltage and current. With remote sensing, the maximum output voltage of the power supply equals the rated output voltage, minus the total voltage drop across the connecting wires. Figure 3.11 illustrates the strapping and connections required for remote sensing. Note that the sensing wires are polarized.

NOTE: The RSTL voltage sensing points remain at the output busbars. It will not sense voltage at the load.

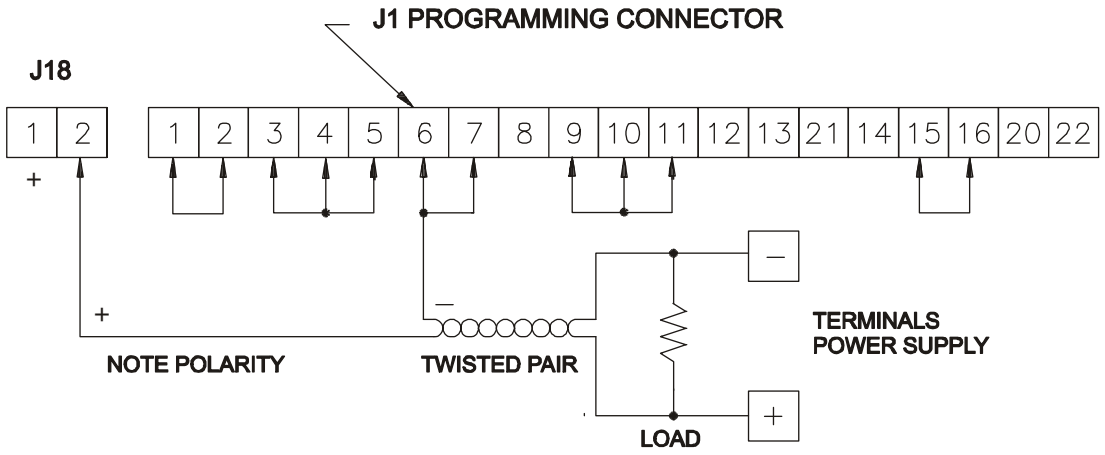


Figure 3.11: Remote Sensing

3.7 PARALLEL OPERATION

NOTE: Lambda-EMI does not recommend connecting more than two ESS power supplies in parallel. Contact the factory before connecting three or more supplies in parallel.

1) The J1 programming connector should be configured before connecting the two power supplies in parallel.

   Caution: Verify that step 1 is done properly before proceeding.

2) Advance the Current control of each supply one half turn clockwise.

3) Use the Voltage control on each unit to set the required output voltage.

4) Turn off both power supplies and rotate each Current control to its maximum counterclockwise position.

5) Connect each positive load terminal to the positive side of the load. Connect each negative load terminal to the negative side of the load. **NOTE: Individual leads**

between the power supply and load must be equal in length and of sufficient gauge to provide a low impedance.

6) Turn both power supplies on.

7) Use the Voltage controls to ensure that each power supply delivers approximately the same load current.

8) Slowly adjust each Current control to limit supply output current just above the value required by the load.

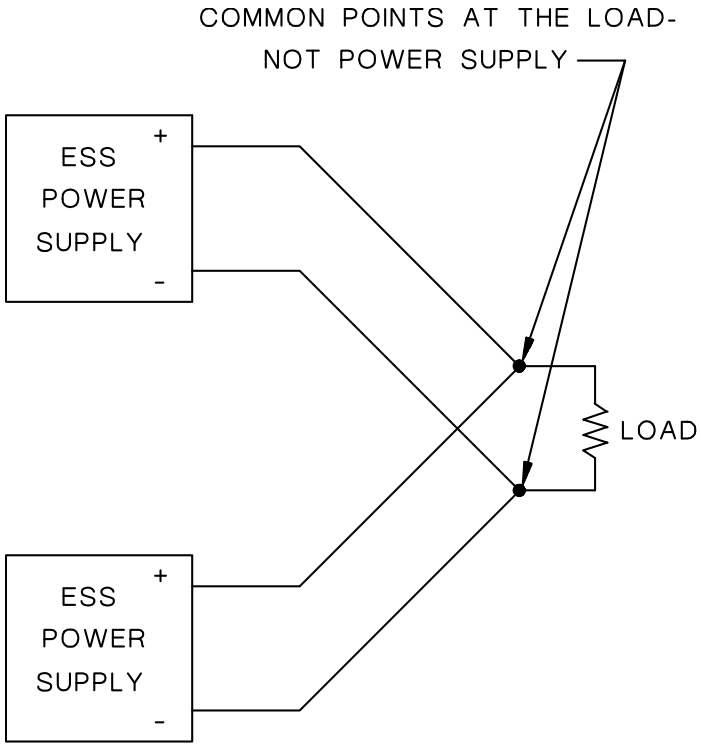


Figure 3.12: Parallel Operation

Recall that the ESS power supply has a variable OVP trip point from about 0 to 110% of output voltage. Consult Lambda-EMI, Inc. for overvoltage protection using parallel supply connections.

3.7.1 PARALLEL OPERATION IN MASTER/SLAVE CONFIGURATION

A) Maintain the same connections used for parallel operation (Figure 3.12). Adjust the strapping of each (master and slave supply) J1 programming connector as shown in Figure 3.13. The power supply designated master controls the voltage and current output of the slave supply.

B) Figure 3.14 for Master/Slave with OVP Master/Slave. In this configuration both Master and Slave will shut down with an OVP Function.

NOTE: RSTL can only be used in Master Supply, and the P1/J1 should be configured according to Fig. 3.13 and 3.14. Please contact the factory to configure a unit with RSTL for Slave Operation.

Advance the Voltage and Current controls of the slave supply to maximum clockwise position. Use the Voltage and Current controls of the master supply to set load voltage and current.

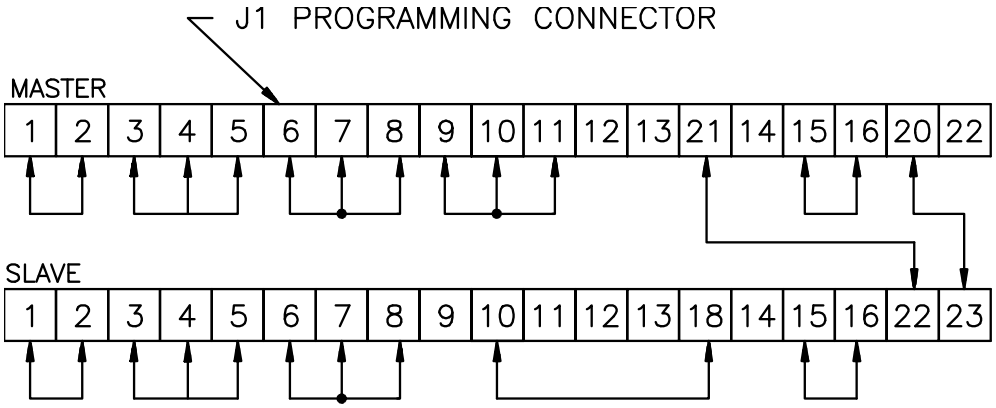


Figure 3.13: Parallel Operation in Master/Slave Configuration

NOTE: The Slave power supply should be set at 1% to 5% higher in the voltage channel than the master (otherwise the master will lose control of the slave and the slave will seek the voltage setting of the front panel setting).

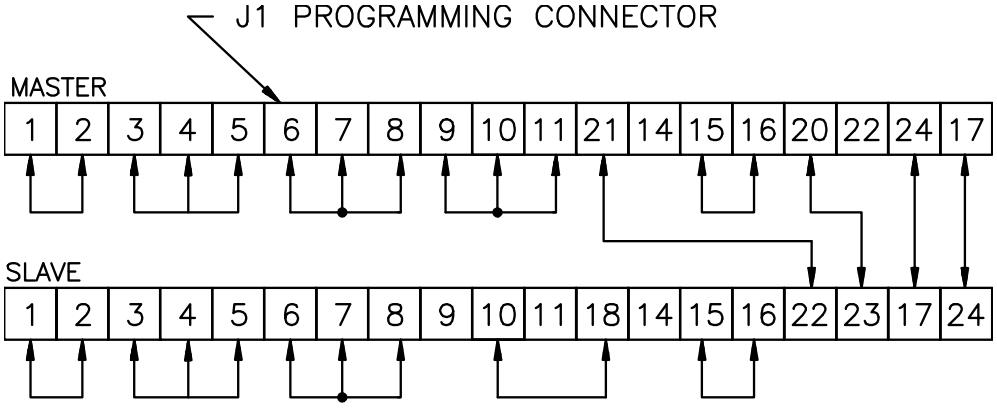


Figure 3.14: Paralleled Operation in Master/Slave Configuration with OVP Master/Slave

Note: See Figure 3.14.3 and 3.14.4 for units with the 0-10V Option.

Advance the Voltage and Current controls of the slave supply to maximum clockwise position. Use the Voltage and Current controls of the master supply to set load voltage and current.

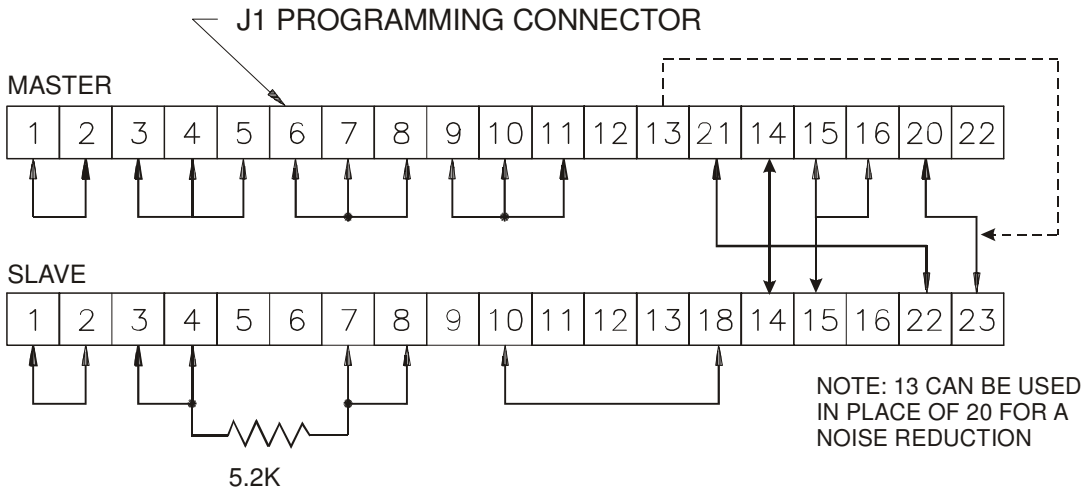


Figure 3.14.1: Parallel Operation in Master/Slave Configuration Total Control with Higher Slave Voltage

NOTE: The Slave power supply is set at 1% to 5% higher in the voltage channel than the master (otherwise the master will lose control of the slave and the slave will seek the voltage setting of the front panel setting).

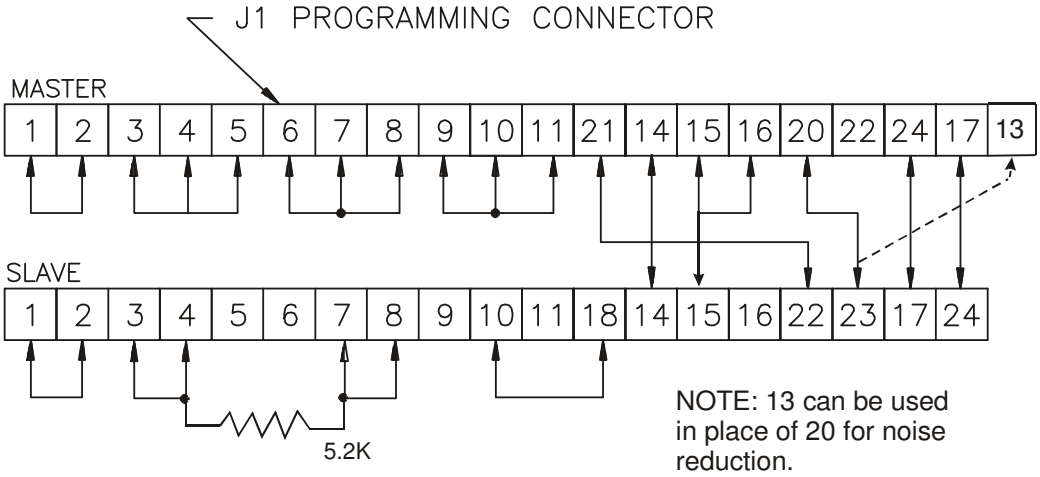


Figure 3.14.2: Paralled Operation in Master/Slave Configuration with OVP with Master On/Off Total Control Master/Slave and Higher Voltage Slave

Advance the Voltage and Current controls of the slave supply to maximum clockwise position. Use the Voltage and Current controls of the master supply to set load voltage and current.

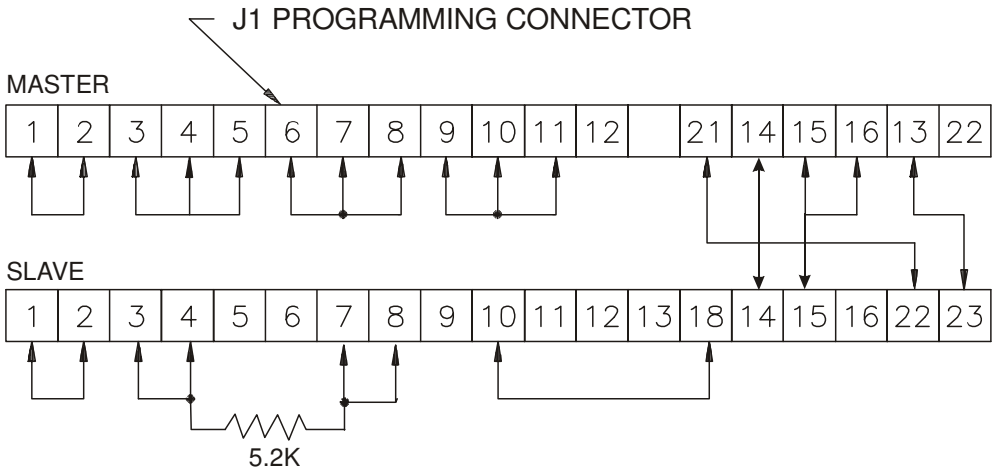


Figure 3.14.3: Parallel Operation in Master/Slave Configuration 0806 Total Master Control On/Off Local Control Note: Figure 4 for External 3.15 & 3.8 For Master only.

NOTE: The Slave power supply is set at 1% to 5% higher in the voltage channel than the master (otherwise the master will lose control of the slave and the slave will seek the voltage setting of the front panel setting).

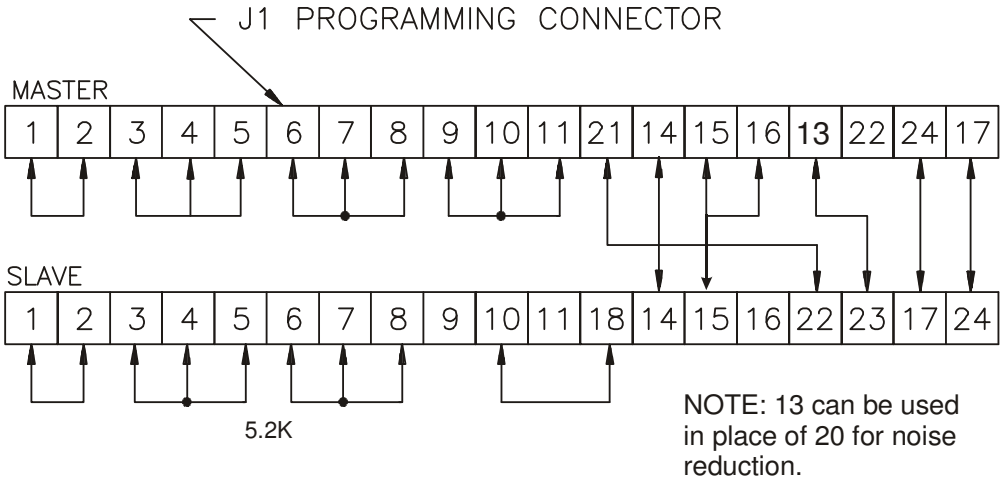


Figure 3.14.4: Paralled Operation in Master/Slave Configuration with OVP Total Control Master/Slave Local Control Note: Figure 3.78 and 3.8 for Voltage Current for Master on.

3.8 SERIES OPERATION

NOTE: Lambda-EMI, does not recommend more than two ESS power supplies connected in series. Contact the factory before connecting three or more supplies in series.

No external programming can be conducted between power supplies other than Isolated Programming. (See Figure 3.24 for alternate series operation). The output of each power supply is connected to A100 control board. **Damage will occur if both commons are wired together**.
Two ESS supplies are connected in series by connecting the negative output terminal of one supply directly to the positive output terminal of the second supply. In local Voltage and Current controls of each supply are adjusted independently. Total output or load voltage equals the sum of the individual supply outputs. Although the supply output terminals are floating, the maximum voltage at any one terminal must not exceed 600 volts with respect to chassis ground. **NOTE**: Individual leads between the power supply and load must be equal in length and of sufficient gauge to provide a low impedance. The leads between output terminals of the supply must be of equal gauge.

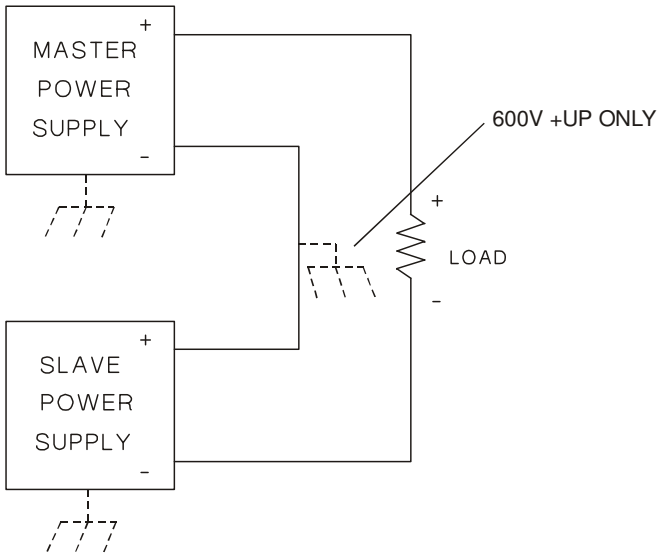


Figure 3.15: Series Operation

3.9 REMOTE METERS

If strong AC or RF fields are present, remote meter leads should be shielded. Connect the supply end of the shield to J1-25. Do not terminate the load side of the shield.

A remote voltmeter is connected between J18-2 (positive) and J1-7 (negative). The voltmeter reads the voltage at the load in conjunction with remote sensing. To read voltage at the supply output terminals, connect the voltmeter across J18-1 (positive) and J1-8 (negative).
Figure 3.16 illustrates a remote voltmeter that indicates voltage across the output terminals of the power supply. Remote sensing is not used. Figure 3.16 illustrates a remote voltmeter that indicates voltage across the load.

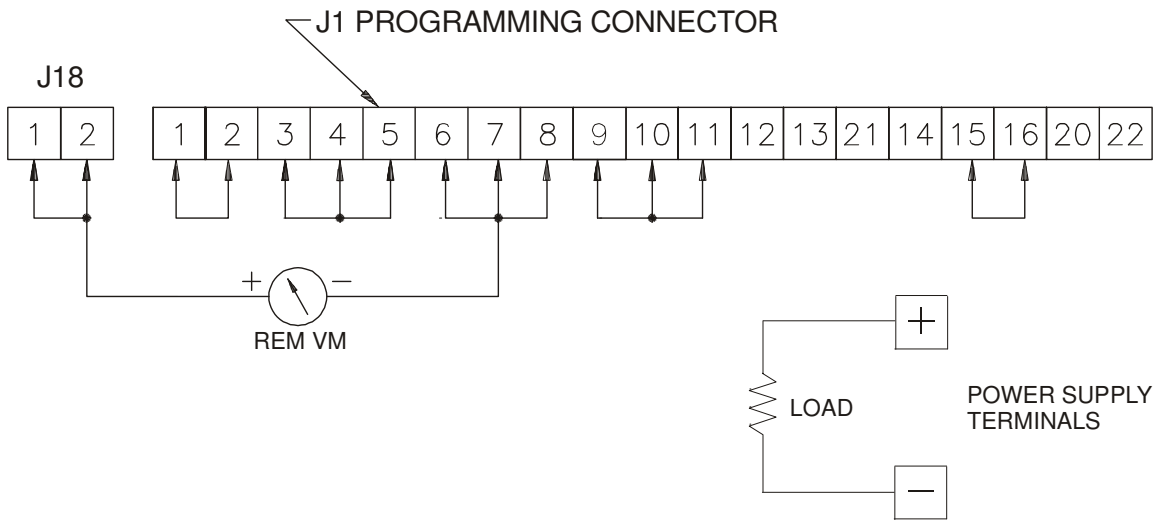


Figure 3.16: Remote Meter Across Output

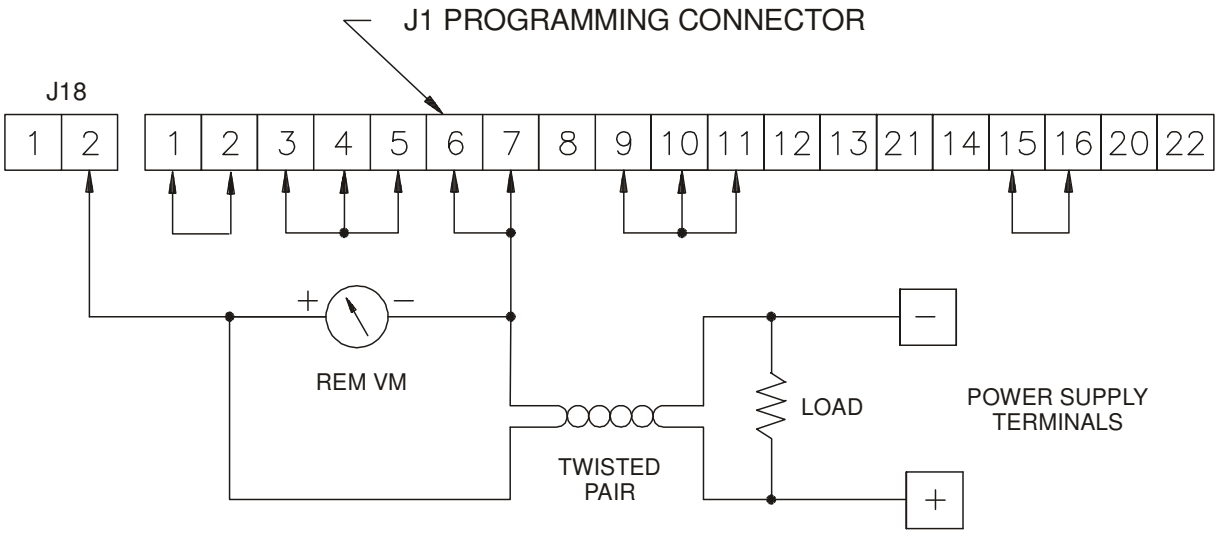


Figure 3.17: Remote Meter Across Load

A) To measure load current, use a remote millivolt meter (100 mV full scale sensitivity), rated output current calibrated in amperes. Connect the meter across J1-12 (negative) and J1-25 (positive). The power supply generates 100 mV across J1 pins 12 and 25 at full rated output current. See Figure 3.18.

B) Connect 0-5 Vdc meter from J1-20(+) to J1-8 (-V). Full output current, will generate a full scale reading of 5 Vdc. See Figure 3.19.

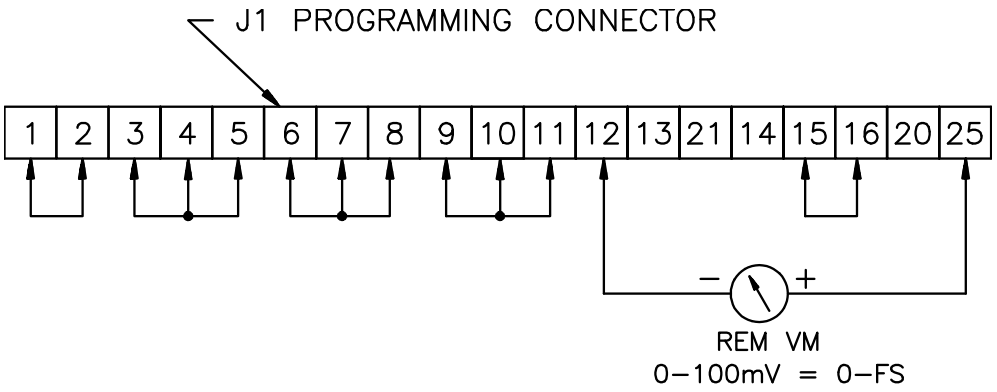


Figure 3.18: Remote Meter Across Shunt

Use a higher sensitivity meter movement with a series calibration resistor to compensate for IR drops generated across long remote leads.

VOLTAGE AND CURRENT MONITOR, 0-5 VDC OUTPUT

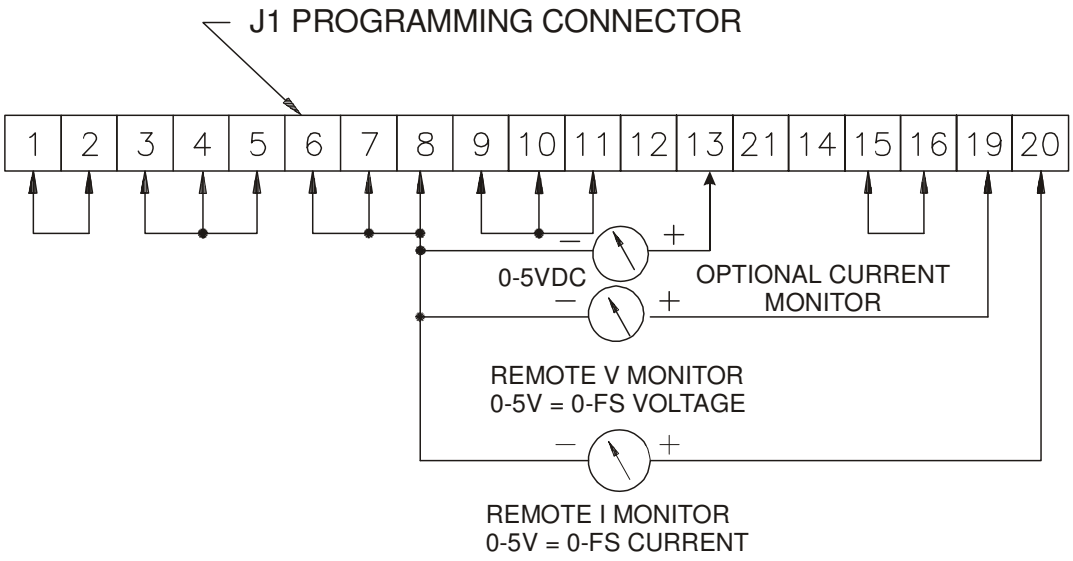


Figure 3.19: Voltage and Current Monitor

3.5.1 REMOTE PROGRAMMING BOTH VOLTAGE AND CURRENT

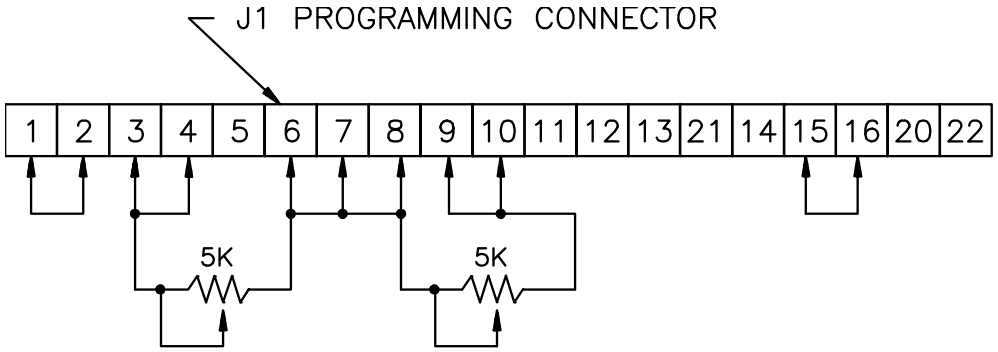


Figure 3.20:
Remote Programming by External Resistance for Constant Current and Constant Voltage

NOTE: You cannot Remote program with external resistance in units with an RSTL or 0-10V Program.

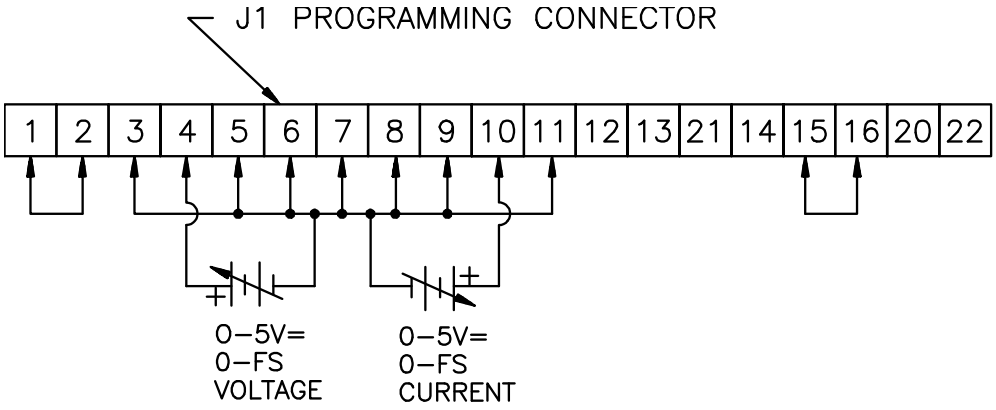


Figure 3.21:
Remote Programming by External Voltage for Constant Current and Constant Voltage

3.1 3.11 REMOTE INTERLOCK AND DRY CONTACT

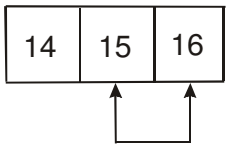
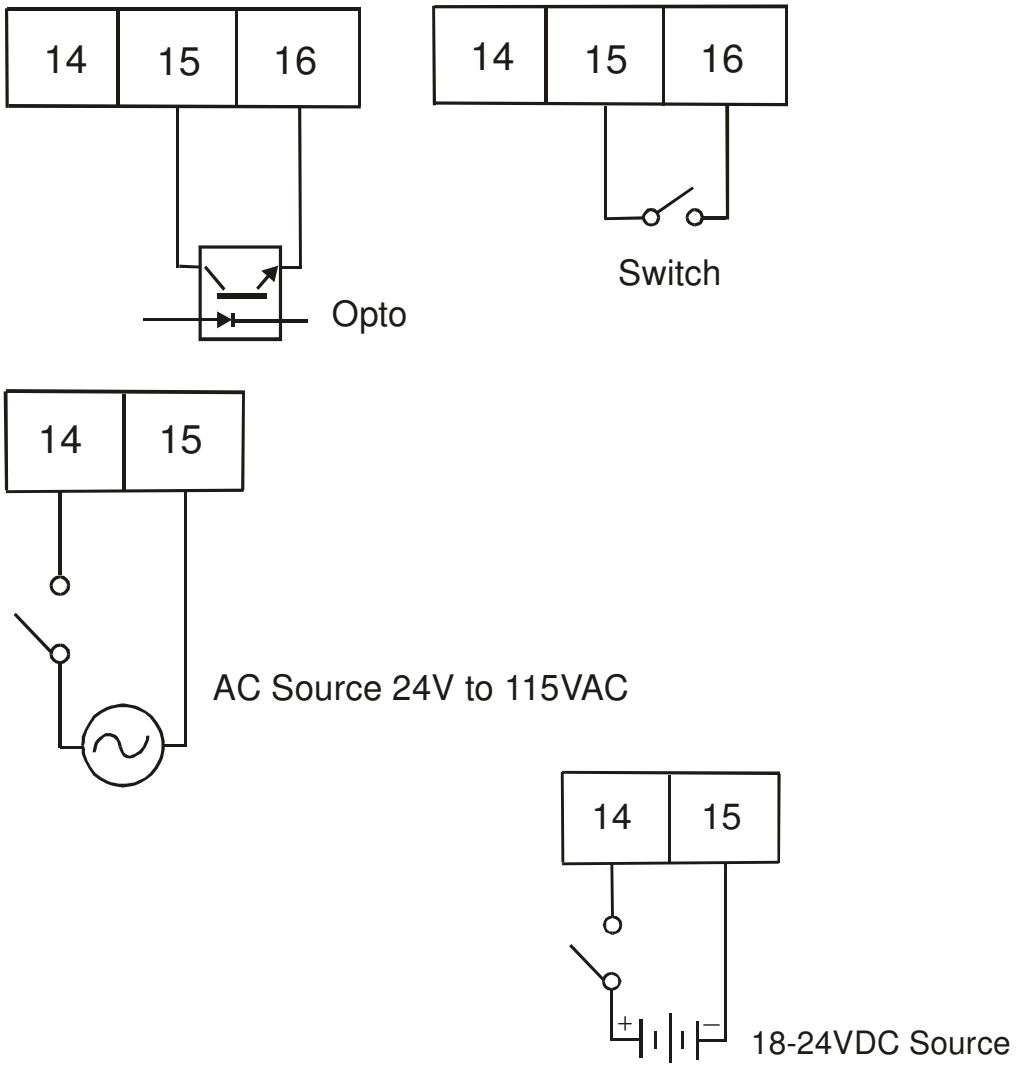


Figure 3.22

In normal configuration. Interlock is jumpered as shown in Figure 3.22. An opto coupler switch, relay contact or other closure device can replace Link 15 to 16. The interlock when opened disables the power supply output and indicates a control failure on front panel. Pin 14 can be used with an ac source of a range of 24V to 115VAC 50-400Hz or an 18-24VDC source. Connection hookups are shown in the following figures.



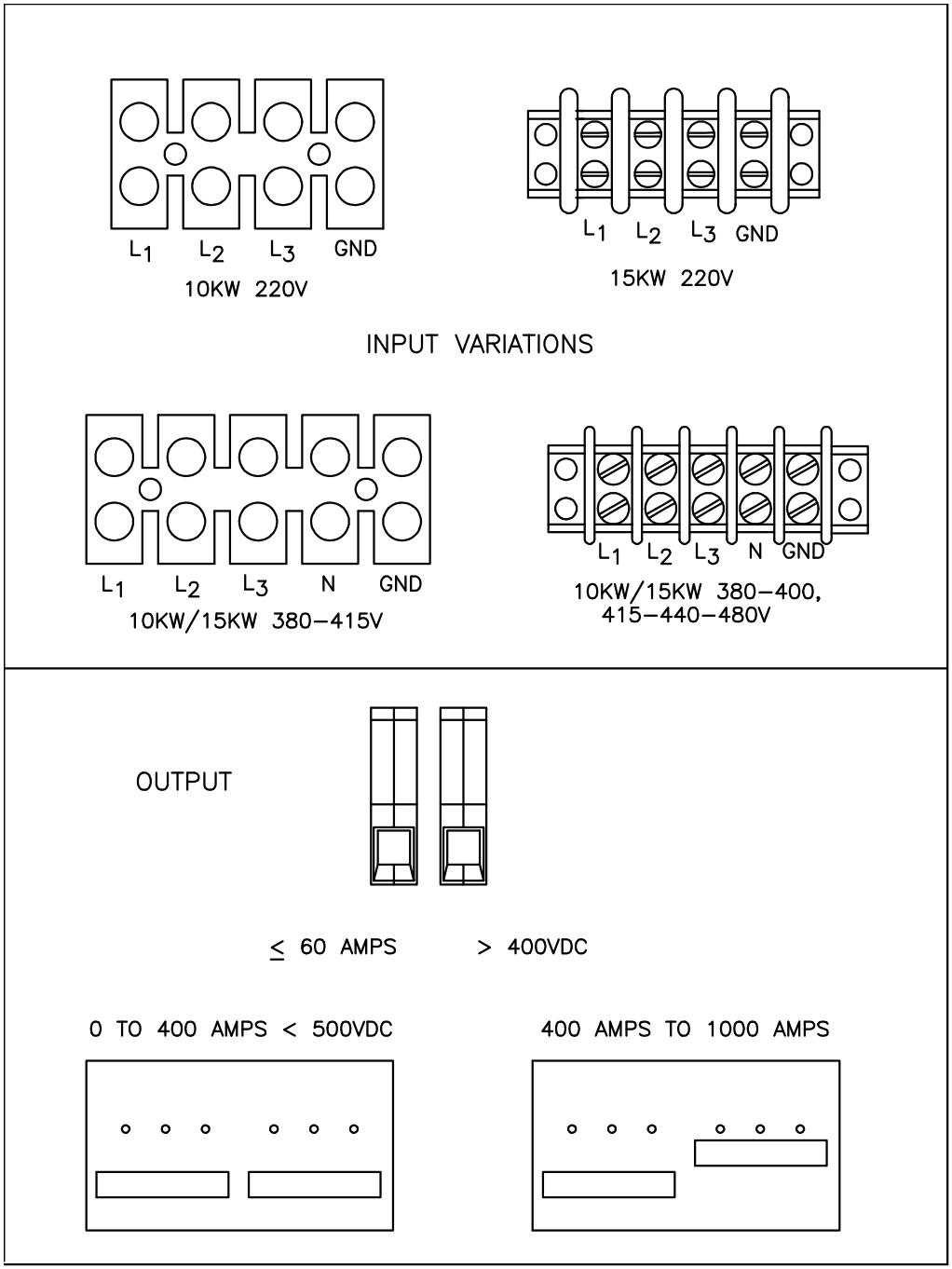


Figure 3.23 Rear Panel Reference

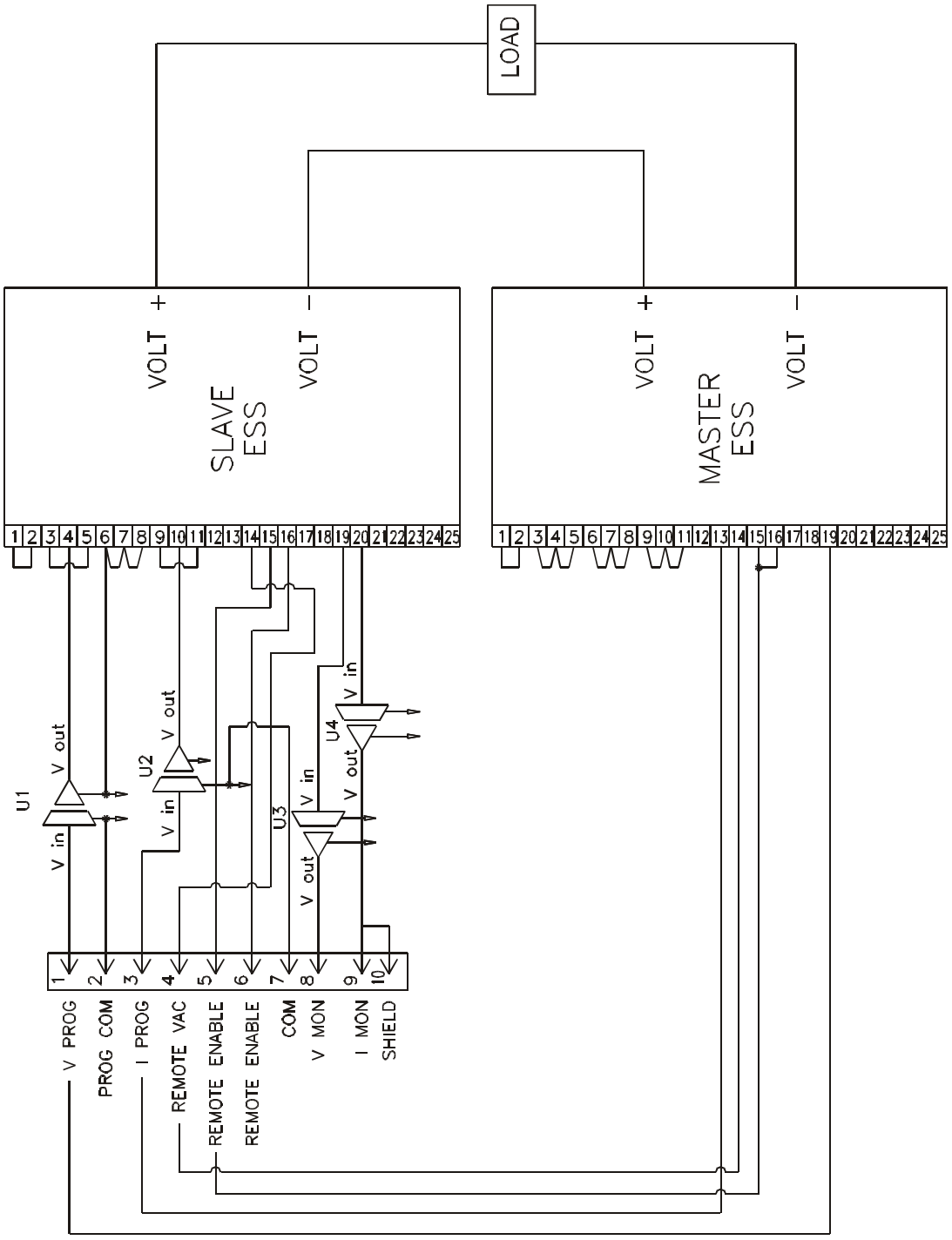


Figure 3.24 Series Operation with Opto Isolators

4 RSTL CONTROLLER BOARD

4.1 INTRODUCTION TO THE RSTL CONTROLLER BOARD

This board is factory-installed for remote computer control of ESS power systems manufactured by Lambda-EMI. The RSTL is designed to functionally duplicate the voltage and current controls on the front panel of a power supply. These controls select the programming levels and provide metering of the supply output. The RSTL, when set for REMOTE mode, disables the front panel control pot but (the meters still read), and asserts control of the power supply. The RSTL also disables the analog program when in control.

4.2 RSTL CONNECTION TO COMPUTER

The RSTL is designed to be connected to a computer via a GPIB or RS232 cable. The switch on the back of the RSTL (red DIP switch) is used to set the GPIB address and RS232 data rate. The default setting when shipped from the factory is address #6 and 9600 bits per second (see section 4.7.1 for details).

4.3 CONTROLLING THE POWER SUPPLY

This section explains programming the supply, reading back its output and querying its status.

Each command sent to the RSTL must be followed by a CR LF (ASCII 13 and 10). Normally this is taken care of during the configuration of the IEEE-488 card installed in your computer. For example, the National Instruments cards have an End Of String (EOS) byte that is controlled by the user. Try using the default setting of the IEEE-488 card, if you have problems *then* look to see if the end of string terminator is set correctly.

Send the command "?M" and read the result using either the GPIB or RS232 interface. The RSTL will return the firmware revision, model and serial numbers. In addition, the voltage and current of the power supply will be returned. If they do *not* match your unit then they will need to be changed using the following commands:

"Set * Voltage dddd" = "S*Vdddd" = Set scaling voltage to dddd Volts.

"Set * Current dddd" = "S*Cdddd" = Set scaling current to dddd Amps.

dddd = 0000 to 1000 (must use four digits).

After the voltage and current are correctly identified, the following commands will be sufficient to test out the basic functionality of the RSTL control of the power supply:

The RSTL is designed to functionally duplicate the voltage and current controls on the front panel of a power supply.

"**SR**" tells the RSTL to put the supply in REMOTE operating mode. In this mode the front panel controls are switched out of the control circuit and the RSTL digital to analog converters provide the control signal to the supply. These D/A converters are controlled by the following two programming commands (among others - see Section 4.7.4 for other commands):

"**PV%50**" tells the RSTL to program the voltage output of the supply to 50% of full scale (see 4.7.5 for further details).

"**PC%100**" tells the RSTL to program the current output of the supply to 100% of full scale (see 4.7.4 for further details).

"**MV**" tells the RSTL to measure the voltage output of the supply (see 4.7.4 for further details).

"**MC**" tells the RSTL to measure the current output of the supply (see 4.7.5 for further details).

4.4 GENERAL DESCRIPTION

The RSTL board is factory installed within the ESS power supply. The RSTL communicates via the General Purpose Interface Bus (GPIB) or the RS232C serial communications link.

The RSTL allows remote duplication of the power supply manual operating modes. Front panel controls are locked out when the user places the power supply in REMOTE mode.

Programming of the Voltage and Current channels is via 12 bit D/A converters. The offset (zero) and gain (span) trimming of the programming signals is accomplished by 4 8-bit D/A's pumping current into the programming loop. The values used to trim the unit are stored in EEPROM in the microcontroller. At power up the trim levels are restored.

Readback is via a 21-bit A/D converter. The software routines used for calibration "use up" some of this resolution, leaving an apparent 16-bit resolution. This is more accurate than needed for the great majority of supplies. Trim adjustments for OFFSET and GAIN, in both Voltage and Current channels, for PROGRAM and READBACK are implemented in software. Readback trim settings may be disabled at any time, the default mode at power up is TRIM ON. Trim settings are stored in nonvolatile EEPROM address space.

4.5 ELECTRICAL SPECIFICATIONS

OPERATING TEMPERATURE: 0 TO 40 DEGREES CENTIGRADE.
ISOLATION from IEEE(RS232) to POWER SUPPLY: 1000Vac.
AC INPUT: 95-130 VAC or 190-260 VAC 1Ø 47-63 Hz
IEEE-488.1: SWITCH SELECTABLE PRIMARY ADDRESS.

RS232C: 8-BIT WORD, 1 STOP BIT, 1 START BIT.
SWITCH SELECTABLE BAUD RATE 150 TO 9600 Bd.

PROGRAMMING RESOLUTION: 12-BIT
PROGRAMMING LINEARITY ERROR: ± 1.5 LSB.
PROGRAMMING FS. DRIFT ERROR: ± 200 PPM/degree C.
PROGRAMMING ZERO DRIFT ERROR: < 100uV/degree C.
PROGRAMMING SETTLING TIME: 100uS
READBACK RESOLUTION: > 15 bits (depends on readback setpoints).
READBACK LINEARITY ERROR: < 0.005 % FSO.
READBACK DRIFT ERROR: ± 2 LSB MAX. (0 TO 40 degrees C).
READBACK CONVERSION RATE: < 100 mS.
PROGRAMMING CALIB.: SOFTWARE (USING TRIMDACS - NO POTS)
READBACK CALIB: SOFTWARE (NO POTS)
REMOTE SHUTDOWN: DISABLE SUPPLY PWM

4.6 MECHANICAL SPECIFICATIONS

The RSTL is contained in a printed circuit board assembly mounted internally in the ESS power supply unit.

4.7 OPERATING INSTRUCTIONS

The following subsections describe the operation of the RSTL in detail.

4.7.1 GPIB AND RS232 INTERFACES

The RSTL interfaces to a computer using either GPIB or RS232 data transfer methods. See IEEE Std 488.1 for mechanical details of the GPIB connection. The RS232 port follows the 9-pin IBM AT serial port standard for DCE devices. The RSTL accepts a command string from either port and processes that string. If any messages are generated by the command string (e.g. Voltage Readback) the message is placed in an output buffer.

After the command string is processed the contents of the output buffer are transmitted over the RS232 lines. At any time the output buffer may be read using the GPIB. All messages are terminated with a carriage-return and a line-feed character.

The RSTL may be a Talker or a Listener.

The response of the RSTL to a Device Clear Command is to zero the voltage and current programming DACs. If the power supply is in remote mode it will be zeroed. If in local mode there will be no change in supply output. However, unless new voltage and current values are programmed in, the power supply will be zeroed upon returning to remote operation. The GPIB address and the RS232 baud rate are selected using the 8-position DIP switch on the rear of the supply. The settings are as follows:

SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**	**SW7**	**SW8**	**FUNCTION**
Bd3	Bd2	Bd1	AD5	AD4	AD3	AD2	AD1	
			X	X	X	X	X	IEEE ADDRESS
X	X	X						RS232 BAUD RATE
0	0	0						RS232 DISABLED
0	0	1						150 BAUD
0	1	0						300 BAUD
0	1	1						600 BAUD
1	0	0						1200 BAUD
1	0	1						2400 BAUD
1	1	0						4800 BAUD
1	1	1						9600 BAUD

Table 4.1 Dip Switch Settings

The baud rate is user selectable. However, the RSTL requires an 8-bit word, 1 stop, and 1 start bit for proper communications. There is *no* hardware handshaking, a properly received character will be echoed back over the RS232 line, assuming that the echo function is enabled. The default is to echo all characters, modifiable using the SET BACKTALK command:

SB1 = echo on, SB0 = echo off.

Since there is a finite amount of time required to perform a command, the user should not send a second command until the first command is complete. The unit is ready for the second command when bit 4 in the serial poll register is set.

The serial poll register is used as follows:

b0 set = Not Used.
b1 set = Not Used.
b2 set = Not Used.
b3 set = Not Used.
b4 set = supply ready to accept commands, when this bit is set after a command the results of the command (e.g. MV results) are now in the output buffer.
b5 set = Not Used.
b6 set = service request sent.
b7 set = power on initialization, reset by CLR or device clear finish. This bit simply indicates that the unit has been turned on. This bit is reset by a device clear command. If the bit then becomes set again, it is because the controller has reinitialized for some reason.

As an alternative method, the RSTL is able to assert a service request upon the implementation of a command that results in some return message. The command "SQ1" will enable this feature, "SQ0" will disable it. The default is NO service request.

"SQ0" = Don't assert SRQ when ready for next command (def).
"SQ1" = Assert SRQ when ready for next command.

4.7.2 SET-UP COMMANDS

There are several commands that may be issued to the RSTL to select operating conditions. Each must be followed by a CR LF (ASCII 13, 10).

The following two commands set the scaling values used by the RSTL in calculating correct programming and readback values. These have no effect in the HEX or %FULL SCALE modes. If not set properly the RSTL will return erroneous readback data and will program the supply incorrectly. The result is stored in nonvolatile memory.

"Set * Voltage dddd" = "S*Vdddd" = Set scaling voltage to dddd Volts.
"Set * Current dddd" = "S*Cdddd" = Set scaling current to dddd Amps.
dddd = 0000 to 1000 (must use four digits).

The set commands are as follows:

"Set Local" = "SL" = local operation (def)
"Set Remote" = "SR" = remote operation

"Set Backtalk 0" = "SB0" = RS232 echo off
"Set Backtalk 1" = "SB1" = RS232 echo on (def)

"Set Message length 0" = "SM0" = short output
"Set Message length 1" = "SM1" = verbose output (def)

"Set Trim 0" = "ST0" = disable trim adjustments
"Set Trim 1" = "ST1" = enable trim adjustments (def)

These commands may be explicitly spelled out in the command string sent to the ESS RSTL, but only those letters that are capitalized are actually needed. The rest are ignored.

e.g. "Set Message 0" is the same as "SM0"
"Set Remote" is the same as "SR"

Due to the limited WRITE/ERASE endurance of the EEPRO< in the RSTL's microcontroller, EMI cautions users from executing any of the following commands more than 10,000 times.

set_routine ( )	SD00	S*S
set_char( )	D01	SR
do_trim_progs ( )	SD10	SL
TRVO	SD11	SFXX
TRVG	S*DV0	PVL
TRCO	S*DV1	PCL
TRCG	S*DC0	
TPVO	S*Vdddd	
TPVG	S*Cdddd	
TPCO	S*L0	
SGCXX	S*L1	
SGVXX	S*XR	

4.7.3 INQUIRY COMMANDS

There are several inquiry commands used to check the operating conditions of the RSTL. Each command must have as its first character a question mark (?). Each must be followed by a CR LF (ASCII 13, ASCII 10). Each of these commands will result in a message being placed in the output buffer. The length of the returned message is determined by the setting of the BACKTALK bit (see 4.7.2)

The inquiry commands are as follows:

"? Model" = "?M" = Place Software Revision, Model and Serial number in output buffer

"? String" = "?S" = Previous command string ?

"? Operation" = "?O" = Local or remote operation?

"? Voltage channel " = "?V" = Voltage DAC programming value (decimal)?
"? Voltage channel heX" = "?VX" = Voltage DAC programming value (hex)?

"? Voltage channel Limit" = "?VL" = Voltage programming soft limit (decimal)?
"? Voltage channel Limit heX" = "?VLX" = Voltage programming soft limit (hex)?

NOTE: Models over 1000 volts, the limit will not set above 999.9 volts.

"? Current channel" = "?C" = Current DAC programming value (decimal)?
"? Current channel heX" = "?CX" = Current DAC programming value (hex)?

"? Current channel Limit" = "?CL" = Current programming soft limit (decimal)?

"? Current channel Limit heX" = "?CLX" = Current programming soft limit (hex)?

NOTE: Models over 1000 Amps, the limit will not set above 999.9 Amps.

"? Trim Voltage " = "?TV" = Trimming values for voltage channel?
"? Trim Current" = "?TC" = Trimming values for current channel?

These commands may be explicitly spelled out in the command string sent to the RSTL controller, but only those letters that are capitalized are actually needed. The rest are ignored.

"?M" will put a message in the output buffer of the following form:

"Rev 3.0 RSTL 10-1000 Serial 91A-1234"

This is of the form : Rev #1 RSTL voltage-current Serial #2, where #1 is the firmware revision number and #2 is the unit's serial number.

"?S" will return the last command string sent to the RSTL. This can be useful for debugging command sequences or verifying correct command reception.

"?O" will put one of the following messages in the output buffer:

"L operation" or "L"
"R operation" or "R"

if unit is in SHUTDOWN mode:

"R operation SHUTDOWN" or
"R SHUTDOWN"

"?V" will put the following message in the output buffer: "PVoltage = ddd.d Volts"
"?C" will put the following message in the output buffer: "PCurrent = ddd.d Amps"

"?VL" will put the following message in the output buffer: "PVoltage Limit = ddd.d Volts"
"?CL" will put the following message in the output buffer: "PCurrent Limit = ddd.d Amps"

"?VX" will put the following message in the output buffer: "Voltage = xxx"

"?CX" will put the following message in the output buffer: "Current = xxx"
"?VLX" will put the following message in the output buffer: "PVoltage Limit = xxx"
"?CLX" will put the following message in the output buffer: "PCurrent Limit = xxx"

xxx = the hex programming values of 000 to FFF.

"?TV" will put the following message in the output buffer: "1 ww xx yyyy zzzz"

Where the first character indicates whether or not the trim adjustments are disabled:

(1 = enabled, 0 = disabled).

ww = the hexadecimal value of the voltage programming offset trim value.

xx = the hexadecimal value of the voltage programming gain trim value.

yyyy = the hexadecimal value of the voltage readback offset trim value.

zzzz = the hexadecimal value of the voltage readback gain trim value.

"?TC" will put the following message in the output buffer: "1 ww xx yyyy zzzz"

This gives the same result for the current channel as "?TV" gives for the voltage channel.

4.7.4 MEASUREMENT COMMANDS

The RSTL is capable of measuring the output voltage and output current of the power supply. The optional A/D converter provides approximately 16-bit resolution. The readback message is returned as a measure of Voltage, Amperage or, for fastest operation, simply the hexadecimal output of the A/D converter. The length of the returned message is determined by the setting of the BACKTALK bit (see 4.7.2)

The measurement commands are as follows:

"Measure V" = "MV" = measure output voltage and return result in Volts format.

"Measure V heX" = "MVX" = measure output voltage and return result in hex format.

"Measure C" = "MC" = measure output current and return result in Amps format.

“Measure C heX" = "MCX" = measure output current and return result in hex format.

These commands may be explicitly spelled out in the command string sent to the RSTL controller, but only those letters that are capitalized are actually needed. The rest are ignored.

Assuming a 10 Volt, 1000 Amp ESS supply at 10 Volts and 500 Amps, the following messages would be returned using the following commands:

"MV" will put one of the following messages in the output buffer:
"Voltage = +10.000 Volts" or "+10.000"

"MC" will put one of the following messages in the output buffer:
"Current = 500.0 Amps" or "500.0"

"MCX" will put one of the following messages in the output buffer:
"Current = 8000" or "8000"

Note the value of the hex string: Zero = 0000 hex
Full Scale = ffff hex

4.7.5 PROGRAMMING AND SOFT LIMIT COMMANDS

The Voltage and Current programming channels have resolutions of 12-bits. In addition to these two channels there are two corresponding "soft limit" values that can be programmed. The soft limit is simply a programmed maximum or limit point. If, for example, the Voltage channel is programmed to some value in excess of the soft limit, the voltage output will not be allowed to exceed the soft limit. If the soft limit is increased then the output will increase until the initial programming level is reached. The default soft limit for both channels is full scale.
NOTE: Soft limits will not set above 999.9 Volts or 999.9 Amps.

There are several methods available to program the control and limit channels, these are:

Programming in Volts or Amps.
Programming as a percentage of full scale.
Programming the DAC directly in hexadecimal.

The programming channel commands are of the following forms:

Direct programming (Volts or Amps):

"Program Voltage 10.000" = "PV10.000" = Program Voltage to 10.000 Volts.

"Program Current 485" = "PC485" = Program Current to 485 Amps.

"Program Voltage Limit 10.000" = "PVL10.000" = Program Voltage Limit to 10.000 Volts.

"Program Current Limit 485" = "PCL485" = Program Current Limit to 485 Amps.

NOTE: Soft limits will not set above 999.9 Volts or 999.9 Amps.

Percentage full scale programming (0 to +%99.99):

"Program Voltage %50.00" = "PV%50" = Program Voltage to %50 of full scale.
"Program Current %99.99" = "PC%99.99" = Program Current to %99.99 of full scale.
"Program Current -%0.25" = "PC-%.25" = Program Current to negative %0.25 full scale.

"Program Voltage Limit %50.00" = "PVL%50" = Program Voltage Limit to %50 of FS.

"Program Current Limit %99.99" = "PCL%99.99" = Program Current Limit to %99.99 FS.

"Program Current Limit -%0.25" = "PCL-%.25" = Program Current Limit to neg. %0.25 FS.

Hexadecimal programming (0000h to ffffh):

"Program Voltage heX 0000" = "PVX0" = Program Voltage DAC to 000h (zero).
"Program Voltage heX 7ff" = "PVX7ff" = Program Voltage DAC to 7ffh (half scale).

"Program Current heX fff" = "PCXfff" = Program Current DAC to fffh (full scale).

"Program Voltage heX Limit 0000" = "PVXL0" = Program Voltage Limit to 000h (zero).
"Program Voltage heX Limit 7ff" = "PVXL7ff" = Program Voltage Limit to 7ffh (half scale).

"Program Current heX Limit fff" = "PCXLfff" = Program Current Limit to fffh (full scale).

4.7.6 TRIM PROGRAM COMMANDS (SOFT PROGRAMMING CALIBRATION)

The RSTL does not have any potentiometers to adjust the zero and full scale programming levels of the current and voltage channels. The calibration, or "trimming" function is accomplished by using TRIMDACS to adjust these parameters. The four trim levels are programmed using hexadecimal input coding. The adjustment range is between 00h and ffh. The nomenclature of the four trim programming parameters is (hh = hex programming level):

TRIM VOLTAGE CHANNEL OFFSET hh
TRIM VOLTAGE CHANNEL GAIN hh
TRIM CURRENT CHANNEL OFFSET hh
TRIM CURRENT CHANNEL GAIN hh

The trim programming commands are of the following forms:

"Trim Program Voltage Offset 80" = "TPVO80"=
Set voltage offset programming D/A to hex 80 (1/2 scale).

"Trim Program Voltage Gain ff" = "TPVGff"=
Set voltage gain programming D/A to hex ff (full scale).

"Trim Program Current Offset 40" = "TPCO40"=
Set current offset programming D/A to hex 40 (1/4 scale).

"Trim Program Current Gain c0" = "TPCGc0"=
Set current gain programming D/A to hex c0 (3/4 scale).

4.7.7 TRIM MEASURE COMMANDS (SOFT READBACK CALIBRATION)

The measurement, or readback, of the power supply's output voltage and current is accomplished by a high resolution A/D converter. To allow for software trimming of the readback levels the input to the A/D is pulled up slightly above zero and the full scale range slightly exceeds the actual signal to be measured. By taking a "snapshot" of the voltage and current sense signal at their zero and full scale points the RSTL can calculate all measured values. There are four commands used to take this snapshot; they must only be used when the output of the supply is at the appropriate level. The four trim readback parameters are:

"Trim Read Voltage Offset" = "TRVO" = Set voltage read zero point
"Trim Read Voltage Gain" = "TRVG" = Set voltage read full scale point
"Trim Read Current Offset" = "TRCO" = Set current read zero point
"Trim Read Current Gain" = "TRCG" = Set current read full scale point

The procedure to use these commands is as follows:

VOLTAGE READBACK ZERO:
Set the voltage output of the supply to zero using the "PV" command or equivalent.
Send the command "TRVO". This will store the voltage readback offset value in the EEPROM for later use in readback calculations.

VOLTAGE READBACK FULL SCALE:
Set the voltage output of the supply to full scale using the "PV" command or equivalent.
Send the command "TRVG". This will store the voltage read gain value in the EEPROM for later use in readback calculations

CURRENT READBACK ZERO:

Set the current output of the supply to zero using the "PC" command or equivalent.
Send the command "TRCO". This will store the current readback offset value in the EEPROM for later use in readback calculations.

CURRENT READBACK FULL SCALE:
Set the current output to full scale using the "PC" command or equivalent.
Send the command "TRCG". This will store the current read gain value in the EEPROM for later use in readback calculations.
If the readback seems to be *correct toward the full scale end but erroneous toward the zero end*, then repeat the zero procedure.
If the readback seems to be *correct toward the zero end but erroneous toward the full scale end*, then repeat the full scale procedure.

4.8 SERVICE PROCEDURES

4.8.1 GENERAL

The RSTL controller board is factory-installed; there are no user serviceable parts on it. Any operational difficulty with the board should be reported to Electronic Measurements Inc. The RSTL controller is shipped precalibrated from the factory; if it becomes necessary to recalibrate the operating parameters (Programming, Readback, etc.) this may be done by the user.

4.8.2 CALIBRATION

There are several end-user calibrations that may be made, these include:

Programming Voltage Zero
Programming Voltage Gain (full scale)

Programming Current Zero
Programming Current Gain (full scale)

Readback Voltage Zero
Readback Voltage Gain

Readback Current Zero
Readback Current Gain

The programming channels may be trimmed by approximately ± 10% using the 8-bit trim adjustments DACs. The DACs can be programmed in two ways, either directly using a hexadecimal input (00 to ff), or as a percentage of full scale (0% to 99%). Direct hex programming provides greater resolution and is the preferred method.

The trim setting should only be adjusted after the unit under test has fully warmed up.

The readback channels are trimmed quite differently from the programming channels. Internal to the RSTL is an AD7710 21-bit A/D converter. the input to this converter is slightly offset in the positive direction to force a zero input to cause some slight reading. the gain of the buffer-amplifier stage before A/D is set to provide a full-scale signal manipulation to “normalize” the readback data to the actual supply output levels. Readback trimming is limited to about +10% max on offset adjustments, and 20% max on gain adjustments.

Items needed for RSTL controller calibration:

RSTL Controller installed in a power supply.
4 1/2 digit voltmeter.
Calibrated external shunt (optional - internal shunt is very accurate).
Shorting strap or other load capable of handling the full current of the power supply.
Computer with IEEE-488 or RS232 port (see 4.8.3 for demonstration programs).

INITIAL SETUP:
Turn circuit breaker to OFF position.
Disconnect AC power from the power supply.
Connect IEEE or RS232 ports to computer or other IEEE-488 Controller.
Connect the AC power source to the supply and the RSTL (the RSTL will now be powered up if it is a separate unit).
Turn the power supply's AC circuit breaker to the ON position.
Establish communications between the computer and the RSTL.
Turn the power supply's AC circuit breaker to the OFF position.

VOLTAGE CHANNEL CALIBRATION:
Either disconnect the load from the power supply (open circuit) or adjust it such that the supply will be able to put out its full voltage.

Place meter across output terminals, observing proper polarity.
Turn the circuit breaker to ON position.
Send command "SR" (see 4.7.2).

VOLTAGE PROGRAM ZERO:
Send commands "PVX005" and "PCXFFF" (see 4.7.5).
Calculate the proper output voltage by dividing the full scale voltage of the power supply by 4096 and multiplying the result by 5 ((Vfs/4096) * 5 = zero calibration point).
The Meter should read the calculated zero calibration value ± 0.1% F.S.
Adjust TRIM PROGRAM VOLTAGE OFFSET until meter reads correct voltage (see 4.7.7)

VOLTAGE PROGRAM FULL SCALE:
Send command "PVXFFF" and "PCXFFF" (see 4.7.5).
Meter should read F.S. Voltage ± 0.1% F.S.
Adjust TRIM PROGRAM VOLTAGE GAIN until meter reads correct voltage (see 4.7.7).

VOLTAGE READBACK ZERO:
Program the supply to zero voltage (e.g. "PV0").
When the output voltage is zero ± 0.1 %, send the command: "TRVO". This will store the voltage read offset value in the EEPROM for later use in readback calculations (see 4.7.7).
Send command "MV" to initiate a read of the voltage channel (assuming the readback is calibrated).
Check to make sure the reading is now correct (voltage should equal zero).

VOLTAGE READBACK FULL SCALE:
Program the supply to full-scale voltage.
When the output voltage is at full-scale ± 0.1 %, send the command : "TRVG". This will store the voltage read gain value in the EEPROM for later use in readback calculations.
Send command "MV" to initiate a read of the voltage channel.
Check to make sure the reading is now correct (voltage should equal full scale).

Program and measure the voltage for several points throughout the supply's range. The programming and readback should track closely.

CURRENT CHANNEL CALIBRATION:
Turn circuit breaker to OFF position.
Either connect the load to the power supply and adjust it such that the supply will be able to put out its full current or connect the shorting strap to the power supply. If using an external shunt connect the shunt in series with the load or shorting strap.

Turn circuit breaker to ON position.
Send command "SR".

CURRENT PROGRAM ZERO:
Send the commands "PCX005" and "PVXFFF".
Calculate the proper output current by dividing the full scale current of the power supply by 4096 and multiplying the result by 5 ((Ifs/4096) * 5 = zero calibration point). NOTE: The full scale current value corresponds the voltage across the shunt being measured when the output current is at full scale. The typical E/M internal shunt will measure 100 milliVolts at full output current. The zero calibration point is therefore equal to (100/4096)*5 = 0.122 milliVolts. The meter should read the calculated zero calibration value ± 0.1% F.S. Adjust TRIM PROGRAM CURRENT OFFSET until meter reads correct current (see 4.7.7).

CURRENT PROGRAM FULL SCALE:
Send command "PCXFFF".
Meter should read F.S. Current ± 0.1% F.S.
Adjust TRIM PROGRAM CURRENT GAIN until meter reads correct current.

CURRENT READBACK ZERO:
Program the supply to zero current.
When the output current is zero ± 0.1 %, send the command: "TRCO". This will store the current read offset value in the EEPROM for later use in readback calculations.
Send command "MC" to initiate a read of the voltage channel.
Check to make sure the reading is now correct.CURRENT READBACK FULL SCALE:

Program the supply to full-scale current.
When the output current is at full-scale ± 0.1 %, send the command : "TRCG". This will store the current read gain value in the EEPROM for later use in readback calculations.
Send command "MC" to initiate a read of the current channel.
Check to make sure the reading is now correct.

Program and measure the current for several points throughout the supply's range. The programming and readback should track closely.

4.8.3 DEMONSTRATION GWBASIC PROGRAM

The following is a GWBASIC program to operate the RSTL controller card. This program requires the use of a National Instruments GPIB interface card in an AT-type PC. In addition, the Universal Language Interface program (ULI - included with National Card) should be run prior to running this GWBASIC program. See the National Instruments manual for proper installation and setup of the IEEE-488 Interface Card.

Line 2000 is the serial poll wait routine. After a command is sent the program looks for b4 to be set in the serial poll output register.

```
10    CLS
20    OPEN "GPIB0" FOR OUTPUT AS #1
30    OPEN "GPIB0" FOR INPUT AS #2
40    PRINT #1, "ABORT"
50    PRINT #1, "GPIBEOS CR LF"
60    PRINT "ESS TEST....."
70    PRINT "UNIT UNDER TEST MUST BE AT ADDRESS 6"
80    PRINT:PRINT "Enter Command..."
90    INPUT CMD$
110   IF CMD$ = "S" THEN GOSUB 1005
111   IF CMD$ = "C" THEN GOSUB 3000
120   PRINT #1,"OUTPUT 6 ;",CMD$
125   GOSUB 2000
140   PRINT #1, "ENTER 6"
150   INPUT #2, RD$
160   PRINT RD$
170   GOTO 80
1005  PRINT#1,"SPOLL 6"
1006  INPUT#2,SPR%
1007  PRINT SPR%
1009  GOTO 1005
1010  RETURN
2000  PRINT#1,"SPOLL 6"
2010  INPUT#2,SPR%
2015  PRINT HEX$(SPR%)
2020  IF SPR% AND 16 THEN 2040
2030  GOTO 2000
2040  RETURN
3000  PRINT#1,"CLEAR 6"
3010  RETURN
```

Table 4.2 Demonstration GWBasic Program

4.8.4 DEMONSTRATION QUICK-C PROGRAM

The following is a Quick-C program to operate the RSTL controller card. This program requires the use of a National Instruments GPIB interface card in an AT-type PC. See the National Instruments manual for proper installation and setup of the IEEE-488 Interface Card.

```
/*
        SIMPLE INTERACTIVE RSTL PROGRAM USING
        MICROSOFT QUICK-C & NATIONAL INSTRUMENTS PCII-A CARD
*/
#include <c:\qc25\include\stdio.h>
#include <c:\qc25\include\math.h>
#include <c:\qc25\include\ctype.h>
#include <c:\qc25\include\dos.h>
#include <c:\qc25\include\graph.h>
#include <c:\qc25\include\time.h>
#include <c:\qc25\include\sys\types.h>
#include <c:\qc25\include\sys\timeb.h>
/* The following is provided on the National Instruments distribution disk */
#include <c:\gpib-pc\decl.h>

/*----------------------------------------*/
/* IEEE functions and definitions */
/*----------------------------------------*/

#define ERR     (1<<15)     /* Error detected          */
#define TIMO    (1<<14)     /* Timeout                 */
#define RQS     (1<<11)     /* Device needs service    */

extern int      ibsta,
                iberr,
                ibcnt;

/*-------------------------------------------------------------------------*/
/* Application program variables passed to GPIB functions */
/*-------------------------------------------------------------------------*/

char            rd[512];        /* read data buffer */
int             rstl,           /* RSTL identifier */
                brd0;           /* National GPIB board identifier */
char            spr;            /* serial poll response byte */

main()
{
void            read_rstl();

char            command[40];

        _clearscreen(_GCLEARSCREEN); /* clear display screen */
```

```
/*-------------------------------------------------------------------------*/
/* initialize the National Controller at address 0 on the GPIB */
/*-------------------------------------------------------------------------*/

        brd0 = ibfind ("GPIB0");

        if(brd0 < 0)
        {
                printf("Didn't find brd0\r\n");
                finderr("GPIB0");
        }
        ibeos(brd0,"\n");

/*-------------------------------------------------------------*/
/* initialize the RSTL at address 6 on the GPIB */
/*-------------------------------------------------------------*/
        rstl = ibfind("DEV6");

        if(rstl < 0)
        {
                printf("Didn't find rstl at dev6\r\n");
                finderr("DEV6");
        }
        if (ibclr(rstl) & ERR)
        {
                error(); /* clear rstl, check for error */
        }
        printf("Initializing RSTL...\r\n");
        write_rstl("sr\r\n");
        for(;;)  /* simple command loop */
        {
                printf("\nEnter Command >>> ");
                gets(command);
                write_rstl(command);

                  for(sp_byte = 0x00; (sp_byte & 0x10) == 0x00 ;) /* wait for
                ready bit to be set */
                {
                  ibrsp(rstl,&sp_byte);
                  printf("serial poll = 0x%02x\r\n",sp_byte);
                }
                read_rstl();
                printf("\n%s",rd);
        strncpy(rd," ");
        }
}  /*                END OF MAIN()                        */
```

```
/*-------------------------------------------------------------------*/
/* The following routine will write a string to the RSTL */
/*-------------------------------------------------------------------*/

int
write_rstl(char message[])
{
        if (ibwrt (rstl,message,strlen(message)) & ERR)
                error();
if (ibwrt (rstl,"\r\n",2) & ERR)
                error();
        ibcmd (brd0,"_?",2); /* UNT UNL */
}
/*-----------------------------------------------------------*/
/* The following routine will read a string from the RSTL */
/*-----------------------------------------------------------*/

void
read_rstl()
{
        if (ibrd(rstl,rd,40) & ERR)
                error();
        ibcmd (brd0,"_?",2); /* UNT UNL */
}
/*--------------------------------*/
/* National error routines */
/*--------------------------------*/

int
finderr(char device[]) /* ibfind failure error routine */
{
   printf("Ibfind error on %s; does device or board\n",device);
   printf("name given match configuration name?\n");
}

int
error() /* general error handling routine */
{
   printf("GPIB function call error:\n");
   printf("ibsta=0x%x, iberr=0x%x,",ibsta,iberr);
   printf(" ibcnt=0x%x\n",ibcnt);
}
int
rstlerr() /* device error handling routine */
{
   printf("Device error\n");
   printf("ibsta=0x%x, iberr=0x%x,",ibsta,iberr);
   printf(" ibcnt=0x%x\n",ibcnt);
}
```

4.8.5 DEMONSTRATION LAB WINDOWS FOR DOS PROGRAM

The following is a LabWindows for DOS program to operate the RSTL controller card. This program requires the use of a National Instrument LabWindows software package and a National Instruments GPIB interface card in an AT-type PC. See the National Instruments manual for proper installation and setup of the IEEE-488 Interface Card.

```
/*
/*      SIMPLE INTERACTIVE LAB WINDOWS FOR DOS PROGRAM
/*
/*
#include "C:\LW\INCLUDE\lwsystem.h"
#include "C:\LW\INCLUDE\utility.h"
#include "C:\LW\INCLUDE\gpib.h"
#include "C:\LW\INCLUDE\formatio.h"
#include "C:\LW\INCLUDE\userint.h"
#include "C:\LW\INCLUDE\graphics.h"
#include "C:\LW\INCLUDE\analysis.h"
#include "C:\LW\INCLUDE\vxi.h"
#include "C:\LW\INCLUDE\rs232.h"

/*---------------------------------------------------------------------*/
/* The following are IEEE functions and definitions */
/*---------------------------------------------------------------------*/
#define ERR     (1<<15)      /* Error detected           */
#define TIMO    (1<<14)      /* Timeout                  */
#define RQS     (1<<11)      /* Device needs service     */

int ibsta,
   iberr,
   ibcnt;

/*---------------------------------------------------------------------------*/
/* Application program variables passed to GPIB functions */
/*---------------------------------------------------------------------------*/

char    command[80];    /* command input buffer */

int     rstl,           /*  RSTL */
       brd0;            /* National GPIB board */

int     spr;            /* serial poll response byte */

int     status;

long    stptme,strtme;
long    pretme,eltme;
long    strtime,ptime;
main()
{
/*-----------------------------------*/
```

```
/* Local variable assignment */
/*-----------------------------------*/
  void    supply_init();
    char    *read_rstl();
/*-------------------------------------------------------------------------*/
/* initialize the National Controller at address 0 on the GPIB */
/*-------------------------------------------------------------------------*/

    brd0 = ibfind ("GPIB0");

    if (brd0 < 0)
    {
        FmtOut("Didn't find board and GPIB0\r\n");
        finderr("GPIB0");
    }

    /*-----------------------------------------------------------*/
    /* Set end of string character to LineFeed, 0x0a */
    /*-----------------------------------------------------------*/

    ibeos(brd0,0x0a);

    /*-----------------------------------------------------*/
    /* initialize the RSTL at address 6 on GPIB */
    /*-----------------------------------------------------*/

    FmtOut("Initializing RSTL...\r\n");
    rstl = ibfind ("DEV6");
    if(rstl < 0)
{
        FmtOut("Didn't find device at DEV6\r\n");
        finderr("DEV6");
    }

    if (ibclr(rstl) & ERR)   /* Clear device at address 6 */

    {
         error(); /* clear rstl, check for error */
    }

    for(;;)  /* Infinite Command and Message Readback loop */
    {
        FmtOut("Enter command : ");
        ScanIn("%s",command);
        FmtOut("       Command: %s\r\n",command);
        write_rstl(command);
        FmtOut ("        Return: %s \r\n", read_rstl() );
    }
}
/*-------------------------------------*/
/* RSTL-Specific subroutines */
/*-------------------------------------*/
```

```
/* The following routine will write a string to the RSTL */

int
write_rstl(char message[])
{
    if (ibwrt (rstl,message,StringLength(message)) & ERR)
        error();
    ibwrt (rstl,"\r\n",2);
}

/* The following routine will read a string from the RSTL */

char
*read_rstl()
{
    int     xyz;
    char    read_data[80];

    for(xyz = 0 ; xyz < 80; xyz++)
        read_data[xyz]='\0';

    if (ibrd(rstl,read_data,80) & ERR)
        error();
    return(read_data);
}
/* National error routines */

int
finderr(char device[]) /* ibfind failure error routine */
{
   FmtOut("Ibfind error on %s; does device or board\n",device);
   FmtOut("name given match configuration name?\n");
}
int
error() /* general error handling routine */
{
   FmtOut("GPIB function call error:\n");
   FmtOut("ibsta=0x%x, iberr=0x%x,",ibsta,iberr);
   FmtOut(" ibcnt=0x%x\n",ibcnt);
}
int
rstlerr() /* device error handling routine */
{
   FmtOut("Device error\n");
   FmtOut("ibsta=0x%x, iberr=0x%x,",ibsta,iberr);
   FmtOut(" ibcnt=0x%x\n",ibcnt);
}
```

5 THEORY OF OPERATION

5.1 REFERENCE

01-481-XXX Main schematic 220, 380, 400, 415, 480 Vac input (XXX depends on model).

01-000-360 A200 Inverter Board. All models.
01-000-635 A100 Board Schematic 220, 380, 415, 480 Vac.

The 220 Vac version works with 3 phase four wire systems. The Input AC is rectified by CR1. A raw DC bus is created with a parallel combination of C1 and C2. Refer to main schematic. The power is processed by four high frequency transformers coupled with full bridge buck converters. The raw DC bus is connected to the input of a full bridge inverter. The output from the bridge is controlled by the duty cycle of the PWM. For 220 Vac input, all four modules are connected to the parallel combination of C1 and C2.

5.2 POWER FLOW

The AC power enters through TB1 on the rear of the unit and passes through the A300 line filter board. The load side of the line filter is connected to the front panel circuit breaker. The raw DC bus is created by the series or parallel combination of C1 and C2. L1 controls the peak charging current which is inherent in capacitive input filters. Additionally, L1 also increases the conduction angle, thereby improving the power factor of the system.

The inverter board consists of four full bridge inverters. The output of the inverter is a 33 kHz PWM square wave, which is fed to the primary of transformers T1A to T1D. The secondaries of the transformers are connected to a full wave rectifier and an LC averaging filter. Each module is connected to the output bus bar. The output has preload resistors mounted on the heatsink assembly. The output filter consists of L2A-2D, L3, C7, C8, C9, and C10. An RC snubber is used to minimize the voltage spike across the diodes.

5.3 INVERTER MODULE

The full bridge inverter consists of four IGBTs. T1 is designed such that Q1 and Q4 are turned on simultaneously while Q2 and Q3 are turned off. T2 senses the switching of the IGBTs and the switching of the HF power transformer's primary current. CR9, CR10, CR11, and CR12 rectify the signal from T2 and generate a voltage across the burden resistor R14. The signal across R14 is connected to the A100 card for control purposes. C5 snubs the spikes generated by the primary leakage inductance of the HF power transformer. CR2, CR4, CR6 and CR8 are the anti-parallel diodes across the switches. The RC snubber across the device limits the dv/dt so that latching of the IGBTs is prevented. L1, C13 and C14 form a bypass circuit which delivers the entire pulse current of the inverter, thereby reducing the area of high frequency pulse current. The signal from TS1 shuts the PWM down in case of over heating. The A100 board controls steady state volt-second balance across the high frequency power transformer to prevent saturation of T1.

5.4 SIGNAL FLOW

A100 BOARD: This board generates ± 15 volts and +5 volts for "Housekeeping" purposes. Other functions of the A100 control board:

1) Reference Generation

2) CC/CV Control

3) Control of PWM

4) Supervisory Functions

5) Over current protection

5.5 REFERENCE GENERATION

Separate constant current references are provided for voltage and current channels. The collector current of Q1 drives the voltage channel. The collector current of Q2 drives the current channel. The current sources are referenced by U6, a highly stable voltage source. The current through the sources is adjustable by R6 and R8. The current sources are factory adjusted to 1 mA, and terminate at J1-3 and J1-9 on rear panel programming connector.

5.6 ERROR AMPLIFIERS

Constant voltage control and error amplification are implemented by U7. The reference (0-5 Volts) is connected to the non-inverting terminal of U7. An attenuated version of the output voltage is connected to the inverting terminal of U7. A voltage of 0 to 5 volts across R136 is the equivalent of 0 to 100% of the output voltage. The output of the voltage channel amplifier can be measured at A1. It should be -0.7 volts for the shutdown condition and 6 volts for maximum duty cycle. The offset null is adjusted by R15. Constant current is implemented by U8 and U9. The references are connected to the non-inverting inputs of U9.

The output current is sensed by shunt R12 mounted in the power supply. The output of the current channel can be measured at B1. It should be -0.7 volts shutdown or 6 volts. Voltage and current channels are "ORed" via diodes CR41 and CR31, and thus provide automatic crossover from current to voltage control and vice versa.

5.7 PULSE WIDTH MODULATOR

The "core" of the A100 board consists of the four UC 3825 controllers. U15, U16, U17 and U18 are synchronized by the clock consisting of U4, U20, U21, U22, U23, and output drivers U22A-B, which comprise the sync needed to control the point at which the oscillator ramp begins.

All error amplifiers of U15, U16, U17 and U18 have a unity gain. Their inputs are tied together and receive their signal from U7 and U9. Q4, Q6, Q8, and Q10 isolate the clock signal from the oscillators to provide slope compensation for U15, U16, U17 and U18.

Signals are fed through diodes CR62, CR70, CR63 and CR71 to pin 7. At pin 7, the clock signal and the current signal are combined. C54, C64, C74 and C84 block DC from Q4, Q6, Q8 and Q10 from appearing on pin 7 of each PWM.

The duty cycle of the PWM is controlled by comparing the output of the error amplifiers (U15, U16, U17 and U18) to the ramp of the oscillator and the current sense signal of the high frequency transformers.

Q5, Q9, Q7 and Q11 make up the soft start. When their bases are pulled low or their emitters are pulled low, the PWM shuts down. When the bases or the emitters are released, the PWMs will slowly widen pulse width and then are controlled by error amps.

5.8 SUPERVISORY FUNCTIONS

U14, U11, and U12 and the associated components form the supervisory circuit. These functions include: undervoltage lockout, phase loss detection, overvoltage protection, control failure, inrush current suppression, mode detect and over- temperature lockout. Inrush current limitation and mode detection are implemented by U12. The other functions are implemented by the power supply's supervisor chip U14 (UC3544).

5.9 REMOTE TURN ON CIRCUIT

This feature allows the user to control the power supply from a remote location with a 12-24 Vdc, 24-115 Vac or a dry contact closure. U4 provides isolation from the power supply ground. When using a dry contact closure, the power is supplied by the bias transformer, rectified on the A100 board, and then routed to J14 to CR47. The interlock side is opened or closed by J1 15 and J1 16.

5.10 INRUSH CURRENT LIMITING CIRCUIT

The soft start is controlled by the A100 board and works in conjunction with the K1 that is on the input rectifier assembly. When power is applied to the supply, the output of U12 is low. The input bus capacitors are charged via K1 with a resistor to limit the inrush current. After the elapsed time, which is determined by R47, R49 and C42, the output of U12 switches to high, closing both poles of the relay (K1). The soft start pins of U15, U16, U17, and U18 go high, enabling the PWMs.

5.11 MODE DETECT

The output of the voltage channel and current channel are compared by the second op-amp of U12. The output of the comparator switches between plus and minus 15 volts, depending on the magnitude of its input signal. If the output is positive, the voltage LED on the front panel lights; if it is negative, the current LED lights.

5.12 THERMAL SHUTDOWN

The heatsink’s temperature is sensed by individual thermostats wired in parallel. The thermostats are normally open but they close when the temperature exceeds 70 degrees Celsius. A closed thermostat will pull the soft start pins of U15, U16, U17, and U18 low, disabling the PWMs.

5.13 PHASE LOSS CIRCUIT

The phase loss circuit is the same for all the models, except that the 220 Vac model does not detect a neutral loss.

5.13.1 PHASE LOSS CIRCUIT FOR THE 220 VAC

The incoming AC line is rectified (on the PCB A600 assembly) and optically coupled to the control section. The output of the opto-coupler is controlled by R602 and R601. The output of the opto-coupler is connected to pin 9 of U14 (on the A100 board) and is compared to the 2.5 volts reference on pin 8. For normal operation, pin 11 is high (15 volts). When a phase loss or a low line occurs, pin 11 switches to low causing the soft start pins of U15, U16, U17, and U18 to go low, thus disabling the PWMs and turning the phase loss LED on.

5.13.2 PHASE LOSS CIRCUIT FOR THE 380, 415 AND 480 VAC

The incoming AC line is rectified (on the PCB A600 assembly) and optically coupled to the control section. The output of the opto-coupler is controlled by R4, R6 and R7. The output of the opto-coupler is connected to pin 9 of U14 (on the A100 board) and is compared to the 2.5 volts reference on pin 8. For normal operation, pin 11 is high (15 volts). When a phase loss or a low line occurs, pin 11 switches to low, causing the soft start pins of U15, U16, U17, and U18 to go low, thus disabling the PWMs and turning the phase loss LED on. The neutral loss circuit is comprised of R1, R2, R3, CR7, CR9, CR1 and U1. If the neutral line is disconnected, a voltage will develop across R5 causing U1 to disable U2. Therefore, the soft start pins of U15, U16, U17, and U18 will go low disabling the PWMs.

5.14 OVERVOLTAGE PROTECTION

This feature allows the user to control the power supply's overvoltage trip point. The overvoltage control (R16) located on the front panel controls an adjustable 2.5 volt reference which is fed to the U14 on the A100 board. An attenuator on the A100 board also couples the DC signal to U14. When the signal of the attenuator is higher than the adjustable 2.5 volt reference, U14, drives a DC signal to the A900 board. U801 (SCR optocoupler) drives Q601, which crowbars the output of the power supply. At the same time, U14 pulls the (SS line) low, which shuts off the PWM.

6 MAINTENANCE

6.1 MAINTENANCE

To be performed only by qualified service personnel. Prior to removing the cover, refer to Section 1.2, page 1 for safety warnings.

6.2 INTRODUCTION

This section provides a troubleshooting guide, module replacement procedures and a calibration procedure. The troubleshooting guide addresses the most common symptoms and their causes. The replacement procedure outlines the removal and replacement of the Field Replaceable Units (FRUs). The calibration procedure outlines the adjustment of the A100 board. Whenever any troubleshooting, replacement or calibration is done, the schematics and components listed in section 6.10 should be used for reference.

6.3 TROUBLESHOOTING GUIDE

SYMPTOMS	POSSIBLE CAUSE
No Output. Control Failure LED is on.	Remote on/off is disconnected. A100 board failure, inverter failure or neutral disconnected on 380, 414, 480 Vac input models, or OVP fired. NOTE: When remote is OFF, control failure will be ON. This is a normal condition.
Phase Loss LED is on	AC line low or phase/neutral is disconnected.
Supply working, but Power On LED is not glowing.	Faulty Power On LED.
Supply not working and Power On LED not glowing	F1 fuse blown. Bias supply failure or fan(s) failure.
Inverter LED is glowing	Inverter failed (replace inverter), check diodes on output assembly.
RSTL doesn't work	Check address switch.
Circuit breaker trips	Input rectifier failed or inverter failed.
Unit output goes too high. Voltage and current are unadjustable.	Wires to voltage or current pots are disconnected. Voltage or current pot is broken.
Cannot reach full output	One or two inverters have failed.
High ripple	One of the output caps has failed.
Overheating	One of the fans have failed or an inverter is overheating.

Table 6.1: Troubleshooting Guide

6.4 FIELD REPLACEABLE UNITS (FRUS)

This supply is comprised of several modules (assemblies). If a module fails, simply replace it with an identical one. A front panel LED will glow to indicate which module (assembly) has failed. FRUs (modules) are replaced by removing the screws on the top cover which allows access to the modules. When ordering a FRU, please refer to its Lambda-EMI number and the model number of the power supply. The table below provides a list of the modules and their EMI part numbers.

FRU	AC Input Voltage Of Supply	EMI Part Number
A200 Inverter Board	220-480	23-227-001
A100 Control Board	220, 380-415, 480	20-906-7XX 20-906-8XX
A900 OVP Board	220-480	20-460-1XX
Main Rectifier Assembly	220, 15KW 220, 10KW 380 415 480	26-330-004 26-330-002 26-330-009 26-330-010 26-330-005
Fan Assembly	All Models	12-481-003
RSTL A500	All Models	20-758-001

Table 6.2: FRUs

Caution: Proper ESDS (Electrostatic Discharge Sensitivity) procedures should be adhered to whenever replacing a module or troubleshooting the power supply.

Prior to removing the top cover of the power supply, Refer to **Safety Precautions,** section 1.2 of page 1. Simply loosen the screws that attach the cover to the chassis and remove the cover.

6.5 INVERTER A200

There are four inverter board assemblies in the power supply. Inverter failures are indicated on the front panel by their LEDs. To remove a module, loosen the five captive screws on the plate between inverters 1 and 2 (or inverters 3 and 4), then remove the plate. Unplug the multi-pin cable near the top and remove the screws holding the red and black wires. Lift out the module and unplug the red two pin connector. Install the new module in the reverse order. All four inverter modules are removed and installed in the same manner.

6.5.1 INVERTER A200 TEST

After the module has been replaced, the following test procedure should be done:

A) With no load connected to the output terminals of the power supply, adjust the front panel's Voltage and Current controls fully counter clockwise.

B) Apply power. Turn on the front panel CB (supply starts after a ten second delay). Turn up the Current and Voltage controls until the output is about 15% of Max. voltage, then adjust the load for about 20% of Max. current.

6.6 A100 CONTROL BOARD

All of the plugs (12 total) on the A100 board should be disconnected before removing the board. Unscrew and remove the six screws which hold the board to the chassis. Remove J1

which is located on the rear panel. The board should now be free of any connections and can be simply removed. Replace in the reverse order and be sure the connectors are correctly plugged back into the PCB. If unsure, mark the connectors before unplugging.

A) Rotate the front panel controls fully counter clockwise.

B) Apply AC power. Turn on the front panel CB and slowly advance the current control 1/4 turn. Slowly advance the voltage control. The output should gradually increase as the Voltage control is rotated.

6.7 FAN ASSEMBLY

The procedure for removing the fans is as follows. Unscrew the captive screws (two for each) that attach each fan to the chassis. After the base screws are loose, remove the two screws near the top which screw into the flat chassis plate where the A100 PCB is mounted. After unsoldering the wires to the AC terminal, the fan assembly can be removed. To install, follow the reverse order.

6.8 MAIN RECTIFIER ASSEMBLY

To remove the rectifier assembly, face the front panel. The chassis left side cover has to be removed. This side cover is fastened with seven screws to the chassis. After this side is removed the rectifier assembly can be accessed. The two bottom flat head screws, hold the bracket to the chassis.

After the flat head screws are removed, the five large wires and eleven small wires must be removed before the assembly is ready for removal. Because of the large number of wires, mark each wire as it is being removed so that it can be replaced correctly. The reassembling is the reverse sequence of that used to remove the module.

A) Adjust the front panel controls fully counter clockwise.

B) Apply AC power and turn the front panel CB on.

C) Advance the current control fully counter clockwise and slowly adjust the voltage control until system output voltage is achieved.

D) Apply full load current and the output voltage deviation should be less than 0.1% of maximum output. The unit can now be returned to service.

6.9 A900 OVP BOARD

A) After the board has been replaced, the operation of the board should be checked.

B) Apply AC power and turn on the CB.

C) Adjust front panel OVP control fully clockwise, as the voltage of the set increases to the front panel setting of the voltage pot on front panel, turn the OVP control pot counter clockwise until the OVP activates. After the OVP has been activated, turn CB off and return OVP setting to the desired point. Turn CB back to verify that set is functioning properly.

6.10 CALIBRATION

Calibration of the A100 Board is necessary whenever replacing the A100 Board, the voltage control, or the current control. The following is the calibration procedure for the A100 Board. Refer to schematic #01-000-716.

1. Remove cover.
2. Rotate voltage and ammeter potentiometers counter clockwise.
3. Turn power supply on.
4. Partially rotate voltage potentiometer clockwise.
5. Connect negative lead of DVM to pin 2 of U24.
6. Connect positive lead of DVM to cathode of CR31.
7. Digital meter should display 6 Vdc.
8. Rotate voltage potentiometer counter clockwise.
9. Adjust R15 until DVM displays -0.6 volts.
10. Partially rotate current potentiometer clockwise.
11. Connect positive pin of DVM to cathode of CR41 (keep negative lead of DVM at pin 2 of U24).
12. DVM should display 6 volts.
13. Rotate current potentiometer fully counter clockwise.
14. Adjust R21 until DVM displays -0.6 volts.
15. Connect positive pin of DVM to collector of Q1 (keep negative lead of DVM at pin 2 of U24).
16. Connect another DVM across output of power supply (no load is connected to output).
17. Rotate voltage potentiometer fully clockwise.
18. Voltage of collector Q1 should be 5 ± 0.01 Vdc, if not adjust R6.
19. Adjust R148 until output of power supply is equal to $V_{out\ max.} \pm 0.1$ Vdc.
20. Disconnect DVMs. Turn off circuit breaker. Connect $R_{load} \leq$ (maximum output voltage÷ maximum output current) to output terminals of power supply.
21. Connect a DVM to pins 1 & 2 of J2 (shunt R12). Refer to the A100 board schematic (use R25 and R26 for convenience).
22. Connect positive lead of another DVM to collector of Q2. Connect negative lead to pin 2 of U24.
23. Turn on circuit breaker. Rotate current potentiometer fully clockwise. Verify that the supply is in the current mode; the current LED should glow.
24. Voltage of collector Q2 should be 5 ± 0.01 Vdc, if not adjust R8.
25. Adjust R34 until voltage across shunt (pins 1 & 2 of internal J2) is $100 \pm .01\%$.

6.1 SCHEMATICS AND COMPONENTS

The following pages contain component charts and schematics to be used as references for any troubleshooting, replacement or calibration.

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