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OPERATOR MANUAL FOR

EMS

POWER SUPPLY

83-473-000 Revision J

MODEL _____

SERIAL NUMBER _____

LAMBDA EMI

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Table of Contents

1 **GENERAL INFORMATION**	1 - 1
1.1 INTRODUCTION	1 - 1
1.2 SAFETY PRECAUTIONS	1 - 1
1.3 SPECIFICATIONS	1 - 2
1.3.1 INPUT POWER	1 - 2
1.3.2 AC INRUSH CURRENT	1 - 2
1.3.3 REGULATION	1 - 3
1.3.4 TRANSIENT RESPONSE	1 - 4
1.3.5 STABILITY	1 - 4
1.3.6 REMOTE PROGRAMMING	1 - 4
1.3.7 METER TOLERANCE	1 - 5
1.3.8 PHYSICAL SPECIFICATIONS	1 - 5
1.4 OVERALL EFFICIENCY	1 - 5
1.5 ENVIRONMENTAL SPECIFICATIONS	1 - 6
1.5.1 ELECTRICAL INSTALLATION CATEGORIES	1 - 6
1.5.2 OPERATING TEMPERATURE	1 - 6
1.6 OVER TEMPERATURE PROTECTION	1 - 6
1.7 OVERVOLTAGE PROTECTION (FOR OUTPUTS ≤ 300 VDC)	1 - 6
1.8 RSTL CONTROLLER BOARD	1 - 6
1.9 COOLING	1 - 7
1.10 MODEL NUMBER	1 - 7
1.11 RETURNING EQUIPMENT	1 - 8
2 INSPECTION AND INSTALLATION	2 - 1
2.1 VISUAL INSPECTION	2 - 1
2.2 LOCATION	2 - 1
2.3.1 EMC REQUIREMENTS	2 - 2
2.4 ELECTRICAL INSPECTION	2 - 3
3 OPERATING INSTRUCTIONS	3 - 1
3.1 FRONT PANEL	3 - 1
3.2 OPERATING MODES	3 - 2
3.2.1 CONSTANT VOLTAGE MODE	3 - 2
3.2.2 CONSTANT CURRENT MODE	3 - 2
3.2.3 OUTPUT NULLING	3 - 2
3.3 PROGRAMMING MODES	3 - 2
3.3.1 LOCAL PROGRAMMING	3 - 3
3.3.2 REMOTE PROGRAMMING OF VOLTAGE CHANNEL	3 - 4
3.3.3 REMOTE PROGRAMMING OF CURRENT CHANNEL	3 - 6
3.4 PARALLEL OPERATION	3 - 8
3.5 PARALLEL OPERATION - MASTER/SLAVE	3 - 9
3.6 SERIES OPERATION	3 - 10
3.7 SERIES OPERATION MASTER/SLAVE	3 - 11
3.8 REMOTE METERS (P.S. WITH OUTPUT OF 300V OR LESS)	3 - 11
3.9 REMOTE SENSING (P.S. WITH OUTPUT VOLTAGE 300V OR LESS)	3 - 12
3.9.1 REMOTE SENSING (P.S. WITH OUTPUT VOLTAGE OVER 300V)	3 - 12
3.10 REMOTE TURN ON	3 - 12
3.11 LOAD CONNECTION	3 - 13
4 THEORY OF OPERATION	4 - 1
4.1 PRINCIPLES OF OPERATION	4 - 1

4.2 INPUT SECTION 4 - 1
4.3 A200 INVERTER BOARD 4 - 1
4.4 OUTPUT SECTION 4 - 2
4.5 A100 CONTROL BOARD 4 - 2
4.5.1 SUPERVISORY FUNCTIONS 4 - 2
4.5.2 OVER CURRENT PROTECTION 4 - 3
4.5.3 SET-POINT REFERENCE 4 - 4
4.5.4 VOLTAGE CONTROL CHANNEL 4 - 4
4.5.5 CURRENT CONTROL CHANNEL 4 - 4
4.5.6 AUTOMATIC CROSSOVER 4 - 4
4.5.7 PULSE WIDTH MODULATOR FOR THE 600W/1KW 4 - 4
4.5.8 PULSE WIDTH MODULATOR FOR THE 2.5KW/5KW 4 - 5
4.5.9 TRANSISTOR DRIVE FOR THE 600W/1KW 4 - 5
4.5.10 TRANSISTOR DRIVE FOR THE 2KW/2.5KW AND 5KW 4 - 5
5 CALIBRATION AND TROUBLESHOOTING 5 - 1
5.1 INTRODUCTION 5 - 1
5.2 INSPECTION AND CLEANING 5 - 1
5.3 CALIBRATION 5 - 1
5.3.1 ANALOG METER ZERO CALIBRATION 5 - 1
5.3.2 VOLTAGE CHANNEL AND VOLTMETER CALIBRATION 5 - 2
5.3.3 CURRENT CHANNEL AND AMMETER CALIBRATION 5 - 2
5.4 TROUBLESHOOTING 5 - 3

List of Figures

FIGURE 2.1: DELTA TO WYE CONNECTION 2 - 2
FIGURE 3.1: FRONT PANEL, (5KW MODEL SHOWN) 3 - 1
FIGURE 3.2: OPERATING MODES 3 - 2
FIGURE 3.3 REAR PANEL “D” CONNECTOR 3 - 3
FIGURE 3.4: LOCAL PROGRAMMING 3 - 3
FIGURE 3.5: REMOTE PROGRAMMING BY EXTERNAL RESISTANCE, VOLTAGE MODE 3 - 4
FIGURE 3.6A: REMOTE PROGRAMMING BY EXTERNAL VOLTAGE, VOLTAGE MODE 3 - 5
FIGURE 3.6B: REMOTE PROGRAMMING BY EXTERNAL VOLTAGE,VOLTAGE MODE (AS PER 0 - 10V OPTION). 3 - 5
FIGURE 3.7: REMOTE PROGRAMMING BY EXTERNAL CURRENT, VOLTAGE MODE. 3 - 6
FIGURE 3.8: REMOTE PROGRAMMING BY EXTERNAL RESISTANCE, CURRENT MODE 3 - 7
FIGURE 3.9A: REMOTE PROGRAMMING BY EXTERNAL VOLTAGE, CURRENT MODEL 3 - 7
FIGURE 3.9B: REMOTE PROGRAMMING BY EXTERNAL VOLTAGE, CURRENT MODE (AS PER OPTION) 3 - 8
FIGURE 3.10: REMOTE PROGRAMMING BY EXTERNAL CURRENT, CURRENT MODE 3 - 8
FIGURE 3.11: PARALLEL OPERATION 3 - 9
FIGURE 3.12: PARALLEL OPERATION, MASTER/SLAVE 3 - 10
FIGURE 3.13: SERIES OPERATION 3 - 10
FIGURE 3.14: SERIES OPERATION, MASTER/SLAVE 3 - 11
FIGURE 3.15: REMOTE SENSING 3 - 12
FIGURE 4.1: SIMPLIFIED EMS POWER SUPPLY 4 - 1

List of Tables

TABLE 1.1: INPUT POWER 1 - 2
TABLE 1.3: RIPPLE FOR THREE PHASE 1 - 4
TABLE 1.4: REMOTE PROGRAMMING ACCURACY 1 - 5
TABLE 1.6: PHYSICAL SPECIFICATIONS 1 - 5
TABLE 1.7: MODEL NUMBER 1 - 7
TABLE 3.1: FRONT PANEL CONTROLS AND LEDS 3 - 1
TABLE 3.2: TB1/J1 3 - 3
TABLE 3.3: RECOMMENDED WIRE SIZE FOR LOAD CONNECTION 3 - 13
TABLE 5.1: TROUBLESHOOTING GUIDE 5 - 3

1 GENERAL INFORMATION

1.1 INTRODUCTION

This manual contains instructions for the operation and maintenance of the 600W, 1KW, 2KW, 2.5KW, and 5KW EMS power supply series manufactured by Lambda EMI, Inc. of Neptune, NJ. The EMS series has been developed specifically for laboratory test and burn-in applications. The EMS supply produces a well regulated adjustable DC voltage or current source.

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 modification are contained in Addenda and take precedence where conflicts exist. Please take care to refer to the correct information for your unit.*

1.2 SAFETY PRECAUTIONS



All EMS power supplies are designed to minimize the risk of fire or shock hazard operation. 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 hardwired, 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 ground is connected prior to supplying input AC power.
2. Proper grounding from the input AC power is required to reduce the risk of electric shock. Ensure that the ground connected has at least the same gauge wire as the supply leads.
3. Where high leakage exists and there is a warning label on the rear panel, the protective earth ground must be connected. (⏚ Symbol for protective earth ground).
4. Use extreme caution when connecting input AC power and never apply the incorrect input voltage, refer to ratings label.

5. Use extreme caution when connecting the high voltage output cable including the separate ground connecting the supply to the load.
6. Ensure all load capacitors are completely discharged prior to connection. Never handle the output cable when the power supply is operating.
7. Always replace fuses with the same type and Volt/Amp ratings.
8. Never attempt to operate the power supply in any manner not described in this manual.
9. Never remove DANGER and WARNING labels from the power supply, and replace lost or damaged labels immediately.
10. The power supply should only be serviced by Lambda EMI factory qualified personnel.

1.3 SPECIFICATIONS

All performance specifications, unless otherwise stated, are defined in the local programming configuration. Ripple, programming speed, transient response and stability are optimized with the power supply so configured.

1.3.1 INPUT POWER

The following provides the maximum input current at a given output power, phase, input voltage and the recommended wire size to be used for input connection.

Output Power Rating of Supply (W)	Phase	Frequency (Hz)	Input voltage (Vrms)	Max. Input Current	Recommended Wire Size for AC input	
					AWG	mm2
600	1	47-63	105-125	11.3	14	4.1
600	1	47-63	190-253	6.3	16	2.6
600	1	47-63	90-110	13.2	14	4.1
1K	1	47-63	105-125	18.8	12	6.5
1K	1	47-63	90-110	22.0	10	10.4
1K	1	47-63	190-253	10.4	14	4.1
2K	1	47-63	190-250	20.8	10	10.4
2K	1	47-63	180-220	21.9	10	10.4
2.5K	3	47-63	190-250	16.5	12	6.5
2.5K	1	47-63	180-220	27.4	10	10.4
5K	3	47-63	190-250	24.0	10	10.4
5K	3	47-63	342-418	13.5	14	4.1
5K	3	47-63	374-456	12.4	14	4.1
5K	3	47-63	180-220	25.3	10	10.4
5K	3	47-63	360-440	12.0	14	4.1
5K	3	47-63	396-484	11.0	14	4.1

Table 1.1: Input Power

1.3.2 AC INRUSH CURRENT

Soft start is standard on all EMS models. Input line current during turn-on, turnoff, power interruption, or reapplication is less than that at full load.

1.3.3 REGULATION

A. A regulation of less than 0.1 % of the maximum rated output is maintained over the entire range of the input line voltage given in table 1.1

B. Voltage Mode: A load change of 100% (from full load to no load) will cause an output voltage deviation of less than 0.1% of maximum output voltage.

C. Current Mode: A load change of 100% (from full load to a short) will cause an output current deviation of less than 0.1% of maximum output current.

Watts	Model Number	Max. Ripple (mV)p-p Carrier
600	EMS 7.5-75	100
1000	EMS 7.5-130	75
2000	EMS 7.5-250	75
2500	EMS 7.5-300	75
600	EMS 10-60	100
1000	EMS 10-100	75
2000	EMS 10-200	75
2500	EMS 10-250	75
600	EMS 20-30	100
1000	EMS 20-50	75
2000	EMS 20-100	75
2500	EMS 20-125	75
600	EMS 30-20	100
1000	EMS 30-33	75
2000	EMS 30-65	75
2500	EMS 30-80	75
600	EMS 40-15	100
1000	EMS 40-25	75
2000	EMS 40-50	75
2500	EMS 40-60	75
600	EMS 60-10	100
1000	EMS 60-18	75
2000	EMS 60-33	75
2500	EMS 60-40	75
600	EMS 80-7.5	100
1000	EMS 80-13	100
2000	EMS 80-25	100
2500	EMS 80-30	100
1000	EMS 100-10	100
2000	EMS 100-20	100
2500	EMS 100-25	100
1000	EMS 150-7	120
2000	EMS 150-13	120
2500	EMS 150-16	120
1000	EMS 300-3.5	150
2000	EMS 300-6	150
2500	EMS 300-8	150
1000	EMS 600-1.6	250
2000	EMS 600-3.3	250
2500	EMS 600-4	250

Table 1.2: Ripple for Single Phase

Watts	Model Number	Max. Ripple (mV) p-p Carrier
2500 5000	EMS 7.5-300 EMS 7.5-600	75 75
2500 5000	EMS 10-250 EMS 10-500	75 75
2500 5000	EMS 20-125 EMS 20-250	75 75
2500 5000	EMS 30-80 EMS 30-165	75 75
2500 5000	EMS 40-60 EMS 40-125	75 75
2500 5000	EMS 60-40 EMS 60-80	75 75
2500 5000	EMS 80-30 EMS 80-60	100 100
2500 5000	EMS 100-25 EMS 100-50	100 100
2500 5000	EMS 150-16 EMS 150-33	120 120
2500 5000	EMS 300-8 EMS 300-16	150 150
2500 5000	EMS 600-4 EMS 600-8	250 250

Table 1.3: Ripple for Three Phase

1.3.4 TRANSIENT RESPONSE

The voltage transient resulting from switching the load from 70% to 100% of full load will be less than 10% of the maximum output voltage of the supply. The voltage will recover to ±2% of its original value within 650 μs for units up to 20v. For units above 20 volts the recovery time is increased by a factor of $V_{max} / 20$.

1.3.5 STABILITY

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

1.3.6 REMOTE PROGRAMMING

All EMS models are capable of being remotely programmed by means of an external resistance, external DC voltage source or an external DC Current source. The remote programming controls all switching action in the power supply. The following table provides the remote programming accuracy at full output.



CAUTION!
Hazardous voltages may be present on the terminal block or inside the J1 connector. Insure unit is powered off and disconnected prior to servicing. Refer to Section 1.2

Voltage Mode

Programming Method	0-5 Vdc	0-10Vdc	0 - 5KΩ	0 - 1 mA
Output Voltage	± 2.5 %	± 5 %	± 2.5 %	±5%

Current Mode

Programming Method	0-5 Vdc	0-10 Vdc	0-100 mVdc	0- 100Ω	0 - 1 mA
Output Current	± 2.5%	± 5 %	± 2.5 %	± 2.5%	±5%

Table 1.4: Remote Programming Accuracy

1.3.7 METER TOLERANCE

The tolerance of an analog front panel voltmeter or ammeter at full scale is ±2 % of full scale. The tolerance of a digital front panel voltmeter or ammeter at full scale is ±2 % of full scale.

1.3.8 PHYSICAL SPECIFICATIONS

POWER (W)	HEIGHT		WIDTH		DEPTH		WEIGHT	
	inches	mm	inches	mm	inches	mm	lbs	kg
600W/1KW	1.75	44	19	48	17	432	18	8
2KW/2.5KW	3.5	29	19	48	18	457	35	16
5KW	5.25	133	19	48	21	533	60	27

Table 1.6: Physical Specifications

1.4 OVERALL EFFICIENCY

Efficiency ranges from 69% to 85% depending on the output voltage. Units with higher output voltages have higher efficiency. Efficiency is measured at nominal input line voltage and full load (maximum current and maximum voltage).

1.5 ENVIRONMENTAL SPECIFICATIONS

- Operating Temperature: 0-50°C without derating
- Storage Temperature: -40 to +85°C
- Operating Humidity: 20 - 95% RH non-condensing
- Storage Humidity: 20-95% RH non-condensing
- Altitude: 10,000 ft.

1.5.1 ELECTRICAL INSTALLATION CATEGORIES

- Overvoltage Category II
- Pollution Degree 2

1.5.2 OPERATING TEMPERATURE

All EMS power supplies are capable of continuous duty performance without deviation from their specifications in ambient temperatures between 0°C and 50°C. The output voltage temperature coefficient is 0.02%/°C of the rated output voltage. The output current temperature coefficient is 0.03%/°C of the rated output current. For ambient temperatures between 50°C and 70°C the supply's output power is de-rated by a factor of 5% per 1°C. Units may be safely stored at temperatures of -55°C to +85°C.

1.6 OVER TEMPERATURE PROTECTION

Automatic protection against excessive temperatures is provided by a thermostat mounted on the heat sink. If the heat sink temperature reaches allowable maximum temperature, the unit will shut down to prevent damage. An automatic restart circuit will be activated once safe operating temperature levels are restored.

1.7 OVERVOLTAGE PROTECTION (FOR OUTPUTS £ 300 VDC)

The Overvoltage protection circuitry, adjustable from the front panel, is standard on all EMS models. This circuitry will short circuit (crowbar) the power supply's output to protect the load, and turns the control circuitry off if the output voltage reaches the preset value. This protection is effective regardless of the cause of the overvoltage.

1.8 RSTL CONTROLLER BOARD

This is an optional board that can be installed at the customer's request. Units which have RSTL installed have all the features of a standard unit except Remote Sense. The installation of the RSTL would require an additional 1.75" to the height of the power supply. 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 controls (the meters still read), and asserts control of the power supply. RSTL is not currently available in CE models. Contact the factory for further information.

1.9 COOLING

All units are forced air cooled with air entering through the front and sides and exiting through the rear. A thermostat protects the unit from excessive ambient temperature as well as inadequate forced air cooling. Restart is automatic upon removal of thermal overload.

1.10 MODEL NUMBER

The following chart explains the model number for the EMS Power Supply family. The options provided by Lambda EMI are not limited to the chart. For example, 0-10 V programming of the voltage channel, 0-5 V and 0-10 V of the current channel are not listed in the chart. For any additional options not covered by the chart, the customer can contact the Sales Department at Lambda EMI.

EMS XX - XXX - X - X - XX - XX

DC VOLTAGE RANGE

DC CURRENT RANGE

AC INPUT VOLTAGE SELECTION		
FOR THIS OUTPUT WATTAGE	WITH THIS INPUT VOLTAGE	USE THIS SUFFIX
600 watts & 1 KW	115 ± 10VAC 47-63Hz 1ϕ	1
600 watts & 1 KW	220 ± 30VAC 47-63Hz 1ϕ	2
600 watts & 1 KW	100 ± 10VAC 47-63Hz 1ϕ	6
600 watts & 1 KW 1KW, 2 KW & 2.5KW	230 ± 23VAC 47-63Hz 1ϕ	3
2 KW	220 ± 30VAC 47-63Hz 1ϕ	5
2.5 KW	200 ± 20VAC 47-63Hz 1ϕ	7
2.5 KW	220 ± 30VAC 47-63Hz 3ϕ	2
	225VAC ± 25VAC 47-63Hz 1ϕ USER SELECTABLE	
5 KW	200 ± 20VAC 47-63Hz 3ϕ	7
5 KW	380 ± 38VAC 47-63Hz 3ϕ	8
5 KW	415 ± 41VAC 47-63Hz 3ϕ	9
5 KW	200 ± 20VAC 47-63Hz 1ϕ	10
5 KW	480 ± 48VAC 47-63Hz 3ϕ	11
5 KW	440 ± 44VAC 47-63Hz 3ϕ	12
5 KW	400 ± 40VAC 47-63Hz 3ϕ	13
REFER TO AC INPUT SECTION FOR ADDITIONAL INFORMATION OR CONSULT FACTORY		

OPTIONS	
FEATURE	SUFFIX
LOCK BUSHING	LB
10 TURN CURRENT CONTROL	10T
OUTPUT TERMINAL COVERS	TV
RS232/IEEE 488 PROGRAMMER CONSULT FACTORY	RSTL
Units comply with CE requirements	CE

PANEL METERS	
Analog	OMIT
Digital	D
1. No charge for Digital Meters 2. 600W & 1KW Units - Digital Meters only.	

Table 1.7: Model Number

EXAMPLES: EMS 30-30-1-D, EMS 10-500-2-RSTL,
EMS II 20-250-2-LB, EMS 10-250-2-LB-10T

1.11 RETURNING EQUIPMENT

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, Inc., noting the model and serial number of the equipment. Lambda EMI will determine the proper course of action and arrange for repair or replacement. Before returning any equipment to the factory, the following steps should be taken:

1. Notify Lambda EMI, Inc., Customer Service Dept. 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.

2 INSPECTION AND INSTALLATION

2.1 VISUAL INSPECTION

Prior to shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the unit is unpacked, inspect for any damage that may have occurred in transit. Verify the following:

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

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 lenses.

If any damage is found, follow the "Returning Equipment" instructions.

2.2 LOCATION

This instrument is fan cooled. Sufficient space must be allocated so that a free flow of cooling air can reach the sides of the instrument when it is in operation. Insure that there is 4" (10cm) front and rear as well as 2° (5cm) on each side for adequate air flow. It is also desirable, although not mandatory, that the unit should be located so as to allow cooling air to enter through the top cover. 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 (or equivalent) that encloses the sides, top and rear must be used.

2.3 ELECTRICAL INSTALLATION

Except for test purposes, 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 voltage can be applied. The user should ensure that the AC input wires are of the proper gauge (refer to Table 1.1). Units with IEC connector require a line cord with the appropriate IEC 380 style connector. The safety ground wire must be the same gauge as the AC input wires to ensure that it does not open and create a safety hazard. Load wires to be connected to the POS. and NEG. output terminals must be of sufficient size to prevent substantial IR voltage drops between the output terminals and the load.

1. **600W and 1KW**: Units will be factory set for 115 or 230 Vac input. This will be decided by customer upon ordering and will be indicated on unit upon delivery. Look for AC input rating on the rear terminal of the power supply received and operate accordingly.

WARNING
Do not operate a 115 Vac unit at 230 Vac; Unit will be damaged.

A. Install single phase line terminals marked AC. Connect GND line to terminal marked GND.

B. For units marked CE, the product provides more than 3.5mA of earth leakage current. Protective earth connection is essential before connecting the supply. An appropriate warning marking is placed on the rear panel. (⏚ Symbol for protective earth ground).

2. **2KW and 2.5KW:** Units are operated from a single-phase or three-phase 190-250Vac input depending on model. Phase rotation need not be observed when connecting the power line to the input terminal of the power supply.

A. Install the three phase line to terminals marked Phase A, Phase B and Phase C.

B. Connect the GND line to terminal marked GND.

C. Units with - CE marking are designed for a 230VAC single phase connection. Install the input power lines to the terminals marked L1 and L2 respectively. Connect the protective earth ground to the terminal marked ⏚.

NOTE: *It is important that single phase power should be applied between terminals Phase A and Phase B.*

3. **5KW:** Unit is designed to operate on 190-250Vac, 342-418Vac, or 374-456Vac three-phase input depending on the options selected when ordered.

A. Install three phase lines to terminals marked Phase A, Phase B and Phase C. Phase rotation need not be observed.

B. Connect GND lead to terminal marked GND, or ⏚.

C. For units with inputs of 380 Vac or higher, a Wye configuration of the input source is required. Connect the neutral to the terminal labeled N. For inputs sources (delta) that lack the neutral, EMI provides two transformers (EMI part numbers 28-004-890 and 28-004-952) for delta to Wye conversion. Transformer number 28-004-952 is used for powering a single unit whereas transformer 28-004-890 can be used to power two units.

D. Units with -CE marking are designed for 400VAC Wye configuration. See above note.

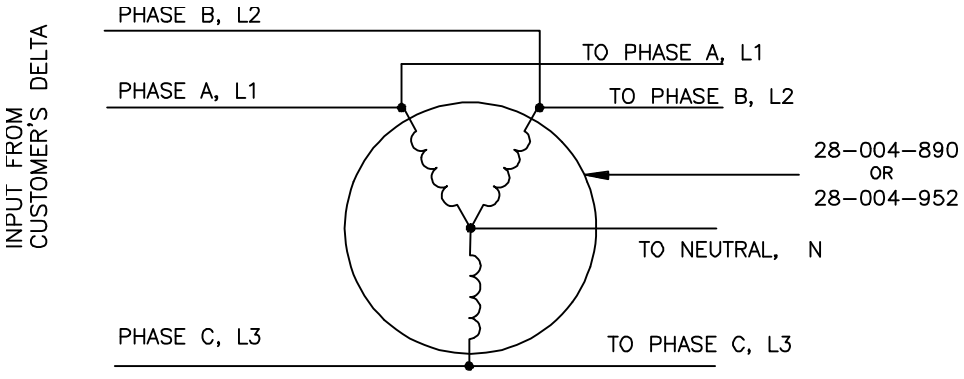


Figure 2.1: Delta to Wye Connection

2.3.1 EMC REQUIREMENTS

Units with the -CE suffix have been tested to the EMC requirements of EN 50081-1 and EN 50081-2, However in the presence of high ambient RF noise, shielding may be required on the load or the remote control cables.

2.4 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 five second delay. The main AC breaker should not be cycled on and off any sooner than 30 seconds. This will ensure proper operation of the soft start circuitry. The status of the indicators is as follows:

   i) POWER ON indicator is glowing. ii) OVER VOLTAGE 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, wait 10 seconds and then flip the circuit breaker ON to reset 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. Rotate the current knob completely counter clockwise. Flip OFF the circuit breaker of the supply.

I. Apply a short across the output terminals of the supply. Make sure that the short can sustain the maximum output current of the supply. Refer to Table 3.3 (Section 3.11) for recommended wire size.

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 Customer Service for assistance.

3 OPERATING INSTRUCTIONS

The EMS power supply could be operated in several different configurations. Section 3 gives a detailed description of configuring the supply to the desired application.

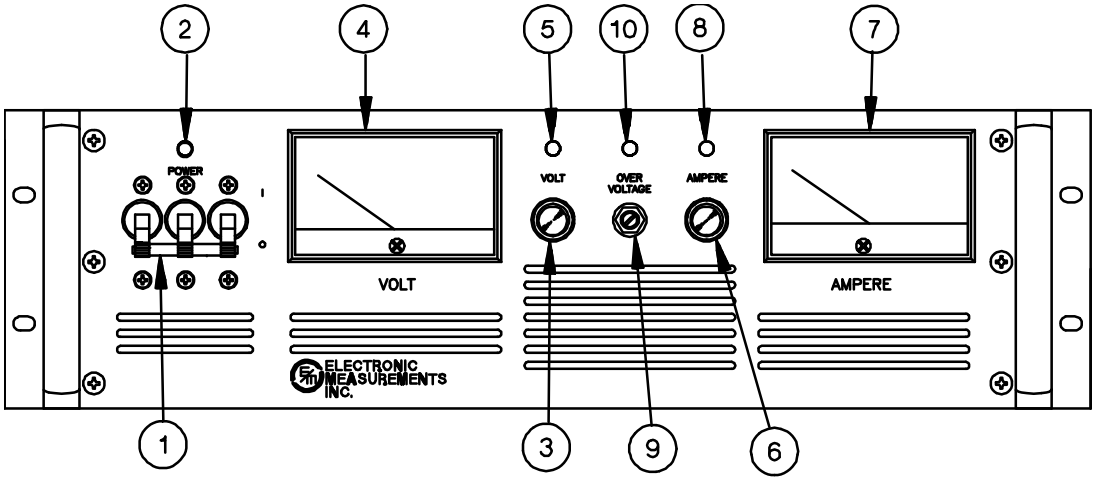


Figure 3.1: Front Panel, (5KW model shown)

3.1 FRONT PANEL

The following table provides a listing of the controls and indicators that are located on the front panel along with a brief description of their functions. Figure 3.1 shows the location of each control and indicator.

REFERENCE NO.	CONTROL/INDICATOR	FUNCTION
1	Circuit Breaker	Connects and disconnects AC input to supply
2	Power On LED	When glowing indicates that the supply is on
3	Voltage Control	Adjusts the output voltage from zero to full scale
4	Voltmeter	Displays output voltage of power supply
5	Voltage LED	When glowing indicates that the supply is in the constant voltage mode
6	Current Control	Adjusts the output current from zero to full scale
7	Ammeter	Displays output current of power supply
8	Current LED	When glowing indicates that the supply is in the constant current mode
9	OVP Adjust	Sets Overvoltage trip level
10	OVP LED	When glowing indicates that the output of the supply has exceeded the Overvoltage trip level

Table 3.1: Front Panel Controls and LEDs

3.2 OPERATING MODES

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 followings:

- The load connected to the output terminals of the power supply R_L .
- The front panel voltage control setting V_{set} .
- The front panel current control setting I_{set} .

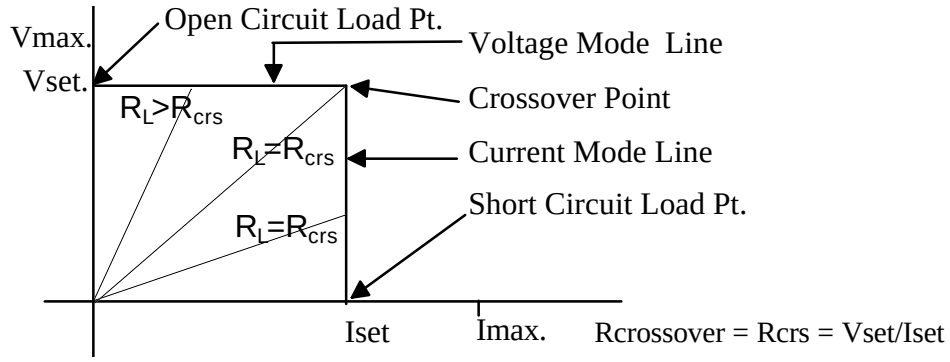


Figure 3.2: Operating Modes

3.2.1 CONSTANT VOLTAGE MODE

The power supply will operate in this mode (Voltage Channel active) whenever the current through the load is lower 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 V_{set} .

3.2.2 CONSTANT CURRENT MODE

The power supply will operate in this mode (Current Channel active) whenever the voltage of the load is less than that defined by front panel voltage 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 I_{set} .

3.2.3 OUTPUT NULLING

See figure 3.2 operating modes diagram. When controlling the supply from the front panel pots in constant voltage or constant current mode, the operation is as follows:

1. The voltage potentiometer may not drive the current in the output to zero when a short is applied across output.

2. The current potentiometer may not drive the voltage in the output to zero when the output is an open circuit.

3.3 PROGRAMMING MODES

CAUTION
Hazardous voltages may be present on the terminal block or inside the J1 connector ON UNITS WITH OUTPUTS ABOVE 50VDC. Insure unit is powered off and disconnected prior to servicing. Refer to Section 1.2

The power supply could be configured for either Local or Remote programming. The supply is programmed by the shorting connections on terminal strip TB1, or J1 (the 25 Pin "D" shell connector) located on the rear panel (See Figure 3.3). The terminal designations of TB1 are silk screened. Refer to Table 3.2 for Terminal/Pin designations. In Local programming, the power supply is controlled by the front panel's Voltage and Current Knobs. Remote programming (externally controlled at TB1or J1) is done by the following:

A. External resistance

B. External DC Voltage

C. External DC Current

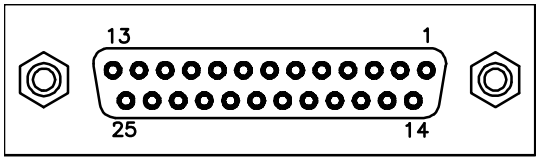


Figure 3.3 Rear Panel "D" Connector

PIN #	PIN DESCRIPTION
1	+ Voltage (+V)
2	+ Voltage Remote (+V REM)
3	Voltage Programming Current (V PROG I)
4	Voltage Amplifier (V AMP IN)
5	Voltage Programming Resistance (V PROG R)
6	Voltage Programming Resistance Common (V PROG R COM)
7	- Voltage Remote (-V REM)
8	- Voltage (-V)
9	Current Programming Current (I PROG I)
10	Current Amplifier (I AMP IN)
11	Current Programming Resistance (I PROG R)
12	- Shunt (-I)
13	Inverted I Amplifier In
14	+ Shunt (+I)
15 & 16	Remote Voltage Turn On (Remote V IN)
16 & 17	Remote Dry Contact Turn On (Remote SW)

Table 3.2: TB1/J1

3.3.1 LOCAL PROGRAMMING

When shipped from the factory, each supply is configured for constant voltage, constant current, local programming, local sensing, single unit mode of operation. In this mode of operation the voltage and the current control knobs assert control over the output of the supply. Local programming is used in most applications. All performance specifications, unless otherwise stated, are defined in this configuration. Ripple, programming speed, transient response and stability are optimized with the power supply so configured. Refer to Figure 3.4 for strapping connections.

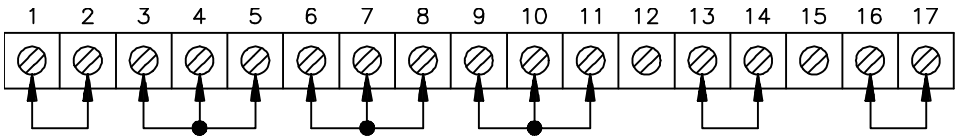


Figure 3.4: Local Programming

3.3.2 REMOTE PROGRAMMING OF VOLTAGE CHANNEL

The front panel's voltage control is disabled in this programming mode. Remote programming of the voltage channel (Voltage mode operation) can be implemented at the rear panel by one of the following:

A. External resistance of 0-5kW

B. External DC Voltage of 0-5V (0-10 Volts is an option)

C. External DC Current of 0-1mA

The wire connecting the programming terminals of the supply to the remote programming device should be twisted or, if strong AC or RF fields are present, shielded.

CAUTION

If the remote programming function fails or is inadvertently adjusted so that the output voltage is programmed to levels of greater than 10% above ratings, damage to the output filter capacitors may occur. To protect against this, it is suggested that the overvoltage protection be adjusted to limit the maximum voltage excursion and safely shut the power supply down.

A. **External Resistance:**

Variable resistance of 0 to 5kΩ programs the output from zero to full rated voltage. The output of the supply can be set to a fixed voltage by using a fixed programming resistor which can be calculated from the following equation:

$R_{prog.}$ = (Desired Voltage ÷ Full Rated Output Voltage) X 5k

1. Remove the jumper between terminals TB1-4 and TB1-5, or J1-4 and J1-5.
2. Connect the programming resistance between terminals TB1-4 and TB1-7, or J1-4 and J1-7.

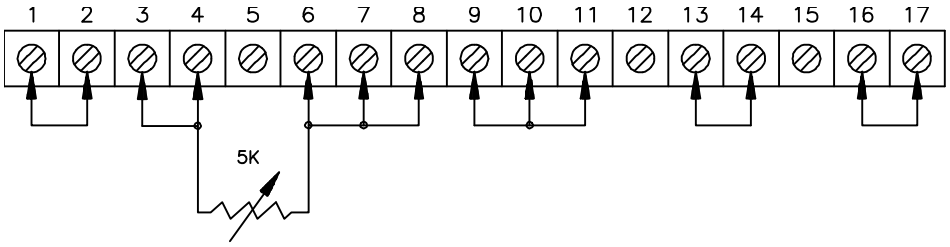


Figure 3.5**:** Remote programming by External Resistance, Voltage Mode

CAUTION

An opening in the remote programming circuit is effectively a high programming resistance and will allow an uncontrolled voltage rise exceeding the maximum output of the power supply. This may cause possible damage to the power supply and/or load. For this reason, any programming resistor switcher must have shorting contacts. This type of shorting switch connects each successive position before disconnecting the preceding one.

B **External DC Voltage:**

A variable voltage programs the output from zero to full rated voltage. Configure the strapping connections on TB1/J1 as shown on Figure 3.6

1. Remove the jumpers between terminals TB1-3, TB1-4 and TB1-5 or J1-3, J1-4 and J1-5.
2. If unit has the 0 to 10 V programming option, connect a link between TB1/J1-5 and TB1/J1-6 as shown in Figure 3.6b. Otherwise, if the unit has the default 0 to 5 V programming connect as shown in Figure 3.6a.
3. Connect the programming voltage source between TB1/J1-4 (positive) and TB1/J1-6 (negative).

NOTE: *Apply the appropriate programming voltage. Do not apply 0-10V programming to a unit that has the default (0-5V) programming.*

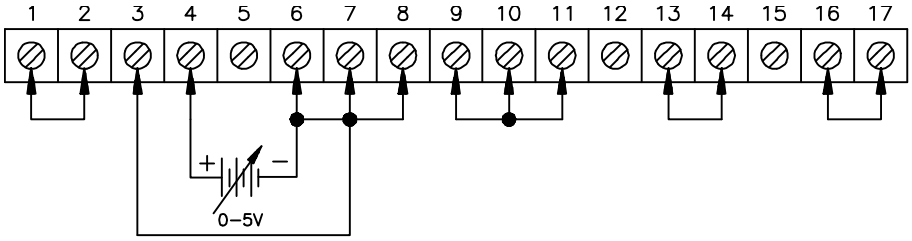


Figure 3.6a**:** Remote Programming by External Voltage, Voltage Mode

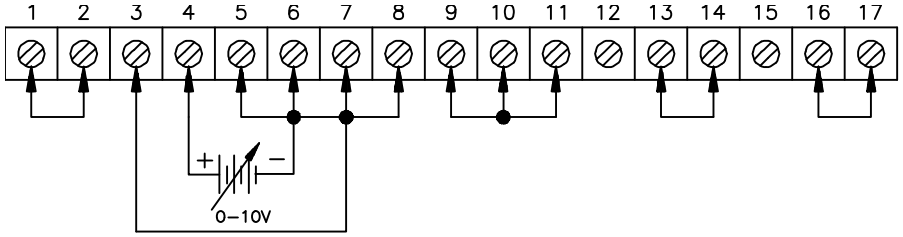


Figure 3.6b: Remote Programming by External Voltage,
Voltage Mode (as per 0 - 10V Option).

C. **External DC Current:**

A current of 0 to 1mA programs the output from zero to full rated voltage. Configure the strapping connections on TB1 or J1 as shown on Figure 3.7.

1. Remove the jumpers between terminals TB1/J1-4, and TB1/J1-5.
2. Connect a 5K Ohm, 1% 0.5w resistor between TB1/J1-4 and TB1/J1-6.
3. Connect the programming current source between terminals TB1/J1-4 (positive) and TB1/J1-6 (negative).

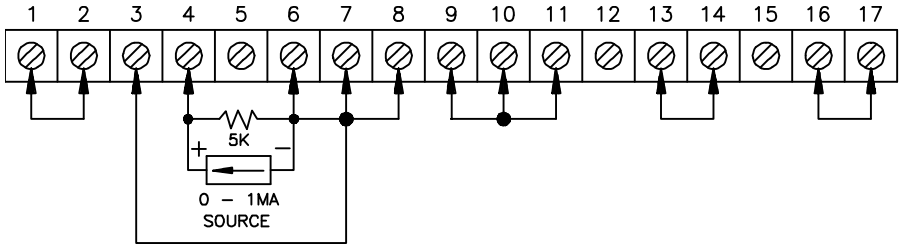


Figure 3.7: Remote Programming by External Current, Voltage Mode**.**

3.3.3 REMOTE PROGRAMMING OF CURRENT CHANNEL

The front panel's current control is disabled in this programming mode. Remote programming of the current channel (Current mode operation) can be implemented at the rear panel by one of the following:

1. External resistance of 0-100 ohm
2. External DC Voltage of 0-100 mV (0-5V or 0-10V is an option)
3. External DC Current of 0-1mA

The wire connecting the programming terminals of the supply to the remote programming device should be twisted or, if strong AC or RF fields are present, shielded.

CAUTION

If the remote programming function fails or is inadvertently adjusted so that the output voltage is programmed to levels of greater than 15% above ratings, damage to the output filter capacitors may occur. To protect against this, it is suggested that the overvoltage protection be adjusted to limit the maximum voltage excursion and safely shut the power supply down.

A. **External Resistance :**

A variable resistance of 0 to 100 Ohms programs the output from zero to full rated current. The output of the supply can be set to a fixed current by using a fixed programming resistor which can be calculated from the following equation:

$$R_{prog.} = (\text{Desired Current} \div \text{Full Rated Output Current}) \times 100 \text{ ohm}$$

1. Remove the jumper between terminals TB1/J1-10 and TB1/J1-11.
2. Connect the programming resistance between terminals TB1/J1-10 and TB1/J1-12.

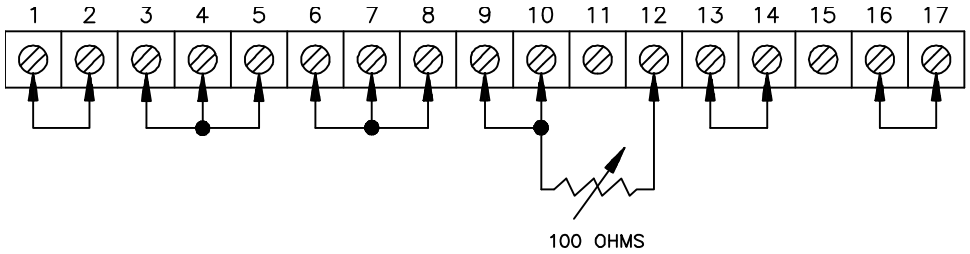


Figure 3.8**:** Remote programming by External Resistance, Current Mode

CAUTION

An opening in the remote programming circuit is effectively a high programming resistance and will allow an uncontrolled current rise exceeding the maximum output of the power supply. This may cause possible damage to the power supply and/or load. For this reason, any programming resistor switcher must have shorting contacts. This type of shorting switch connects each successive position before disconnecting the preceding one.

B. **External DC Voltage:**

To program the output from zero to full rated current, configure the strapping connections on TB1/J1 as shown on Figure 3.9a. A signal from a higher potential source may be attenuated to the 100mV level by a resistor divider. For best performance, the source impedance of this divider should not exceed 1000 Ohms. (May not be needed for the 0-5V or 0-10V programming options).

1. Remove the jumpers between terminals TB1/J1-9, TB1/J1-10 and TB1/J1-11.
2. If unit has the 0-5V or 0-10V programming options, connect a link between TB1/J1-11 and TB1/J1-12 as shown in Figure 3.9b. Otherwise, if the unit has the default (0-100mV) programming , connect as shown in Figure 3.9a.
3. Connect the programming voltage source between terminals TB1/J1-10 (positive) and TB1/J1-12 (negative).

NOTE: *Apply the appropriate programming voltage. Do not apply 0-5V or 0-10V programming to a unit that has the default (0-100mV) programming. The Voltage source must be isolated from the EMS "V-" terminal.*

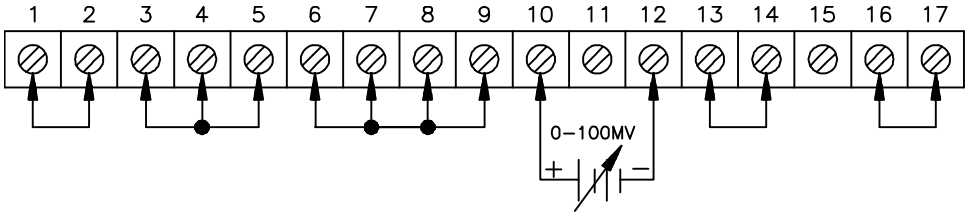


Figure 3.9a: Remote Programming by External Voltage, Current Model

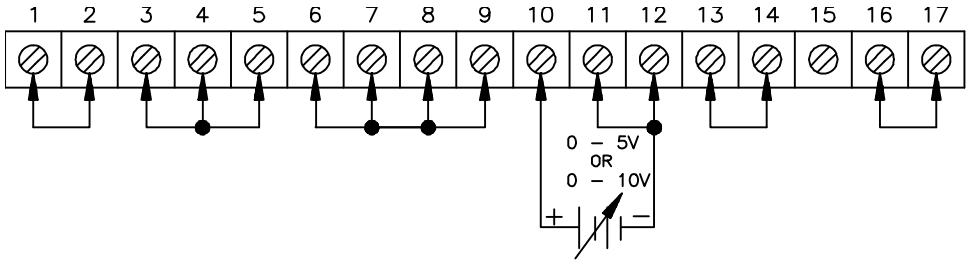


Figure 3.9b: Remote Programming by External Voltage, Current Mode (as per Option)

C. **External DC Current:**

A current of 0 to 1mA programs the output from zero to full rated current. Configure the strapping connections on TB1/J1 as shown on Figure 3.10.

1. Remove the jumper between terminals TB1/J1-9, TB1/J1-10 and TB1/J1-11.
2. Connect a 100 Ohm, 1% 0.5W resistor between TB1/J1-10 and TB1/J1-12.
3. Connect the programming current source between terminals TB1/J1-12 (negative) and TB1/J1-10 (positive).

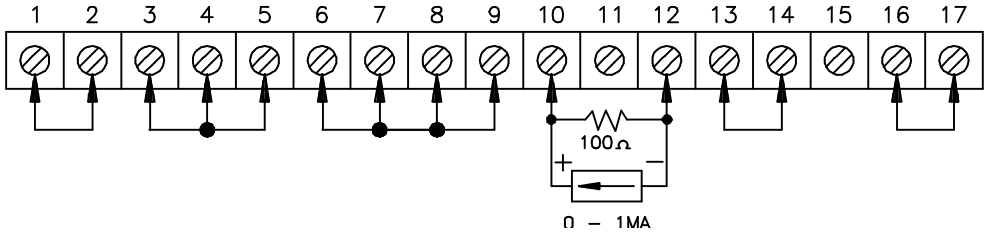


Figure 3.10: Remote Programming by External Current, Current Mode

3.4 PARALLEL OPERATION

NOTE: *It is not recommended to operate more than three EMS power supplies in parallel without thorough evaluation by the user, with counseling from the Engineering Department of Electronic Measurements, Inc. This will help avoid any failures in the application due to instability and OVP of the power supplies. The simplest parallel connection is that of attaching the positive and negative terminals to their respective load points. The procedure is as follows:*

1. Turn on all units (open circuit) and adjust to the appropriate output voltage.
2. Turn supplies off and connect all positive output terminals to the positive side of the load and all negative supplies to the negative side of the load as in Figure 3.10.

NOTE*: Individual leads connecting the units to the load must be of equal length and oversized to provide as low an impedance as practical for the high output currents.*

3. Set the current controls clockwise.
4. Turn units on one at a time, until the sum of the power supply current capabilities exceeds the load current drawn.
5. Using the voltage controls, balance each unit voltage for equal output current. Set the current controls to limit just above running current so that if the output voltage of any

unit drifts upward, it will become current limited rather than carry an excessive share of load current.

IMPORTANT: *In order to run power supplies with OVP in parallel, modifications must be made. Please contact the factory for further instructions, before connecting supplies with OVP in parallel.*

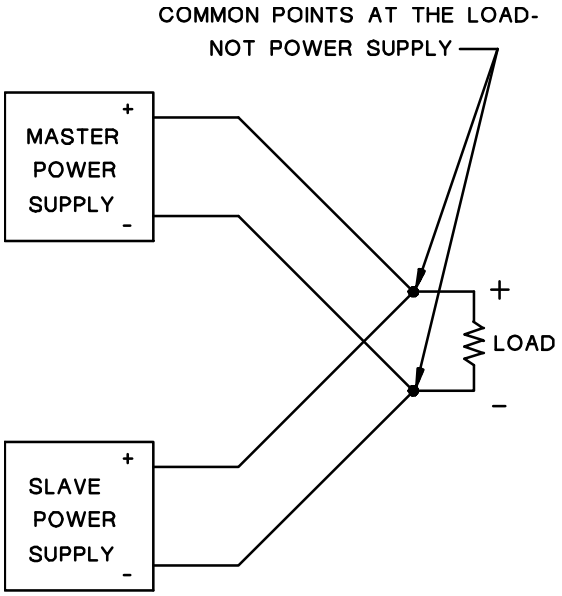


Figure 3.11: Parallel Operation

3.5 PARALLEL OPERATION - MASTER/SLAVE

In this configuration, the power supply designated the master is used to control the voltage and current operation of all other supplies, referred to as slaves.

1. Disconnect the following links of all slaves:

   TB1/J1-13, TB1/J1-14
   TB1/J1-9, TB1/J1-10 & TB1/J1-11

2. Connect a link between TB1/J1-10 and TB1/J1-12 of all slaves.
3. Connect a wire between the master supply TB1/J1-12 and TB1/J1-13 of each slave.
4. Rotate Current control of slave fully clockwise.
5. Turn each slave on and then the master.
6. Adjust the master for required output voltage or current. The output leads from each power supply must be of equal resistance (wire gauge and length) to ensure equal sharing. Refer to Figure 3.11.
7. In case of noise problems, add a 1µF capacitor between TB1/J1-13 & 14 of Slave and replace the jumper between TB1/J1-13 of Slave and TB1/J1-12 of Master with a 4.7kΩ resistor.

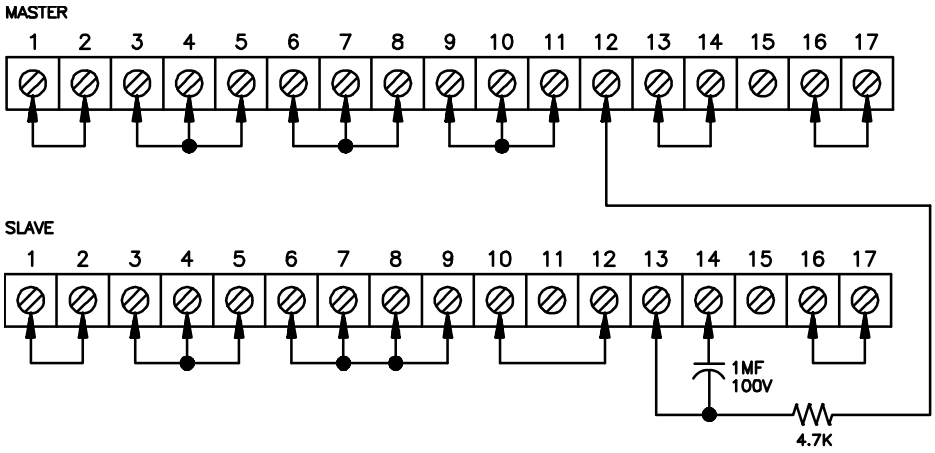


Figure 3.12: Parallel Operation, Master/Slave

3.6 SERIES OPERATION

Two EMS power supplies can be operated in series simply by connecting the negative output terminal of one unit to the positive output terminal of the other. In this configuration each unit is adjusted independently, and the total output voltage is the sum of each unit's output voltage.

NOTE: *The voltage at any output terminal must never exceed 600V with respect to chassis ground. Consult Electronic Measurements, Inc. Engineering Department for series operation of more than two power supplies.*

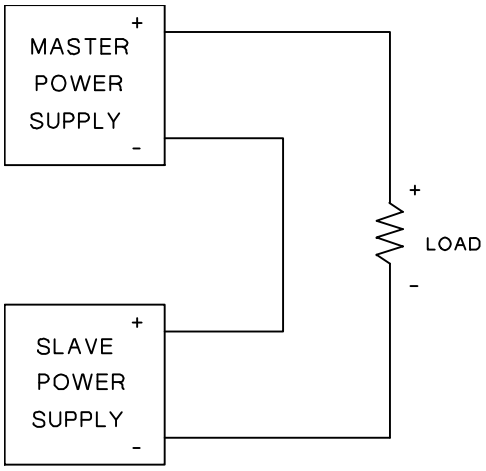


Figure 3.13: Series Operation

3.7 SERIES OPERATION MASTER/SLAVE

This configuration allows the customer to use two or more power supplies as a single unit. The master power supply controls the output voltage across the load. The supply that is designated the master should be set to a voltage higher than or equal to that of the slave. The voltage of the slave is determined by R_X.

$$R_X = \left[(V_M + V_S)\frac{V_{SMAX.}}{V_S} - 5\right]K\Omega, \qquad V_S \leq V_M$$

V_M, output voltage of master power supply.
V_S, desired output voltage of slave power supply.
V_{SMAX}, maximum rated output voltage of slave power supply.

1. Turn circuit breaker off.
2. Connect load as shown in Figure 3.13.
3. Disconnect link between TB1/J1-3 and TB1/J1-4 on slave.
4. Connect R_X between TB1/J1-4 of slave and TB1/J1-2 of master. Refer to Figure 3.13.
5. Rotate voltage control of slave fully clockwise.
6. Turn on slave(s) and then master.
7. Adjust master supply for desired output voltage across load.

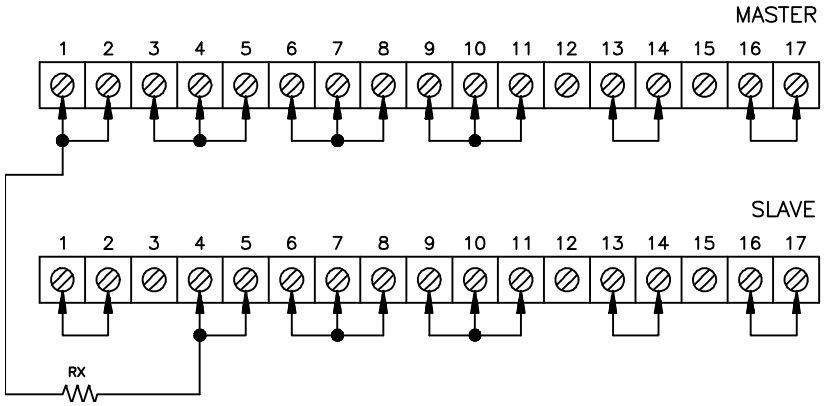


Figure 3.14: Series Operation, Master/Slave

3.8 REMOTE METERS (P.S. WITH OUTPUT OF 300V OR LESS)

A remote voltmeter may be connected between TB1/J1-2 (positive) and TB1/J1-7 (negative). If remote sensing is also being used, the remote voltmeter will indicate the voltage at the load. To indicate the voltage at the power supply output terminals, connect the remote voltmeter between terminals TB1/J1-1 (positive) and TB1/J1-8 (negative).

A remote millivoltmeter, may be connected between terminals TB1/J1-12 (negative) and TB1/J1-13 (positive). A voltage of 0 to 100mV across these terminals indicates output current from zero to full rating, unless otherwise specified (see main schematic). To compensate for voltage drops in long remote ammeter leads, a meter movement having a full scale sensitivity of less than 100mV is used in series with a calibrating resistor.

The leads to the remote meters should be twisted, and if strong AC or RF fields are present, the lead should be shielded. One end of the shield should be grounded to terminal TB1/J1-14 and the other end left floating.

3.9 REMOTE SENSING (P.S. WITH OUTPUT VOLTAGE 300V OR LESS)

In applications where the effect of the voltage drop (IR drop) of the load wires would adversely affect the performance of the load. It is possible to sense the voltage at the load rather than at the output terminals of the power supply. Remote sensing will therefore remove the effect of changes in load current through the power distribution system. The maximum available load voltage then equals the rated power supply output voltage less the total of the IR drop.

Instructions for Remote Sensing (Non RSTL Units):

1. Remove jumpers between the following terminals: TB1/J1-1 and TB1/J1-2, TB1/J1-7 and TB1/J1-8.
2. Connect the positive point of load to TB1/J1-2.
3. Connect the negative side of the load to TB1/J1-7 and TB1/J1-6.
4. If the sense points are separated from each other by some distance, it is sometimes necessary to connect a capacitor across the load, or between TB1/J1-2 and TB1/J1-7, within the range of 5 to 50uF.

3.9.1 REMOTE SENSING (P.S. WITH OUTPUT VOLTAGE OVER 300V)

Instruction for Remote Sensing :

1. Remove jumpers between the following terminals : TB1/J1-1 and TB1/J1-2, TB1/J1-7 and TB1/J1-8.
2. Connect the positive point of load through a (V_O x 1000) ohm resistor to TB1/J1-2.
3. Connect the negative side of the load to TB1/J1-7 and TB1/J1-6

NOTE: *Since the voltmeter is internally connected to the sensing terminals, it will automatically indicate the voltage at the load, not the power supply output terminal voltage.*

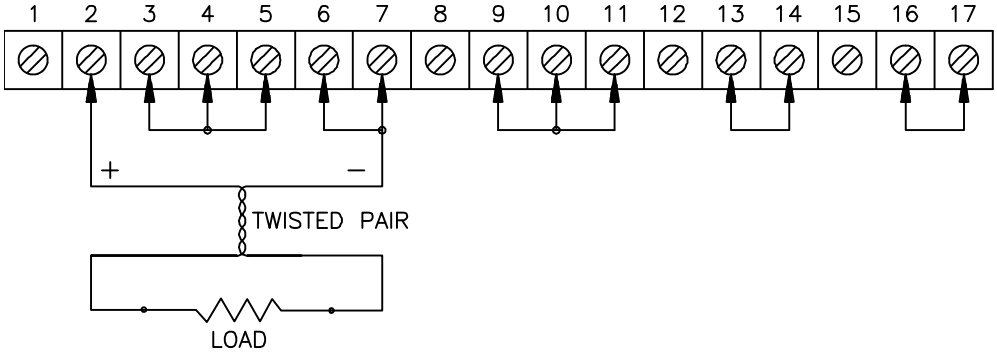


Figure 3.15: Remote Sensing

3.10 REMOTE TURN ON

EXTERNAL VOLTAGE SOURCE: Connect either an external 12-24 Vdc voltage supply or a 24-115 Vac voltage supply to pins TB1/J1-15 & 16. The link between Terminals 16 & 17 must be removed. NOTE: Terminals are polarity sensitive DC. Terminal 15 is positive and terminal 16 is negative.

DRY CONTACT: Connect a N/O voltage switch or contactor between terminal 16 & 17 of TB1/J1. Open contact implies Power supply is disabled and close contact enable the power supply.

3.11 LOAD CONNECTION

Each load must be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires must be as short as possible and twisted or shielded if strong AC or RF fields are present to reduce noise pickup. Either positive or negative voltages can be applied to the load by grounding one of the output terminals to chassis. The system should not be grounded at more than one point. Connections between the load and power supply should be very tight especially on units rated for high output current. The wires to the load should be as short as possible and heavy enough to carry the maximum output current of the supply. The following table may be helpful in determining the proper wire size.

CURRENT (Amps)	RECOMMENDED COPPER WIRE SIZE	CURRENT (Amps)	RECOMMENDED COPPER WIRE SIZE
200	4/0	30	10
150	2/0	20	12
120	0	15	14
80	4	10	16
60	6	6	18
45	8	LESS	20

Table 3.3 Recommended Wire Size for Load Connection

4 THEORY OF OPERATION

4.1 PRINCIPLES OF OPERATION

The basic principle of operation is outlined in this section. A simplified diagram of the EMS power supply is shown below in figure 4.1. The power supply is made of the input section (rectifier and the filter), the inverter (A200 Bd.), the output section, and the control section which is made of the A100 Bd. The input AC voltage is rectified and filtered to produce an unregulated high voltage dc. The unregulated high voltage dc is then converted by the inverter (A200 Bd.) into a high frequency ac square wave. This waveform is stepped up or down by a high frequency isolation transformer. The secondary output is rectified and filtered to produce the required low ripple output voltage. The output is attenuated down and compared against a reference voltage, thus regulating the output. Regulation is achieved through modulation of the pulse-width generated by the control stage (A100 Bd.).

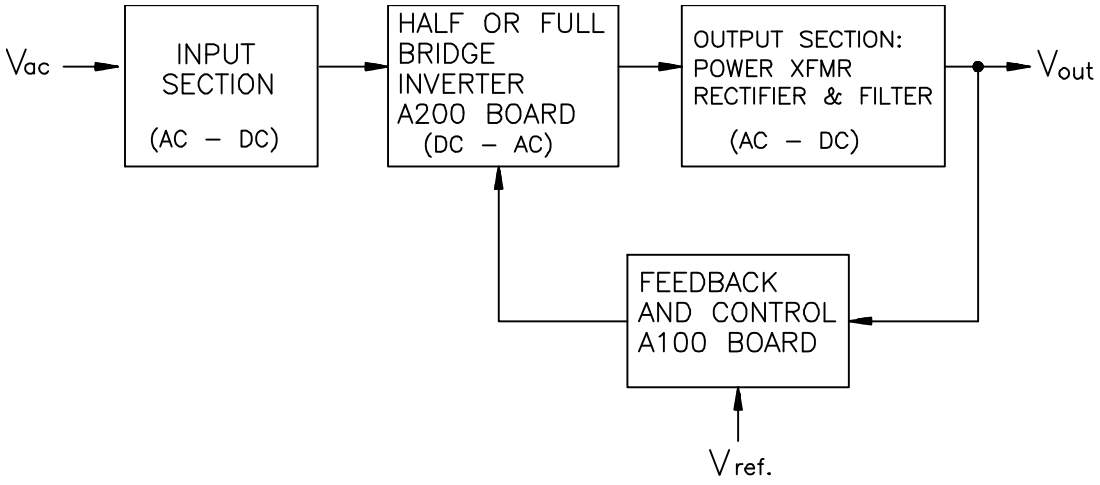


Figure 4.1: Simplified EMS Power Supply

4.2 INPUT SECTION

The AC input enters through TB2 on the rear of the unit. It passes through the power line filter on the A300 board. The purpose of the Power Line Filter is to attenuate high frequency conducted emissions generated inside the unit, thus reducing the high frequency current emitted onto the power source. The load side of the line filter connects to a DPDT switch which allows power to pass through to the rectifier bridge to supply the DC bus capacitors C1 and C2. At turn on, the contact of K1 is in the open position, limiting the inrush current through the rectifiers. After a delay of about 3 to 4 seconds, the contact closes allowing normal power transfer. The input AC voltage is rectified and filtered producing an unregulated high voltage dc.

4.3 A200 INVERTER BOARD

The unregulated high voltage DC is fed into the A200 Inverter board, which consists of a set of power transistors configured as a half or full bridge inverter (half bridge for the 600W/1KW). The DC bus is locally bypassed by two capacitors minimizing the area of high

frequency current loops. In the half bridge (600w/ 1KW) only one transistor is turned on at a time. In the full bridge, the two diagonally opposite transistors Q1 and Q4 or Q2 and Q3 are turned on simultaneously. The result of this switching is to produce a quasi-square waveform that is impressed on the primary of the power transformer. Each transistor is protected by a fast recovery inverse parallel diode and by a turn-off snubbing network, reducing the switching stress and associated power loss. Snubbing of voltage spikes induced by the leakage inductance is implemented by R3 and C3 in the half bridge and by C7, R7A and R7B in the full bridge. C17 and C18 in the full bridge and C4 and C5 in the half bridge are used to ensure steady state Volt-Second balance across the primary of the power transformer, this in turn prevents transformer saturation. The output of the A200 inverter board is available at terminals HF1 and HF2.

4.4 OUTPUT SECTION

The high frequency power transformer T1 provides the necessary isolation and the step up or step-down that is required for the output dc voltage. Fast recovery rectifiers (or Schottky diodes for low voltage units) convert the secondary output into a unipolar pulse-width waveform. Filtering is achieved with an LC combination.

4.5 A100 CONTROL BOARD

All of the control circuitry is located on the A100 Control Board. The board receives its power from the bias transformer T2. The secondary of T2 is full-wave rectified and filtered. The voltage regulators provide the regulated bias voltages ±15v (±12v for the 600W/1KW). The bias voltages are used to power all the integrated circuits on the board. The control circuitry includes the supervisory function, over current protection, Reference Generation, Feedback and TRANSISTOR drive circuit.

4.5.1 SUPERVISORY FUNCTIONS

Most supervisory functions are performed by U4 and associated circuitry. These functions include: Turn-on delay, Undervoltage lockout, Overvoltage protection, Mode detect, and Remote Turn-on. In every fault condition Q5 is pulled low, activating the digital shutdown ports on the PWM.

Turn-on Delay (soft-start)

U4 provides a three to four second delay by comparing the 5 Volt reference with the voltage on C26. When power is applied, C26 charges through R34 with the necessary time constant to provide the desired delay. During the delay (charging period of C26 to 5 volts), pin 1 of U4 is negative turning off Q9 and thus disabling the relay K1. When the voltage across C26 reaches 5 volts, pin 1 of U4 goes positive turning on Q9, thereby activating the relay (K1) which causes the bus charging resistor R1 to be shorted. At the same time, the CR17 clamp on Q5 is released enabling the PWM.

Undervoltage Lockout

The unregulated side of the positive voltage regulator (an indirect measure of the AC input voltage) is sensed through R17 and R18 at pin 6 of U4. When the unregulated voltage at CR1 is below approx. 13V, pin 7 of U4 goes high, keeping Q5 fully on (saturated). Pin 5 & 8 of PWM (Pin 9 for the 600W/1KW) is thus clamped low by CR15 shutting down the

PWM. When the voltage rises above 13V, pin 7 of U4 latches low, and thus Q5 will turn off if permitted by diodes CR12, CR14, CR16 and CR17, controlled respectively by the Remote Turn-on, Thermostat protection, Overvoltage protection and Turn-on delay circuits.

(3) Overvoltage Protection

The overvoltage trip setpoint is set by potentiometer R8. The output voltage is sensed by R26 and R27. The amplifier has positive feedback latching, which requires removal of AC power for resetting after the OVP has been activated. C23 prevents noise tripping of the latch. Once Pin 8 of U4 latches high, Q5 is turned on and thus the control pin is pulled low, causing shutdown of the modulator. Also, Q8 is fired and the output of the power supply is crowbarred. The OVP LED is lighted through J3/8 for the 600W/1KW and through J3/12 for the 2KW/2.5KW and 5KW.

(4) Mode Detect

R38 samples the voltage at the output of U6. In the 600W/1KW and the 2/2.5KW, U4 compares the output of the voltage channel to GND (zero) whereas in the 5KW the voltage channel is compared to the current channel through R39. When the voltage channel is in control the output of U4 at pin 14 is high and that lights the VOLTAGE MODE LED through R41. If the Current Channel is in control the output of U4 at pin 14 is low and the CURRENT MODE LED lights through R40.

(5) Remote Turn-on

This feature allows the user to control the power supply from a remote location with either 12-24 Vdc or 24-115 Vac or a dry contact closure. U3 (U2 for the 5KW) provides isolation from the power supply ground. With the internal LED of U3 (U2) not activated, Q4 is turned on, which shuts down the modulator through CR12 and Q5. Any event that activates the internal LED, allows the modulator to function and thus let power pass to the power supply output. The internal LED of U3 (U2) can be activated in two ways: (1) Application of external voltage (AC or DC) across TB1/J1-15 and TB1/J1-16; (2) Dry contact closure across TB1/J1-16 and TB1/J1-17.

With dry contact closure, the power is supplied by the relaxation oscillator consisting of T1, Q3 and associated components. Each time that Q3 conducts, it discharges C18 through the primary of T1, inducing a voltage in its secondary winding. This voltage is rectified by CR8 and filtered by C15. The Remote Turn On may be disabled by connecting a jumper from cathode of CR11 to ground.

4.5.2 OVER CURRENT PROTECTION

A measure of transformer primary current and switch current is monitored by the current transformer(s) on the inverter Bd. The signal is rectified and filtered producing an unregulated dc voltage that is used for peak current limiting.

The rectified voltage from the inverter is fed into the inverting terminal of a comparator and is compared to a reference that is attenuated down from the 5Vdc of the PWM. The reference is set by a potentiometer. This circuit is activated when the switch current in the inverter exceeds 22 Amps as in fault conditions like saturation of the power transformer or short circuit on the inverter. Pins 5 and 8 (Pin 9 for 1KW) of the PWM are pulled low shutting down the PWM. Peak Current Limiting is not available on the 20-337-XXX A100 Bd. of the 600W/1KW units.

4.5.3 SET-POINT REFERENCE

Separate constant current sources provide reference voltages for the voltage and current channels. The collector current of Q1 drives the *voltage control potentiometer* that is located on the front panel, whereas Q2 drives the *current control potentiometer*. The positive bias voltage supply is RC filtered with R8 and C10 to minimize noise feedthrough. The current sources are referenced by the voltage across CR5, a temperature compensated zener diode. The current from each of the sources is adjustable to 1mA by R3 and R5.

4.5.4 VOLTAGE CONTROL CHANNEL

Voltage control and error amplification are implemented by U6 and associated components. The non-inverting input is routed from the (+) sensing terminal TB1/J1-2 (+V Rem) through R49 and R50 attenuating the output voltage to a 0-5 volts level for 0-100% of the output voltage. The inverting input is routed form TB1/J1-4 (V Amp In) through R51 and R53. The signal at TB1/J1-4 is the voltage reference set by a 1mA current that flows through the programming resistance R4 (in the normal mode of operation).

The voltage amplifier compares the reference and sense voltages and amplifies the error with appropriate compensation for loop gain shaping. The R54, C40 feedback combination provides a pole-zero combination, with a pole at DC for best DC regulation. The R51, C36, R53 combination provides phase lead as required for overall loop stability. R55 is an offset adjustment for zero nulling, and is set during calibration.

4.5.5 CURRENT CONTROL CHANNEL

Current control and error amplification are implemented by U5 (U8 for the 5KW) and associated components. The non-inverting input is routed from the current shunt (+) sense terminal TB1/J1-13 (Inv Amp In) through R45. The inverting input is routed from TB1/J1-10 (I Amp In) through R44. The signal at TB1/J1-10 is the current reference set by a 1mA current that flows through the programming resistance R5 (in the normal mode of operation). The error amplifier U5 compares the reference and sense currents and amplifies the error, with appropriate compensation provided by R44, R48, C29 and C31. Offset adjustment is provided by R47 (R77 for the 5KW) and is set during calibration.

4.5.6 AUTOMATIC CROSSOVER

The outputs of the voltage and current channels are "ORed" via diodes CR31 and CR27, and thus provide automatic crossover from current to voltage control, and vice versa. In the 600w/ 1KW and 2KW/2.5KW, the U5 and Q10 combination ensures that the current channel output may never fall too far below the voltage output, thus reducing the transition time at crossover. Additional attenuation of the analog channels' output is provided by R64, R65 and R66 (R67 and R68 for the 5KW) before the signal is fed to the input amplifier of the modulator.

4.5.7 PULSE WIDTH MODULATOR FOR THE 600W/1KW

The PWM for the unit is a UC1524A IC. This IC performs several tasks. The main function of the PWM is to convert the error signals from the voltage and current error amplifiers to a pulse width modulated signal (CLK1 and CLK2) which is proportional to the error voltage . The pulse width modulated signal is fed to the inverter to control the output

current and voltage. The 1524 also provides an accurate 5.1 volt DC reference which is used for the under and over voltage lockout circuits. The PWM also contains an amplifier which converts the error signals phase by 180° (at DC) so the signal into the PWM has the proper phase. The PWM also provides an oscillator used to control the frequency of the pulse width modulated signal.

4.5.8 PULSE WIDTH Modulator for the 2.5KW/5KW

U15 performs all the PWM functions. The industry standard UC3526 was chosen in this application. Its primary function is to convert the differential analog signal on pins 1 and 2 to PWM signals on pin 16 and pin 13. The 5 Volts reference is used on the A100 board for supervisory functions and for driving the input of the gate drive buffers. Pin 5 and pin 8 can be pulled low for any fault condition by either Q5 in the supervisory circuit or by the current limiting circuit.

4.5.9 Transistor Drive for the 600W/1KW

The outputs of U8 are "ORed" to provide a PWM signal at 50KHz. This is used as a clock for the power MOSFET driver IC (U1) located on the A200 half bridge inverter board. The totem pole outputs of the UC3706 drive T2. With the internal flip-flop active, the outputs of U1 at pins 6 and 11 are alternating providing balance transformer drive and insuring that only one transistor is turned on at a time.

4.5.10 Transistor Drive For the 2KW/2.5KW and 5KW

IXLD4429, an industry standard MOSFET driver, was chosen to drive the A200 Full Bridge Inverter because of its high peak current capability and high speed. The output of the PWM at pins 13 and 16 are alternating and are fed into the IXLD4429 MOSFET drivers. The IXLD4429 drives the pulse transformer(s) providing the 180 degrees out of phase that is required to keep only the diagonally opposite transistors conducting simultaneously.

5 CALIBRATION AND TROUBLESHOOTING

5.1 INTRODUCTION

A regularly scheduled maintenance of once a year is recommended for the EMS series power supply. As a minimum, maintenance should consist of a thorough cleaning of the interior, and a visual inspection of the fans and components on the printed circuit boards.

NOTE: *Maintenance and/or calibration procedures contained in this section will not void the unit warranty.*



CAUTION

Hazardous voltages are present during normal operation. Before removing the cover, the power source should be disconnected, and a period of 20 minutes allowed for the discharge of storage capacitance. Refer to Safety Precautions.

5.2 INSPECTION AND CLEANING

1. Clean exterior with a clean dry cloth.
2. Remove screws from all sides of cover and remove cover.
3. Check for loose wires, burn marks, etc.
4. Remove dust from parts (fans) with a small, long bristled brush or use an air blower to remove the dust.

5.3 CALIBRATION

The calibration procedure that follows applies to a properly functioning unit. Any malfunction must be corrected before proceeding with calibration. It is necessary only to remove the top cover to make these calibrations. The following equipment is required for calibration :

1. Digital voltage Multimeter.
2. Adjusting screw driver.
3. Jumper capable of handling the maximum output current of the power supply.

5.3.1 Analog Meter Zero Calibration

The zero set for both voltage and current front panel analog meters is located on the panel meters and is accessible at the front panel. Zero adjust should be performed with power removed. For power supplies with analog meters this calibration should be performed before

proceeding to the next step. The digital meter doesn't have a zero adjustment and the full scale is on the back of the meter, or on the A100 PCB R406 or R402.

5.3.2 VOLTAGE CHANNEL AND VOLTMETER CALIBRATION

1. Disconnect any load from output of the power supply.
2. Connect a digital voltmeter across output terminals.
3. Turn the *Voltage* control completely counterclockwise and *Current* control clockwise.
4. Apply input power and turn the circuit breaker on.
5. While monitoring the voltmeter that is across the output terminals, adjust R55 until the power supply output voltage starts to increase in the normal polarity. Adjust R55 in the opposite direction until the output voltage decreases to zero. Do not continue adjustment past this point.
6. Rotate *Voltage control* fully clockwise. While monitoring the voltmeter that is across the output terminals, adjust R3 until voltage across output terminals is equal to the maximum rated output voltage of the power supply.
7. The front panel voltmeter should agree within 2%. If it does not, adjust the potentiometer that is located on the front panel voltmeter (adjust R406 on A100 bd. if unit is a 600w/ 1KW) and check its zero adjustment if voltmeter is analog, (digital meter has no Zero Adjustment).
8. Turn circuit breaker off.

5.3.3 Current Channel and Ammeter Calibration

9. Connect a short across the output terminals of the power supply.
10. Connect a millivoltmeter across the current shunt sense terminals observing correct polarity.
11. Turn the *Voltage control* clockwise and the *Current control* completely counterclockwise.
12. Turn the circuit breaker on.
13. Adjust R47 (or R77 if unit is a 5KW) until the voltage across shunt starts to increase. Adjust R47 (or R77) in the opposite direction until the voltage across shunt decreases to zero. Do not continue adjustment past this point.
14. Turn *Current control* completely clockwise. Adjust R5 until voltage across sense terminals of the shunt is equal to the rated voltage of the shunt which in most cases is 100 mV. Some power supplies (usually high current units) are equipped with a 50 mV shunt.
15. The front panel Ammeter should read the maximum output current of the power supply. If not, adjust the potentiometer that is located on the front panel ammeter. If the unit is a 600W/1KW adjust R402 which is located on the A100 Bd, the digital meter has no Zero Adjustment.
16. Turn circuit breaker off.
17. Disconnect the AC input power.

5.4 TROUBLESHOOTING

Using this section in conjunction with section IV and the schematics that are provided in this manual, will help tremendously in troubleshooting the power supply by isolating and locating the cause of the fault. Before attempting to troubleshoot the power supply, perform Section 2.4 to determine whether the fault is with the associated circuitry or with the power supply. If the supply fails the Electrical Inspection test, check for appropriate link connections at TB1/J1 (refer to Section 3). The following table provides a listing of the most common symptoms and their causes.

SYMPTOM	PROBABLE CAUSE
Low or no output voltage or output current	a) Front panel meter is defective. b) Check input voltage. c) Fuse blown d) A100 Bd. Check for voltage at cathode of CR15 with respect to pin 7 of TB1/J1. If low (< 4V) check which of the following diodes is turned on: CR12 remote turn on, CR13A (undervoltage, CR14 thermostat, CR16 OVP and CR17 soft start.
Low or no output voltage or output current with OVP LED glowing	a) OVP Adjust rotated counterclockwise.
Circuit breaker trips	a) Input diode bridge(s) CR1 (CR2,CR3) shorted. b) Transistors on A200 Bd. shorted. c) Output diode Bridge(s) shorted.
Oscillates/ High Ripple	a) Output capacitor(s) defective. b) Feedback channel unstable.
Overheating	a) Check load connections. Especially on high current units, load connections should be very tight. b) Fan(s) are defective.
Output goes high (activating OVP). Voltage and/or current is not adjustable.	a) Links on TB1/J1 are disconnected. b) Voltage or Current control is disconnected or defective.

Table 5.1: Troubleshooting Guide

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