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# INSTRUCTION MANUAL

## REGULATED POWER SUPPLIES

LP SERIES

LAMBDA

LAMBDA ELECTRONICS CORP.—MELVILLE, L. I., N. Y.

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# SPECIFICATIONS AND FEATURES

Specifications apply for the non-metered and the metered models.

DC OUTPUT--Voltage regulated for line and load

Voltage Range.....TABLE I

VOLTAGE RANGE

| MODEL | LP-410 | LP-411 | LP-412 | LP-413 | LP-414 | LP-415 |
|---|---|---|---|---|---|---|
| VOLTAGE RANGE VDC | 0-10 | 0-20 | 0-40 | 0-60 | 0-120 | 0-250 |

Multi-Current Ranges.....Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range.

TABLE II

MAX. CURRENT

| MODEL | MAX. CURRENT AT AMBIENT OF: | | | |
|---|---|---|---|---|
| | 30°C | 40°C | 50°C | 60°C |
| LP-410 | 2A | 1.8A | 1.6A | 1.4A |
| LP-411 | 1.2A | 1.1A | 1.0A | 0.8A |
| LP-412 | 0.70A | 0.65A | 0.60A | 0.50A |
| LP-413 | 0.45A | 0.41A | 0.37A | 0.33A |
| LP-414 | 0.20A | 0.18A | 0.16A | 0.12A |
| LP-415 | 80MA | 72MA | 65MA | 60MA |

REGULATED VOLTAGE OUTPUT

Regulation (line).....0.01 percent plus 1.0 millivolt for input variations from 105-132 or 132-105 volts AC

Regulation (load).....0.01 percent plus 1.0 millivolt for load variations from no load to full load or full load to no load


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Remote Programming

External Resistor ..... Nominal 200 ohms/volt output

Programming Voltage..... One-to-one voltage change

Ripple and Noise ..... 500 microvolts rms; 1.5 millivolts peak-to-peak with either positive or negative terminal grounded, for all units except LP415-FM; 1.0MV rms; 3.0MV peak-to-peak for LP415-FM

Temperature Coefficient ..... Output change in voltage less than (0.015% + 0.5 mv) /°C

DC OUTPUT--Current regulated for line and load; automatic crossover with voltage limit

Multi-Current Ranges ..... Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range. For maximum current range see Table II. Minimum current 1% of 30° ambient rating in Table II or 5 ma., whichever is greater.

Voltage Range ..... For voltage range see Table I; voltage ratings apply for entire current range.

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line) ..... Less than 0.2% or 5 milliamperes, whichever is greater, variations from 105-132 or 132-105 volts AC

Regulation (load) ..... Less than 0.2% or 5 milliamperes, whichever is greater, for load voltage changes from 0 to max. or max. to 0 volts DC

AC INPUT--105-132 volts AC at 57-63 Hz. For input power see Table III. For 440 HZ input, consult factory.

TABLE III
INPUT POWER, WATTS*

| MODEL | INPUT POWER |
|---|---|
| LP-410 | 85 Watts |
| LP-411 | 75 Watts |
| LP-412 | 70 Watts |
| LP-413 | 65 Watts |
| LP-414 | 60 Watts |
| LP-415 | 50 Watts |

*With output loaded to full 30°C rating and input voltage 132 volts AC, 60 Hz



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OVERLOAD PROTECTION

Thermal ..... Thermostat, resets automatically when over-temperature condition is eliminated

Electrical

External ..... Adjustable, automatic, electronic current-limiting circuit, settable to 105 percent of rated current; limits output current to preset limit for protection of load and power supply when external overloads and direct shorts occur

Internal ..... Fuse, "SLO-BLO", 1.5A, fuse F1 protects the AC input circuit. Overload of the supply does not cause fuse failure

Fuse F2 provides protection against internal circuit failure in conjunction with overvoltage protector option

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal block on rear of chassis with 5-foot, 3-wire detachable line cord for all models; five-way binding posts provide for additional positive (+), ground, and negative (-) DC output connections, on front panel of FM models

OVERSHOOT--No overshoot of output voltage under conditions of power turn-on, power turn-off or power failure

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from 0°C to 60°C ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE-(non-operating) -55°C to +85°C

METERS-Voltmeter and ammeter on metered suffix (FM) models

CONTROLS

DC output controls ..... Coarse and fine voltage controls and coarse and fine current controls permit adjustment of DC output; located on front panel of all models

Binding Posts (+) (-) (GND).... Five-way binding posts on all models.

Remote Sensing. . . . . Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

Power. . . . . Panel mounted switch and indicator light for all units

Test Jacks (+) (-). . . . . Test jacks for non-metered models permit checking DC voltage output with external meters



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## PHYSICAL DATA

| | |
|---|---|
| Size | 5-3/16"H x 4-3/16"W x 10"D |
| Weight | 7 lbs. net; 8 lbs. shipping wt. |
| Panel Finish | Brushed aluminum clear anodized panels with grey inlay (standard); special finishes available to customer's specifications at moderate surcharge |

## MOUNTING:

| | |
|---|---|
| Laboratory bench, table top. | Bumpers secured to the base of all LP units permit proper circulation of air through the unit. Removal of bumpers will restrict free-flow of air through the unit, avoid removing bumpers |
| Standard 19" Rack | All LP units can be used with rack adapters:<br>LRA-1 (slide accomodation provided)<br>LRA-2 (conventional mount) See figure 13 |

## MODEL OPTIONS

| | |
|---|---|
| Suffix "R" Fungus Proofing Option | Standard LP power supplies can be obtained with fungus proofing treatment with MIL V 173 varnish for all fungi nutrient components |
| Suffix "FM" Meter Option | Standard LP power supplies can be obtained with voltmeter and ammeter. |
| Suffix "V" Option | Standard LP power supplies can be obtained for 205-265 VAC, 50 Hz input |

## ACCESSORIES

| | |
|---|---|
| Rack Adapters | Rack adapter LRA-1, with or without chassis slides is available as well as rack adapter LRA-2 which is used for simple rack installations where chassis slides are not required |
| Blank Panels | Half-rack and quarter-rack panels can be used with the Lambda rack adapters, see figure 13 |
| Overvoltage Protector | Externally mounted, Overvoltage Protectors LHOV-4, LHOV-5 and LHOV-6 are available for use with LP power supplies LP-410, LP-411, LP-412 and LP-413 |



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# THEORY OF OPERATION

## GENERAL

The Lambda power supply consists of an AC input circuit and transformer; a bias supply consisting of an auxiliary rectifier and filter, and preregulator; a main regulator circuit consisting of the main rectifier and filter, a series regulator, emitter follower driver(s), a current comparator, a voltage comparator, a voltage amplifier, current and voltage sensing networks and a voltage reference circuit.

The circuit arrangement is shown in block diagram form, Figure 10. The circuitry is discussed with reference to the block diagram and the schematic diagram.

## FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing a built-in thermostat and fuse F1, which protect the supply against overheating and internal faults.

The main rectifier, a full-wave rectifier, provides the power which is filtered by capacitor C9 and then regulated via a series regulator and delivered to the output. Half-wave auxiliary rectifier CR1 provides voltage filtered by capacitor C2 for voltage amplifier Q4 and preregulator Q1. Preregulator Q1 provides regulated power for zener diode CR3, which is the reference element for the current sensing circuit, for current comparator Q2, Q3, voltage comparator Q5, Q6, and for Q7 and zener diode CR7, which together function as the voltage reference for constant voltage operation. CR8 provides voltage compensation which acts to reduce the effect of temperature changes on the emitter-base bias of Q7.

Constant voltage or constant current crossover circuit operation is determined by changes in the load. A change in the output voltage is sensed by voltage sensing divider R30A, B, which has a constant current of 5 milliamperes flowing in the divider element, determined by Q7 and the setting of calibration control R20. This output voltage variation causes a change to the input of Q6 of the voltage comparator, which compares it with the reference voltage determined by CR7, resulting in an error signal at the output of Q5. In constant voltage operation, the voltage across R29 is less than the preset voltage across R6A, B; Q2 and CR4 are at cutoff; Q3 is in saturation and CR6 is conducting. If the load current decreases, causing a rise in output voltage, Q6 conducts less, Q5 is biased toward cutoff and the current from R18 flows through OR gate diode CR6 instead of Q5. This action causes amplifier Q4 to conduct more heavily, reducing drive current to the base of driver Q8, causing the series regulator impedance to increase and the output voltage to decrease accordingly.

Simultaneously, Q2 of the current comparator samples the load current through current sensing resistor R29 and compares it with the reference voltage across current sensing divider R4, R5 and R6A, B, determined by zener diode CR3. In constant current crossover operation, the voltage across R29 is approximately equal to the preset voltage across R6A, B, Q2 will conduct and bias Q3 toward cutoff, causing the current from R10 to flow through OR gate diode CR4 instead of Q3. Similarly, this action will cause amplifier Q4 to conduct more heavily, reducing drive current to the base of Q8, causing the series regulator impedance to increase and the output voltage to decrease accordingly, effectively maintaining a constant current. This output voltage decrease, sensed by the voltage sensing network, causes Q6 to be reverse biased, turning it off and causes turn-on of Q5 till saturation occurs



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and OR gate CR6 stops conducting. The unit now continues to function in the constant current mode of operation, with OR gate diode CR4 controlling the turn-on bias of Q4, which in turn controls the drive current to the series regulator and ultimately the output voltage of the supply.

In model LP-415 tandem transistors Q9, Q11 are used to share the total series regulator voltage. Resistors R32 and R33 fix the base of Q10 at approximately one-half of the total series regulator voltage. The emitter current from Q10 controls tandem regulator Q11, which tracks with Q9 to split voltage and power. For example, when voltage across Q9 increases due to a regulating action, the current in R32 and R33 also increases, causing base of Q10 to be biased toward cutoff which in turn biases Q11 toward cutoff so that the voltage across Q11 increases until the voltage across Q11 and Q9 are approximately equal.



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# OPERATING INSTRUCTIONS

## CONTROLS, INSTRUMENTS AND FUSES

Power ON-OFF Switch. The power ON-OFF switch, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red power on indicator glows.

OUTPUT VOLTAGE Control. The OUTPUT VOLTAGE control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC voltage over a range of 0-9, 0-19, 0-39, 0-59, 0-117.5, 0-247.5 volts as applicable, and a fine adjustment potentiometer, which varies the DC voltage over a one-volt range.* Clockwise rotation results in increasing voltage. The total DC voltage output for voltage regulated operation is equal to the sum of each shaft setting; for current regulated operation the maximum voltage limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

*For model LP-415 the DC voltage fine adjustment range is 2.5 volts.

CURRENT LIMITER Control. The CURRENT LIMITER control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC current over 90% of the rated current range* and a fine adjustment potentiometer, which varies the DC current over 10% of the rated current range. Clockwise rotation results in increasing current. The total DC current output for current regulated operation, is equal to the sum of each shaft setting; for voltage regulated operation the maximum current limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

*Operation for output current below rated limits can result in no output or no regulation.

Output Voltage Meter. A DC voltmeter monitors the voltage at the output terminals of metered (FM) units for the rated voltage range.

Output Current Meter. A DC ammeter monitors the load output current of metered (FM) units for the rated current range.

Fuses. Fuse F1, internally located, is a 1.5 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Fuse F2, internally located, provides protection against internal circuit failure. See schematic diagrams for current ratings of pertinent F2 fuse.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. DC output connections can also be made at the five-way binding posts located on the front panel of FM models. Apply input power through the line cord or directly to terminals 1 and 2 if the line cord is removed. Always connect the ungrounded (hot) power lead to terminal 1.

The supply positive terminal is brought out to terminal 6. The supply negative terminal is brought out to terminal 4. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 9. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the rear output terminals. Connect measuring devices directly to terminals or use the shortest leads possible.



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## GROUND CONNECTIONS

The Lambda power supply can be operated either with negative or positive output terminal grounded or with no terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

> NOTE: When operating the supply with neither terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

## BASIC MODES OF OPERATION

This power supply is designed to operate as a constant voltage source or as a constant current source. Automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant voltage source while the load current does not equal the current value, $I_{LIM}$, set by the CURRENT LIMITER control When load current $I_L = \frac{V}{R_L} = I_{LIM}$, the supply will cross over automatically and will operate as a constant current source. Further decrease in value of load resistance $R_L$ results in decrease of voltage across the load while current remains regulated to $I_{LIM}$.

Constant Current (Automatic Crossover). The power supply will function as a constant current source while the load voltage $V_L$ does not equal the voltage value set by the OUTPUT VOLTAGE control. When load voltage $V_L$ equals the value set by the OUTPUT VOLTAGE control, the supply will automatically cross over and operate as a constant voltage source.

## SUPPLY LOAD CONNECTIONS

> NOTE: Refer to DETAILED OPERATING PROCEDURES for step-by-step instructions for operation of power supply.

### Connections For Operation as a Constant Voltage Source

The output impedance and regulation of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on these characteristics, remote sensing is used. Recommended types of supply-load connections with local or remote sensing are described in the following paragraphs.

Refer to figure 1 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 2.



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Two-Wire Connection, Figure 3. The two-wire connection, with local sensing, is the connection suitable for application with relatively constant load.

Four-Wire Connection, Figure 4. The four-wire connection with remote sensing, provides complete compensation for the DC voltage drops in the connecting cables. Compensation for lead drop is also valid for gradual changes of load current.

Programmed Voltage Connections, Using External Resistor, Figure 5. Discrete voltage steps can be programmed with a resistance voltage divider valued at 200 ohms/volt output and a shorting-type switch as shown in figure 5. When continuous voltage variations are required, use variable resistor with the same 200 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation.

As shown in figure 5, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 6. The power supply voltage output can be programmed with an externally connected programming power supply. The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

The programming supply must have a reverse current capability of 6 ma. minimum.

Alternatively, when supplies with less than 6 ma. reverse current capability are used, a resistor capable of drawing 6 ma. at the minimum programming voltage must be connected across the output terminals of the supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

Connections For Operation as a Constant Current Source

Automatic Crossover Constant Current Connections, Figure 3. Figure 3 shows the connections which are used when operating the power supply as a constant current source with automatic crossover, using local setting of current control*

*Setting control for output currents below rated limits can result in no output or no regulation.

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the OUTPUT VOLTAGE control setting, the power supply crossover circuit will cause the unit to operate as a constant voltage supply.

Connections For Series Operation

The voltage capability of LP power supplies can be extended by series operation of two LP power supplies of equal* voltage ratings. A maximum of 300 volts can be connected between either the +DC or -DC terminal and chassis ground, and a maximum voltage capability of 500 volts is possible for model LP415.

*For applications using supplies of unequal ratings, consult factory for details of operation.

Diodes $CR_1$ and $CR_2$, must each be capable of withstanding the maximum rated current of the units in the series combination, figure 7.


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This method permits operation for either constant voltage or constant current with automatic crossover to either mode of operation whenever the respective limiting operating current or voltage is reached. Figure 7 shows connection for either local or remote sensing.

## Connections For Parallel Operation

The current capability of LP power supplies can be extended by parallel operation of two LP power supplies of equal* voltage capacities. The two units are shown connected for parallel operation in figures 8, 9. One power supply designated the "master" or (M) unit controls its own output as well as the output of the second power supply, designated the "slave" or (S) unit.

*For applications using supplies of unequal voltage ratings, consult factory for details of operation.

Unit (S) operates to regulate its current in a ratio to that of the (M) unit by comparing the current in its internal sampling resistor with that current sampled by the master internal sampling resistor. When power supplies of unequal current capacities are parallel connected, the division of current supplied will be approximately equal to the ratio of the current ratings of the supplies.

Parallel connected units can be operated for constant voltage with local sensing, figure 8, or remote sensing, figure 9, as well as for constant current with automatic crossover, figure 8. When operating for constant voltage, the (M) unit can automatically cross over into constant current operation.

## DETAILED OPERATING PROCEDURES

### SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

### Constant Voltage Operation, Adjustable Current Limit

1. Remove AC power to the supply and place power ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size from figures 1 and 2 and choose desired type of supply-load connection from figures 3 and 4.

3. Connect supply to load as shown on the selected connection diagram.

NOTE: When shipped from the factory, the supply is ready for use as a local-sensing constant voltage source with automatic crossover or as a constant current source. Jumpers are connected at the factory as shown in figure 3. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs to the desired voltage setting.


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5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER controls to the desired current limit setting. If no intermediate current limit is required, turn the control CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on Specifications and Features.

6. Apply AC power to the supply.

7. Place power ON-OFF switch in ON position and check that red power ON indicator is lit.

8. Check that output current* and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER controls to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 6 and 4, or at front panel test jacks (+) and (-) for voltage checks only; for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

9. Power supply is now in proper operation.

Programmed Constant Voltage Operation, Adjustable Current Limit

1. Remove AC power input to the supply and place power ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1 and 2 and choose desired type of supply-load connection from figures 5 or 6. Refer to paragraph on Programmed Voltage Connections.

3. Connect supply to load as shown on the selected connection diagram. As shown in figure 5, take care to use a shorting-type switch for the external programming control when several voltages are desired and the programming voltage method is not used.

4. Turn OUTPUT VOLTAGE control knobs to the extreme CCW position. Adjust external programming voltage control to desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER controls to the desired current limit setting. If no intermediate current limit is desired, turn the controls CW to the position for full rated current for the ambient temperature of operation. Refer to section on Specifications and Features.

6. Apply AC power to the supply.

7. Place power ON-OFF switch in ON position and check that red power ON indicator is lit.

8. Check that output current* and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER controls and external programming voltage control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4


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and 6, or at front panel test jacks (+) and (-) for voltage checks only; for remote sensing connections check at the load terminations of sensing leads on terminals 3 and 7.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

Constant Current Operation With Crossover, Adjustable Voltage Limit

1. Remove AC power input to the supply and place power ON-OFF switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1 and 2 and connect load to the supply as shown in figure 3.

3. Turn the CURRENT LIMITER controls to the desired current setting.

4. When load voltage must be limited to an intermediate value within the voltage rating of the supply, turn OUTPUT VOLTAGE control knobs to the desired voltage limit setting. If no intermediate voltage limit, within rating of supply is desired, turn controls to the full CW position to obtain voltage limit at maximum voltage rating of the supply.

5. Apply AC power to the supply.

6. Place power ON-OFF switch in ON position and check that red power ON indicator is lit.

7. Check that output current* and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER controls as required to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6, or at front panel test jacks (+) and (-) for voltage checks only.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

8. Power supply is now in proper operation.

Series Connection Constant Voltage Operation, With Current Limit

1. Remove AC power input to both units and place power ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and connect in accordance with figure 7. Refer to paragraph on Connections for Series Operation.

3. Select diodes $CR_1$ and $CR_2$ in accordance with instructions contained in Connections for Series Operation.

4. Turn OUTPUT VOLTAGE control knobs of both units to obtain the desired output voltage. These settings must be the output voltage for the combination.

5. When current to the load must be limited to an intermediate value within current rating of the units, turn the CURRENT LIMITER controls of each unit to a setting equal to


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desired total current limit for the combination. If no intermediate current limit is required, turn the controls of each unit CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on Specification and Features.

6. Apply AC power to the supplies.

7. Place power ON-OFF switches of both units in ON position and check that red power ON indicators are lit.

8. Check that output current* and output voltage meters indicate desired values; total voltage is equal to sum of output voltage of both units. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER controls of the units to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals of both units; positive (+) terminal 6 of unit (1) and minus (-) terminal 4 of unit (2) are the output terminals of the series combination.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

Use front panel jacks (+) of unit (1) and (-) of unit (2) to make output voltage check for the series combination. For remote sensing connection, make checks at the load terminations of sensing leads from terminal 7 of unit (1) and from terminal 3 of unit (2).

9. Power supplies are now in proper operation.

Series Connection Constant Current Operation, With Voltage Limit

1. Remove AC power input to both units and place power ON-OFF switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and make supply-load connections shown in figure 7A. Refer to paragraph on Connections for Series Operation.

3. Select diodes $CR_1$ and $CR_2$ as instructed in Connections for Series Operation paragraph.

4. Turn CURRENT LIMITER controls of each unit to the desired setting.

5. When load voltage must be limited to an intermediate value within the voltage rating of the series combination, turn the OUTPUT VOLTAGE control knobs to a position for total intermediate voltage required for the combination. Total voltage is the sum of the voltage settings of each unit.

If no intermediate voltage limit is required, turn the controls to the full CW position to obtain voltage limit at the maximum combined ratings of the supplies.

6. Apply AC power to the supplies.

7. Place power ON-OFF switches of both units to ON position and check that red power ON indicators are lit.



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8. Check that output current* and output voltage meters indicate desired values; total voltage is the sum of (1) and (2) unit voltages. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER controls of units to obtain correct indications. For non-metered models, use externally connected meters and check that correct meter indications exist at output terminals of the (1) and (2) units; positive (+) terminal 6 of (1) unit and minus (-) terminal 4 of the (2) unit are the output terminals of the series combination.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

Use front panel jacks (+) of (1) unit and (-) of (2) unit to make output voltage check on non-metered units.

9. Power supplies are now in proper operation.

Parallel Connection Constant Voltage Operation, With Current Limit

1. Remove AC power input to each supply and place power ON-OFF switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 8 for local sensing, or figure 9 for remote sensing. Choose correct value for $R_{EXT}$ from VALUE CHART.

NOTE: When shipped from the factory, each supply is ready for use as a local-sensing constant voltage source with automatic crossover or as a constant current source. Jumpers are connected at the factory as shown in figure 3. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the connection diagram.

4. Turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage setting, and turn the output voltage controls on the (S) unit to fully CCW position.

5. When current to the load must be limited to an intermediate point, turn the CURRENT LIMITER controls on both the (M) and (S) units to the desired current limit setting. Set current limit control on the (M) and (S) units to the position indicating the current value to be delivered by the respective unit. If no intermediate current limit is desired, turn the controls CW on both (M) and (S) units to the position for full rated current for the maximum ambient temperature of operation. Refer to section on Specifications and Features.

6. Apply AC power to each supply.

7. Place power ON-OFF switches on (M) and (S) units in ON position and check that red power ON indicators are lit.

8. Check that output current* and output voltage meters on both (M) and (S) units indicate desired values; as required, adjust OUTPUT VOLTAGE controls and CURRENT LIMITER controls on (M) unit to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at



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output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit for voltage check only; for remote sensing connection, check at the load termination of sensing leads on terminals 3 and 7 of the (M) unit.

* Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

9. Power supplies are now in proper operation.

Parallel Connection Constant Current Operation, With Voltage Limit

1. Remove AC power input to each supply and place power ON-OFF switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and connect load to the supplies as shown in figure 8. Refer to paragraph on Connections for Parallel Operation.

3. Turn the CURRENT LIMITER control knobs on (M) unit to the desired current setting. Turn OUTPUT VOLTAGE control knobs on the (S) unit to full CCW position.

NOTE: When setting the CURRENT LIMITER knobs on the (M) and (S) units take care to set the control so that each unit indicates the proportion of total current that the unit must supply.

4. When load voltage must be limited, turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage limit setting. If no voltage limit within rating of the supply is desired, turn controls on the (M) unit to the full CW position.

5. Apply AC power to each supply.

6. Place power ON-OFF switches on (M) and (S) units in ON position and check that red power ON indicators are lit.

7. Check that output current* and output voltage meters on both units indicate desired values; adjust OUTPUT VOLTAGE controls and CURRENT LIMITER controls, as required, to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit for voltage check only.

*Ammeter indicates a nominal 5 milliamperes offset from zero, which is the sensing divider current and not load current. For load current use the 5 ma. point as zero point.

8. Power supplies are now in proper operation.

## OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

### Thermostat Shutdown

The thermostat opens the input circuit only when the temperature of the transformer exceeds a maximum safe value. The thermostat will automatically reset when the temper-


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ature of the transformer decreases to safe operating value. After eliminating the cause(s) for overheating and allowing time for the power supply to cool to a proper temperature, resume operation of the supply. Refer to appropriate operation paragraph in DETAILED OPERATING PROCEDURES.

Fuse Shutdown

Internal component failure is prevented by fuses which protect the components from damage caused by excessive currents. Fuses will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse protected circuit operative. When the LP unit is used with the overvoltage protector option, fuse F2 will provide protection against internal component failure.



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