PRELIMINARY

INSTRUCTION MANUAL

FOR

REGULATED POWER SUPPLIES

P.O. # A-313616-9928Z
Job # 776230
Bill # 544155

MODELS LK - 350 — LK 352

BEARING SERIAL NO.

PREFIX A

This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics Corp. All information contained herein applies to all metered and non-metered LK full-rack models unless otherwise specified.

LAMBDA ELECTRONICS CORP. MELVILLE, L.I., N.Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

IM LK-FR

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SPECIFICATIONS AND FEATURES

The following specifications apply for all non-metered and metered LK full-rack models.

DC OUTPUT--Voltage regulated for line and load

Voltage Range .....

TABLE I
VOLTAGE RANGE

MODEL	350	351	352
VOLTAGE RANGE VDC	0-20	0-36	0-60

Multi-Current Ranges . . . . . Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range with input frequency 57-63 Hz. Derating for 50 Hz input frequency.

TABLE II

MODEL	CURRENT RANGE AT AMBIENT OF:			
	40°C	50°C	60°C	71°C
LK-350	0-35 A	0-31A	0-26A	0-20A
LK-351	0-25A	0-23A	0-20A	0-15A
LK-352	0-15A	0-14A	0-12.5A	0-10A

REGULATED VOLTAGE OUTPUT

Regulation (line) . . . . . 0.015 percent or 1.0 millivolt, whichever is greater for input variations from 105-132 or 132-105 volts AC

Regulation (load) . . . . . 0.015 percent or 1.0 millivolt, whichever is greater for load variations from 0 to full load or full load to 0

Remote Programming

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

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

Ripple and Noise . . . . . 0.5 millivolts rms with either positive or negative terminal grounded

Temperature Coefficient . . . . . Change in output voltage less than 0.015%/^{o}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 5% of 40^{o} rating in Table II.

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

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line) . . . . . Less than 10 milliamperes or 0.1%, whichever is greater, for input variations from 105-132 or 132-105 volts AC

Regulation (load) . . . . . Less than 10 milliamperes or 0.1%, whichever is greater, for load voltage changes from 0 to rated VDC or rated VDC to 0 volts.

AC INPUT--105-132 volts AC at 57-63 Hz

OVERLOAD PROTECTION

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

Electrical

External Overload Protection . . . . 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 short circuits occur

Internal . . . . . "SLO-BLO" 30A fuse F1 protects the AC input circuit. Overload of the supply does not cause fuse failure.

INPUT AND OUTPUT CONNECTIONS -- Heavy duty terminal block on rear of chassis with 5-foot, 3-wire detachable line cord for all 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^{o}C to 71^{o}C ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE- (non-operating) -55^{o}C to $+85^{o}$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
Remote Sensing	Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation
Power	Panel mounted circuit breaker and indicator light for all units.

PHYSICAL DATA

Size	5-1/4"H x 19"W x 16-1/2"D
Weight	95 lbs. net; 125 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 LK models 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 mounting

MODEL OPTIONS

Suffix "OV" Overvoltage Protection Option. .	All LK power supplies are available with a built-in overvoltage protection circuit which prevents damage to the load that can be caused by excessive power supply output voltage.

Suffix "R" Fungus Proofing Option . . .	Standard LK power supplies can be obtained with fungus proofing treatment with MIL V 173 varnish for all fungi nutrient components
Suffix "FM" Meter Option	Standard LK power supplies can be obtained with voltmeter and ammeter

OPERATING INSTRUCTIONS

CONTROLS, INSTRUMENTS AND FUSES

ON-OFF Circuit Breaker. The ON-OFF circuit breaker, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red 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 0-19, 0-35 or 0-59 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.

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.

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 30 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. 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 8. 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.

OV ADJ Control. This potentiometer is only used on units with the OV Overvoltage Protector option. The OV ADJ control permits screwdriver setting of the overvoltage protection point through an access hole in the front panel.

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 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 this characteristic, 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.

Two-Wire Connection, Figure 3. The two-wire connection with local sensing, provides simplest connection suitable for applications 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 a 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 output voltage 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.

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 LK power supplies can be extended by series operation of two LK power supplies of equal or unequal voltage ratings. A maximum of 200 volts can be connected between either the +DC or -DC terminal and chassis ground.

The two units are shown connected for series operation in figure 7. Figure 7 shows the series connection diagram which would be suitable for use in all applications.

Diodes CR_A and CR_B, which protect the units against reverse voltage, must be capable of withstanding the maximum rated current.

The series connection 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, when the series combination is operated for constant voltage; figure 7a shows the connection required when the series combination is operated for constant current.

CONNECTIONS FOR PARALLEL OPERATION

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

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 as well as for constant current with automatic crossover. 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 input to supply and place ON-OFF circuit breaker 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 constant current source with automatic crossover or as a local-sensing constant voltage 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.

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

4. Turn OUTPUT VOLTAGE control knobs to the 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 CURENT LIMITER control knobs to the desired curent limit setting. If no intermediate current limit is required, turn the control knobs CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to supply.

7. Place ON-OFF circuit breaker in ON position and check that red 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 control knobs 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; for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

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 ON-OFF circuit breaker in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1 and 2. 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 control knobs to the desired current limit setting. If no intermediate current limit is desired, turn the control knobs CW to the position for full rated current for the ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place ON-OFF circuit breaker in ON position and check that red indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER knobs 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 and 6; for remote sensing connections, check at the load terminations of sensing leads on terminal 3 and 4.

9. Power supply is now operating properly.

CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

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

2. Determine load requirements and connect load to the supply as shown in figure 3.

3. Turn the CURRENT LIMITER knobs to the desired current settings.

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 control knobs 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 ON-OFF circuit breaker in ON position and check that red indicator is lit.

7. Check that outout current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs 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.

8. Power supply is now in proper operation.

SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the (B) and (A) units and place ON-OFF circuit breakers in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and choose correct type of series supply-load connections from figure 7. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown on the selected connection diagram. As required, select diodes CR_A and CR_B in accordance with instructions contained in Connections for Series Operation.

4. Turn (A) and (B) unit OUTPUT VOLTAGE control knobs to the desired total voltage setting.

5. When current to the load must be limited to an intermediate value within current rating of the units, turn each CURRENT LIMITER control knob to the desired setting. If no intermediate current limit is required, turn the control knobs of each unit CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

> NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

6. Apply AC power to the supplies.

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

8. Check that output current and output voltage meters indicate desired values; total voltage is equal to sum of (A) and (B) units. As required, adjust OUTPUT VOLTAGE control knobs of both units to obtain correct indication; overload supply and adjust CURRENT LIMITER control knobs of both 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 of (A) unit and minus (-) terminal of the (B) unit are the output terminals of the series combination.

For remote sensing connection, make checks at the load terminations of sensing leads from terminal 7 of (A) and from terminal 3 connection of (B) unit.

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 ON-OFF circuit breaker 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 3 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 8.

> NOTE: When shipped from the factory, each supply is ready for use as a constant current source or as a local-sensing constant voltage source. Jumpers are connected at the factory. 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 on the (M) unit to the desired voltage setting, and turn the OUTPUT VOLTAGE control knobs 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 control knobs 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 CURRENT LIMITER control knobs 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.

6. Apply AC power to each supply.

7. Place ON-OFF circuit breakers on (M) and (S) units in ON position and check that red 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 control and CURRENT LIMITER CONTROL on (M) unit to obtain correct meter 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.

9. Power supplies are now in proper operation.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermostat Shutdown

The thermostat causes the circuit breaker to open the input circuit only when the temperature of the transistor heat radiator exceeds a maximum safe value. The thermostat will automatically reset when the temperature of the radiator 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, place ON-OFF circuit breaker in the ON position and resume operation of the supply. Refer to appropriate operation paragraph in DETAILED OPERATING PROCEDURE.

Fuse Shutdown

Internal failure of supply causes the fuse to clear the circuit, removing input power from the supply. Overloading of the unit will not cause fuse failure. 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.

MAINTENANCE

GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. Refer to the section on specifications and features for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunctions before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumper and supply-load connections or fuse failure due to metal fatigue.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an in-circuit transistor checker. If no checker is available, transistors can be checked with an ohmmeter that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.