

INSTRUCTION MANUAL

FOR

REGULATED POWER SUPPLIES

MODELS

LP-520-FM - LP-524-FM

This manual applies to units bearing  
serial no. prefixes A&B

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 LP models unless otherwise specified.

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**manual # /**

LAMBDA ELECTRONICS CORP.

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

IM-LP520

## TABLE OF CONTENTS

Section	Page
SPECIFICATIONS AND FEATURES.....	1
THEORY OF OPERATION.....	5
OPERATING INSTRUCTIONS.....	7
Controls, Instruments, and Fuses.....	7
Ground Connections.....	8
Basic Modes of Operation.....	8
Supply-Load Connections.....	8
Detailed Operating Procedures.....	10
Operation After Protective Device Shutdown.....	17
MAINTENANCE.....	18
General.....	18
Trouble Analysis.....	18
Checking Transistors and Capacitors.....	18
Printed Circuit Board Maintenance Techniques.....	18
Trouble Chart.....	19
Adjustment of Voltage Calibration Control R108....	22
Adjustment of Current Calibration Control R102....	22
Performance Checks.....	23
SERVICE.....	24
PARTS ORDERING.....	24
USE OF RACK ADAPTERS (Fig. 15)	
Installation of 1/2 Rack Units into LRA-1 (Fig. 15)	
Shipment of Units Mounted in LRA-1 (Fig. 15)	
Mounting Chassis Slides (Fig. 15)	
Using Blank Panels and Blank Chassis (Fig. 15)	

SPECIFICATIONS AND FEATURES

Specifications apply for all models.

DC OUTPUT - Voltage regulated for line and load.

Voltage Range.....TABLE I  
VOLTAGE RANGE

MODEL	LP-520-FM	LP-521-FM	LP-522-FM	LP-523-FM	LP-524-FM
VOLTAGE RANGE VDC	0-10	0-20	0-40	0-60	0-120

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 (AMPS)

MODEL	MAXIMUM CURRENT AT AMBIENT OF:			
	30°C	40°C	50°C	60°C
LP-520-FM	5.0	4.7	4.3	3.7
LP-521-FM	3.3	3.0	2.6	2.3
LP-522-FM	1.8	1.6	1.4	1.2
LP-523-FM	0.9	0.8	0.7	0.6
LP-524-FM	0.5	0.45	0.4	0.35

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.

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.

Temperature Coefficient...Output change in voltage less than (0.015% + 0.3 mv) /°C

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 rating: 6 ma.

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 6 milliamperes for load voltage changes from 0 to max. or max. to 0 volts DC

AC INPUT - 105-132 volts AC at 47-440 Hz. For input power see Table III Ratings apply for 57-63 Hz; for other input frequencies consult factory.

TABLE III  
INPUT POWER, WATTS\*

MODEL	INPUT POWER	MODEL	INPUT POWER
LP-520-FM	161 Watts	LP-523-FM	101 Watts
LP-521-FM	161 Watts	LP-524-FM	117 Watts
LP-522-FM	158 Watts		

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

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....."SLO-BLO", 3A fuse F101 protects the AC input circuit. Overload of the supply does not cause fuse failure.

Fuse F2 (or, as applicable F102) 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.

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 - -55°C to +85°C  
(non-operating)

METERS - Voltmeter and ammeter on all models.

#### CONTROLS

DC Output Controls.....Coarse and fine voltage controls and coarse current control 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.

#### PHYSICAL DATA

Size.....5-3/16"H x 4-3/16"W x 15-1/2"D

Weight.....14 lbs. net, 18 lbs. shipping wt.

#### MOUNTING

Laboratory bench table top - Secure the four bumper feet to the bottom of the unit using four 6x32 screws and lockwashers supplied with the power supply. Bumpers must be used to permit proper circulation of air through the unit. Removal of bumpers will restrict free flow of air, avoid removing bumpers. See figure 14 for outline drawing.

Standard 19" Rack.....All LP units can be used with rack adapters: LRA-1 (slide accomodation provided) LRA-2 (conventional mount) See figure 15.

#### MODEL OPTIONS

Suffix "R" Fungus.....Standard LP power supplies can be obtained with fungus proofing treatment with MIL V 173 varnish for all fungi nutrient components.

Suffix "V" Option.....Standard LP power supplies can be obtained for 205-265 VAC, 47-63Hz input or 187-242VAC, 47-63Hz input. Standard "V" option units are factory wired for 187-242V, but can be rewired for 205-265V.

#### 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. See figure 15.

Blank Panels.....Quarter-rack panels can be used with the Lambda rack adapters, see figure 15.

Overvoltage Protector.Externally mounted, Overvoltage Protectors LHOV-4, LHOV-5, and LHOV-6 are available for use with LP power supplies LP-520-FM, LP-521-FM, LP-522-FM, and LP-523-FM.

## 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, a voltage reference\* and a current amplifier\*.

\*This circuit element is part of integrated circuit IC101.

The circuit arrangement is shown in block diagram form, figure 11. 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 thermostat and fuse F101, which protect the supply against overheating and internal faults.

The main rectifier, a full wave rectifier, provides the power which is filtered by capacitor C109 and then regulated via a series regulator and delivered to the output. Half-wave auxiliary rectifier CR101 provides voltage filtered by capacitor C101 for the preregulator located in IC101. \*\*Auxiliary supply, half wave rectifier CR201 provides voltage filtered by C203 for auxiliary series regulator Q1.

#### Constant Voltage Circuit Operation

Constant voltage developed by IC101 across R101, R102 produces a constant current of 5 milliamperes through R108, R106, and Q103B. This current is fed through dividers R1, R2 which, in turn, develop a constant reference voltage for one input to the voltage comparator. A second input, the load voltage, is compared to the reference voltage by the comparator. A change in output voltage produces an error signal at the output of the comparator. If the output voltage tends to rise, the comparator conducts, less current flows through CR104 and current to driver Q101 is reduced. This action increases the voltage across the series regulator thus reducing the output voltage.

On model LP-524-FM, auxiliary series regulator Q1 shares power with series regulator Q2 when maximum power is dissipated in Q2. The base of emitter follower Q4, supplied through R202, results in a fixed base bias for the auxiliary series regulator. Changes in operation for Q1 occur when the emitter bias of Q1 changes. Output voltage adjustments to less than 120 volts and crossover to constant current operation will change emitter bias of Q1 through the regulating action of Q2. Q2 biases Q1 for operation toward cutoff and accordingly, shares power dissipation with Q2.

\*\*Applies to model LP-524-FM only.

## Constant Current Operation

Constant current developed by IC101 flows through resistor R3. A reference voltage, developed at the wiper of R3 is applied at one input to the current comparator. A second input to the comparator is the voltage developed across R107. If the current to the load tends to increase, the voltage across R107 increases causing the comparator to conduct. This action reduces current to driver Q101 and increases the series regulator impedance, thus limiting the output current. The current limit value is determined by the setting of resistor R3.



## 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, 0-119 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 varies the DC current over the rated current range\*. Clockwise rotation results in increasing current. 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 over the rated voltage range.

Output Current Meter. A DC ammeter monitors the load output current over the rated current range.

Fuses. Fuse F101, internally located, is a 3A ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Fuse F102, (or, as applicable, F2) internally located, provides protection against internal circuit failure. See schematic diagrams for current ratings of pertinent F102 (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. 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 10. 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.

## 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  $I_L = V/RL = I_{LIM}$ , 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 a 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.

Two-Wire Connection, Figure 3. The two-wire connection, with local sensing, is the connection suitable for application with relatively constant load where extremely close load regulation over full-rated current excursion is not required at the 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. A 1MF, 35V capacitor may be required to reduce noise, between terminals 3,4 and 6,7 whenever remote sensing is used. +S and -S sensing leads must be twisted together.

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.

#### 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 240 volts is possible for model LP-524-FM.

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

The two units are shown connected for series operation in figures 7 and 8. Figure 7 shows the series connection diagram which would be suitable for use in all applications where exact one-to-one voltage tracking of the "master" (M) unit by the "slave" (S) unit is not required. The slight offset in tracking is easily compensated for by adjusting the OUTPUT VOLTAGE controls on the (S) unit.

Figure 8 shows the series connection diagram suitable for applications where exact one-to-one voltage tracking is required. In this series configuration, resistor  $R_{BAL}$  permits the (S) unit to track the (M) unit on an exact one-to-one basis, thereby eliminating the possibility of an offset voltage existing between the two units.

Resistor  $R_{BAL}$  should be a two-watt, 10 ohm/volt output, resistor. This value would permit wide-range compensation for manufacturing differences inherent in the components used in each unit. Resistors  $R_S$  and  $R_M$  function in the voltage sensing circuits of both units, enabling the (S) unit to reference its output voltage to that of the (M) unit. In figure 7,  $R_S$  performs a similar function. Capacitor  $C_S$ , used to eliminate stray AC pickup, is rated at 2.5 mfd, 250V.

For either series mode of operation, select  $R_S$  and  $R_M$  on the basis of 200 ohms per volt of (M) unit output voltage.  $R_S$  must equal  $R_M$ . Choose  $R_S$  and  $R_M$  to be low temperature coefficient resistors.

Diodes  $CR_M$  and  $CR_S$ , which protect the units against reverse voltage must be capable of withstanding the maximum rated current of the (M) unit, and must have a reverse blocking voltage equal to 2.5 times the maximum rated output voltage.

Both methods permit 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. As shown in figures 7 and 8, each method permits 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 9 and 10. 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 to be equal 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.

Parallel connected units can be operated for constant voltage with local sensing, figure 9, or remote sensing, figure 10, as well as for constant current with automatic crossover, figure 9. 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. Apply AC power to the supply but place power ON-OFF switch in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

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. Do not connect load.
3. Place power ON-OFF switch in ON position and check that red indicator is lit.
4. Set CURRENT LIMITER control fully CW and adjust OUTPUT VOLTAGE control knobs to obtain desired voltage indication. When the current to the load must be limited to an intermediate value within the current rating of the supply, proceed as follows: a) place power ON-OFF switch in OFF position, b) connect jumper between +V and -V terminals, c) place power ON-OFF switch in ON position and adjust CURRENT LIMITER control to obtain the desired meter indication, d) place power ON-OFF switch in OFF position and remove jumper.
5. Connect supply to load as shown on selected connection diagram.
6. Place power ON-OFF switch in ON position and check that red indicator is lit.
7. Check that output current and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to obtain correct meter indications.
8. Power supply is now in proper operation.

## PROGRAMMED CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Apply AC power to the supply, but place power ON-OFF switch in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size and length from figures 1 and 2, and choose desired type of supply load connections from figures 5 or 6. Refer to paragraph on Programmed Voltage Connections.
3. Connect supply terminals 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 used. Do not connect load.
4. When current to the load must be limited to an intermediate value within the current rating of the supply, proceed as follows:
  - a) Connect jumper between +V and -V terminals
  - b) Place power ON-OFF switch in ON position and adjust CURRENT LIMITER control to obtain the desired current limit meter indication.
  - c) Place power ON-OFF switch in OFF position and remove jumper between +V and -V terminals.
5. Connect supply to load as shown on the selected connection diagram.
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; as required, adjust CURRENT LIMITER knob and external programming voltage control to obtain correct meter indications.
8. Power supply is now operating properly.

#### CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

1. Apply AC power to the supply, but place power ON-OFF switch in OFF position.

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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size from figures 1 and 2, and connect supply terminals as shown in figure 3. Do not connect load.
3. Adjust CURRENT LIMIT control to the desired output current as follows:
  - a) Connect jumper between +V and -V terminals.
  - b) Place power ON-OFF switch in ON position and adjust CURRENT LIMITER control to obtain the desired load current as indicated on current meter.

- c) Place power ON-OFF switch in OFF position and remove jumper between +V and -V terminals.
4. Place power ON-OFF switch in ON position and adjust OUTPUT VOLTAGE control knobs to obtain the desired voltage limit point as indicated on voltage meter.
  5. Place power ON-OFF switch in OFF position and connect load to the supply as shown in figure 3.
  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 control as required to obtain correct indications.
  8. Power supply is now in proper operation.

\*SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Apply AC power input to the "slave" (S) and "master" (M) units, and place power ON-OFF switches in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size from figures 1 and 2 choose correct type of series supply-load connections from figures 7 and 8. Refer to paragraph on CONNECTIONS FOR SERIES OPERATION.
3. Connect power supply terminals as shown on the selected connection diagram. As required, select resistors  $R_{BAL}$ ,  $R_S$ , and  $R_M$  and diodes  $CR_S$  and  $CR_M$  in accordance with instructions contained in CONNECTIONS FOR SERIES OPERATION. Do not connect load.
4. \*\*Place power ON-OFF switches in ON position and adjust OUTPUT VOLTAGE control knobs on the (M) unit to obtain the desired meter indication. Adjust (S) unit OUTPUT VOLTAGE controls until (S) unit voltage meter indication equals (M) unit voltage meter indication. This setting will be approximately one-half of the combined (M) and (S) unit output voltage. The (S) unit will track any change in (M) unit output voltage made with the (M) unit OUTPUT VOLTAGE control. Place power ON-OFF switch in OFF position.

\*Applies only to units of equal voltage and current capacities, when units of unequal ratings are series connected, consult factory.

\*\*This step does not apply to figure 8.

5. When current to the load must be limited to an intermediate value within the current rating of each supply, proceed as follows:
  - a) Connect jumpers between +V and -V terminals on the (M) unit
  - b) Place power ON-OFF switch in ON position and adjust CURRENT LIMITER control on the (M) unit to the desired current limit point, as indicated on current meter.
  - c) Set CURRENT LIMITER control on (S) unit slightly above CURRENT LIMITER control setting on (M) unit.
  - d) Place power ON-OFF switch in OFF position and remove jumpers between +V and -V terminals.
6. Connect supplies to load as shown on the selected connection diagram.
7. Place power ON-OFF switches in ON position and check that red power-on indicator is lit.
8. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications.
9. Power supplies are now in proper operation.

#### SERIES CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Apply AC power input to the "slave" (S) and "master" (M) units and place power ON-OFF switches in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size from figures 1 and 2 and choose correct type of series supply-load connections from 7A and 8A. Refer to paragraph on CONNECTIONS FOR SERIES OPERATION.
3. Connect power supply terminals as shown on the selected connection diagram. As required, select resistors  $R_{BAL}$ ,  $R_S$ , and  $R_M$  and diodes  $CR_S$  and  $CR_M$  as instructed in CONNECTIONS FOR SERIES OPERATION. Do not connect load.
4. Place power ON-OFF switches in ON position.
5. Adjust (S) unit OUTPUT VOLTAGE controls until (S) unit voltage meter indication equals (M) unit voltage meter indication. The (S) unit will track any change in (M) unit output voltage made with the (M) unit OUTPUT VOLTAGE control.
6. When the voltage to the load must be limited to an intermediate value within the voltage rating of the series combination, proceed as follows:



- a) Place power ON-OFF switch of the (M) unit in ON position.
  - b) Turn the (M) unit OUTPUT VOLTAGE control knobs until voltage meter indicates approximately one-half the total rating desired for the series combination.
  - c) Place power ON-OFF switch in OFF position.
7. Adjust CURRENT LIMITER control for the desired load current as follows:
    - a) Connect jumpers between +V and -V terminals on (M) unit.
    - b) Place power ON-OFF switch in ON position and adjust CURRENT LIMITER control to the desired load current as indicated on (M) unit current meter.
    - c) Set CURRENT LIMITER control on (S) unit slightly above CURRENT LIMITER control setting on (M) unit.
    - d) Place power ON-OFF switch in OFF position and remove jumpers between +V and -V terminals.
  8. Connect supplies to load as shown on the selected connection diagram.
  9. Place power ON-OFF switches in ON position and check that red power-on indicator is lit.
  10. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications.
  11. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Apply AC power input to the "slave" (S) and "master" (M) units and place power ON-OFF switches in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size from figures 1 and 2 and choose correct type of parallel supply-load connections from figures 9 and 10. Connect supply terminals as shown on the selected connection diagram, but do not connect load.
3. Place power ON-OFF switches of both (M) and (S) units in ON position.
4. Turn (M) and (S) unit CURRENT LIMITER controls fully CW.
5. Adjust (M) unit OUTPUT VOLTAGE control for the desired voltage as read on (M) unit voltage meter.

6. Place power ON-OFF switches of both units in OFF position.
7. When current to the load must be limited to an intermediate value within the current rating of each supply, proceed as follows:
  - a) Connect supply to the load and place a jumper across load terminals.
  - b) Place power ON-OFF switches in ON position and adjust (M) unit CURRENT LIMITER control for desired meter reading. The short circuit current will be the sum of (M) & (S) unit current meter readings.
  - c) Place power ON-OFF switches in OFF position and remove jumper across load.
8. Place power ON-OFF switches in ON position and check that red power-on indicator is lit.
9. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications.
10. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Apply AC power input to the "slave" (S) and "master" (M) units and place power ON-OFF switches in OFF position.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic cross-over 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. When the five way binding posts are used, do not remove barrier strip jumpers.

2. Determine load requirements, select wire size from figures 1 and 2, and choose correct type of parallel supply-load connections from figure 9. Connect supply terminals as shown on the selected connection diagram, but do not connect load.
3. Place power ON-OFF switches of both (M) and (S) units in ON position.
4. Turn (S) unit current limiter control fully CW.
5. Adjust (M) unit OUTPUT VOLTAGE control for the desired voltage limit point as read on (M) unit voltage meter.
6. Place power ON-OFF switches of both units in OFF position.
7. Set the desired load current as follows:
  - a) Connect supply to the load and place a jumper across load terminals.
  - b) Place power ON-OFF switches in ON position and adjust (M) unit CURRENT LIMITER control for desired meter reading. The regulated current will be the sum of

- (M) and (S) unit current meter readings.
- c) Place power ON-OFF switches in OFF position and remove jumper across load.
8. Place power ON-OFF switches in ON position and check that red power-on indicator is lit.
  9. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications.
  10. 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 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, 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.

## MAINTENANCE

### GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. 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 malfunction 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.

Use the electrical schematic diagram and block diagram, figure 11, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

### CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an instrument 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.

For good transistors, the forward resistance for any junction is always greater than zero.

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, wherever possible, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

### PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder, it is a good contact. Do not attempt to cover with solder.
2. Voltage measurements can be made from either side of the board.

Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to the measuring instrument.

3. Wherever possible, use a heat sink when soldering transistors.
4. Broken or damaged printed wiring is usually the result of an imperfection, strain, or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.
5. When unsoldering components from the board, never pry or force loose the part; unsolder the component by using the wicking process described below:
  - a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or No. 16 stranded wire with 1/2 inch insulation removed.
  - b) Dip the wick in liquid rosin flux.
  - c) Place the wick onto the soldered connection and apply soldering iron onto the wick.
  - d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

#### TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

- a) AC power of proper voltage and frequency is present at input terminals.
- b) Either positive or negative terminal is connected to chassis ground.
- c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

## TROUBLE SHOOTING CHART

<u>Symptom</u>	<u>Probable Cause</u>	<u>Remedy</u>
1. Zero volts DC output	OUTPUT VOLTAGE controls turned fully CCW.	Check OUTPUT VOLTAGE controls for proper setting and correct as necessary.
	CURRENT LIMITER control turned fully CCW.	Check CURRENT LIMITER for proper setting & correct as necessary.
	Short circuit across output of supply.	Check load and load connections, correct as necessary.
	F101 and/or F102 (F2) open.	Replace F101 or F102 (F2); if it blows immediately, check for shorted transistors Q1 or as applicable, Q2, Q3 & capacitors C10 & C111 (or as applicable, C11) replace as necessary.
	Series regulator section open.	Check Q1, (Q2,Q3) for open, replace as necessary.
	Open CR109 (CR9), CR110 (CR10), (or as applicable CR111, CR112).	Check CR109 (CR9), CR110 (CR10) (CR111, CR112) for open; replace as necessary.
	Open CR104.	Check CR104 for open, replace as necessary.
	Open Q103.	Check Q103 for open & replace as necessary.
	Current sensing resistor open.	Check R107 for open, R3 for short; replace as necessary.
	Jumpers between terms 10-9 and 7-6 open.	Check supply terminal connections; correct as necessary.
Aux. rectifier CR101 open.	Check CR101 for open; replace as necessary.	
2. Unable to adjust output voltage	Damaged OUTPUT VOLTAGE controls.	Check R1 and R2 for short or open; replace as necessary.

TROUBLE SHOOTING CHART

<u>Symptom</u>	<u>Probable Cause</u>	<u>Remedy</u>
2. (con't)	Jumper between terms 4-3 open.	Check supply terminal connections; correct as necessary.
3. High ripple at line frequency or twice line frequency and unregulated DC output.	Series regulator transistors shorted.	Check Q1 (Q2,Q3) for short and replace as necessary.
	Open C109 (or, as applicable, C9)	Check C109 (C9) for open, replace as necessary.
	Defective main rectifier causes ripple at twice line frequency.	Check for open in CR113 thru CR120 (as applicable).
4. Same as 3, except intermittent.	Foreign matter fallen into unit.	Check for loose bench hardware and wire clippings that may have fallen through cover.
5. High ripple at frequency other than line or twice line frequency.	Oscillation due to defective component in filter network.	Check for open C10, C102, C111 and check for open and/or short in C106 & R114. Replace defective component.
6. Large spikes at output.	Capacitors C8 (C108) (or, as applicable, C103, C104) open.	Replace C8 (C108) or (C103, C104) as necessary.

## ADJUSTMENT OF VOLTAGE CALIBRATION CONTROL R108

The adjustment procedure requires that the power supply is removed from associated equipment is at an ambient temperature of 25-30°C and is operated at nominal line voltage, no load.

Whenever R1, R2, R106, R108, Q103 or IC101 are replaced and voltage indications do not reflect maximum ratings, adjust R108 as follows:

1. Apply AC power to the supply and place power ON-OFF switch in OFF position.
2. Break seal on wiper of R108 from resistor housing.
3. Place power ON-OFF switch in ON position.
4. Turn OUTPUT VOLTAGE controls (R1, R2) fully CW.
5. Adjust R108 until maximum output voltage is reached (as indicated on voltage meter). If better than 2% accuracy is required, connect a DVM (John Fluke Model 825A or equivalent) at supply output terminals to measure output voltage.
6. Place power ON-OFF switch in OFF position.
7. After adjustment is completed, remove AC power input to the supply and reseal wiper of R108 to potentiometer housing.

## ADJUSTMENT OF CURRENT CALIBRATION CONTROL R102

The adjustment procedure requires that the power supply is removed from associated equipment is at an ambient temperature of 25-30°C and is operated at nominal line voltage.

Whenever IC101, R3, R101, R102 and R107 are replaced, and current indications do not reflect maximum ratings, adjust R102 as follows:

1. Apply AC power to the supply and place power ON-OFF switch in OFF position.
2. Unsolder wiper of R102 from resistor housing and set at midpoint position.
3. Place a jumper between +V and -V terminals.
4. Turn CURRENT LIMITER control (R3) fully CW.
5. Place power ON-OFF switch in ON position.
6. Adjust R102 until output current (as read on current meter) is 110% of rating for the supply. Refer to table II for maximum current ratings.
7. Place power ON-OFF switch in OFF position.
8. After adjustment is completed, remove AC power input to the supply and solder wiper of R102 to resistor housing.



## PERFORMANCE CHECKS

### Checks With Constant Voltage Operation

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 12. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC DVM (John Fluke Model 871A or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power-supply line regulation accuracy on the differential meter.

Use a VTVM, Ballantine 320 or equivalent, to measure rms ripple voltage of the power supply DC output. Use oscilloscope to measure peak-to-peak ripple voltage of the power supply DC output.

### Checks With Constant Current Operation

Check the ripple or regulation of the power supply using the test connection diagram shown in figure 13. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Check the power supply load regulation accuracy while switching from the short circuit to load condition. Measure the voltage across sensing resistor  $R_s$ . Use John Fluke Model 871A or equivalent for the DVM connected across  $R_s$ . For  $R_s$ , use a resistor having the same value as resistor R107 in the unit being tested. To obtain regulation figure substitute values obtained into regulation formula:

$$\frac{\Delta E}{R_s} = \text{Regulation in milliamperes,}$$

where  $\Delta E$  is the voltage change in millivolts and  $R_s$  is the resistance of the sensing resistor.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power supply line regulation accuracy using the VTVM and the regulation formula:

$$\frac{\Delta E}{R_s}$$

## SERVICE

When additional instructions are required or repair service is desired, contact the nearest office of the Lambda Electronics Corp. where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

## PARTS ORDERING

Standard components and special components used in the Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

## PARTS LIST

The electrical parts located on Lambda Models LP520-FM — LP524-FM are listed here. Parts common to a group of models are listed first. Unique parts of individual models within the group are listed separately, by model, immediately following the group common-parts listing. In addition, there are separate listings of parts for the "V" option and LHOV accessory.

<u>COMMON PARTS</u> MODELS LP520-FM — LP524-FM			
<u>CIRC. DESIG.</u>	<u>DESCRIPTION</u>	<u>LAMBDA NO.</u>	<u>UNIT PRICE</u>
C1 thru C7	Not assigned		
C12	Cap., mylar, 0.033 mf ±10%, 400 vdc	CGL-33-006	\$ .50
C101	Cap., elect., 100 mf -10 +75%, 35 vdc	CBR-10-108	1.22
C102	Cap., mylar, 0.047 mf ±10%, 200 vdc	CGL-47-018	.39
C105	Cap., mylar, 0.1 mf ±10%, 200 vdc	CAM-10-012	.65
CR1 thru CR16	Not assigned		
CR101	Rectifier	FBL-00-030	1.40
CR102, CR103, CR105	Not assigned		
CR106, CR107	Same as CR101		
CR108	Rectifier, zener diode	FBM-Z119	.85
CR110, CR115, CR116, CR121	Not assigned		
CR124	Rectifier, zener diode	FBM-Z139	.27
DS1	Pilot light	HRD-00-007	1.00
F1	Not assigned		
F101	Fuse, 3A, 3AG, SLO-BLO	FFC-03-000	.25
IC101	Integrated Circuit	FBT-00-034	10.71
Q102	Not assigned		
Q103	Transistor, dual, NPN, PNP	FBN-L117	4.25
R3	Res., var., ww, 500 ohms ±5%, 5 w	DNR-50-013	2.25
R101	Res., film, 8,870 ohms ±1%, ¼ w	DCS-89-073	.15
R102	Res., var., ww, 10,000 ohms ±10%, 1½ w	DNT-10-009	1.25
R106	Res., ww, 1,200 ohms ±3%, 2 w	DFS-12-030	.90
R108	Res., var., cermet, 1,200 ohms ±20%, 1 w	DRS-12-014	1.77

<u>COMMON PARTS (Cont.)</u> MODELS LP520-FM — LP524-FM (Cont)			
<u>CIRC. DESIG.</u>	<u>DESCRIPTION</u>	<u>LAMBDA NO.</u>	<u>UNIT PRICE</u>
R109	Res., comp., 36,000 ohms ±5%, ½ w	DEB-3635	\$ .24
R110	Not assigned		
R112	Res., comp., 22,000 ohms ±10%, ½ w	DEB-2231	.12
R115	Res., comp., 2,200 ohms ±10%, ½ w	DEB-2221	.12
R119	Res., comp., 4,700 ohms ±10%, ¼ w	DCB-4721	.12
R120	Res., comp., 6,800 ohms ±5%, ¼ w	DCB-6825	.11
R122	Not assigned		
R123	Res., comp., 1,000 ohms ±10%, ¼ w	DCB-1021	.10
R124	Res., comp., 22 megohms ±10%, ¼ w	DCB-2261	.06
S1	Switch, SPST	FDA-11-040	2.22
XF1	Not assigned		
XF101	Fuse clips (2 req'd)	HRM-00-005	.10
<u>UNIQUE PARTS</u> MODEL LP-520-FM			
C8	Cap., mylar, 0.018 mf ±10%, 200 vdc	CGL-18-005	.50
C9	Cap., elect, 5,500 mf -10 +100%, 30 vdc	CBS-55-091	4.23
C10	Cap., elect., 1,000 mf -10 + 100%, 28 vdc	CBS-10-025	3.01
C11	Cap., mylar, 0.1 mf ±10%, 200 vdc	CAM-10-012	.65
C103, C104	Not assigned		
C106	Cap., mylar, 0.001 mf ±10%, 200 vdc	CGK-10-004	.46
C107	Cap., elect., 3 mf -10 +75%, 100 vdc	CBN-30-015	1.58
CR9	Rectifier	FBL-00-054	1.50
CR10	Not assigned		
CR17 thru CR20	Same as CR9		

UNIQUE PARTS (Cont)  
MODEL LP520-FM (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
CR104	Rectifier	FBL-00-030	\$ 1.40
CR109,	Not assigned		
CR111			
thru			
CR114,			
CR117			
thru			
CR120,			
CR122,			
CR123			
F2	Fuse, 10A, 3 AG, NORM-BLO	FFB-10-000	.10
M1	Voltmeter, 0-10 V	EBP-10-040	10.80
M2	Ammeter, 0-5A	EDN-50-037	10.80
Q1	Transistor, NPN	FBN-36485	4.13
thru			
Q3			
Q4	Transistor, NPN	FBN-36486	2.25
Q101	Transistor, NPN	FBN-L109	2.25
R1,	Res., dual, var., ww,	DNS-20-060	6.30
R2	2,000 ohms $\pm 5\%$ , 2 w (1 req'd)		
R103	Res., comp., 4700 ohms $\pm 10\%$ , $\frac{1}{2}$ w	DEB-4721	.12
R104	Res., ww, 480 ohms $\pm 3\%$ , 5 w	DFR-48-080	.50
R105	Res., comp., 47 ohms $\pm 10\%$ , $\frac{1}{2}$ w	DEB-4701	.12
R107	Res., ww, 0.1 ohm $\pm 5\%$ , 5 w	DFM-10-074	.78
R111	Res., film, 430 ohms $\pm 5\%$ , $\frac{1}{2}$ w	DCR-43-047	.15
R113	Res., film, 390 ohms $\pm 2\%$ , $\frac{1}{2}$ w	DCR-39-046	.21
R114	Res., comp., 330 ohms $\pm 10\%$ , $\frac{1}{4}$ w	DCB-3311	.10
R116	Res., ww, 0.39 ohm $\pm 5\%$ , 5 w	DFM-39-046	1.81
thru			
R118			
R121	Res., comp., 47,000 ohms $\pm 10\%$ , $\frac{1}{4}$ w	DCB-4731	.10
S2	Thermostat	FKA-148-030	1.41
T1	Transformer	ABA-520	42.42
XF2	Fuseholder	HRM-00-009	.42
<u>MODEL LP521-FM</u>			
C8	Cap., mylar, 0.018 mf $\pm 10\%$ , 200 vdc	CGL-18-005	.50
C9	Cap., elect., 3,900 mf -10 +100%, 45 vdc	CBS-39-070	5.00
C10	Cap., elect., 520 mf -10 +100%, 45 vdc	CBR-52-019	2.38
C11	Cap., mylar, 0.1 mf $\pm 10\%$ , 200 vdc	CAM-10-012	.65
C103,	Not assigned		
C104			
C106	Cap., mylar, 0.001 mf $\pm 10\%$ , 200 vdc	CGK-10-004	.46
C107	Cap., elect., 3 mf -10 +75%, 100 vdc	CBN-30-015	1.58
CR9,			
CR10,			
CR17	Rectifier	FBL-00-054	1.50
thru			
CR20			
CR104	Rectifier	FBL-00-030	1.40
CR109,	Not assigned		
CR111			
thru			
CR114,			
CR117			
thru			
CR120			

UNIQUE PARTS (Cont)  
MODEL LP521-FM (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
CR122,	Not assigned		
CR123			
F2	Fuse, 5A, 3 AG, NORM-BLO	FFB-05-000	\$ .10
M1	Voltmeter, 0-20 V	EBP-20-041	10.80
M2	Ammeter, 0-5A	EDN-50-037	10.80
Q1	Transistor, NPN	FBN-36220	2.85
thru			
Q3			
Q4	Transistor, NPN	FBN-35469	2.55
Q101	Transistor, NPN	FBN-L109	2.25
R1,	Res., dual, var., ww, 4,000	DNS-40-061	6.00
R2	ohms $\pm 5\%$ , 2 w (1 req'd)		
R103	Res., comp., 10,000 ohms $\pm 10\%$ , $\frac{1}{2}$ w	DEB-1031	.12
R104	Res., ww, 700 ohms $\pm 5\%$ , 7 w	DFR-70-088	.66
R105	Res., comp., 47 ohms $\pm 10\%$ , $\frac{1}{2}$ w	DEB-4701	.12
R107	Res., ww, 0.1 ohm $\pm 5\%$ , 5 w	DFM-10-074	.78
R111	Not assigned		
R113	Res., comp., 100 ohms $\pm 10\%$ , $\frac{1}{2}$ w	DEB-1011	.12
R114	Res., comp., 330 ohms $\pm 10\%$ , $\frac{1}{4}$ w	DCB-3311	.10
R116	Res., ww, 0.39 ohm $\pm 5\%$ , 5 w	DFM-39-046	1.81
thru			
R118			
R121	Res., comp., 47,000 ohms $\pm 10\%$ , $\frac{1}{4}$ w	DCB-4731	.10
S2	Thermostat	FKA-148-030	1.41
T1	Transformer	ABA-521	34.80
XF2	Fuseholder	HRM-00-009	.42
<u>MODEL LP522-FM</u>			
C8	Not assigned		
C9	Cap., elect., 1,100 mf -10 +100%, 75 vdc	CBS-11-015	5.20
C10	Cap., elect., 200 mf -10 +100%, 100 vdc	CBR-20-082	5.75
C11	Cap., mylar, 0.1 mf $\pm 10\%$ , 200 vdc	CAM-10-012	.65
C103,	Not assigned		
C104			
C106	Cap., mylar, 470 pf $\pm 10\%$ , 200 vdc	CGJ-47-002	.33
C107	Cap., elect., 3 mf -10 +75%, 100 vdc	CBN-30-015	1.58
C108	Cap., mylar 0.018 mf $\pm 10\%$ , 200 vdc	CGL-18-005	.50
CR9,	Not assigned		
CR10			
CR104	Rectifier	FBL-00-030	1.40
CR109	Not assigned		
CR111,	Rectifier	FBL-00-047	1.00
CR112			
CR113,	Not assigned		
CR114			
CR117	Same as CR111		
thru			
CR120			
CR122,	Not assigned		
CR123			
F102	Fuse, 3A, 3 AG, NORM-BLO	FFB-03-000	.10
M1	Voltmeter, 0-40V	EBP-40-042	10.80
M2	Ammeter, 0-2A	EDN-20-036	10.80
Q1	Transistor, NPN	FBN-36487	5.63
thru			
Q3			
Q4	Transistor, NPN	FBN-36488	3.30

UNIQUE PARTS (Cont)  
MODEL LP522-FM (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
Q101	Transistor, NPN	FBN-L108	\$ 2.52
R1	Res., dual, var., ww, 8,000	DNS-80-062	5.50
R2	ohms $\pm 5\%$ , 2 w (1 req'd)		
R4	Res., ww, 900 ohms	DFR-90-049	1.25
	$\pm 5\%$ , 10 w		
R103	Res., comp., 33,000 ohms	DEB-3331	.12
	$\pm 10\%$ , $\frac{1}{2}$ w		
R104	Not assigned		
R105	Res., comp., 100 ohms	DEB-1011	.12
	$\pm 10\%$ , $\frac{1}{2}$ w		
R107	Res., ww, 0.166 ohm	DFM-17-071	.66
	$\pm 5\%$ , 5 w		
R111	Not assigned		
R113	Same as R105		
R114	Res., comp., 1,000 ohms	DCB-1021	.10
	$\pm 10\%$ , $\frac{1}{4}$ w		
R116	Res., ww, 2 ohms	DFN-20-009	.60
thru	$\pm 3\%$ , 3 w		
R118			
R121	Res., comp., 47,000 ohms	DCB-4731	.10
	$\pm 10\%$ , $\frac{1}{4}$ w		
S2	Thermostat	FKA-148-030	1.41
T1	Transformer	ABA-522	34.71
XF102	Fuse clips (2 req'd)	HRM-00-005	.10

MODEL LP523-FM

C8	Not assigned		
C9	Cap., elect., 800 mf	CBR-80-023	5.61
	-10 +100%, 110 vdc		
C10	Cap., elect., 200 mf	CBR-20-082	5.75
	-10 +100%, 100 vdc		
C11	Cap., mylar, 0.1 mf	CAM-10-012	.65
	$\pm 10\%$ , 200 vdc		
C103,	Not assigned		
C104			
C106	Cap., mylar, 470 pf	CGJ-47-002	.33
	$\pm 10\%$ , 200 vdc		
C107	Cap., elect., 3.3 mf	CBN-33-027	2.70
	-10 +50%, 250 vdc		
C108	Cap., mylar, 0.018 mf	CGL-18-005	.50
	$\pm 10\%$ , 200 vdc		
CR9,	Not assigned		
CR10			
CR104	Rectifier	FBL-00-036	.60
CR109	Not assigned		
CR111,	Rectifier	FBL-00-065	1.50
CR112			
CR113,	Not assigned		
CR114			
CR117	Same as CR111		
thru			
CR120			
CR122	Not assigned		
CR123	Rectifier	FBL-00-030	1.40
F102	Fuse, 3A, 3 AG	FFB-03-000	.10
	NORM-BLO		
M1	Voltmeter, 0-60 V	EBP-60-043	10.80
M2	Ammeter, 0-1A	EDN-10-034	10.80
Q1,	Transistor, NPN	FBN-35902	6.15
Q2			
Q3	Not assigned		
Q4	Transistor, NPN	FBN-35903	4.20
Q101	Transistor, NPN	FBN-L108	2.52
R1,	Res., dual, var., 12,000	DNT-12-033	5.25
R2	ohms $\pm 5\%$ , 2 w (1 req'd)		
R4	Res., ww, 2,000 ohms	DFS-20-037	1.25
	$\pm 5\%$ , 10 w		
R103	Res., comp., 68,000 ohms	DEB-6831	.12
	$\pm 10\%$ , $\frac{1}{2}$ w		

UNIQUE PARTS (Cont)  
MODEL LP523-FM (Cont.)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
R104	Not assigned		
R105	Res., comp., 100 ohms	DEB-1011	\$ .12
	$\pm 10\%$ , $\frac{1}{2}$ w		
R107	Res., ww, 0.3 ohm	DFM-30-053	.50
	$\pm 5\%$ , 3 w		
R111	Not assigned		
R113	Same as R105		
R114	Res., comp., 1,000 ohms	DCB-1021	.10
	$\pm 10\%$ , $\frac{1}{4}$ w		
R116	Res., ww, 3 ohms	DFN-30-023	.59
	$\pm 3\%$ , 3 w		
R117	Not assigned		
R118	Same as R116		
R121	Res., comp., 47,000 ohms	DCB-4731	.10
	$\pm 10\%$ , $\frac{1}{4}$ w		
R125	Same as R114		
R126	Res., comp., 100 ohms	DCB-1011	
	$\pm 10\%$ , $\frac{1}{4}$ w		
S2	Thermostat	FKA-118-012	5.00
T1	Transformer	ABA-523	34.83
XF102	Fuse clips (2 req'd)	HRM-00-005	.10

MODEL LP524-FM

C8	Not assigned		
C9	Cap., elect., 400 mf	CBR-40-032	4.25
	-10 +100% 200 vdc		
C10	Cap., elect., 115 mf	CBR-12-031	2.38
	-10 +100%, 200 vdc		
C11	Cap., mylar, 0.068 mf	CGL-68-004	.50
	$\pm 10\%$ , 400 vdc		
C103,	Cap., mylar, 0.01 mf	CGL-10-010	.50
C104	$\pm 10\%$ , 600 vdc		
C106	Cap., mylar, 0.0047 mf	CGK-47-002	.33
	$\pm 10\%$ , 200 vdc		
C107	Cap., elect., 3.3 mf	CBN-33-027	2.70
	-10 + 50%, 250 vdc		
C201	Cap., mylar, 0.0033 mf	CGK-33-006	.50
	$\pm 10\%$ , 400 vdc		
C202	Cap., mylar, 0.0068 mf	CGK-68-001	.34
	$\pm 10\%$ , 400 vdc		
C203	Cap., elect., 55 mf	CBP-55-011	2.32
	-10 +100%, 150 vdc		
CR9,	Not assigned		
CR10			
CR104,	Rectifier	FBL-00-033	1.65
CR109			
CR111,	Not assigned		
CR112			
CR113,	Rectifier	FBL-00-050	1.08
CR114			
CR117	Not assigned		
thru			
CR120			
CR122	Same as CR113		
CR123	Rectifier	FBL-00-030	1.40
F102	Fuse, 1 A, 3 AG,	FFB-01-000	.15
	NORM-BLO		
M1	Voltmeter, 0-120 V	EBR-12-087	10.80
M2	Ammeter, 0-0.5A	EDM-50-047	10.80
Q1,	Transistor, NPN	FBN-35902	6.15
Q2			
Q3	Not assigned		
Q4,	Transistor, NPN	FBN-35903	4.20
Q5			
Q101	Transistor, NPN	FBN-L115	2.75
R1,	Res., dual, var., ww,	DNT-24-034	8.50
R2	24,000 ohms $\pm 5\%$ , 2 w		
	(1 req'd)		
R103	Res., comp., 220,000 ohms	DEB-2241	.12
	$\pm 10\%$ , $\frac{1}{2}$ w		
R104	Not assigned		

UNIQUE PARTS (Cont)  
MODEL LP524-FM (Cont)

<u>CIRC. DESIG.</u>	<u>DESCRIPTION</u>	<u>LAMBDA NO.</u>	<u>UNIT PRICE</u>
R105	Res., comp., 100 ohms ±10%, ½ w	DEB-1011	\$ .12
R107	Res., ww, 0.56 ohm ±5%, 5 w	DFM-56-047	1.00
R111	Not assigned		
R113	Same as R105		
R114	Res., comp., 470 ohms ±10%, ¼ w	DCB-4711	.10
R116	Not assigned		
R118			
R121	Res., comp., 68,000 ohms ±10%, ¼ w	DCB-6831	.10
R125	Res., comp., 1,000 ohms ±10%, ¼ w	DCB-1021	.10
R126	Res., comp., 100 ohms ±10%, ¼ w	DCB-1011	.06
R201	Res., film, 240 ohms ±2%, ½ w	DCR-24-007	.50
R202	Res., film, 7,500 ohms ±5%, ½ w	DCS-75-016	.25
R203	Res., film, 68,000 ohms ±2%, ½ w	DCT-68-012	.30
R204	Res., film, 1,600 ohms ±5%, ½ w	DCS-16-015	.25
R205	Res., comp., 10,000 ohms ±10%, 2 w	DHB-1031	.15
R206	Res., ww, 4 ohms ±5%, 3 w	DFN-40-043	.66
R207	Res., comp., 47,000 ohms ±10%, 2 w	DHB-4731	.50
S2	Thermostat	FKA-118-012	5.00
T1	Transformer	ABA-524	37.89
XF102	Fuse clips (2 req'd)	HRM-00-005	.10

PARTS FOR "V" OPTION

On all LP520 series models with suffix "V", capacitor C12, fuse F101 and transformer T1 change and a resistor is added in series with DS1. Part no. changes for C12, F101, and DS1 Res., are listed here. For transformer T1 used on these models, see standard LP520 series model parts list for the standard transformer part no. and add suffix "G"\* to the part no. Price for T1 does not change.

\* Suffix "V" on units with serial no. prefix A.

PARTS FOR "V" OPTION (Cont.)

<u>CIRC. DESIG.</u>	<u>DESCRIPTION</u>	<u>LAMBDA NO.</u>	<u>UNIT PRICE</u>
<u>ALL MODELS</u>			
C12	Cap., mylar, 0.01 mf ±10%, 600 vdc	CGL-10-010	\$ .50
F101	Fuse, 1.5 A, 3 AG, SLO-BLO	FFC-01-500	.50
DS1 Res.	Res., comp., 120,000 ohms ±10%, ½ w	DEB-1241	.12

PARTS FOR OVERVOLTAGE  
PROTECTOR ACCESSORY MODELS

LHOV-4, LHOV-5, LHOV-6

COMMON PARTS

C1	Cap., mylar, 0.01 mf ±20%, 80 vdc	CGL-10-008	.50
Q1	Transistor, NPN	FBN-L102	2.40
Q2	Transistor, PNP	FBN-L114	3.50
R2	Res., film, 560 ohms ±2%, ½ w	DCR-56-002	.65
R3	Res., film, 200 ohms ±5%, ½ w	DCR-20-010	.20
R4	Res., thermistor, 425 ohms ±5%, 1 ¼ w	DKR-43-001	1.52
R5,	Res., comp., 1,200 ohms	DEB-1221	.12
R6	±10%, ½ w		
R7	Res., comp., 33 ohms ±5%, ¼ w	DCB-3305	.15
R8	Res., comp., 15,000 ohms ±10%, ½ w	DEB-1531	.12
R9	Res., comp., 22 ohms ±10%, ½ w	DEB-2201	.12
R10	Same as R5		
SCR1	Rectifier, silicon controlled	FBP-00-009	6.00

UNIQUE PARTS

MODEL LHOV-4

R1	Res., var., ww, 10,000 ohms ±10%, 1 w	DNT-10-045	3.75
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MODEL LHOV-5

R1	Res., var., ww, 20,000 ohms ±10%, 1 w	DNT-20-010	2.85
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MODEL LHOV-6

R1	Res., var., ww, 30,000 ohms ±10%, 0.6 w	DNT-30-027	9.90
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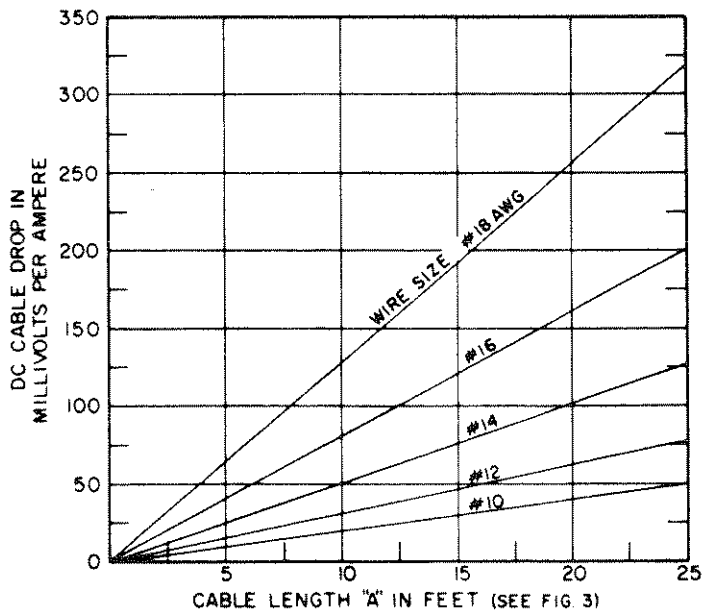


FIG. 1. 2-WIRE CONNECTION (SEE FIG. 4)

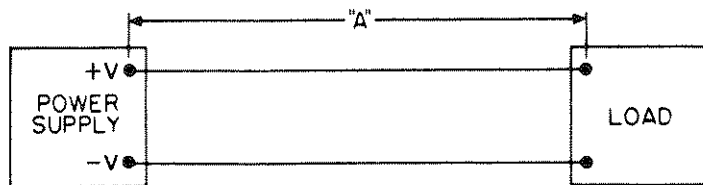
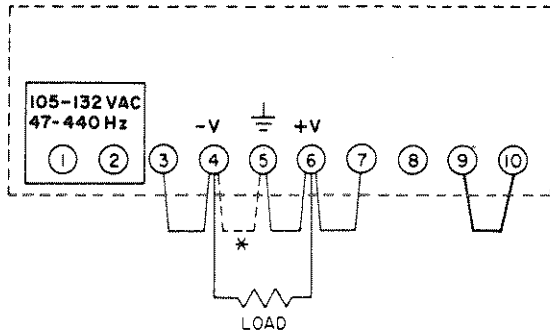
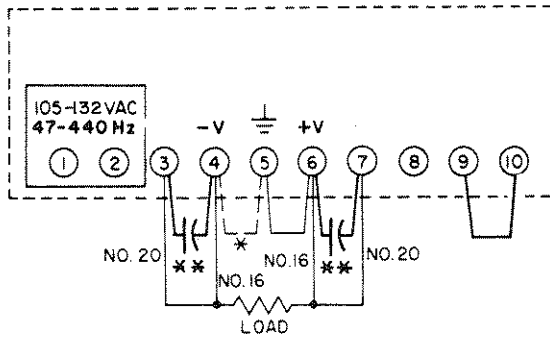


FIG. 2. CABLE LENGTH 'A' IN FEET



NOTE:  
 \* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5

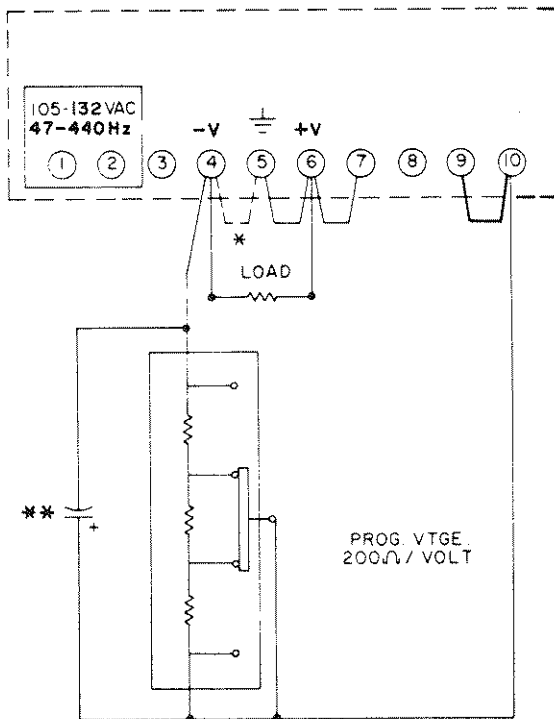
FIGURE 3. TWO-WIRE CONNECTION



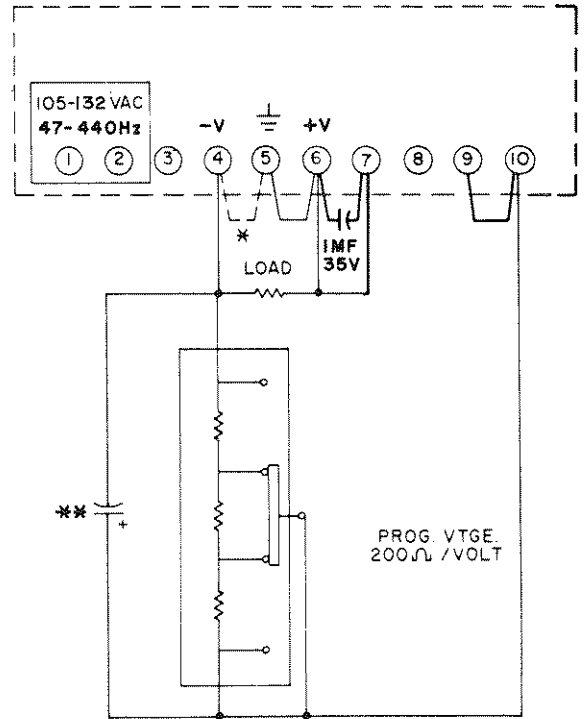
NOTE:  
 \* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.  
 \*\* 1 MF, 35V, ELECT. MAY BE REQUIRED TO ELIMINATE NOISE PICK-UP.

FIGURE 4. FOUR-WIRE CONNECTION





(A) LOCAL SENSING



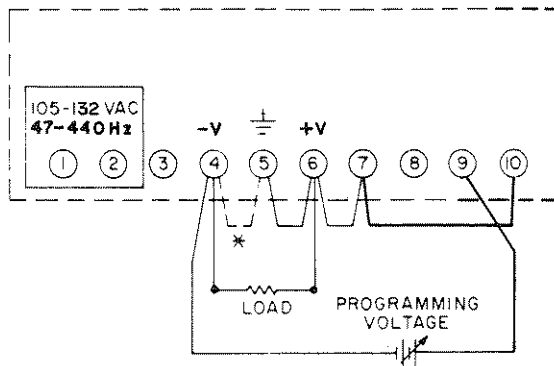
(B) REMOTE SENSING

NOTE:

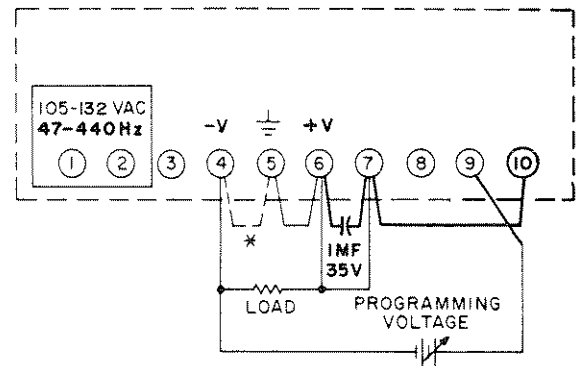
\* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

\*\* 3 MF, 100V USED ON MODELS LP-520-FM — LP-522-FM  
3 MF, 400V USED ON MODELS LP-523-FM — LP-524-FM

FIGURE 5. PROGRAMMED VOLTAGE, WITH EXTERNAL RESISTOR



(A) LOCAL SENSING

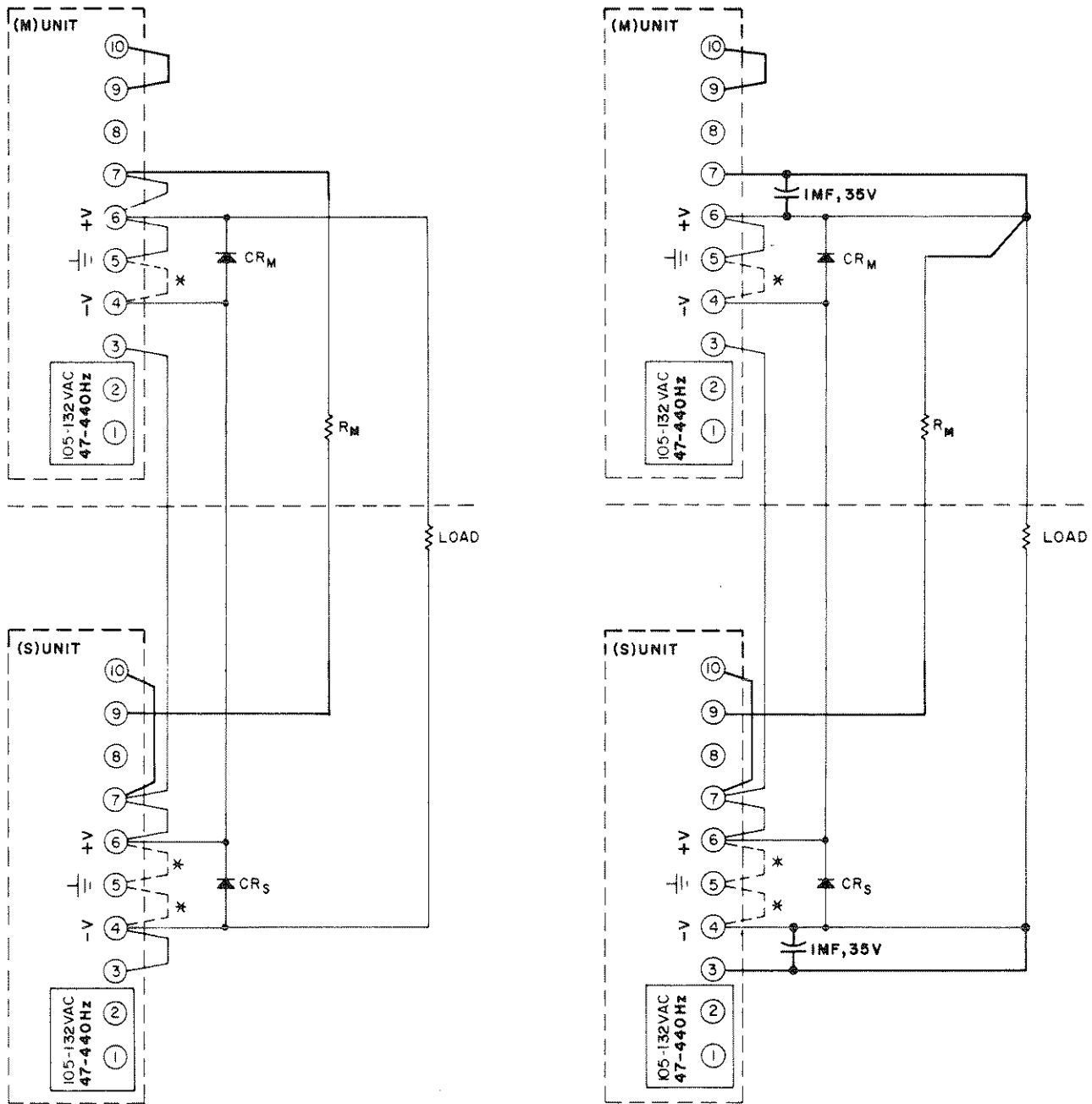


(B) REMOTE SENSING

NOTE:

\* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 6. PROGRAMMED VOLTAGE, WITH EXTERNAL PROGRAMMING VOLTAGE SOURCE



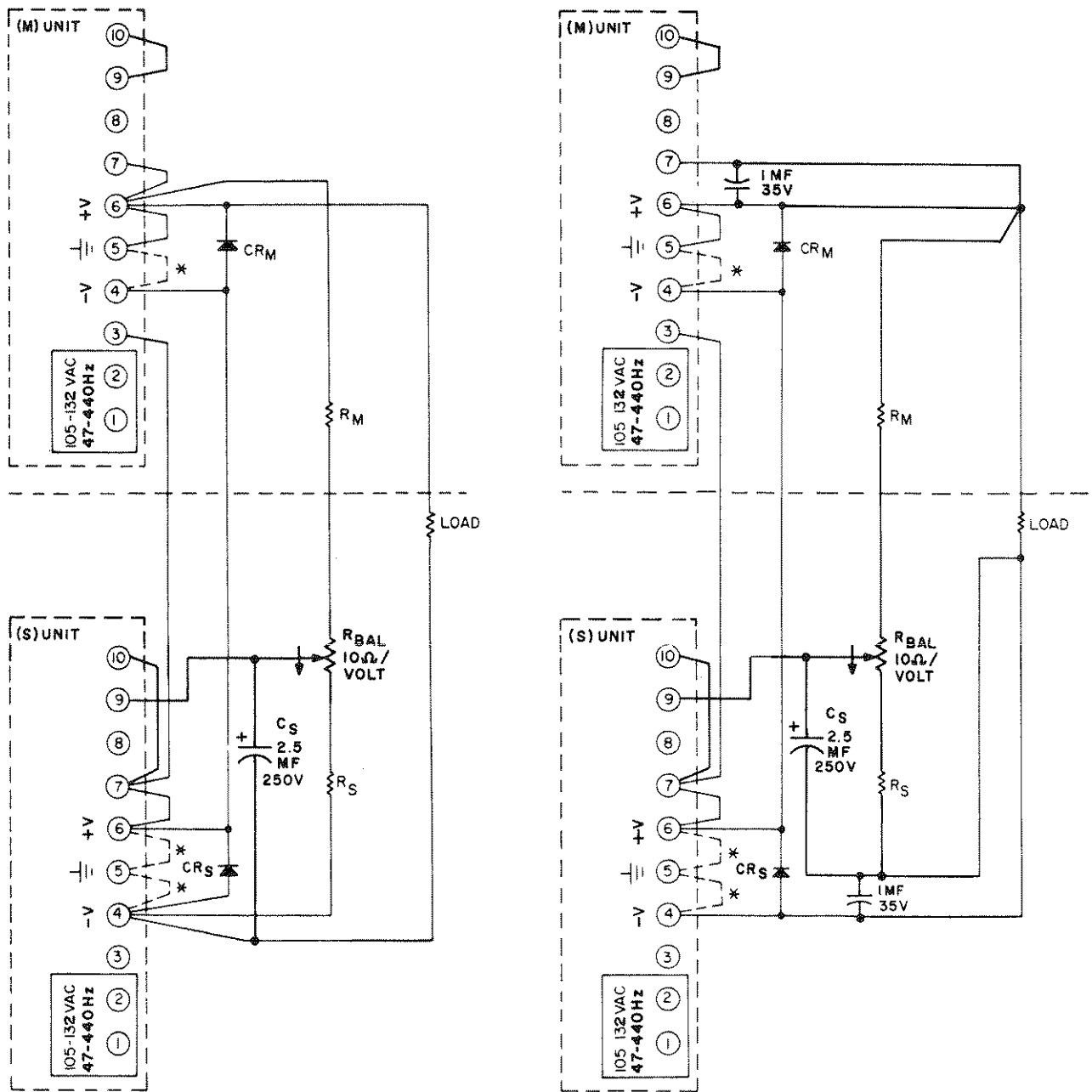
(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE:

\* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION, TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 7. SERIES CONNECTION



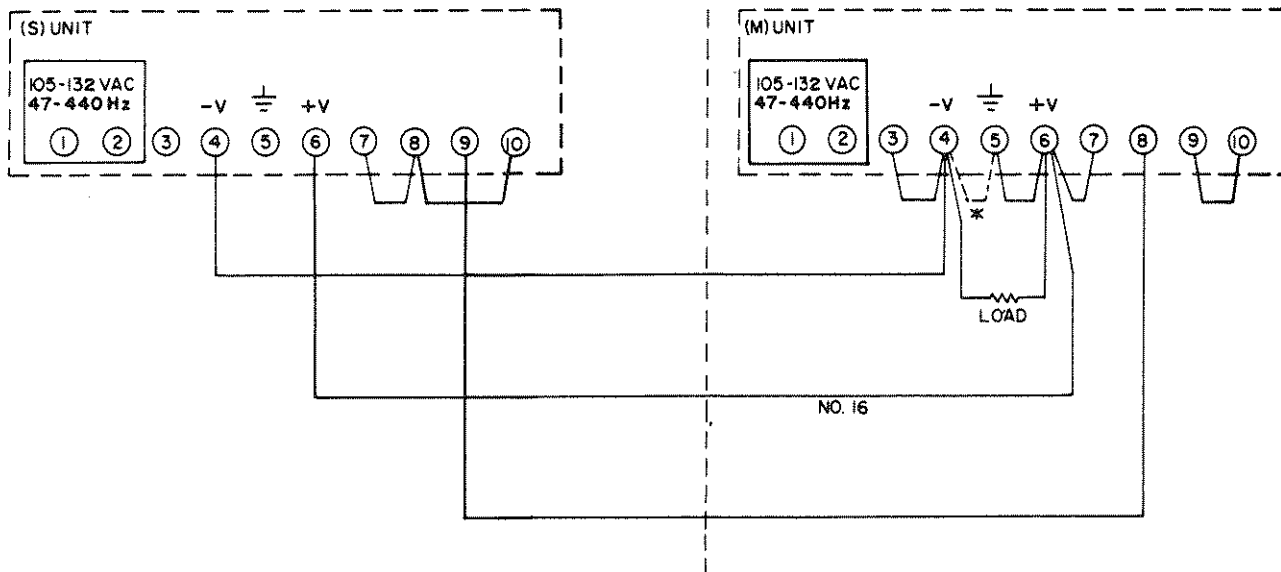
(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE:

\* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

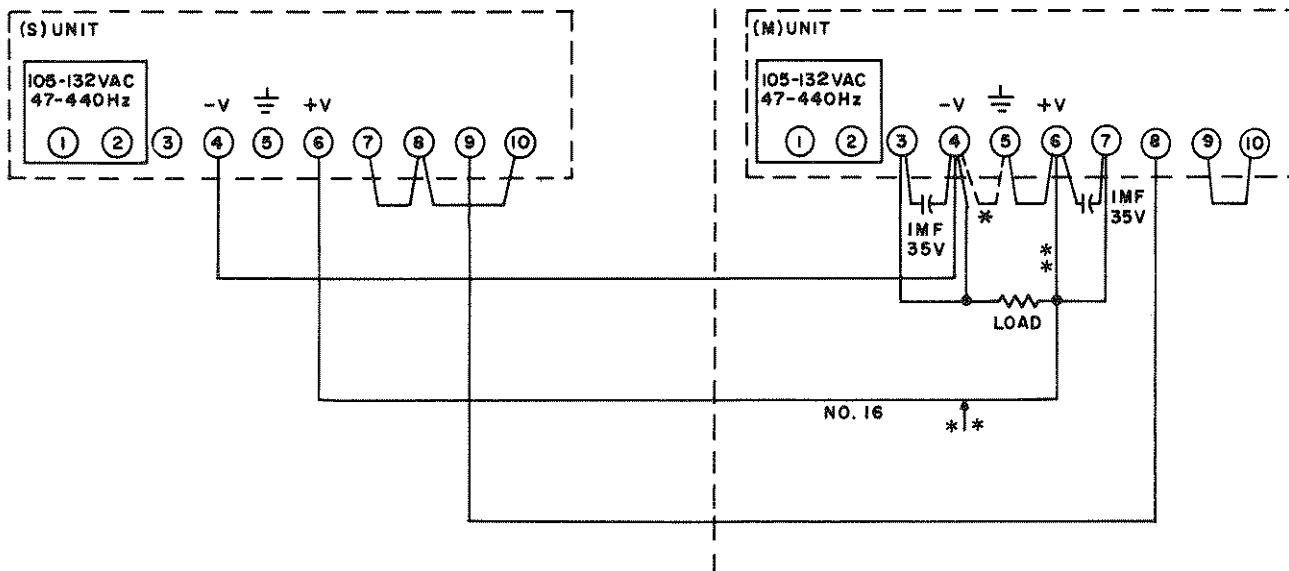
FIGURE 8. ALTERNATE SERIES CONNECTION



**NOTE:**

\* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

**FIGURE 9. PARALLEL CONNECTION, LOCAL SENSING**

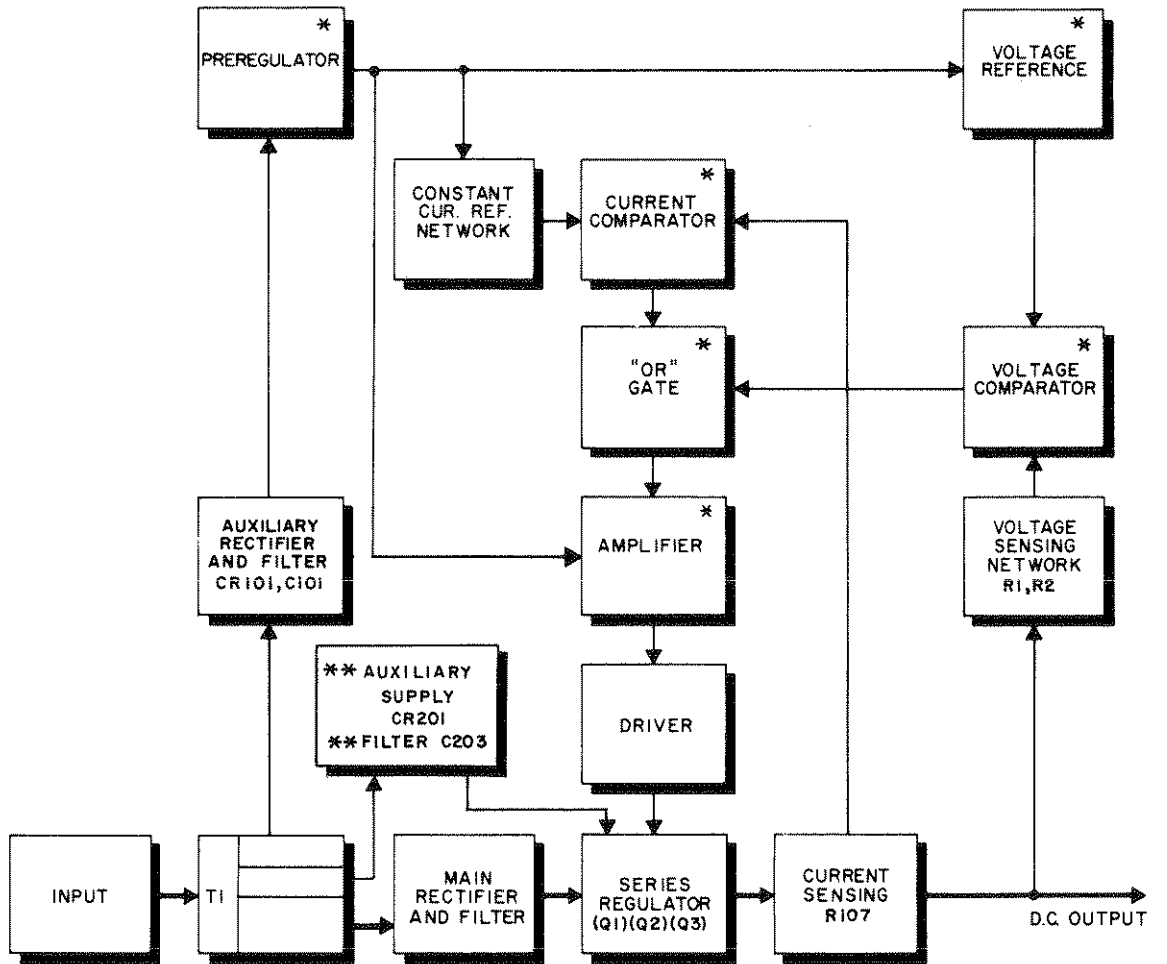


**NOTE:**

\* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

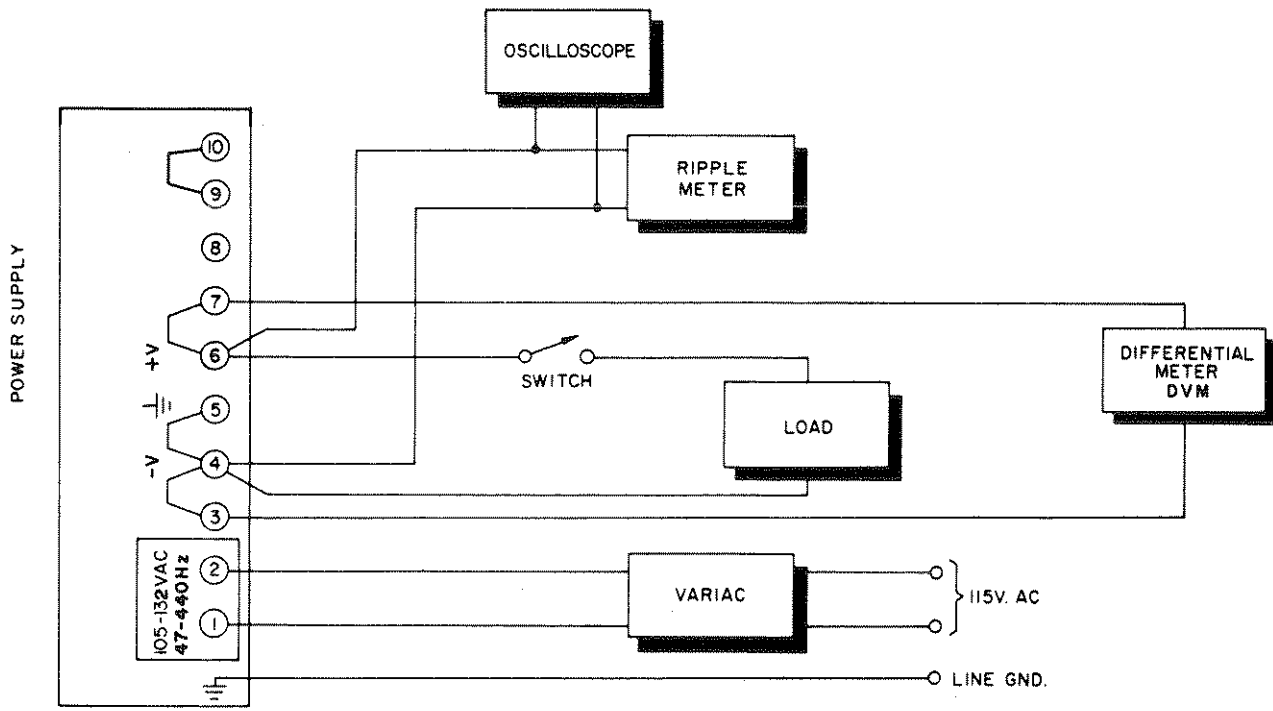
\*\* LEAD LENGTHS MUST BE EQUAL.

**FIGURE 10. PARALLEL CONNECTION, REMOTE SENSING**



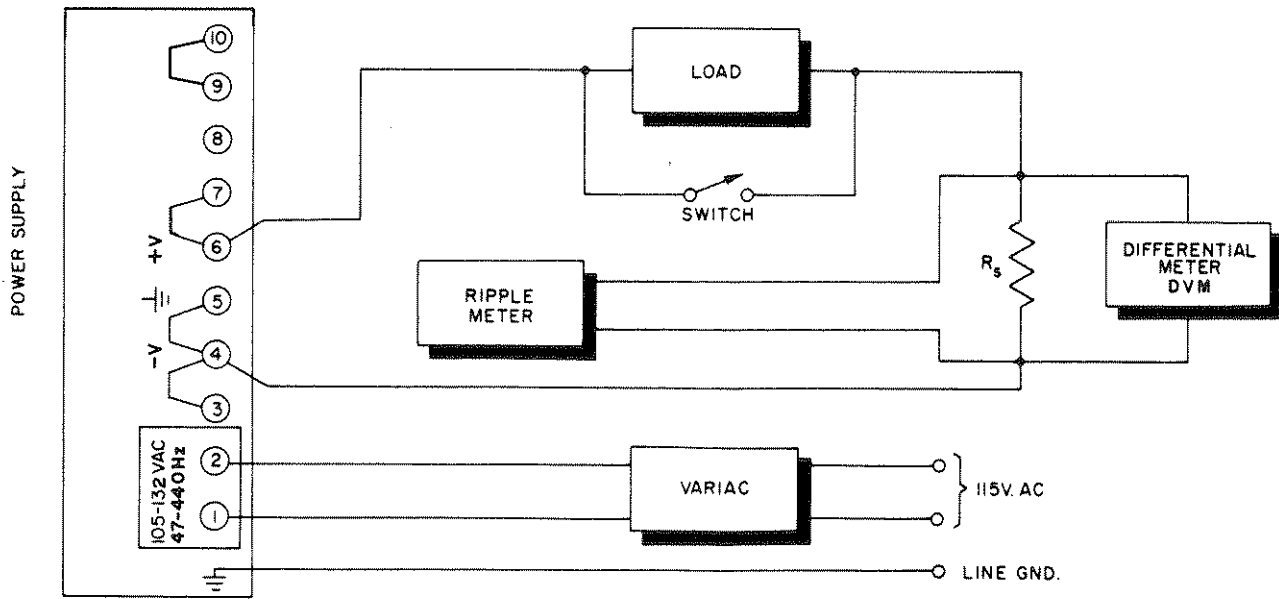
\* THIS CIRCUIT ELEMENT IS LOCATED IN IC1.  
 \*\* APPLICABLE ONLY TO MODEL LP-524-FM

FIGURE II. TYPICAL BLOCK DIAGRAM



- NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
  2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

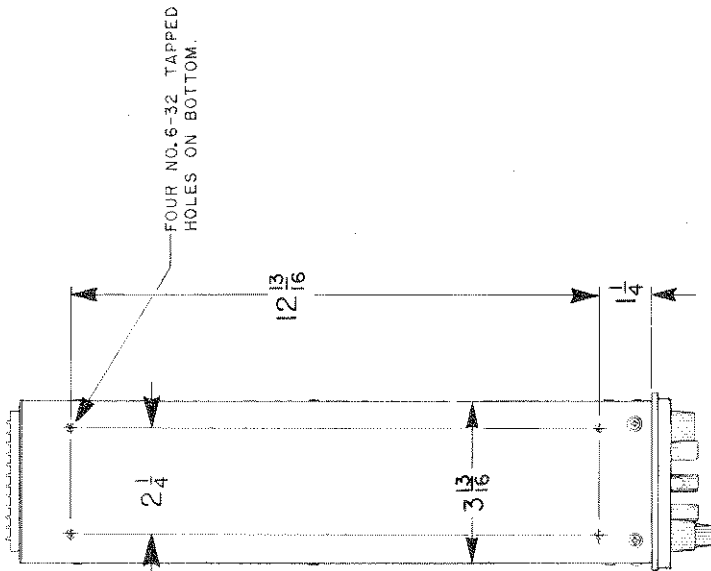
FIGURE 12. TEST CONNECTIONS FOR CONSTANT VOLTAGE PERFORMANCE CHECKS



- NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
  2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 13. TEST CONNECTIONS FOR CONSTANT CURRENT PERFORMANCE CHECKS

REAR INPUT AND  
OUTPUT TERMINALS



NOTE  
CUSTOMERS MOUNTING SCREWS MUST NOT  
PROTRUDE INTO POWER SUPPLY BY MORE  
THAN  $\frac{1}{4}$ .

(2) NO 6-32 TAPPED HOLES FOR MOUNTING  
OF OVERVOLTAGE PROTECTION UNITS,  
MODEL NUMBERS LHOV-4, LHOV-5, LHOV-6.

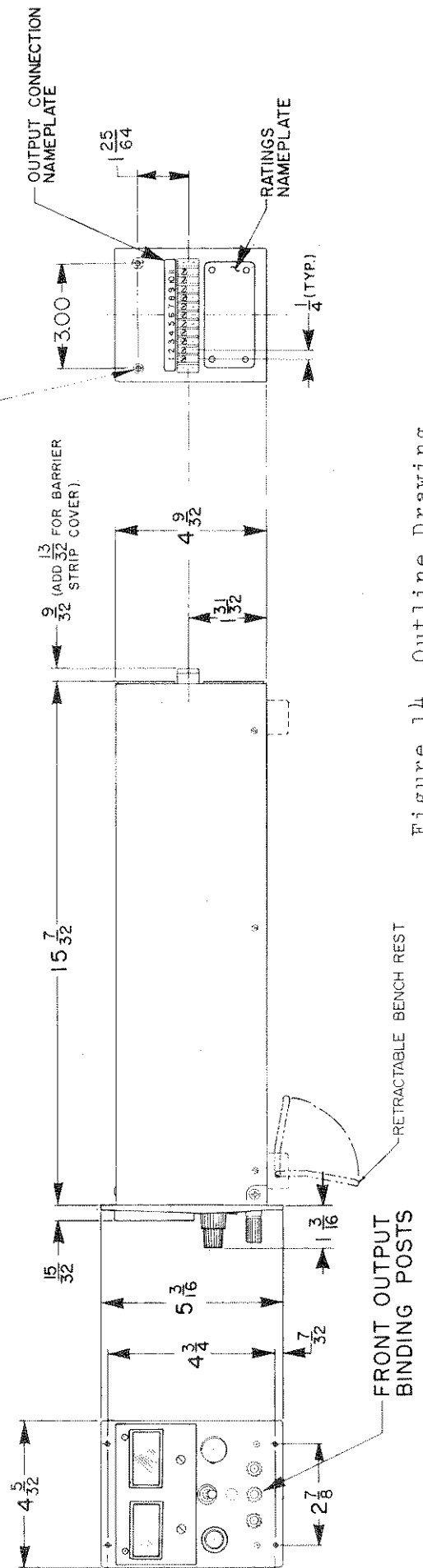


Figure 14. Outline Drawing

