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P/N 4009-318

INSTRUCTION MANUAL
4500L-M

Invertron®

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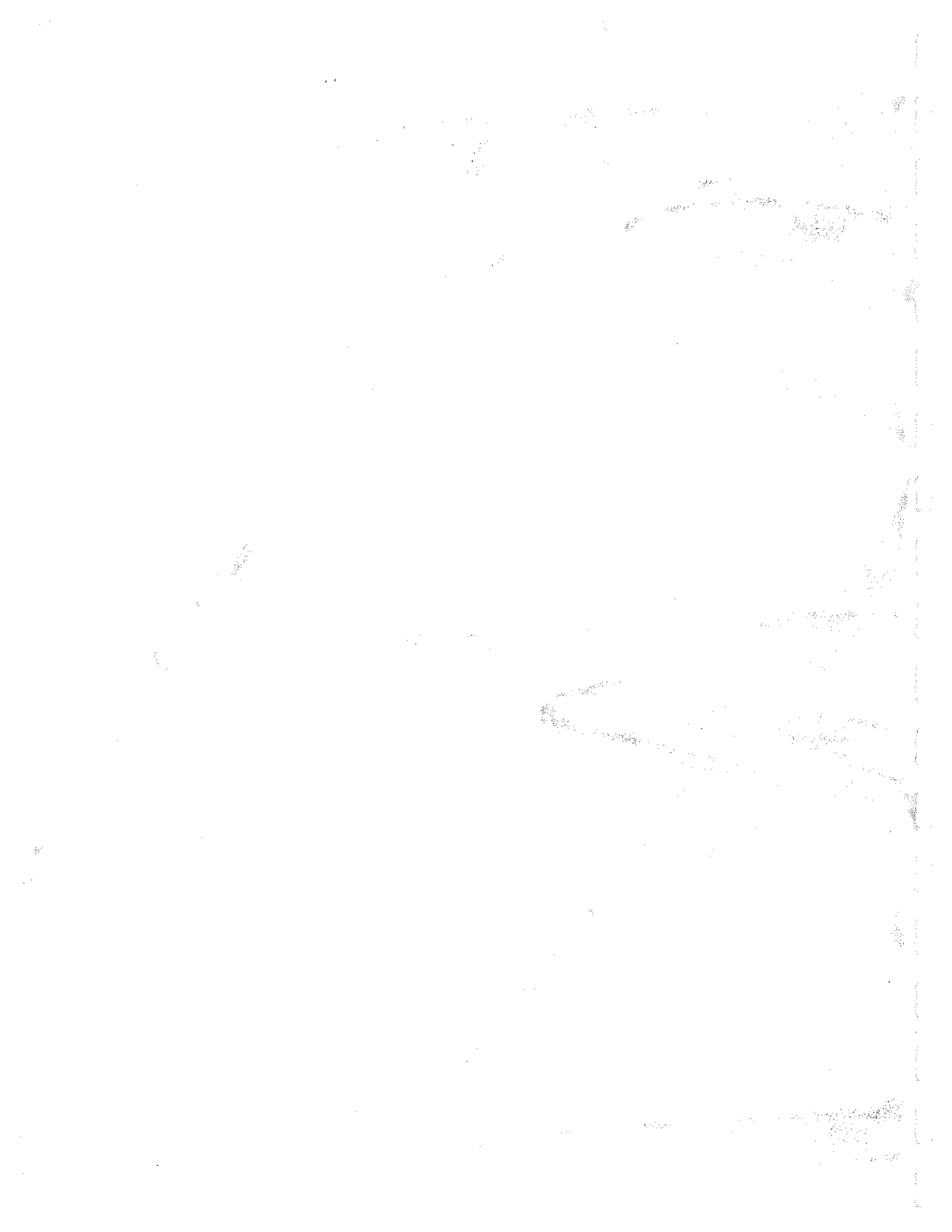
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SECTION 1

INTRODUCTION AND SPECIFICATIONS

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the California Instruments Model 4500L-M. The 4500L-M will hereafter be referred to as the AC Power Module. The Power Modules may be combined in AC Power Systems up to 30,000VA, 3-phase or 1-phase.

1.2 GENERAL DESCRIPTION

This instrument is a high efficiency power source that provides a low distortion sine wave output with either a single or three-phase configuration.

All power systems are constructed from a 4500L-M power source. The following table lists the model number of each power system, the output phase configuration, the number of 4500L's in the system and the output VA per phase. The table also shows that increased power is available at a reduced operating temperature of 35°C.

MODEL	PHASE	#UNITS	VA/PHASE	
			50°C	35°C
4500L-3M	3	1	1500	1667
4500L-1M	1	1	4500	5000
9000L-3M	3	2	3000	3333
9000L-1M	1	2	9000	10000
13500L-3M	3	3	4500	5000
13500L-1M	1	3	13500	15000
27000L-3M	3	6	9000	10000
27000L-1M	1	6	27000	30000

Full power is available from a standard 0 to 135 or 0 to 270 volt range. Optional 67.5/135 volt, 156/312 and 200/400 volt ranges are also available. Full power is available from 45 to 2.00 KHz for all models except for those with a 200/400 voltage range (EHV) option. The EHV option will operate up to 1000 Hz. The 4500L-3M has full power available from 45 Hz to 5.00 KHz. The 4500L-M is illustrated in Figure 1-1.

The output frequency can be programmed down to 17 Hz at a reduced output voltage.

1.3 ACCESSORY EQUIPMENT/RACK SLIDES

Zero Manufacturing Company Model CTN-1-20-E94 rack slides may be attached to the sides of the power source using 8-32 X 3/8 flat head screws.

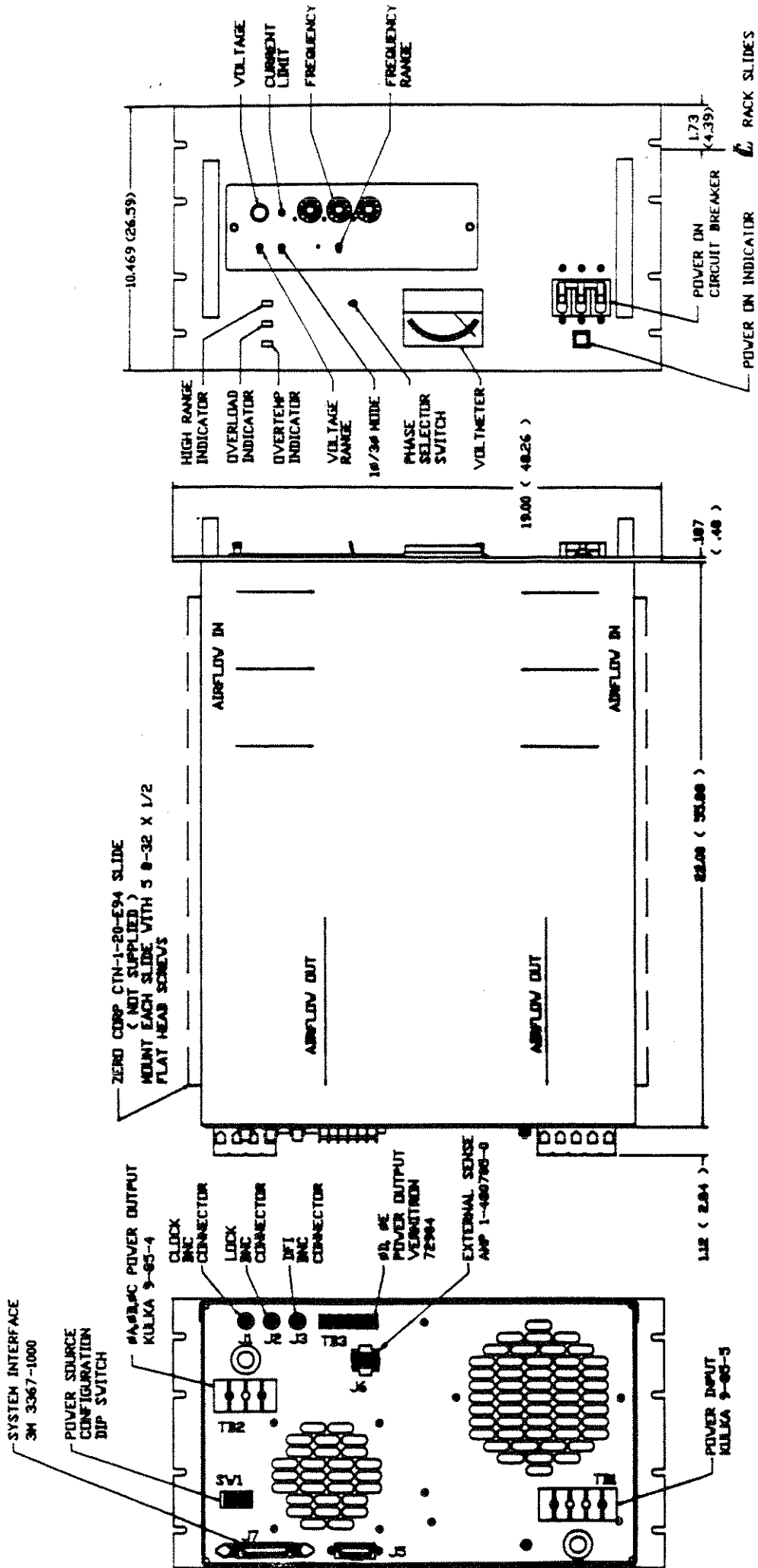


FIGURE 1-1
CALIFORNIA INSTRUMENTS 4500L

1.4 SPECIFICATIONS

Table 1-1 contains the operation specifications of the AC Power System. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, constant line voltages and under no-load conditions unless specified otherwise.

TABLE 1 -1
SPECIFICATIONS 4500L-M

ELECTRICAL

(All specifications apply using External Sense inputs, 25 ±1°C, constant line and load conditions unless specified otherwise after 15 minutes warmup.)

OUTPUT SPECIFICATIONS

MODEL	POWER (At full output voltage)				CURRENT PER PHASE VOLTAGE RANGE			
	TOTAL		PER PHASE		135		270	
	50°C	35°C	50°C	35°C	50°C	35°C	50°C	35°C
4500L-3	4500	5000	1500	1667	11.12	12.34	5.56	6.17
4500L-1	4500	5000	4500	5000	33.34	37.04	16.67	18.52
9000L/2-3	9000	10000	3000	3333	22.24	24.68	11.12	12.34
9000L/2-1	9000	10000	9000	10000	66.66	74.08	33.33	37.04
13500L/3-3	13500	15000	4500	5000	33.34	37.04	16.67	18.52
13500L/3-1	13500	15000	13500	15000	100.0	111.2	50.0	55.6
27000L/6-3	27000	30000	9000	10000	66.66	74.08	33.33	37.04
27000L/6-1	27000	30000	27000	30000	200.0	222.2	100.0	111.1

For other Voltage Ranges:

Current per phase =
(VA per Phase)/Voltage Range

Power Factor:

0 to unity at full rated output VA

Peak Repetitive Current:

2.5 times the maximum TRMS current at 50°C

Peak Non-repetitive (10ms)
Current:

2.7 times the maximum TRMS current at 50°C

OUTPUT SPECIFICATIONS (continued)

Voltage Range: 135 and 270 (Standard)
67.5 and 135 (LV Option)
156 and 312 (HV Option)

Total Distortion:
(Maximum for all harmonics and noise to 300 KHz at full output power with linear load.)

45 Hz to 2 KHz: 1% THD
to 5 KHz: 2% THD

Line Regulation: $\pm 0.02\%$ of range for $\pm 10\%$ line change

Load Regulation: $\pm 0.05\%$ of range from no load to full load

Frequency Range

At Full-scale Voltage 4500L-3M 45* Hz to 5000 Hz
All other models 45* Hz to 2000 Hz
EHV Option 45* Hz to 1000 Hz

Accuracy $\pm 0.005\%$ of programmed value

Resolution: 0.1 Hz from 45.0 to 99.9 Hz
1 Hz from 100 to 999 Hz
0.01 KHz from 1.00 to 5.00 KHz

Phase Angle Accuracy (with the same load on each phase):

Phase B and C relative to phase A: ± 3 degrees

PROTECTION

Output Overload: Will operate at a constant current for an overcurrent condition

Output Short Circuit: Immediate shutdown

Invalid Frequency: Immediate shutdown to 0 volts

Input Overvoltage: Causes a trip of the circuit breaker

Sense Line Fault: The output voltage increases 15%

OverTemperature: Shutdown to 0 volts with automatic re-start

Loss of Input Phase: No output for loss of Phase B or C. Normal operation at reduced power with loss of Phase A.

MEASUREMENTS

Front panel analog voltmeter. Accuracy $\pm 5\%$ of reading.

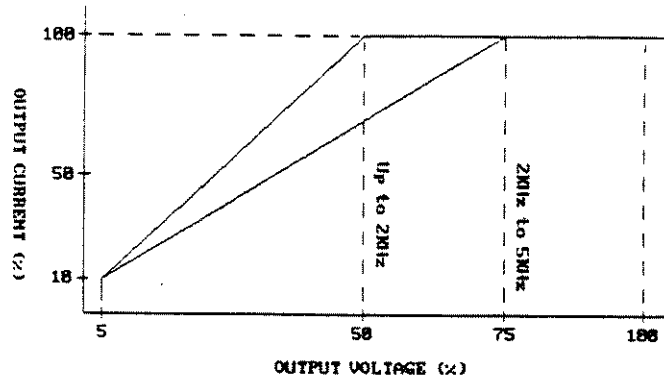
NOTE (*): Operation down to 17 Hz at reduced output voltage.

SUPPLEMENTAL SPECIFICATIONS

LINE INPUT

(For each 4500L Power Source)

Voltage: 187 to 252 L-L three-phase
Current: (PF=.6, EFF=75%, V line=187, full load) 31 Amps
Frequency: 47 to 440 Hz
Efficiency: 75% (typical)
Surge Current
(turn-on,
 $V_{LL} = 252$) 178 Amps
Full Current Range:



Output Voltage

Output noise voltage (20 KHz to 1 MHz at full load:
200 millivolts (typical)

Steady-State Output Impedance:

$$(\text{Voltage Range}) * (0.0005) / (\text{Full Current})$$

Voltage Temperature Coefficient: ± 0.02 volts per $^{\circ}\text{C}$

Voltage Stability: $\pm 0.015\%$ of programmed value
(24 hours, at constant line, load and temperature)

Frequency Temperature Coefficient: ± 5 ppm per $^{\circ}\text{C}$

Frequency Stability: ± 15 ppm per year

SUPPLEMENTAL SPECIFICATIONS (continued)

Isolation Line Input to Output: 500 VRMS

Front Panel Controls:

Power on/off circuit breaker

Current Limit: 1 turn pot for 0 to 100% of rate output current.

Frequency: 3 decade rotary switches. 3 position toggle switch for Frequency Range.

Voltage Amplitude: Varied by 10 turn pot

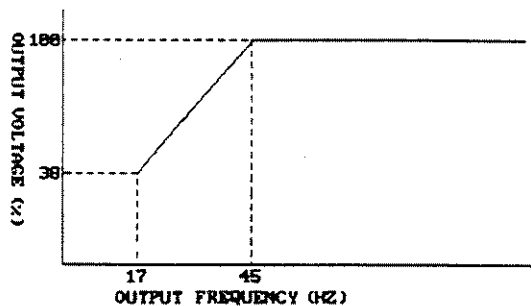
Voltage Range: HI/LO set by toggle switch

Phase Angle: FIXED B = 240, C = 120

Output Relay: Controlled by Remote On signal. Normally on.

Frequency

Range at less than Full Scale Voltage. Refer to graph below:



Default Frequency: At the setting of the switches

Remote Shutdown: A logic Low input will program the voltage to 0 and open the Output Relays.

External Sense: Compensates for up to a 10% drop in the load lines.

External Modulation: An input of 0 to 10 Vrms and DC to output frequency generates 0 to 10% amplitude modulation.

Indicators: Output Overload, Overtemperature, Power On, High Voltage range, Frequency Fault.

SUPPLEMENTAL SPECIFICATIONS (continued)

Dimensions: 10.5 inches (26.7 cm) high, 23 inches (58.4 cm) deep and 19 inches (48.3 cm) wide

Weight: 175 lbs. (79.2 Kg)

Material: Aluminum for front panel, rear panel and top cover. Steel for chassis.

Finish: Front panel - painted gray 26440 per Federal Standard 595
Chassis - zinc plate Type 2 Class 2. Rear panel and top cover - iridite

Air Intake/
Exhaust Intake from both sides of chassis
Exhaust from the rear

Modularity: Oscillator, all amplifiers, DC power supplies, Current Limit Board assembly, Range/Relay Board, all displays

Connectors

Input Power: Kukla terminal block, 9-85-5 (TB1)

Output Power: Kukla terminal block, 9-85-4 (TB2)

External Sense: AMP connector, 1-480705-0 (J6)

System Interface: 3M connector, 3367-1000 (J7)

IEEE-488 connector: J5

Chassis slides: Zero Manufacturing Company Model CTN-1-20-E94

Operating Temperature: 0°C to 50°C at 4500 VA per chassis

Storage Temperature: -40°C to +85°C

Operating Altitude: 0 to 6000 Ft.

OPTIONS

- RPV: 0 to +10 VDC input for 0 to full-scale output voltage. This option is not available with External Modulation.
- 2P: 2-Phase Output; Phase C 90 degrees relative to Phase A. Phase B is disabled.
- EHV: Extra High Voltage (0 to 200 or 400) range.
- HV: High voltage (0 to 156 or 312) range.
- LV: Low Voltage (0 to 67.5 or 135) range.
- LK-M: Master power source
- LK-S: Slave power source
- UP: Universal Input Power: 342 to 456 V_{LL} three phase
- MODE: Allows power system to be programmed to a 1-phase or a 3-phase system.
- AX: Auxiliary outputs. Not available with Master or Slave option

PHASE D:

- | | |
|------------------|--------------------------------------|
| Voltage: | 26.0 Vrms fixed |
| Accuracy: | ±2% |
| Current: | 3.0 Amps (max) |
| Frequency: | 360 to 440 (Tracks the main outputs) |
| Phase: | Tracks Phase A. |
| Distortion: | 1% THD maximum with linear load |
| Line Regulation: | ±0.05% using external sense |
| Load Regulation: | ±0.05% using external sense |

OPTIONS (continued)

PHASE E:

Voltage:	5.0 Vrms fixed
Accuracy:	±5%
Current:	3.0 Amps (max)
Frequency:	360 to 440 Hz (Tracks the main outputs)
Phase:	Tracks the Phase D output
Distortion:	1% THD maximum with linear load
Line Regulation:	±%.1 for 10% line change
Load Regulation:	±10% from no-load to full load

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.2 POWER REQUIREMENTS

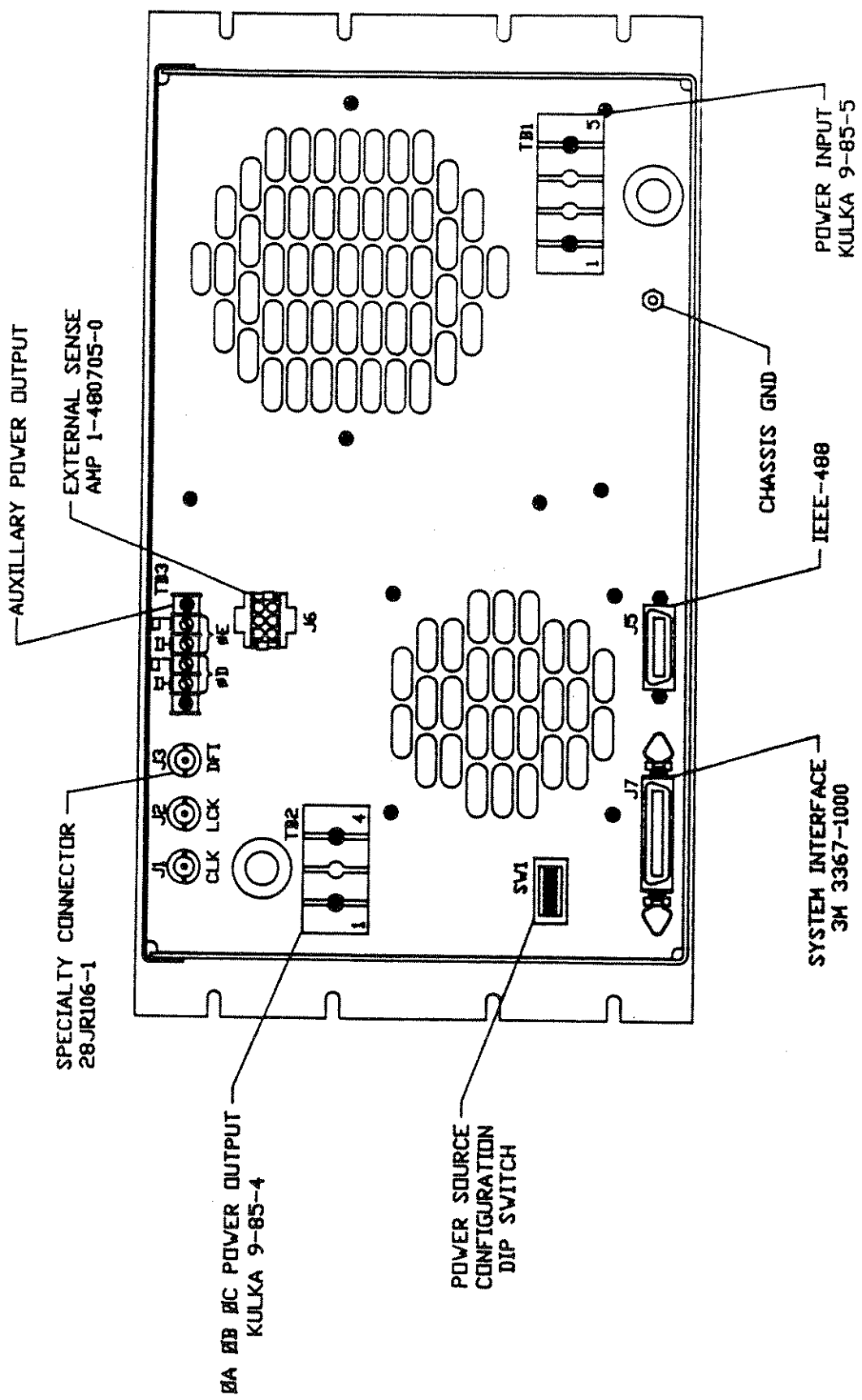
The AC Power System has been designed to operate from a three-phase AC line voltage. The input line voltage may be between 187 volts and 252 volts line-to-line. The frequency may be between 47 Hz and 440 Hz. Select an AC input line and hookup wire to the AC Power System that will deliver 30 amps per phase for each 4500L in the system and still supply a minimum of 187 volts line-to-line.

2.3 MECHANICAL INSTALLATION

The power system has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in paragraph 1-4. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 1-1.

2.4 INPUT WIRING

The AC Power System must be operated from a three-wire three-phase service with a fourth wire for common. The common wire is connected to the chassis of the AC Power System. The mains source must have a current rating greater than or equal to the AC Power System circuit breaker, 20 amps. Refer to Figures 2-1 and 2-2 for the input power connections.



AUXILIARY POWER OUTPUT

EXTERNAL SENSE
AMP 1-480705-0

SPECIALTY CONNECTOR
28JR106-1

0A 0B 0C POWER OUTPUT
KULKA 9-85-4

POWER SOURCE
CONFIGURATION
DIP SWITCH

SYSTEM INTERFACE
3M 3367-1000

CHASSIS GND

POWER INPUT
KULKA 9-85-5

TB1	
PIN	FUNCTION
1	3 PHASE INPUT
2	
3	
5	GROUND

TB2	
PIN	FUNCTION
1	C OUTPUT
2	B OUTPUT
3	A OUTPUT
4	NEUTRAL

J6	
PIN	FUNCTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE
5	D SENSE HI
6	D SENSE LO

FIGURE 2-1

2.5 OUTPUT CONNECTIONS

The output terminal block, TB2, is located at the rear of the power system. For a single power source power system, all load connections must be made at TB2. The external sense inputs allow the power system output voltages to be monitored directly at the load and must be connected. The external sense wires are connected at J6 on the rear panel of the 4500L with oscillator/controller. Refer to Figure 2-2 for all connections.

The output power cables must be large enough to prevent a voltage difference greater than 2 VRMS between TB1 and the voltage between External Sense HI and LO input. Table 2-1 shows the maximum length of the output wires. The table assumes the External Sense input is connected at the load.

TABLE 2-1

MAXIMUM LENGTH OF OUTPUT WIRES

WIRE GAGE (AWG)	MAXIMUM LENGTH (FT) OF WIRE BETWEEN OUTPUT HI AND LOAD
14	MAX LENGTH (ft) = $2 / (\text{MAX CURRENT PER PHASE} \times 0.0027)$
12	MAX LENGTH (ft) = $2 / (\text{MAX CURRENT PER PHASE} \times 0.0017)$
10	MAX LENGTH (ft) = $2 / (\text{MAX CURRENT PER PHASE} \times 0.00111)$
8	MAX LENGTH (ft) = $2 / (\text{MAX CURRENT PER PHASE} \times 0.00061)$

For a 1-phase power system the output power is available on TB1,, pins 3 and 4.

2.6 EXTERNAL SENSE CONNECTIONS

The External Sense inputs must be connected or the power system will not meet its line or load regulation specifications. In addition, the maximum output voltage will be about 15% higher than the rated value. Refer to Figures 2-1 and 2-2.

2.7 OUTPUT VOLTAGE RANGES

The standard voltage ranges for this AC power system are 135 and 270. Selecting of the 270 volt range causes the front panel "HIGH RANGE" lamp to illuminate. The range may be changed from the front panel by a toggle switch. All voltages are programmed line-to-neutral for 3-phase operation.

THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB2 THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.

WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB2

AWG 10 STRANDED WIRE OR LARGER
ALL WIRES TO TB2 MUST BE OF EQUAL LENGTH ±1' (STRANDS 37/26)

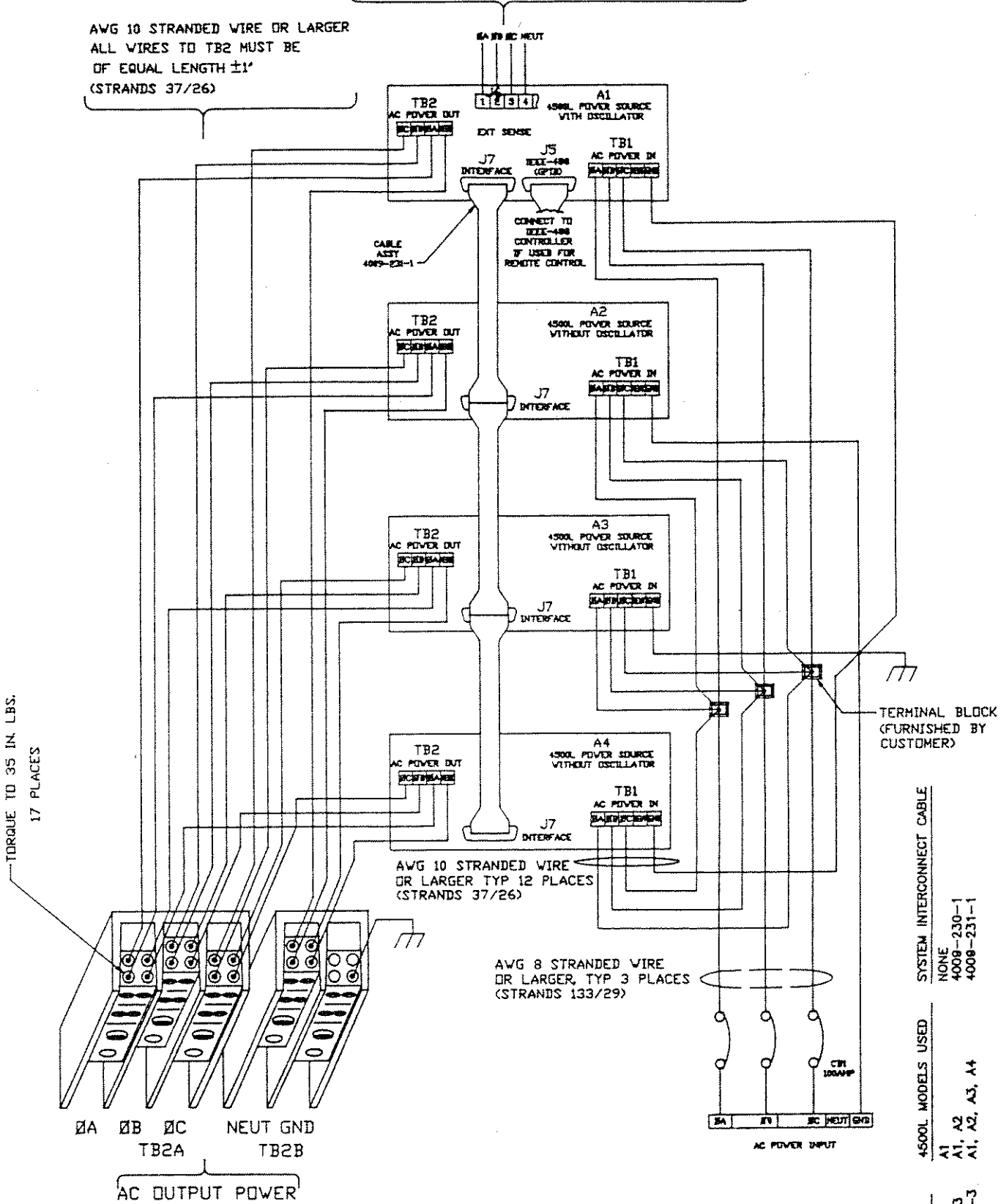


FIGURE 2-2
SYSTEM INTERCONNECT
4500L-3, 9000L/2-3, 18000L/4-3

SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
4500L-3	A1	NONE
9000L/2-3	A1, A2	4008-230-1
18000L/4-3	A1, A2, A3, A4	4008-231-1

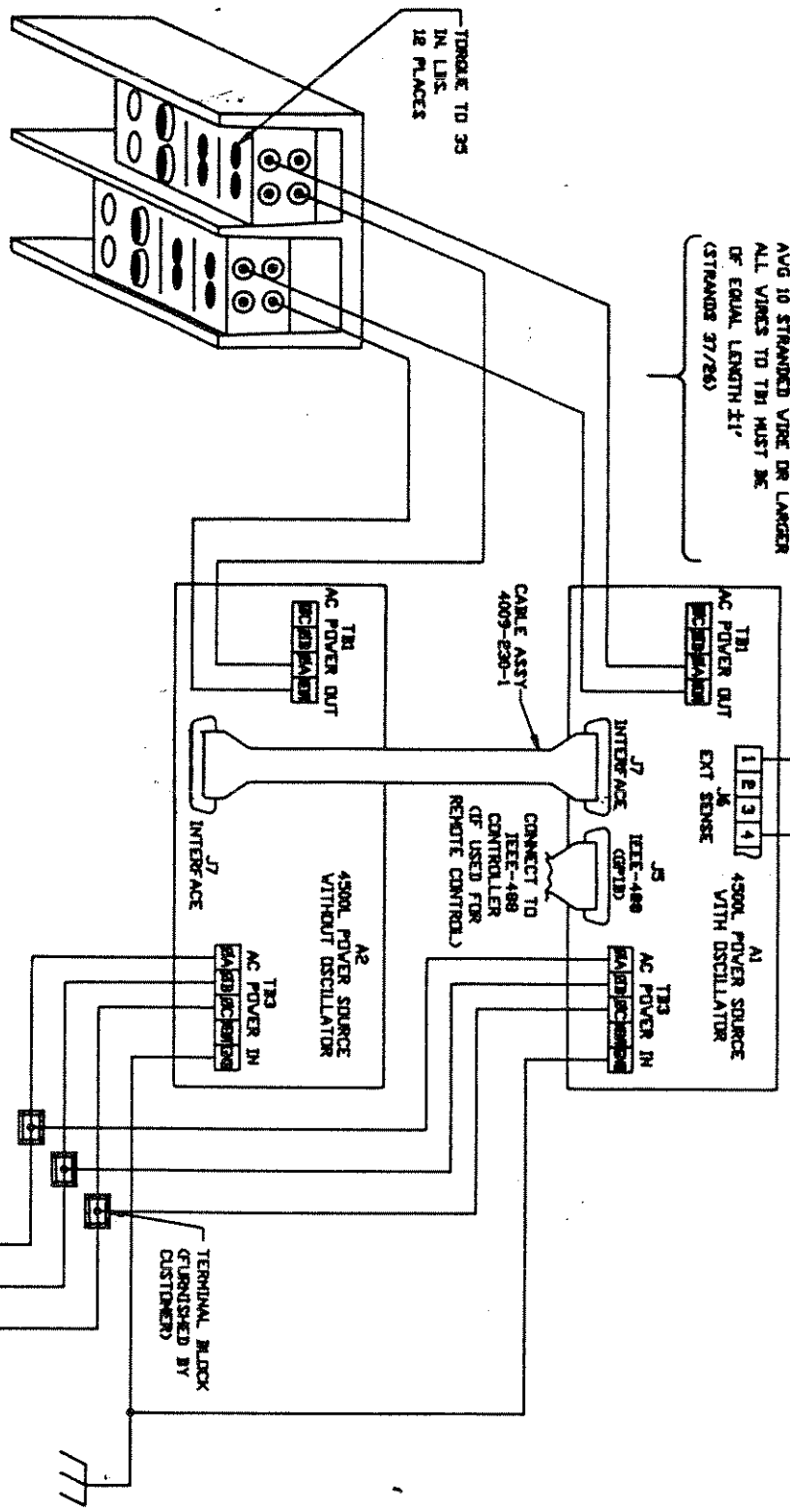
1. TB2A MARATHON PART NUMBER 1423570,
TB2B MARATHON PART NUMBER 1422570.
(SHIPPED WITH POWER SOURCE SYSTEM)

THE REMOTE SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB1. THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE REMOTE SENSE POINT. WHEN A PT OSCILLATOR IS INSTALLED, THE REMOTE SENSE MUST BE TIED DIRECTLY TO TB1.

AVG 10 STRANDED WIRE OR LARGER ALL WIRES TO TB1 MUST BE OF EQUAL LENGTH 21' (STRANDS 37/260)

TORQUE TO 39 IN LBS. 12 PLACES

HI LO
TB2A
AC OUTPUT POWER



AVG 8 STRANDED WIRE OR LARGER, TYP 3 PLACES (STRANDS 133/299)

TERMINAL BLOCK (FURNISHED BY CUSTOMER)

9000L/2-1 SYSTEM INTERCONNECT

THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB2. THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.

WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB2.

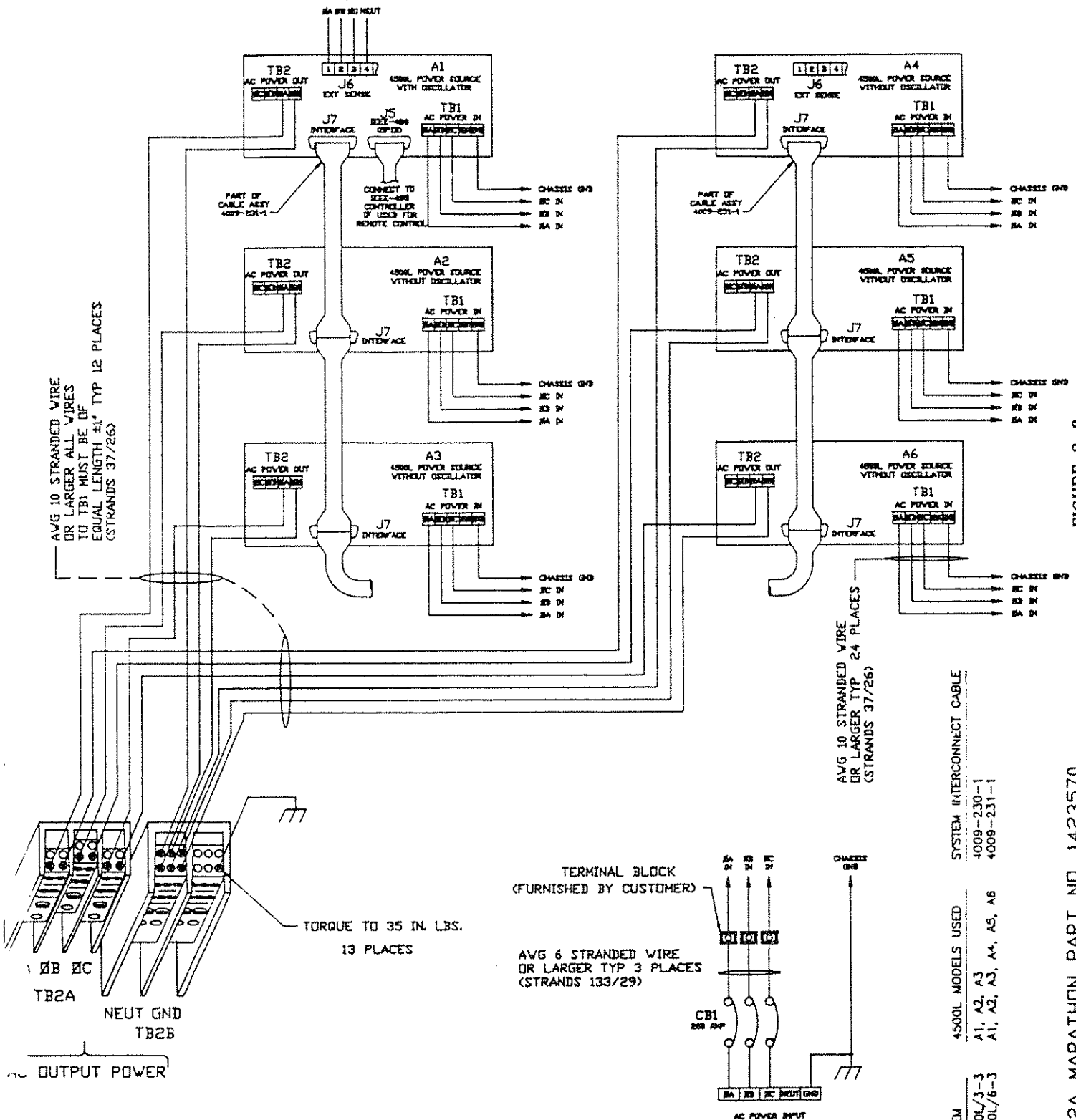


FIGURE 2-2
SYSTEM INTERCONNECT

1. TB2A MARATHON PART NO. 1423570,
TB2B MARATHON PART NO. 1432555.

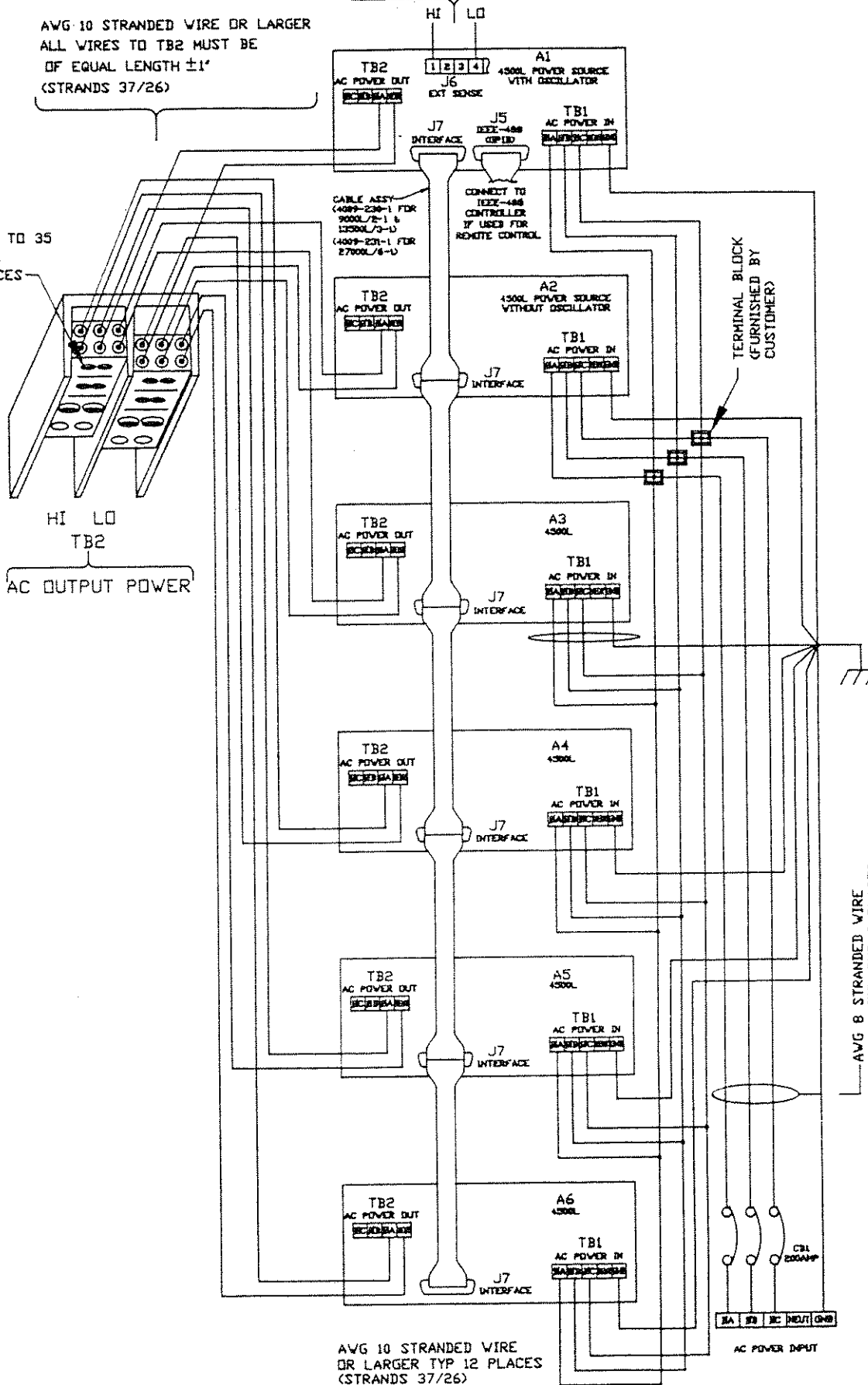
THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB2. THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.

WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB2.

AVG 10 STRANDED WIRE OR LARGER
ALL WIRES TO TB2 MUST BE OF EQUAL LENGTH $\pm 1'$
(STRANDS 37/26)

TORQUE TO 35
IN. LBS.
12 PLACES

HI LO
TB2
AC OUTPUT POWER



AVG 10 STRANDED WIRE
OR LARGER TYP 12 PLACES
(STRANDS 37/26)

SYSTEM INTERCONNECT CABLE

NONE
4009-230-1
4009-230-1
4009-231-1

4500L MODELS USED

A1, A2
A1, A2, A3
A1, A2, A3, A4, A5, A6

SYSTEM

4500L-1
9000L/2-1
13500L/3-1
27000L/6-1

AVG 8 STRANDED WIRE
OR LARGER, TYP 3 PLACES
(STRANDS 133/29)

- FOR 9000L/2-1 & 13500L/3-1 USE 100 AMP CBI. NO CBI FOR 4500L-1
- TB2 (9000L/2-1 & 13500L/3-1) MARATHON PART NUMBER 1422570.
TB2 (27000L/6-1) MARATHON PART NUMBER 1432555.
(SHIPPED WITH POWER SOURCE SYSTEM) NO TB1 FOR 4500L-1

JRE

SYST

7000

DJVN

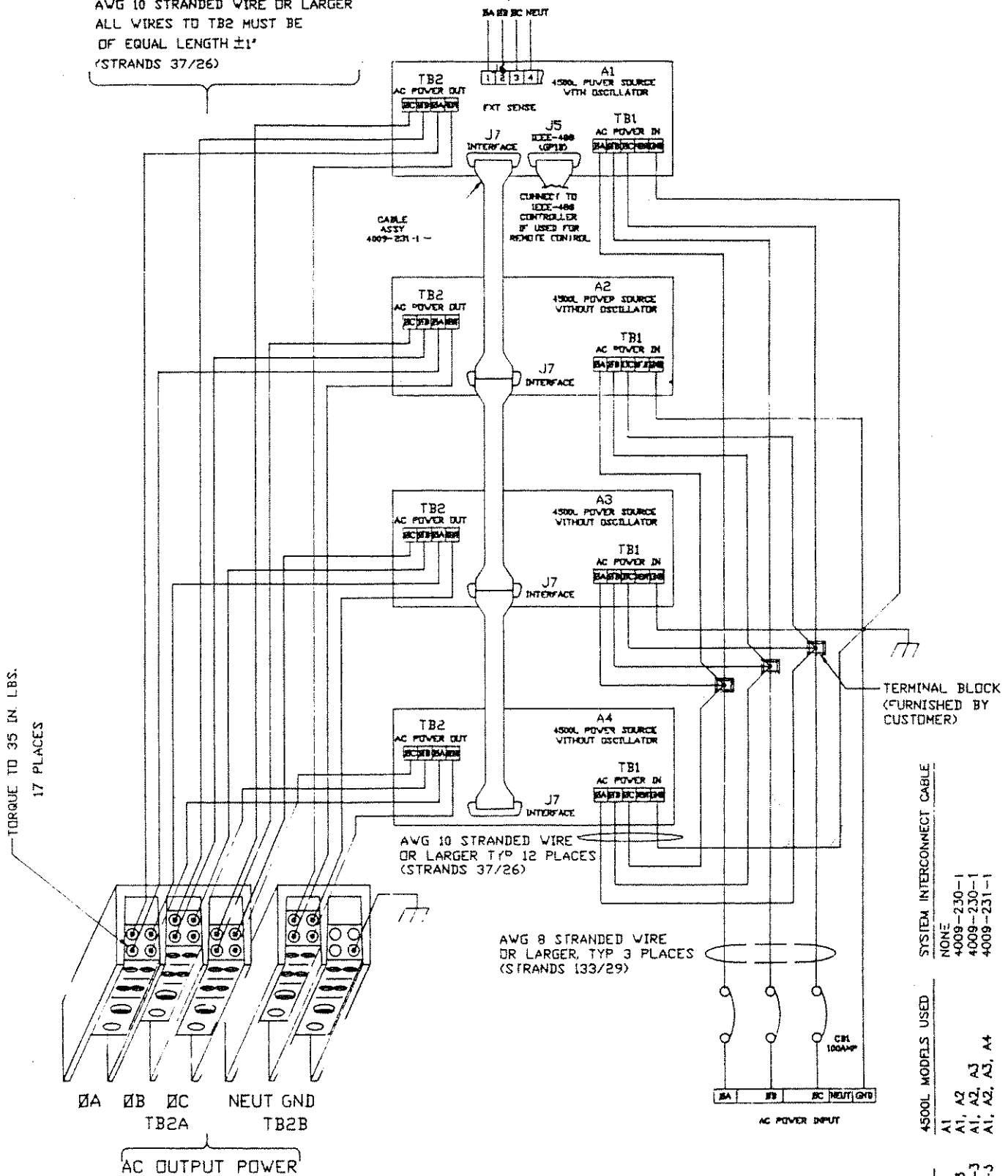
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EM I

THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB2 THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.

WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB2.

AVG 10 STRANDED WIRE OR LARGER
ALL WIRES TO TB2 MUST BE OF EQUAL LENGTH $\pm 1'$
(STRANDS 37/26)



TORQUE TO 35 IN. LBS.
17 PLACES

AVG 10 STRANDED WIRE OR LARGER TYP 12 PLACES (STRANDS 37/26)

AWG 8 STRANDED WIRE OR LARGER, TYP 3 PLACES (STRANDS 133/29)

THE OUTPUT IS AVAILABLE FROM OA AND NEUT WHEN THE POWER SYSTEM IS PROGRAMMED FOR 1-PHASE

SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
4500L-3	A1	NONE
9000L/2-3	A1, A2	4009-230-1
13500L/3-3	A1, A2, A3	4009-230-1
18000L/4-3	A1, A2, A3, A4	4009-231-1

FIGURE 2-2
SYSTEM INTERCONNECT FOR MODE OPTION
4500L-3, 9000L/2-3, 13500L/3-3, 18000L/4-3

1. TB2A MARATHON PART NUMBER 1423570.
TB2B MARATHON PART NUMBER 1422570.
(SHIPPED WITH POWER SOURCE SYSTEM)

NOTE

A special hookup is required for all multiple power source power systems with the MODE option. Refer to Figure 2-2 for the connections. The 1-phase output is always taken from the power output barrier strip terminals Phase A and Neutral terminals.

2.8 FUNCTION TEST

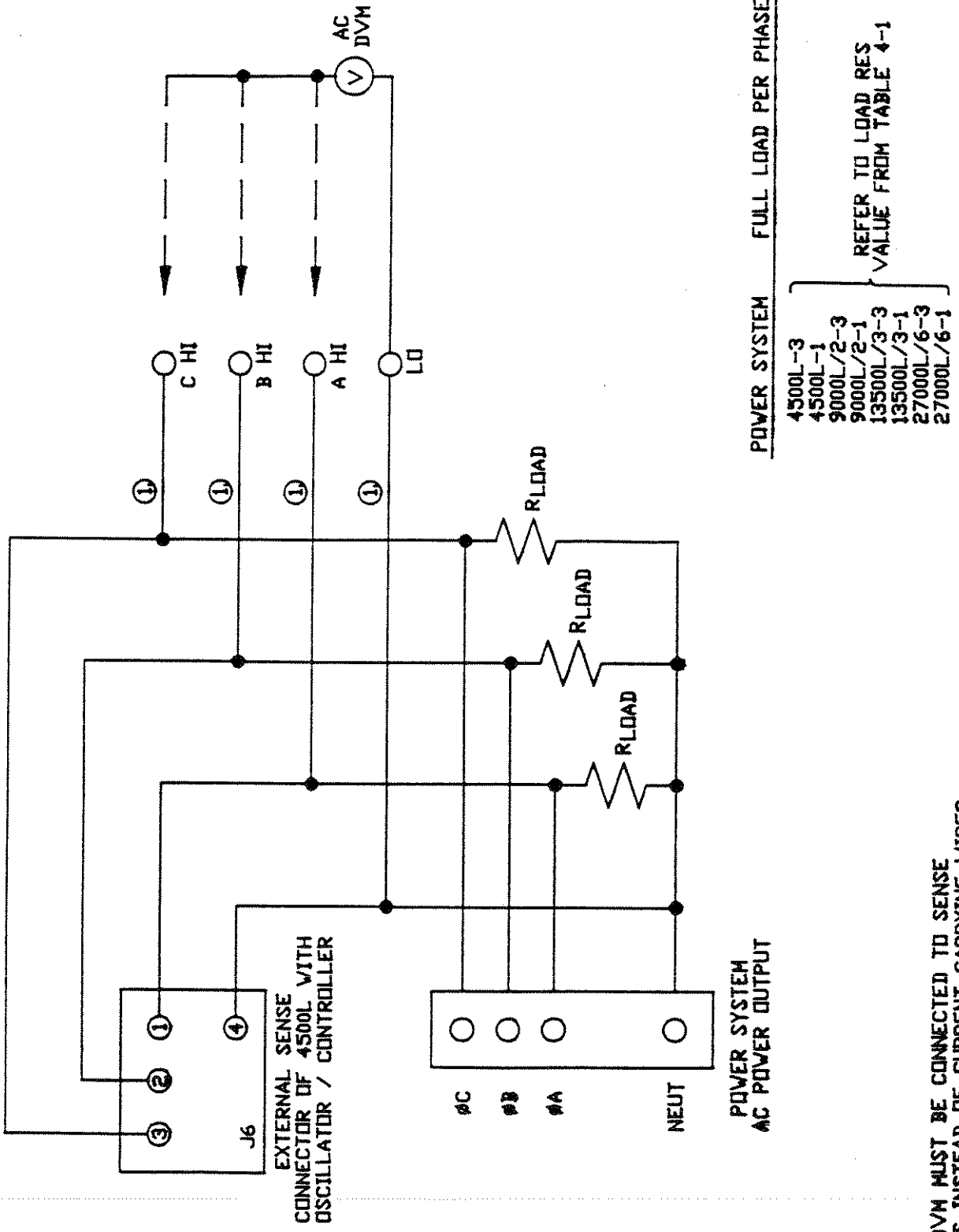
Refer to Figure 2-3 for the test setup. For the single phase load, the three loads used for the three-phase test may be used in parallel. The loads are from Table 4-1. The load values are for full-load on the low voltage range. For other ranges, use the formula: Load (ohms) = (Voltage Range)²/VA rating.

2.8.1 RANGE SWITCHING

- 1) Apply the AC line power and turn on the front panel circuit breaker. No loads should be connected to the output terminal block.
- 2) Verify that the POWER ON lamp is lit.
- 3) Position the front panel VOLTAGE RANGE switch to the HI position for the standard 135/270 volt range power source. This position will select the 270 volt range.
- 4) Verify the HIGH RANGE lamp is lit.
- 5) Adjust the output to 270 volts with the front panel VOLTAGE AMPLITUDE CONTROL.
- 6) Verify that the front panel voltmeter indicates approximately 270 volts for all three phases or for phase A for a 1-phase system.
- 7) Set the Voltage Range switch to the LO position to select the 135 volt range.
- 8) Verify that the front panel voltmeter indicates 135 volts for all phases.

2.9 LOAD REGULATION TEST

- 1) Observe each of the outputs with the AC voltmeter.
- 2) Apply full loads to each phase. Verify that the voltage of each phase remains within (0.0005 x Voltage Range) volts of the no-load voltage.
- 3.) If the output voltage does not remain within the specification limits volts from no-load to full-load, verify that the front panel Current Limit control is set at the extreme clockwise positions.



① NOTE: AC DVM MUST BE CONNECTED TO SENSE LINES INSTEAD OF CURRENT CARRYING WIRES.

FIGURE 2-3
FUNCTION TEST SETUP

SECTION 3

OPERATION

3.1 GENERAL

The AC Power System is controlled from the front panel. Control of the output voltage range, output relay, frequency and current limit is provided from the front panel of the 4500L Power Source with the Oscillator/Controller Module (see Figure 3-1).

3.2 FRONT PANEL CONTROLS

All front panel controls are shown in Figure 3-1.

METER SELECT SWITCH: A voltmeter selector switch is located at the right side of the front panel voltmeter. The three-position switch changes the signal applied to the voltmeter from the three output phases.

CIRCUIT BREAKER: A three-pole circuit breaker is on the left side of the front panel. The circuit breaker is used to switch power to the unit. When the circuit breaker is switched ON, the amber indicator lamp above the circuit breaker illuminates.

OSCILLATOR/CONTROLLER PANEL

The front panel has a subpanel attached to the front of the power source. The following controls are located on this subpanel.

CONTROLLER PANEL

FREQUENCY SELECT DIALS: These three dials set the output frequency within the range set by frequency Range Select switch. When in the 45.0 to 99.9 Hz range, an LED decimal point is lit between the second and third dials to give 0.1 Hz resolution. When in the 100 to 999 range an LED decimal point is lit after the third dial to indicate 1 Hz resolution. When in the 1.00 to 5.00 KHz range, an LED decimal point is lit between the first and second dials to give 0.01 KHz resolution.

FREQUENCY RANGE SELECT: This three-position switch selects which of the three ranges the frequency select dials will use. The lower position selects the 45.0 to 99.9 Hz range. The middle position selects the 100 to 999 Hz range. The upper position selects the 1.00 to 5.00 KHz range.

VOLTAGE AMPLITUDE Knob: This knob simultaneously sets the amplitude of all three phases between zero and full scale of the selected voltage range.

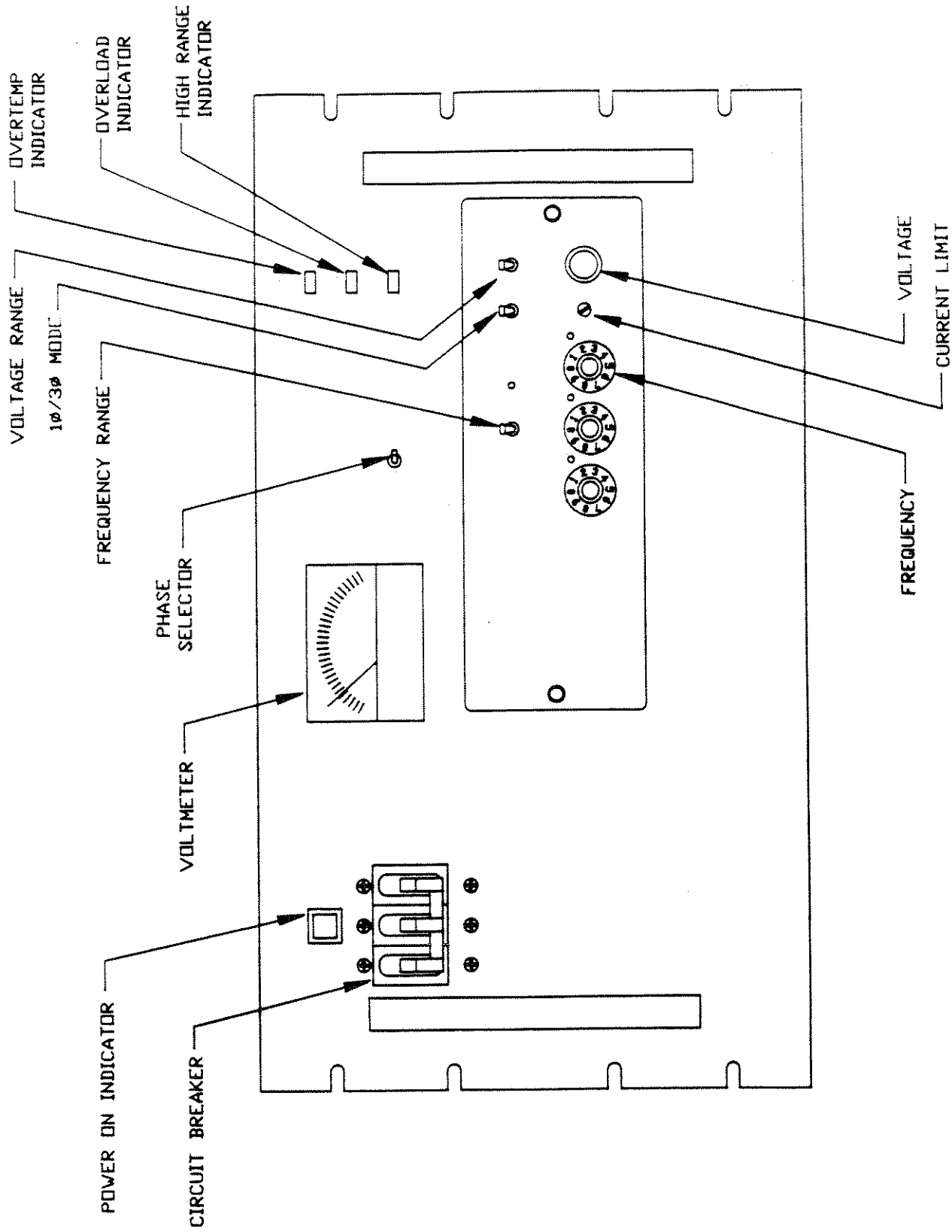


FIGURE 3-1
FRONT PANEL CONTROLS AND INDICATORS

VOLTAGE RANGE Switch: This range select switch sets the output voltage to the low range when in the lower position and to the high range when in the upper position.

CURRENT LIMIT Knob: This knob sets the programmable current limit to all phases simultaneously. Turning the knob fully counterclockwise sets the current limit to zero amps; fully clockwise sets the current limit to the maximum capability of the selected voltage range. The knob sets the limit linearly between the two extremes.

1 \emptyset /3 \emptyset SWITCH: This switch is on the front panel when the MODE option is installed. The switch programs the power system to either a 1-phase or 3-phase output. In the 1-phase position, the power output is taken from the power output barrier strip from the Phase A and Neutral terminals. Refer to Figure 2-2.

LIMIT Lamp: The red LED is lit when the controller is limiting its oscillator drive signals. This occurs for a very short time when power is initially applied or when its voltage range is changed. The LED stays on indefinitely if the output frequency is set above or below the capabilities of the power source or while the REMOTE ON line is held low.

3.3 FRONT PANEL INDICATORS

POWER ON LAMP

This lamp is located just above the input circuit breaker. It illuminates when power is applied and the circuit breaker is on.

ANALOG VOLTMETER

This is an average responding voltmeter that indicates from 0 to 300 volts and shows the actual voltage of the phase A, B and C outputs. The phase is determined by a three position toggle switch at the right side of the meter.

OVERLOAD

This lamp illuminates when the output current exceeds the set current limit value. The output voltage waveform will be clipped while the power system is operating in the current limit mode.

OVERTEMP

This lamp illuminates when the temperature of the power amplifier heatsinks has surpassed a maximum set level. When the fault is detected, the outputs are disabled and must be reprogrammed after the overtemperature condition has been eliminated.

HIGH RANGE

This lamp illuminates when the power source has switched to its high voltage range setting.

3.4 REAR PANEL CONNECTIONS

Refer to Figure 3-2 for an illustration of the 4500L rear panel.

3.4.1 POWER INPUT

TB1 is the terminal block for the 3-phase input voltage. Terminals 1, 2 and 3 connect to each leg of the 3-phase input. Terminal 5 is the chassis connection which should be connected to the input mains ground.

3.4.2 POWER OUTPUT

TB2 is the power output terminal block. Refer to Table 3-1 for identification of the TB2 terminals. Terminals 1 and 2 are only used for 4500L-3M, 9000L/2-3M and all power systems with the MODE option. Refer to Figure 2-2 for the output.

TB2 DESCRIPTION

1	Phase C Output HI
2	Phase B Output HI
3	Phase A Output HI
4	Output Neutral

TABLE 3-1

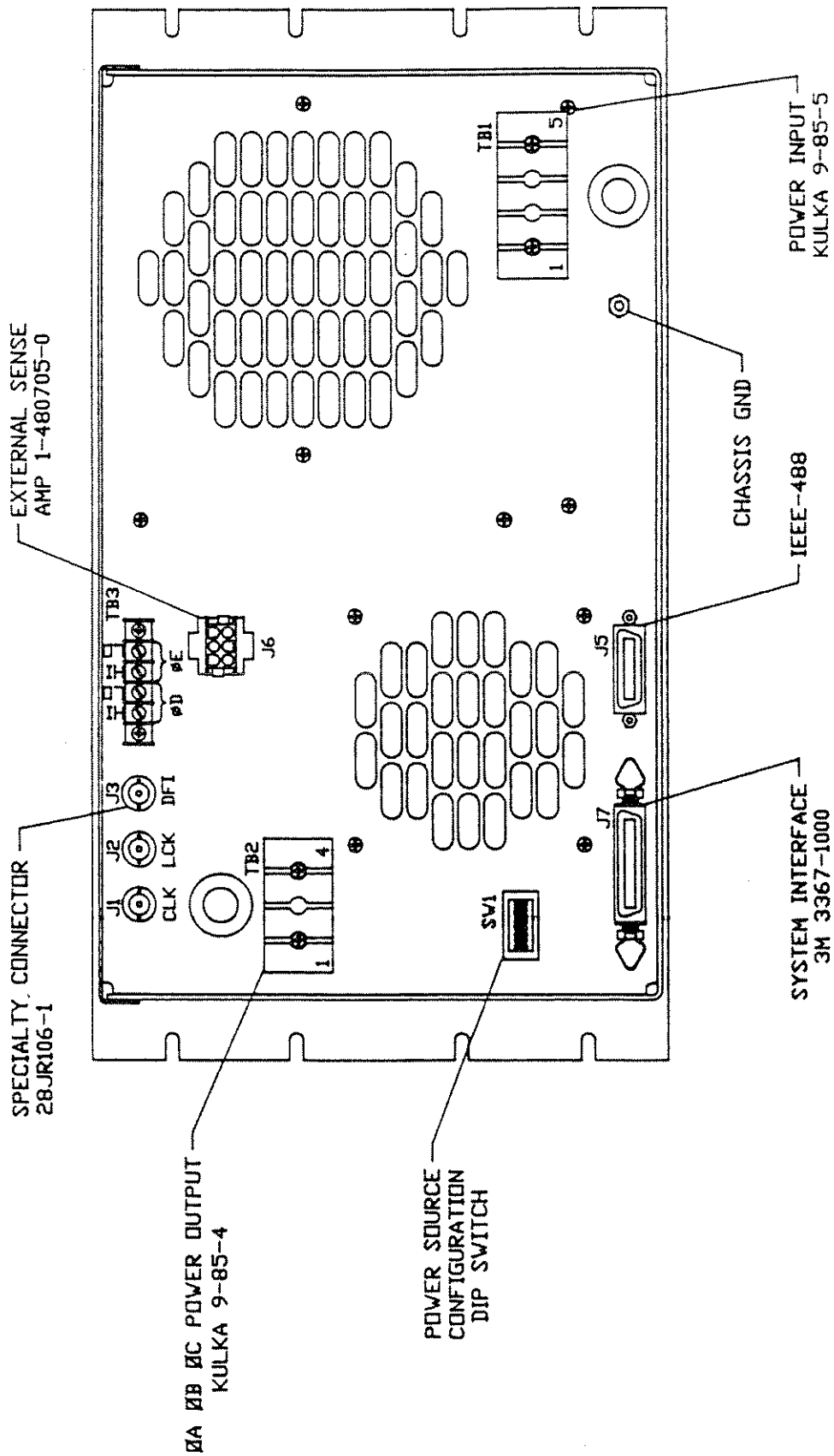
3.4.3 EXTERNAL SENSE

J6 is the external sense input connector. The external sense input of the master 4500L must be connected to the respective AC Power System output. If the inputs are not connected, the power system will not meet line or load regulation specifications. In addition, the output will be approximately 15% higher than the voltage range at maximum output. Table 3-2 identifies the pins of connector J6.

J6	DESCRIPTION	CONNECT TO:
1	Phase A Sense HI	Phase A Output HI
2	Phase B Sense HI	Phase B Output HI
3	Phase C Sense HI	Phase C Output HI
4	Neutral Sense	Neutral Output
5	Phase D Sense HI	Phase D Output HI
6	Phase D Sense LO	Phase D Output LO

TABLE 3-2

J5 is not used.



J6

PIN	FUNCTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE
5	D SENSE HI
6	D SENSE LO

TB2

PIN	FUNCTION
1	C OUTPUT
2	B OUTPUT
3	A OUTPUT
4	NEUTRAL

TB1

PIN	FUNCTION
1	-3 PHASE INPUT
2	
3	
5	GROUND

45001 READ PANEL CONNECTIONS
FIGURE 3-2

3.4.5 SYSTEM INTERFACE

J7 is the System Interface connector. Table 3-3 identifies the pins of the System Interface connector.

J7	Description
1	Analog Common
2	MR B, Phase B amplifier input signal
3	Analog Common
4	CS B, Phase B current sum
5	CT Common, Current Transformer Common
6	OS B, Oscillator Phase B output
7	Analog Common
8	CL B, Phase B DC current limit
9	RPV
10	$\overline{\text{OVR TEMP}}$, Overtemperature indication
11	$\overline{\text{CNF}}$, output relay
12	Not used
13	Not used
14	Not used
15	Not used
16	No connection
17	No connection
18	No connection
19	MR C, Phase C amplifier input signal
20	MR A, Phase A amplifier input signal
21	CS C, Phase C current sum
22	CS A, Phase A current sum
23	OS C, Oscillator Phase C output
24	OS A, Oscillator Phase A output
25	CL C, Phase C DC current limit
26	CL A, Phase A DC current limit
27	D COM, Digital Common
28	$\overline{\text{RNG HI}}$, High Voltage range
30	Not used
31	Not used
32	Not used
36	REMOTE SHUTDOWN

TABLE 3-3

SYSTEM INTERFACE CONNECTOR (J7)

- J7-1 ANALOG COMMON: This is the common for all analog signals on the connector.
- J7-2 MR B: This is the input signal to the phase B amplifier from the internal oscillator drive signal. Make no connection to this pin except for troubleshooting.

- J7-3 ANALOG COMMON: See J7-1.
- J7-4 CS B: Current sum for the phase B output. Make no connections to the pin.
- J7-5 CT COMMON:
- J7-6 OS B: This is the output from the internal phase B oscillator. Use this pin as an input if an oscillator is not installed. A 5.0 VRMS signal will generate a full-scale output voltage.
- J7-7 ANALOG COMMON: See J7-1.
- J7-8 CL B: A DC level from the oscillator used to set the current limit for phase B. Make no connection to the pin.
- J7-9 RPV: External Modulation/Remote Programming Voltage. This input is used in power sources with manual controllers only. The pin normally serves as an external modulation input; a 0.0 to ± 10.0 volt DC input provides 0% to $\pm 10\%$ amplitude modulation. The pin may optionally be configured as a Remote Programming Voltage input. In this case a 0.0 to 10.0 volt DC input provides 0 to 100% of full scale output voltage with the amplitude control potentiometer set fully clockwise.
- J7-10 $\overline{\text{OVR TEMP}}$: A logic low output to indicate an overtemperature condition.
- J7-11 $\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open. Make no connection to the pin.
- J7-12
- J7-13
- J7-14 Not used
- J7-15 Not used
- J7-16 No connection.
- J7-17 No connection.
- J7-18 No connection.
- J7-19 MR C: This is the input signal to the phase C amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

- J7-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.
- J7-21 CS C: Current sum for the phase C output. Make no connection to this pin.
- J7-22 CS A: Current sum for the phase A output. Make no connection to this pin.
- J7-23 OS C: This is the output from the internal phase C oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.
- J7-24 OS A: This is the output from the internal phase A oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.
- J7-25 CL C: A DC level from the oscillator used to set the current limit for phase C. Make no connection to the pin.
- J7-26 CL A: A DC level from the oscillator used to set the current limit for phase A. Make no connection to the pin.
- J7-27 D COM: Digital common.
- J7-28 RNG HI: A logic output from the internal oscillator to control the ramp relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.
- J7-30 Not used.
- J7-31 Not used.
- J7-32 Not used.
- J7-36 REMOTE SHUTDOWN: This is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0. 0 volts and the output relays to open. A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J7-27 (D COM) will simulate a logic low state.

3.4.6 CLOCK

J1 is the CLOCK input for the optional CLK & LK feature. This signal is used by California Instruments oscillator/controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option in the power source with the oscillator/controller.

3.4.7 LOCK

J2 is the LOCK input for the optional CLK & LK feature. This signal is used by California Instruments oscillator/controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option in the power source with the oscillator/controller.

3.4.8 DFI

This connector, J3, is not available with the manual oscillator systems.

3.4.9 øD and øE POWER OUTPUT

TB3 is the terminal block for the optional 26 VAC and 5 VAC output.

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 4

CALIBRATION PROCEDURE

4.1 GENERAL

A routine calibration of the 450OL-M Power Systems is not normally required. The Calibration Adjustment listed below is only required if the indicated assembly is repaired or replaced.

<u>CALIBRATION ADJUSTMENT</u>	<u>ASSEMBLY</u>	<u>PARAGRAPH</u>
OPEN SENSE	CURRENT LIMIT (4009-728)	4.3
GAIN BALANCE	AMPLIFIER (4009-423)	4.4
CURRENT TRANSFORMER	RANGE RELAY (4009-733)	4.5
LOAD BALANCE	AMPLIFIER (4009-423)	4.6
CURRENT LIMIT	CURRENT LIMIT (4009-728)	4.7

4.2 TEST EQUIPMENT REQUIRED

Equipment

AC Digital Voltmeter, Fluke 8840A
100 Amp Current Transformer, Pearson 3468
AC Digital Voltmeter, Fluke 8840A
Resistor Load, Refer to Table 4-1 for values

<u>MODEL</u>	<u>WATTAGE</u>	<u>LOAD PER PHASE</u> <u>(ohms)</u>
4500L-3M	1667	135 RANGE: 10.9 156 RANGE: 14.59 67.5 RANGE: 2.73 200 RANGE: 24
9000L/2-3M	3334	135 RANGE: 5.46 156 RANGE: 7.3 67.5 RANGE: 1.36 200 RANGE: 12
4500L/1-1M } 13500L/3-3M }	5000	135 RANGE: 3.64 156 RANGE: 4.86 67.5 RANGE: 0.91 200 RANGE: 8
9000L/2-1M } 27000L/6-3M }	10000	135 RANGE: 1.82 156 RANGE: 2.43 67.5 RANGE: 0.455 200 RANGE: 4
13500L/3-1M	15000	135 RANGE: 1.21 156 RANGE: 1.62 200 RANGE: 2.66
27000L/6-1M	30000	135 RANGE: 0.607 156 RANGE: 0.811 200 RANGE: 1.33

LOAD PER PHASE

TABLE 4-1

4.3 OPEN SENSE ADJUSTMENT

For the following adjustments, remove all loads from the output. The External Sense inputs must be connected. Switch the power source(s) on and adjust the output to 100.0 Vrms and 60 Hz. Disconnect the External Sense inputs.

All gain adjustments are located on the Current Limit board (A9) in the master power source (the one with the oscillator/controller).

1. Connect the AC DVM to the ϕA of the power system. Adjust R109 for an output of 115 ± 0.1 Vrms.

For all 1-phase Power Systems do not perform steps 2 and 3.

2. Connect the AC DVM to the ϕB output of the power system. Adjust R110 for 115 ± 0.1 Vrms.

3. Connect the AC DVM to the ϕC output of the power system. Adjust R111 for 115 ± 0.1 Vrms.
4. Reconnect the External Sense inputs.

4.4 GAIN BALANCE ADJUSTMENT

The following adjustment is for all power system models except the 4500L-3M. The 4500L-3M does not require a gain balance adjustment. Before performing the adjustment, the top cover of each 4500L must be removed. Remove the Current Limit Board and temporarily remove jumper W2.

If the output of any 4500L is connected to the output of any other 4500L (ex. 9000L/2-1, 9000L/2-3, 13500L/3-1, 27000L/6-3, 27000L/6-1), remove the connection.

The External Sense input to the master 4500L must remain connected. Refer to Figure 2-2 and 2-3 for the proper External Sense connections.

The following steps will verify that the amplifiers to be paralleled have been adjusted to the same gains. In order to perform this, the AC DVM input LO will be connected to the first amplifier output of a given phase. This output is referred to as ALO, BLO or CLO for the respective phase A, B or C output. The AC DVM HI will be connected to each amplifier's output. The amplifier's output is referred to as AHI, BHI or CHI on the AMPLIFIER GAIN BALANCE table.

1. Use the AMPLIFIER GAIN BALANCE table to check all of the amplifiers for the system being tested.

Between the output of each amplifier of a given phase, the AC DVM should display less than 0.3 VAC while the DVM is on the 200 VAC range.

2. If any measurement from the GAIN BALANCE check is out of specification, the gain of the amplifier with the AC Dvm input LO test lead connected must first be checked.

To check the gain of the amplifier, connect the AC DVM between the Output Neutral and Output High of the corresponding output. Connect an additional AC DVM HI input test point of the Current Limit Board indicated below. Connect the LO input to TP1.

OUTPUT	TEST POINT	ADJUSTMENT
A	TP4	R105 PHASE A AMP
B	TP5	R105 PHASE B AMP
C	TP6	R105 PHASE C AMP

3. Program the output to 135.0 or the maximum voltage allowed on the corresponding Voltage Range.
4. With exactly 135.0 volts, or the maximum voltage allowed on the range, the Current Limit test point must be 5.000 \pm 1mv.
5. Adjust R105 so that the voltage at the test point is 5.000 volts or $= V_{out}(5/V_{max})$ if V_{max} is not 135 volts.
6. Repeat step 1) and adjust R105 of the amplifier for the respective output so that the output balance voltage is at a minimum.
7. Remove the input power and reinstall jumper W2 on the Current Limit Board in all 4500Ls.
8. Reconnect the outputs as shown in Figures 2-2 and 2-3.

SYSTEM	MASTER			SLAVE #1			SLAVE #2		
	A	B	C	A	B	C	A	B	C
4500L-1	ALO	AHI	AHI						
9000L/2-1	ALO	AHI	AHI	AHI	AHI	AHI			
9000L/2-3	ALO	BLO	CLO	AHI	BHI	CHI			
13500L/3-1 27000L/6-1	ALO	AHI	AHI	AHI	AHI	AHI	AHI	AHI	AHI
	Additional slaves same as Slave #1								
13500L/3-3	ALO	AHI	AHI	AHI	AHI	AHI	AHI	AHI	AHI
	Additional A Slaves same as Master except A output measured as AHI								
27000L/6-3									
	Additional B Slaves same as Master except A output measured as BHI								
	Additional C Slaves same as Master except A output measured as CHI								

AMPLIFIER GAIN BALANCE TABLE

4.5 CURRENT TRANSFORMER ADJUSTMENT

Before making this adjustment all amplifiers in the power system must be disconnected from the parallel mode of operation. Amplifiers operate in the parallel mode of operation for all power systems except the 4500L-3M.

For all power systems except the 4500L-3M, remove jumper W2 on the Current Limit Board (See Figure 4-1) and all connections to the power output terminal block of each 4500L in the power system. Refer to Figure 4-1 for the location of all adjustments.

1. Apply a 10.9 ohm load to the 0A output of the master 4500L. For the EHV option voltage range (200/400), apply a 22 ohm load. Monitor the output current with a current transformer connected to the AC DVM.
2. Set the output to the lowest voltage range that will deliver 135 volts and 60 Hz. Adjust the output voltage for an output current of 10.0 amps. Adjust the output to 7.0 amps for the EHV option.
3. Connect an AC DVM between TP1 and TP10 on the Current Limit Board. Adjust R4 on the Range/Relay Board for 1.00 Vrms or 0.700 for the EHV option. 1 VAC should indicate a load current of 10 amps.
4. Repeat steps 1 through 3 for all amplifier channels in the AC power system. Refer to Figure 4-1 for the adjustment and meter location test points. All test points and adjustments are on the Range/Relay Board and Current Limit Board in the power source that has the load applied. Table 4-2 lists the adjustment and respective test points.

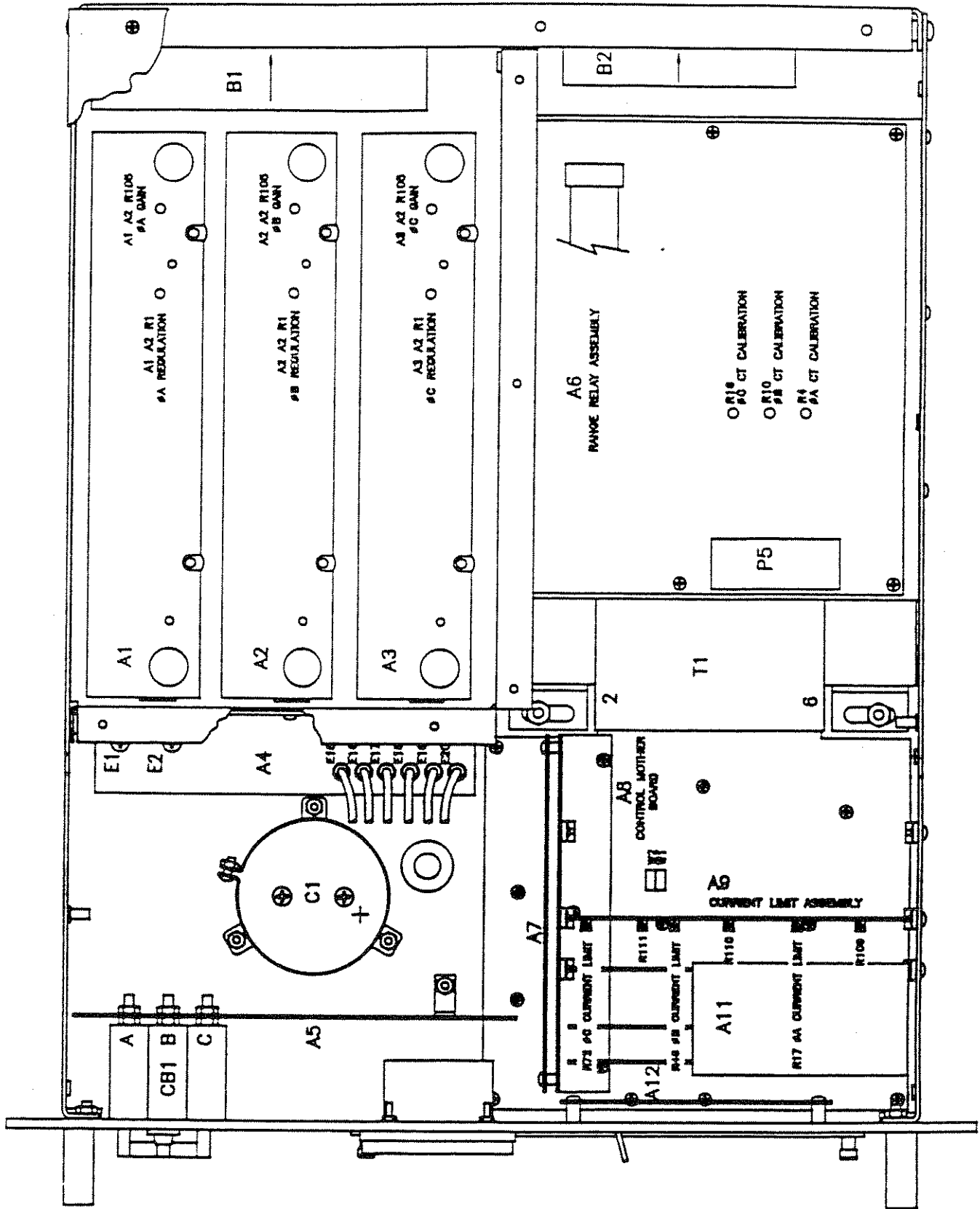


FIGURE 4-1

5. Turn off the input circuit breaker. Reinstall jumper W2 if one was previously removed. Reconnect all connections to the power output terminal block of each 4500L.

LOAD OUTPUT	CONNECT AC DVM TP1 IS GND (on Current Limit Board)	ADJUSTMENT ON RANGE/RELAY BOARD
A	TP10	R4
B	TP2	R10
C	TP3	R16

TABLE 4-2

4.6 LOAD BALANCE ADJUSTMENT

The following adjustment procedure is for all power systems except the 4500L-3M. The power system must be connected as shown in Figure 2-2. A load resistor, see LOAD PER PHASE in Table 4-1, must be connected to the phase A, B or C output of the power system.

For the following adjustments, two external AC Dvms must be used. The DVMS must be connected to test points on the Current Limit Board, A9. The input LO for the DVM is TP1 of the respective Current Limit Board. For all test points and adjustments, refer to Table 4-3 for the respective power system.

1. Set the output to the low voltage range and 80% of the maximum voltage. Set the frequency to 200 Hz and the maximum Current Limit. Apply the LOAD PER PHASE identified in Table 4-1 for the respective power system. Check the voltages listed in Table 4-3. Check that the voltage at the respective test points are within ± 0.1 volts of the reference test point.
2. Set the output to 100% of the range voltage and recheck the Table 4-2 test points. If they differ by more than ± 0.2 volts from the reference, readjust the adjustments at this full load current.

CAUTION

The Load Balance Adjustment should not be made unless an amplifier assembly has been repaired. Each amplifier has been adjusted at the factory for an output regulation of -1.48% with a 1500 watt load.

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: ($\pm 0.1V$)
4500L-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as TP10
	"	"	TP3	R1 AMP C	"
9000L/2-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
9000L/2-3, and 18000/4-3	A	MASTER	TP10	None	Monitor voltage for reference
	"	SLAVES	TP10	R1 AMP A	Same voltage as MASTER TP10
	B	MASTER	TP2	None	Monitor voltage for reference
	"	SLAVES	TP2	R1 AMP B	Same voltage as MASTER TP2
	C	MASTER	TP3	None	Monitor voltage for reference
	"	SLAVES	TP3	R1 AMP C	Same voltage as MASTER TP3

TABLE 4-3

AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: ($\pm 0.1V$)
13500L/3-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE #1	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
	"	SLAVE #2	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
13500L/3-3	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same as MASTER TP10
	"	"	TP3	R1 AMP C	"
	B	SLAVE #1B	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same as SLAVE 1B TP10
	"	"	TP3	R1 AMP C	"
	C	SLAVE #1C	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same as SLAVE 1C TP10
	"	"	TP3	R1 AMP C	"

TABLE 4-3 (continued)
AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: ($\pm 0.1V$)
27000L/6-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE #1	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
	"	SLAVE #2	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
	"	SLAVE #3	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
	"	SLAVE #4	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
"	SLAVE #5	TP10	R1 AMP A	"	
"	"	TP2	R1 AMP B	"	
"	"	TP3	R1 AMP C	"	

TABLE 4-3 (continued)

AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: ($\pm 0.1V$)
27000L/6-3	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE #1A	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
	B	SLAVE #1B	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as SLAVE #1B TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE #2B	TP10	R1 AMP A	"
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
C	SLAVE #1C	TP10	None	Monitor voltage for reference	
	"	"	TP2	R1 AMP B	Same voltage as SLAVE #1C TP10
	"	"	TP3	R1 AMP C	"
	SLAVE #2C	TP10	R1 AMP A	"	
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"

TABLE 4-3 (continued)
AMPLIFIER GAIN BALANCE ADJUSTMENTS

4.7 CURRENT LIMIT ADJUSTMENT

1. Set the front panel Current Limit adjustment to its maximum clockwise position. Set the output voltage AMPLITUDE control to the maximum counterclockwise position.
2. Monitor the ϕA output current with the external current transformer and AC DVM. Connect an oscilloscope to the output.
3. Adjust the output to the low voltage range and the frequency to 60 Hz.
4. Apply the CURRENT LIMIT LOAD value from Table 4-4 to the power system ϕA output only.
5. Increase the output amplitude slowly until the external AC current transformer indicates SET VALUE from Table 4-4. Slowly turn A9-R17 on the Current Limit Assembly in a counterclockwise direction until the output just starts to clip.

Slowly readjust R17 in a clockwise direction just to a point that the clipping disappears. Repeat this step for all ADJUSTMENTS listed in Table 4-5 for ϕA .

6. Remove the load for ϕA and repeat steps 2 through 5 for phase B and C. Adjust the controls specified in Table 45 for phase B and C. Be sure to move the scope to the respective phase.
7. Adjust the front panel Current Limit adjustment to 1/2 value. Verify the output voltage is clipped and the output current is approximately 1/2 of the Set value when any phase has the CURRENT LIMIT LOAD value.

	MODEL	4500L/1-3 1667	9000L/2-3 3333	4500L/1-1 13500L/3-3 5000	9000L/2-1 27000L/6-3 10000	13500L/3-1 15000	27000L/6-1 30000
135/270 RANGE "	VA Per Phase			3	1.5	1	0.5
	LOAD (Ohms)	9	4.5	39.6	79.2	118.9	238
	CURRENT LIMIT:						
	SET VALUE	13.2	24.4	42.5	85	127.5	255
156/312 RANGE "	MAX VALUE	14	28.3	36.8	73.7	110	220
	LOAD (Ohms)	11	5.5	33.6	67.3	100	200
	CURRENT LIMIT:						
	SET VALUE	11.2	22.4	36.8	73.7	110	220
67.5/135 RANGE "	MAX VALUE	11.5	24.5	.7	.3		
	LOAD (Ohms)	1.9	1				
	CURRENT LIMIT:						
	SET VALUE	26.4	52.8	79.3	158.5		
200/400 RANGE	MAX VALUE	28.4	56.7	85.4	170		
	LOAD (ohms)	18	9	6	3	2	1
	CURRENT LIMIT:						
	SET VALUE	9	17.8	26.7	53.5	80	160
	MAX VALUE	9.6	19.1	28.7	57.5	86	180

SETUP VALUES

TABLE 4-4

SYSTEM	PHASE LOADED	ADJUSTMENT	POWER SOURCE
4500L-3	A	R17	MASTER
	B	R46	"
	C	R72	"
4500L-1, 9000L/2-1, 13500L/3-1, 27000L/6-1	A	R17	MASTER & SLAVES
	A	R46	" "
	A	R72	" "
9000L/2-3	A	R17	MASTER & SLAVES
	B	R46	" "
	C	R72	" "
13500L/3-3, 27000L/6-3	A	R17	MASTER
	A	R46	MASTER
	A	R72	MASTER
	B	R17	ALL SLAVES FOR ØB
	B	R46	" "
	B	R72	" "
	C	R17	ALL SLAVES FOR ØC
	C	R46	" "
	C	R72	" "

TABLE 4-5

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

An explanation of the circuits within the AC Power System is given in this section. Refer to Figure 5-1 for a block diagram of the AC Power System.

5.2 OVERALL DESCRIPTION

Input power from the rear panel is routed through the circuit breaker to the Input Power Supply (A5). DC voltages from the Input Power Supply are routed to the Power Mother Board (A4), the Control Mother Board (A8) and the Auxiliary Power Supply (A7).

The oscillator assembly (A11) generates the 3-phase sine wave. In addition it has the frequency control and current limit control limit. The oscillator assembly is connected to the rest of the power source through the Control Mother Board, A10.

The three amplifier modules are A1, A2 and A3. They take their DC supply voltages and input signal from the Power Mother Board, A4. They produce the high power outputs for the primary of the output transformers,, T1, T2 and T3. The outputs are routed through the Power Mother Board to the output transformers.

The Range Relay Board is identified as A6. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The outputs from the AC Power System are taken from the Range Relay Board. This board also has relays that switches the output to the 1-phase mode and opens the outputs. There is also a circuit on the board that senses for incorrect sense line connections.

The board assemblies are described in more detail in the following paragraphs.

5.3 INPUT POWER SUPPLY

This assembly is identified as A5. It generates the high power +300 VDC supply. This supply voltage is connected to the filter capacitor, C1, and to the Power Mother Board. C1 is mounted on the bottom cover of the AC Power System.

The Input Power Supply also has circuits that generate the DC voltages identified as $\pm 18V$, $\pm 15VSW$, $+8VSW$ and $+8V$.

The $\pm 18V$ supplies are used for the Oscillator Module and the Current Limit Board. The $+8V$ supply is used for the oscillator Module. The $\pm 15VSW$ supplies are used for the three Amplifier Modules.

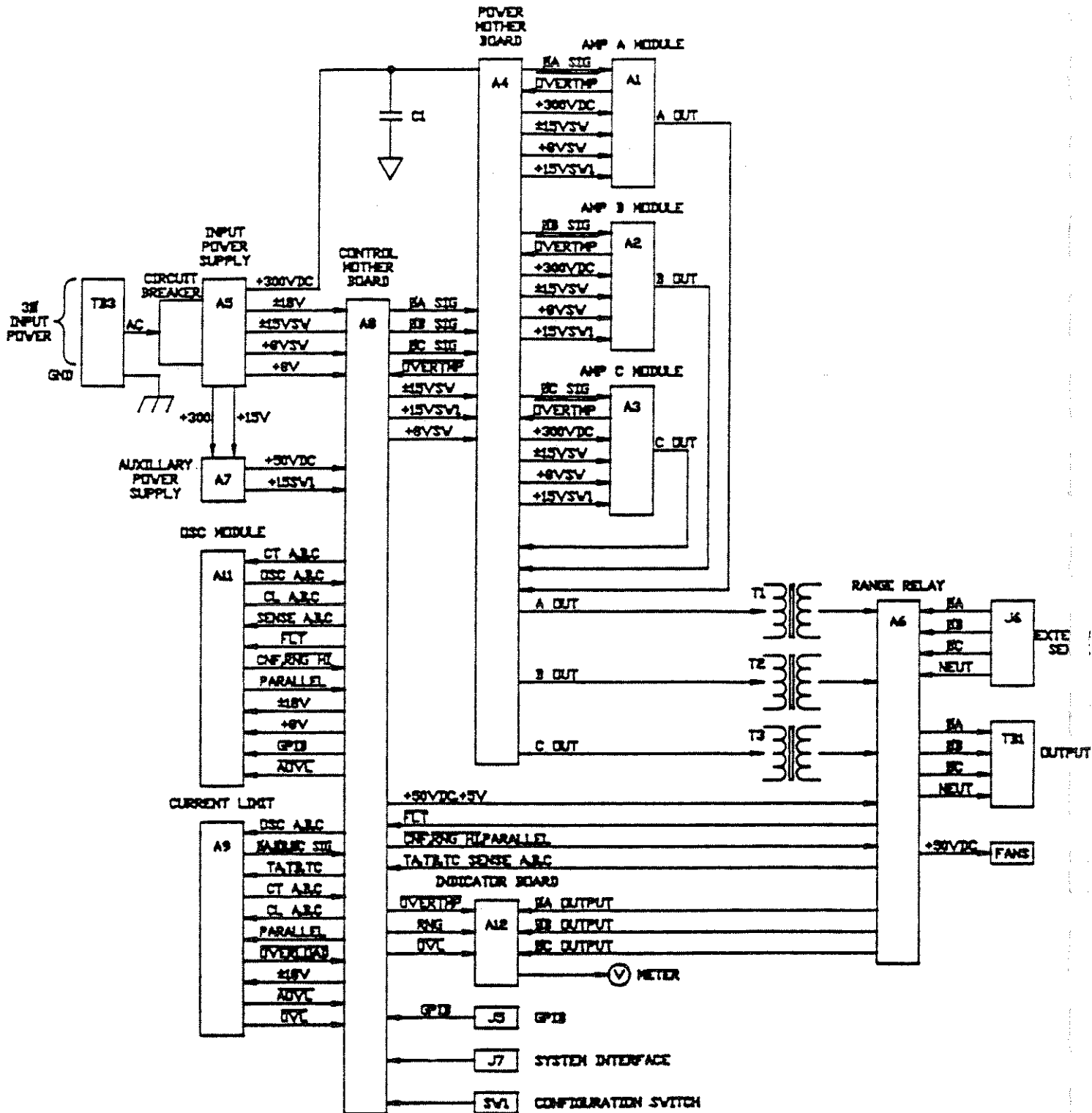


FIGURE 5-1
AC POWER SYSTEM BLOCK DIAGRAM

5.4 AUXILIARY POWER SUPPLY

The Auxiliary Power Supply receives the +300 supply voltage from the Input Power Supply. The +300 supply voltage is then changed to the +50 VDC supply voltage for operating the fans and relays. In addition to the +50 VDC supply, +15VSW1 is also generated. This supply voltage is used for the gate drive signal in the Amplifier Modules.

5.5 CURRENT LIMIT BOARD

The Current Limit Board receives the oscillator signals identified as OSC A, B and C from the Oscillator Module. Analog switches on this board direct the oscillator signals to the respective amplifier module. The analog switches switch the OSC A signal to the three amplifier inputs during 1-phase operation. For 3-phase operation, OSC A, B and C are switched to the amplifiers A, B and C inputs respectively. Gain adjustments are located on this board to match the gains of the 3 Amplifier Modules.

The current limit circuits are also located on the Current Limit Board. These circuits receive a DC signal from the Oscillator Module, CLA, B and C, that is proportional to the current limit value. This DC signal is compared to the output current. The output current signal is identified as TA, TB and TC. This signal is routed to the Current Limit Board from current transformers on the Range Relay Board. If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power System to operate at a constant current. If the output current limits the output voltage to 10% of the programmed voltage amplitude value, the output will default and an AMP FAULT error message will be displayed. The error message will also be reported through the IEEE-488 (GPIB) interface.

5.6 INDICATOR BOARD

The Indicator Board has the reference designator, A12. This board has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

A front panel selector switch is mounted on the Indicator Board. This switch is used to connect the front panel analog meter, M1, to either the phase A, B or C output.

5.7 RANGE RELAY BOARD

The Range Relay Board has all of the AC Power System relays. These Relays are operated from +50 VDC. The output relay is opened by a logic low on the CNF control line. The range relay is switched to the high voltage range by a logic low on the RNG HI control line.

The output is in the 1-phase mode when the PARALLEL control line is driven to approximately +10 VDC.

There are three current transformers on the Range Relay board. These transformers generate an AC voltage that is proportional to the output current. The voltages are identified as TA, TB and TC. A 10 amp load current is represented by a 1.00 VAC signal in the 3-phase mode.

5.8 AMPLIFIER MODULES

The AC Power System has three Amplifier Modules. In the 3-phase mode, one amplifier is used for each of the three outputs. In the 1-phase mode, the three outputs are paralleled at the secondaries of the output transformers.

The Amplifier Modules operate in a switch mode to obtain high efficiency. These switch mode amplifiers operate at 200 KHz.

Each Amplifier Module obtains its input signal from the Current Limit Board. These three input signals are identified as OA SIG, OB SIG and OC SIG. A 5.000 Vrms input signal will generate a full scale output voltage at the output of the AC Power System and 100 Vrms on the primary of the output transformer.

Each Amplifier Module requires +300 DC, ±15 VSW and the +15 VSWI supplies. The +300 VDC supply comes from the Input Power Supply through a 15 amp fuse on the Power Mother Board.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100°C, a control signal is sent to the Oscillator Module. A logic low on the OVERTEMP control line will cause the error message TEMP FAULT to be generated.

5.9 OSCILLATOR/CONTROLLER MODULE

The Oscillator Module is identified with the reference designator, All. The module consists of two printed circuit assemblies. A block diagram for the power controller is given in Figure 5-2. A power controller generates the oscillator waveforms for each of the three phases, sets the frequency, amplitude and current limit level, and senses the output voltage to control amplitude.

The controller module is made of two printed circuit assemblies that are interconnected by a ribbon cable. The Control Board attaches to the front panel.

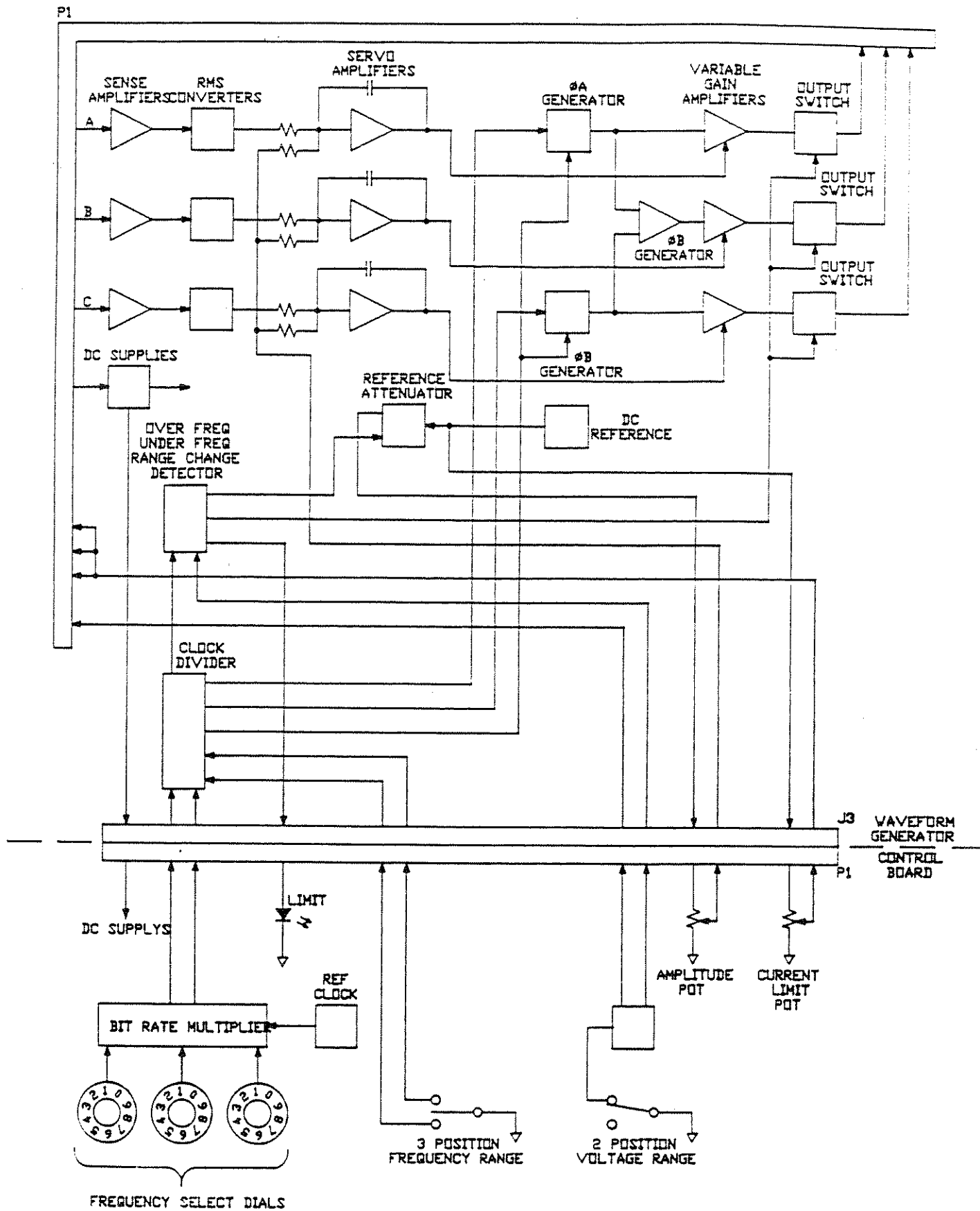


FIGURE 5-2
 OSCILLATOR / POWER MODULE

5.9.1 Control Board

The Control Board is mounted to a small panel. This small panel is mounted on the front panel of the power source. The small panel holds the Frequency Select dials and Frequency Range switch, the Voltage Amplitude potentiometer, the Voltage Range switch and the programmable Current Limit potentiometer.

A block diagram of the Control Board is shown in the lower portion of Figure 5-2. A fixed frequency reference clock drives the bit rate multiplier to control the output frequency of the power source.

The three-position Frequency Range switch signals the Waveform Board to divide the bit rate multiplier output frequency by 1, 10 or 100 depending on the desired frequency range.

The Voltage Range switch directly controls the voltage range relays and also sends a short pulse to the Waveform Board to signal that the voltage range has changed. The Waveform Generator Board uses this pulse to shut off the output voltage while the range relays change state. This is to minimize relay contact wear.

5.9.2 Waveform Generator Board

A block diagram of the Waveform Generator Board is shown in the upper portion of Figure 5-2.

The clock divider divides the bit rate multiplier frequency by 1, 10 or 100 depending on frequency range switch setting. Outputs of the clock divider drive the ϕA and ϕC sine wave generators. The outputs from the ϕA and ϕC generators are summed to form the ϕB oscillator output.

The Over Frequency/Under Frequency/Range detector monitors the clock output and switches off the oscillator output if the frequency is outside the specified range of the unit. The detector also momentarily activates the switches when the voltage range switch position is changed.

The output of each phase of the power system is applied to a differential sense amplifier, converted to an rms-DC equivalent voltage and compared to a DC reference by a servo amplifier. The servo amplifier drives a variable gain amplifier that modulates the oscillator signal. This closed loop system maintains each output at a constant rms voltage.

5.10 AX OPTION (Auxiliary outputs)

The AX option provides two additional outputs to the master 4500L: 26-volt, 3-amp Phase D output, and a 5-volt, 5-amp Phase E output. The option consists of two P.C. boards as well as a cable.

The 26-volt output is generated from a switching amplifier similar to the A, B and C amplifier. see paragraph 5.8.

An oscillator, for the 26 volt output, is contained in the AX option. This oscillator receives a Clock signal from the Oscillator/Controller Module. This clock signal controls the output frequency of the AX option. A Lock signal from the Oscillator/Controller Module locks the output phase of the AX option to the phase A output of the power system.

A External Sense circuit in the module regulates the 26 volt output to precise 26 volts at the External Sense input.

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.



JUMPER ON OSC BOARD HAS TO BE ON W1 & W3 FOR 3PHASE

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power System does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

TABLE 6-1

PARAGRAPH	PROBLEM	PAGE
6.2	Excessive Output Voltage	46
6.3	Poor Output Voltage Regulation	46
6.4	Overtemperature Lamp On	47
6.5	Overload Lamp On	47
6.6	Distorted Output	48
6.7	No Output	48

6.2 EXCESSIVE OUTPUT VOLTAGE

If the power system has an output voltage more than 3% above the output voltage range, the following item may be at fault:

1. The External Sense Input is not connected.

SOLUTION: Connect the External Sense input to the Master Power Source, the one with the oscillator/controller module.

6.3 POOR OUTPUT VOLTAGE REGULATION

If the AC Power System exhibits poor voltage regulation the following item may be at fault:

1. The External Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation check.

SOLUTION: Connect AC voltmeter to External Sense lines.

2. The External Sense Lines are not connected.

SOLUTION: Connect the External Sense lines to the master power source.

6.4 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following may be at fault:

1. Ambient temperature is too high.

SOLUTION: Operate power source between 0 and 35 degrees C.

2. Fan or ventilation holes are blocked.

SOLUTION: Remove obstructions.

3. Fan not working.

SOLUTION: Replace fan. Consult factory.

6.5 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the output load current has exceeded the set current limit value. With multichassis power systems, the OVERLOAD lamp will illuminate if one of the 4500Ls in the system has the circuit breaker off. If the AC Power System OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

SOLUTION: Remove the overload.

2. The set current limit level is set too low for the load being driven.

SOLUTION: Set the front panel Current Limit adjustment to the maximum clockwise position.

3. The set current limit is incorrectly calibrated.

SOLUTION: Perform the calibration in paragraph 4.4.5.

4. One or more 4500Ls powered-down in power system.

SOLUTION: Turn on circuit breaker.

6.6 DISTORTED OUTPUT

The AC Power System output may have a distorted sine wave from the following causes:

1. The power source output is overloaded.

SOLUTION: Remove the overload or set the current limit to a higher value. Observe power source capabilities. See Section 1.

2. The crest factor of the load current exceeds 2.5. With this condition the distortion will be much higher at frequencies above 100 Hz.

SOLUTION: Reduce the load or set the current limit to a higher value.

6.7 NO OUTPUT

If the AC Power System has no output at the rear panel terminal block, TB2, the following items may be at fault:

1. Wrong frequency set. Indicated by front panel LIMIT indicator illuminated.

SOLUTION: Set frequency to value between 45 Hz and 2 KHz.

2. REMOTE SHUTDOWN logic line at J7 pin 36 shorted to D COM or A COM.

SOLUTION: Remove connection to J7, pin 36.

3. There is no input to the power amplifiers from the oscillator. Check the oscillator signals at the system interface connector:

7-24	Oscillator Phase A
J7-6	Oscillator Phase B
7-23	Oscillator Phase C
J7-7	Oscillator common/return

Set the front panel AMPLITUDE control to the maximum clockwise position on the 135 volt or 156 volt range. The three signals should be 5.75 ± 0.5 VAC when there is no output from the respective phase.

SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6.8.

SOLUTION: If the signal at the System Interface connector is greater than 5.0 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6.10.

4. One of the internal fuses, F1, F2 or F3 has failed.

SOLUTION: Replace the fuse. Remove the input power and discharge capacitor C1 before replacing the fuse. Refer to paragraph 6.10.

6.8 MODULE REMOVAL

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Modules, A1, A2 and A3, with the insulator removed.

6.9 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the oscillator Module (assembly 4007-407) follow the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker.
2. Remove the power system's top cover.
3. Remove the front panel Control assembly by loosening the two captive screws on its front panel.
4. Unplug the ribbon cable from the assembly.
5. Remove the Oscillator Module, A11, by pulling up the Waveform Board with the finger holes provided at the end of the board.
6. The module is now removed. To replace the module follow these steps in reverse order.

6.10 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that indicates the failure of an amplifier module (assembly 4009-416), check the condition of the +300 VDC fuses before replacing the amplifier. Refer to Figure 6-1 for the location of the fuses. Fuse F1 is for phase A, F2 for phase B and F3 is for phase C.

CAUTION

Capacitor C1 may have up to +350 VDC after the input circuit breaker has been turned off. Before inspecting fuses F1, F2 and F3, discharge C1. C1 may be discharged through a 5 ohm power resistor.

If it is determined that an amplifier module must be replaced perform the following procedure:

1. Turn off the input circuit breaker.
2. Remove the AC Power System top cover.
3. Remove the four #6 screws that hold the insulator that covers the amplifier module, A1, A2 and A3.
4. Remove any of the three amplifiers by sliding it up and over the guide posts.
5. The amplifier may be replaced by following this procedure in reverse order.
6. Check the amplifiers associated 10 amp fuse and replace it if necessary. Refer to Figure 6-1 for the location of the fuse. F1, F2 and F3 are for the phase A, B and C amplifiers respectively.
7. After an amplifier has been replaced, readjust its gain and the 1-phase adjustment. Refer to Section 4.

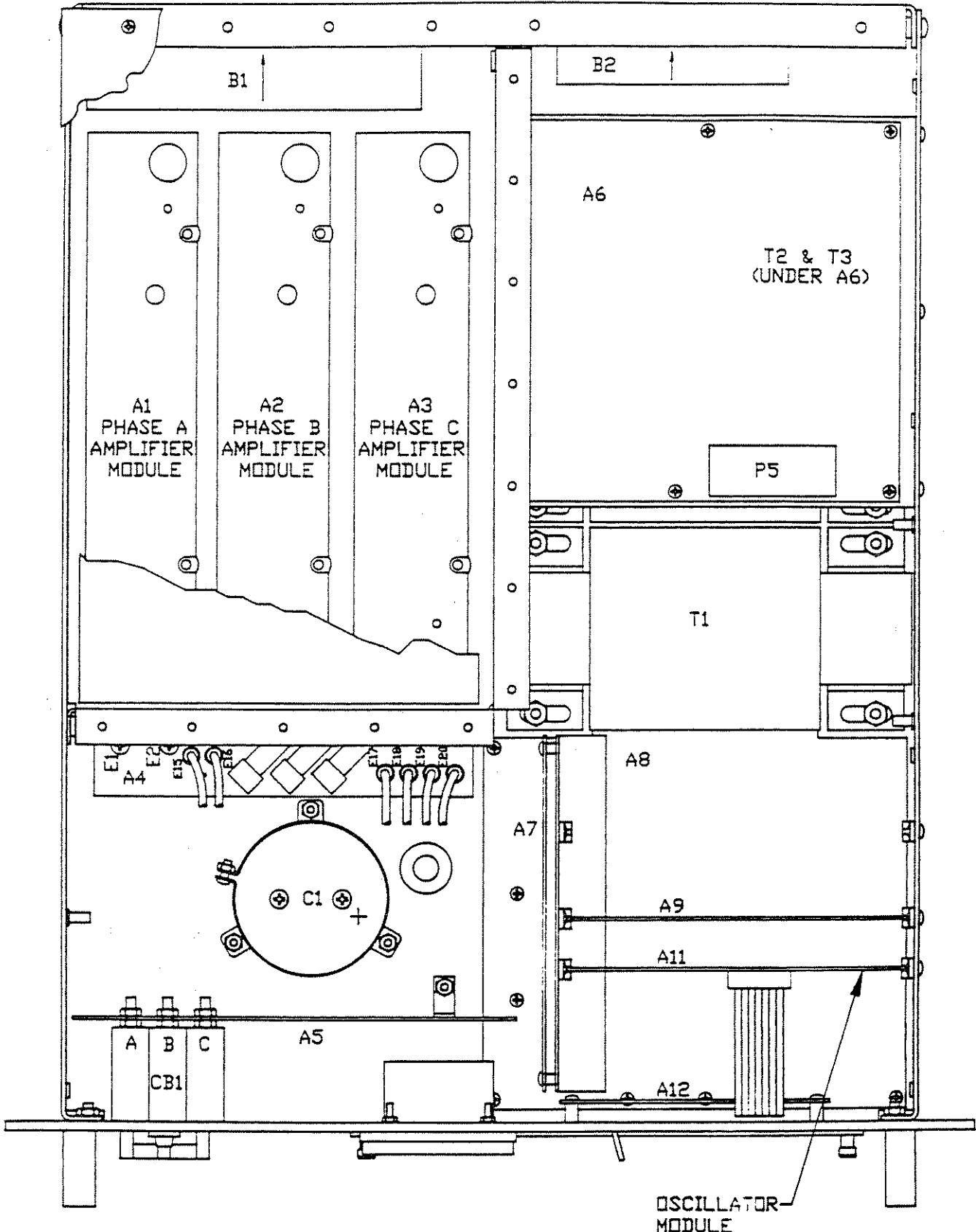


FIGURE 6-1
MODULE LOCATION

SECTION 7

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and a complete list of replaceable parts. The parts are listed by their major assembly in alpha-numeric order by their reference designators. The list includes the parts description, manufacturers' identification (see Appendix A for list of manufacturers), and California Instruments' part numbers.

7.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable, for each replacement part ordered.

- a. Model number and serial number of the instrument.
- b. California Instruments part number for the subassembly where component is located (PARENT ITEM NO.).
- c. Component reference designator (SEQ NO.).
- d. Component description (DESCRIPTION TRUNCATED).
- e. Component manufacturer's FSCM number (VENDOR).
- f. California Instruments part number (COMPONENT ITEM NO.).

All replacement part orders should be addressed to:

California Instruments
Attention: Parts Department
9025 Balboa Avenue
San Diego, California 92123-1509

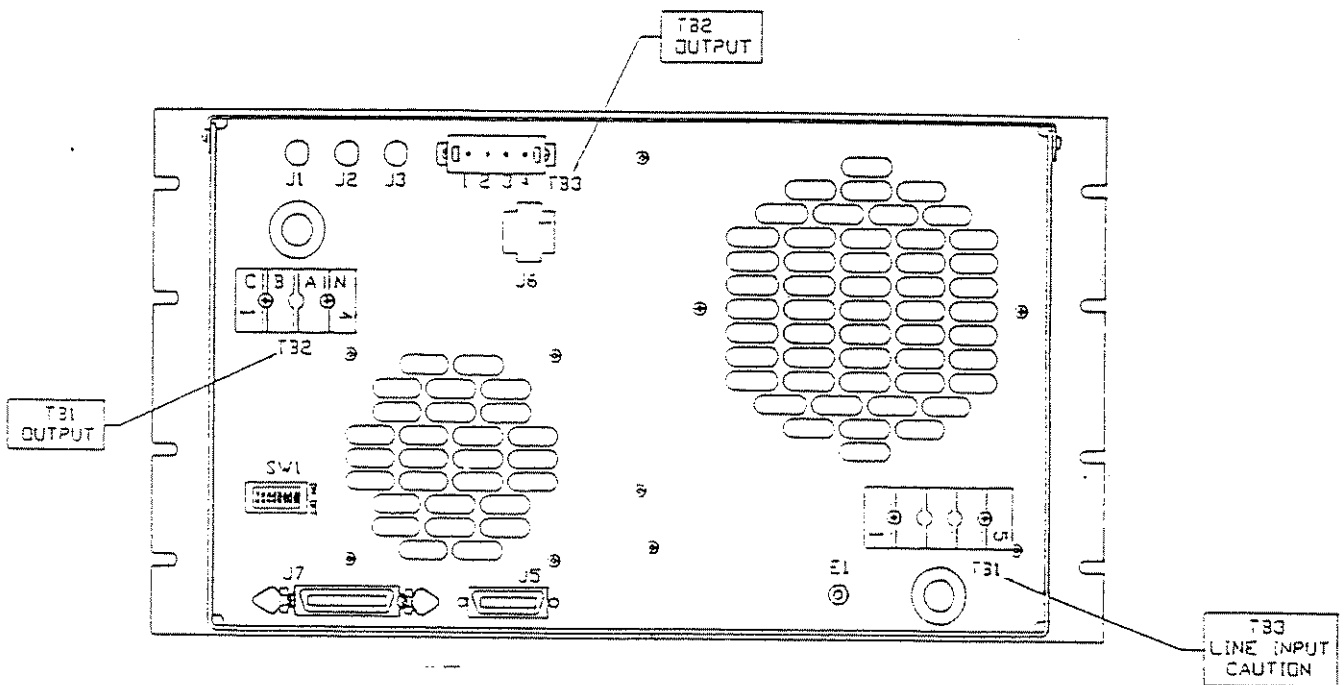
TOP ASSEMBLY REPLACEABLE PARTS
 FOR 4500L-3M
 TOP ASSEMBLY NO: 4009-422-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4009-423-1	HEATSING ASSY, SW AMP	16067	1.0
A2	4009-423-1	HEATSINK ASSY, SW AMP	16067	1.0
A3	4009-423-1	HEATSINK ASSY, SW AMP	16067	1.0
A4	4009-724-1	PC ASSY, MOTHER	16067	1.0
A5	4009-706-1	PC ASSY, POWER SUPPLY	16067	1.0
A6	4009-733-1	PC ASSY, RANGE	16067	1.0
A7	4009-735-1	PC ASSY, AUX POWER SUPPLY	16067	1.0
A8	4009-732-1	PC ASSY, MOTHER, CTRL	16067	1.0
A9	4009-728-1	PC ASSY, CURRENT LIMIT	16067	1.0
A11	4007-407-1	MODULE ASSY, OSC	16067	1.0
A12	4009-707-1	PC ASSY, INDICATOR	16067	1.0
B1	241178	FAN, 6", 48VDC, .45A	63227	1.0
B2	241175	FAN, 4", 48VDC,	60399	1.0
C1	611295	CAP, AL, 3900 μ F, 400V	80031	1.0
F1	270167	FUSE, 15A, 250V	71400	1.0
F2	270167	FUSE, 15A, 250V	71400	1.0
F3	270167	FUSE, 15A, 250V	71400	1.0

ERRATA

4500L-M

The silkscreen on the rear panel has been revised. TB1 is now the output, TB3 is the input line and TB2 is the optional Phase D and E output. All references in the 4500L-M manual should be revised to agree. Refer to Figure 2-1 of the 4500L-M Instruction Manual.



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Appendix A

Number	Vendor Name	City	State				
0000A	Electronics	Westfield	MA	27556	IMB Electronic Products	Santa Fe Springs	CA
1000C	Johnson, Sigs.	Woburn	MA	27735	Vero, Inc.	St. Tarland	TX
2000E(28544)	OPCOA (Petac Elec. Corp.)	Waukegan	IL	27832	Ph-Dyne Electronics	Bridgesport	CT
3000W	Wilton Ross Co.	Waukegan	IL	28480	Romberg Aircraft	Newport Beach	CA
0000E(12749)	Time	Waukegan	IL	28520	Herbert Aircraft Co.	Palmdale	CA
002AC	Time	Waukegan	IL	28608	Navstar Mfg. Company (Hayco)	Enfield	NJ
200AD(55112)	Pleesey (Westlake Cap. Inc.)	Los Angeles	CA	19373	Schiff Ltd.	Reading Ont.	Canada
000AC	Time	Los Angeles	CA	19373	Reardon Inc. Tridair Ind.	Torrance	CA
000AM(54383)	Jan Crystal	Los Angeles	CA	30161	Buick Eng. Inc.	St. Louis	MO
000AL(53495)	Data Components, Inc.	Los Angeles	CA	30887	International Components Corp.	Abury Park	NJ
000AM	Kraus & Hauser	Los Angeles	CA	30983	Avco Engineering, Inc.	Laconia	NH
000AN	Alta Instrument Transformer	Los Angeles	CA		Corban Company	Sylmar	CA
000AB	Unites (Incorporated)	Los Angeles	CA		Electra/Midland (Hepco)	San Diego	CA
000AT(42643)	United Chem-Con	Los Angeles	CA	31827	Electra		
000AD	JMI Technical Prod. Inc.	Los Angeles	CA	31893	Budwig Mfg. Co.	Rancho	CA
000AV(61837)	Semi Processes, Inc.	Los Angeles	CA	32293	Trillidge, Inc.	Pittsburg	PA
000AN	Micro	Los Angeles	CA	32359	Interell	Cupertino	CA
000AZ(43281)	Antronics	Los Angeles	CA	32397	River, Inc.	San Jose	CA
000AT	Silicon Power Cube Corp.	Los Angeles	CA	32605	Bowens Inc. (Trompet Div)	Riverside	CA
000AZ(61271)	Pulsitex	Los Angeles	CA	33135	Jewell Electronics Int'l. Inc.	Manchester	NH
000BA(61944)	Omron Electronics, Inc.	Los Angeles	CA	33716	Loew Electronics, Inc.	Los Angeles	CA
000BA	Hollman Metals, Inc.	Los Angeles	CA	33859	Kingbacher Murray Co.	Los Angeles	CA
000BC	Toraida America, Inc.	Los Angeles	CA	33903	Quocum, Inc.	Los Angeles	CA
000BD(55982)	Electronic Essentials	Los Angeles	CA	34238	Colgate Corp.	Los Angeles	CA
000BE(55285)	Kel-Lam	Los Angeles	CA	34238	Loew Resistor Co.	Los Angeles	CA
000BF(55285)	Securus	Los Angeles	CA	34333	Silicon General	Menlo Park	CA
000BG	Panasonic	Los Angeles	CA	34333	Intel Corporation	Santa Clara	CA
000BH	Canary Components	Los Angeles	CA	34333	Avco Canada Ltd.	Ambert NS	Canada
000BI(54186)	Micro Power Systems	Los Angeles	CA	34333	Linear Technology, Inc.	Burlington, Ont.	Canada
000BJ(04779)	Robinson	Los Angeles	CA	34333	Omni Manufacturing Co.	Shelby	IL
000BK(12150)	Beau Products (Vernicon)	Los Angeles	CA	34333	Parsons-Klein	Orion	PA
000BL(91723)	Corbindler (Gerrard AJ & Co.)	Los Angeles	CA	34333	Penn. Eng. and Mfg. Corp.	Dryden	PA
000BD	Kuspomats Electronic Amer.	Los Angeles	CA	34333	Midwest Components, Inc.	Muskegon	MI
000BP	Silicon Power Cube	Los Angeles	CA	34333	Monsanto, Electronic Special	Cupertino	CA
000BR	Secma	Los Angeles	CA	34333	Products		
000BS	Panel Components Corp.	Los Angeles	CA	50558	Electronic Concepts, Inc.	Saratoga	NJ
00544	Micro-Cal Div., Avery Prod.	Los Angeles	CA	50611	Houser Corp.	San Jose	CA
00779	AMP Inc.	Los Angeles	CA	51167	Acres Electronics, Inc.	Frenchtown	NJ
00853	Sangamo Electronic Co.	Los Angeles	CA	51506	Accurate Screw Machine Co.	Hullay	NJ
00866	Gen. Eng. Co., Inc.	Los Angeles	CA	51703	ICD/Avly	Palo Alto	CA
01082	Gen. Co., Inc. & Mfr. Cap. Dept.	Los Angeles	CA	52073	Circuit Assembly Corp.	Los Angeles	CA
01121	Allen-Bradley Co.	Los Angeles	CA	52745	Time	Buffalo	NY
01139	T.E.S. Co., Silicone Prod.	Los Angeles	CA	53076	Xinks, Inc.	Buffalo	NY
01295	Texas Instruments	Los Angeles	CA	53491	Data Components, Inc.	Eden	CA
01941	Pulse Electronics, Inc.	Los Angeles	CA	54361	Edwards Sheet Metal Works	Greenfield	MA
02111	Spectrol Electronics	Los Angeles	CA	54407	Power-One Co.	Cambridge	MA
02113	Colcraft, Inc.	Los Angeles	CA	55222	Santex, Inc.	New Albany	NY
02235	Fairchild Controls Corp.	Los Angeles	CA	55288	MAP Electronic Hardware, Inc.	Seymour	CT
02236	American Insulation Mach. Co.	Los Angeles	CA	56289	Sprague Electric Company	North Adams	MA
02240	Ampanel Corporation	Los Angeles	CA	56637	ACD Components, Inc.	Manchester	NH
02248	Illinois Tool Works, Inc.	Los Angeles	CA	57440	United Chem-Con Corp.	Philadelphia	PA
02299	USA Code (7211)	Los Angeles	CA	57854	Kel-Ab, Inc.	Eden	MA
03507	General Electric Company	Los Angeles	CA	58474	Superior Electric Company	St. Louis	MO
03508	General Electric Company	Los Angeles	CA	58730	Thomas and Betz Company	Clinton	NJ
03797	Sidema Corporation	Los Angeles	CA	59993	International Rectifier	El Segundo	CA
03811	Pyrex Resistor Co., Inc.	Los Angeles	CA	60395	Semiconductor Div.		
04009	Clairco Corporation	Los Angeles	CA	61394	Xico, Inc.	Hiditas	CA
04099	Arrow-Hart and Reseman Elec.	Los Angeles	CA	61441	See-See-Way, Inc.	San Jose	CA
04713	Motorola Semiconductor Prod.	Los Angeles	CA	61929	Sarona	Palo Alto	CA
04729	Universal Components Corp.	Los Angeles	CA	61929	Aeromat Corp.	Mountainside	NJ
04963	J-M	Los Angeles	CA	62483	Pulse Engineering, Inc.	College Park	MD
05245	Formosa Electronics, Inc.	Los Angeles	CA	62643	Densicon Corp. America	Torrance	CA
05276	Edison Union Garde Corp.	Los Angeles	CA	62786	United Chemical, Inc.	Rosemont	IL
05397	Lyn-Tron, Inc.	Los Angeles	CA	63704	Mitsumi America Ltd.	San Jose	CA
05791	Wesfield Engineering, Inc.	Los Angeles	CA	63791	Star Electronic, Inc.	St. Vernon	NY
05820	Leidco Corp.	Los Angeles	CA	70318	Allmetal Screw Prod. Co.	Garden City	NY
05972	Pandrol Corp.	Los Angeles	CA	70903	Bud Manufacturing Co.	Chicago	IL
06314	Stanton, Myco Metal Prod.	Los Angeles	CA	71212	Sid Industries, Inc.	Wilmington	OH
06340	Amcon Elect. Hardware	Los Angeles	CA	71279	Camelot Theatrical Corp.	Chicago	IL
06465	Precision Homolithics Inc.	Los Angeles	CA	71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
06476	Howell Motors, Inc.	Los Angeles	CA	71450	CTS Corporation	Elkhart	IN
06915	Richco Plastics, Co.	Los Angeles	CA	71468	ITE Corporation	Chicago	IL
07088	Kelvin Electric Company	Los Angeles	CA	71590	Central Div. Globe-Union	Alhambra	CA
07263	Fairchild Camera & Instr.	Los Angeles	CA	71707	Coro-Coil	Providence	RI
07387	Richco Plastics, Co.	Los Angeles	CA	71707	Chicago Miniature Lampworks	Chicago	IL
07556	Unistrac Calore Plastics	Los Angeles	CA	71789	Cinch Manufacturing Company	Midland	NE
07632	Epoxy Prod. Co., Allied Prod. Corp.	Los Angeles	CA	71984	Dow Corning Corp.	Midland	TX
07707	USH Corp. (USH Fastener Div)	Los Angeles	CA	72130	Kimono (Electro Motive)	Williamsville	NY
07716	IRC Incorporated	Los Angeles	CA	72483	Silight Corporation	Bronxville	NY
08028	Lockite (Auto & Consumer Grp)	Los Angeles	CA	72592	General Instruments	Brooklyn	NY
08057	Spane Ind. (Monette Div)	Los Angeles	CA	73130	Eric Technological Prod. Inc.	Brooklyn	NY
08065	Accurate Rubber and Plastics	Los Angeles	CA	73612	Bechtel Instruments, Inc.	Fullerton	CA
08261	Spectra Strip (Ampanel)	Los Angeles	CA	73734	Camelot Theatrical Corp.	Chicago	IL
08289	Blair Delbert Co.	Los Angeles	CA	74193	Federal Screw Products, Inc.	Chicago	IL
08353	Raychem Co. of Canada	Los Angeles	CA	74245	Wolman Electric Company	Troy	NJ
08738	Oxley & Barton (Vaseline Prod. Div.)	Los Angeles	CA	74840	Harvey Hubbell, Inc.	Bridgesport	CT
08779	Signal Transformer	Los Angeles	CA	74870	Illinois Compressor Co.	Waukegan	IL
09214	SE (Semiconductor Prod. Div.)	Los Angeles	CA	75042	S.P. Johnson Company	Philadelphia	PA
09352	C & S Components	Los Angeles	CA	75149	TW Electronic Components	Philadelphia	PA
09922	Burnby Corp.	Los Angeles	CA	75282	Julka Electric Corporation	St. Vernon	NY
10389	Chicago Switch	Los Angeles	CA	75915	Little Rock Co.	Little Rock	AR
11815	Cherry/Metrom (Fastener Div)	Los Angeles	CA	76293	Littlefuse, Inc.	Des Plaines	IL
12406	Elpas Electronics	Los Angeles	CA	76293	Minor Rubber Co., Inc.	Blomfield	NJ
12497	Clerostat Mfg.	Los Angeles	CA	77042	Parot Eng. Equipment Co.	Elizabeth	NJ
13103	Thermalloy Company	Los Angeles	CA	77130	United-Carr Inc., Fastener Div	Katebury	NY
13130	Versatlon Corp (Beav Prod.)	Los Angeles	CA	77142	Potter and Blumfield Div. AMP	E. Princeton	IN
13404	Sherby Corp. Elec. Systems	Los Angeles	CA	78189	Sheneprod Div. IL Tool Works	Chicago	IL
13919	Burr-Brown	Los Angeles	CA	78553	Yinnon Products, Inc.	Chicago	IL
14099	Semtech Corporation	Los Angeles	CA	78730	Johnsonville Products Corp	Chicago	IL
14650	Elwood Sensors Inc.	Los Angeles	CA	79136	Valdes Kohlinier Inc.	Long Island City	NY
14655	Comwell-Obviller Elect. Corp.	Los Angeles	CA	79983	Lierlich Mfg. Corp.	New Rochelle	NY
14726	Hollingsworth Co.	Los Angeles	CA	80031	Hespero/Electro	Northtown	NJ
14752	Electro Cube, Inc.	Los Angeles	CA	80223	United Transformer Co.	New York	NY
14908	Electronic Instrument and Specialty Corp.	Los Angeles	CA	80294	Somers, Inc.	Riverside	CA
15338	ITT Semiconductors	Los Angeles	CA	80495	High Voltage Engineering Corp	Stratford	CA
15454	Amerex Ent (Hodan Div)	Los Angeles	CA	81099	(Anderson Per Prod. Div)		
15436	Electrol	Los Angeles	CA	81121	Triad Transformers Corp.	Venice	CA
15801	Fenwell Electronics	Los Angeles	CA	81348	Winchester Electronics	Oakville	CT
15818	Amplex Telephone, Inc.	Los Angeles	CA	81349	(Prod. Inerts) Promulgated by General Services Administration Washington DC		
15912	Analey	Los Angeles	CA		Military Specification of Commercial		
16087	California Instruments Co.	Los Angeles	CA	81541	Generic Number		
16356	Delcon Radio Div., Gen. Mfg.	Los Angeles	CA	81603	Alpac Corp	Cambridge	MD
16358	Demalson	Los Angeles	CA	81891	Reed Products Co.	Chicago	IL
17856	Siliconix, Inc.	Los Angeles	CA	82389	Bentley-Harris Mfg Co.	Louisville	PA
18078	Umeco	Los Angeles	CA	82877	Steward Grippy	Aurora	IL
18178	Vadeco, Inc.	Los Angeles	CA	82893	Swisscraft, Inc.	Chicago	IL
18318	Comard Electronics Corp.	Los Angeles	CA	82893	Aertron Mfg. Co., Inc.	Woodstock	NY
18324	Synetex	Los Angeles	CA	82893	Vector Electronics, Inc.	Sylmar	CA
18612	Visney Instruments, Inc.	Los Angeles	CA	82893	Verdon M. Smith, Inc.	Bronxville	NY
18677	Scamm Mfg. Co. (Iate Corp.)	Los Angeles	CA	82893	Elec Tool & Screw Corp.	Alhambra	CA
18722	NCA	Los Angeles	CA	82893	Brady W.N. Co.	Alhambra	CA
18736	Volttronics Corp.	Los Angeles	CA	82893	RCA	Harrison	NJ
19080	Robison Company	Los Angeles	CA	82893	Sevenson Mfg. Co., Inc.	Glendale	CA
19604	Buckeye Stamping Company	Los Angeles	CA	82893	Harwood Industries	Arroyo	CA
21845	Soliton Devices (Semi-conductor Group)	Los Angeles	CA	82893	Usen Div., Litton Ind.	Van Nuys	CA
22589	Elastic Stop Nut Corp.	Los Angeles	CA	91002	Nalloy Capacitor Co.	Indianapolis	IN
23050	San C Components Corp.	Los Angeles	CA	91002	Anat, Inc.	Allentown	PA
23936	Pamcor, Inc.	Los Angeles	CA	91002	Dale Electronics, Inc.	Columbus	MS
24011	ECC	Los Angeles	CA	91002	Zico Corporation	Willow Grove	PA
24355	Analog Devices, Inc.	Los Angeles	CA	91002	Industrial Devices, Inc.	Edgewater	NJ
24444	General Semiconductor Inc.	Los Angeles	CA	91002	Keystone Electronics Corp.	New York	NY
24796	Specialty Connector Co., Inc.	Los Angeles	CA	91002	National Tel-Tronics	Washington	DC
24972	ADG-Telefunken Corp.	Los Angeles	CA	91002	Alpha Wire Corp.	Lester	PA
25403	Amperex Electronic Corp.	Los Angeles	CA	91002	Pentagon Products Co.	Lester	PA
25487	Reier Mfg.	Los Angeles	CA	91002	Southco, Inc.	Chicago	IL
26405	Marathon Electric Mfg. Corp.	Los Angeles	CA	91002	Alco Electric Prod., Inc.	Chicago	IL
26806	Amtron Int'l., Inc.	Los Angeles	CA	91002	Netmode Manufacturing Corp.	Abingdon	VA
27014	National Semi-Conductor Corp.	Los Angeles	CA	91002	Arnold Engineering Co.	Abingdon	VA
27191	Cutler-Hammer, Inc.	Los Angeles	CA	91002	Westcoast Company, Inc.	Chicago	IL
27354	Melex	Los Angeles	CA	91002	Military Std		
27355	B & B Motor & Control Corp.	Los Angeles	CA	91002	Electronic Engineering Co.	Santa Ana	CA
				99217	Rubber Tech., Inc.	Costa Mesa	CA
				99462	Sealcraft Corp.	Costa Mesa	CA
				99743	Ize Mfg. Co. (West)	Burbank	CA
				99808	LEK	Burbank	CA
					Protective Closure Co., Inc. (Capless Div)	Buffalo	NY
				99217	Seil Industries, Inc.	Delavan	WI
				99462	Ferracell	New Brunswick	NJ
				99743	IMC	Hayward	CA
				99808	Delevan Electronics Corp.	Aurora	IL

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

