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California INSTRUMENTS

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INSTRUCTION MANUAL
MODEL 4503L

Invertron®

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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 4503L-4132. The 4503L-4132 will hereafter be referred to as the AC Power System.

1-2 GENERAL DESCRIPTION

1-3 This instrument is a high efficiency power source that provides a low distortion sine wave output with either a single or three-phase configuration. The AC Power System can supply up to 4500VA in the single-phase mode or 1500VA per phase in the three-phase mode. Full power is available from either a 0 to 135 volt range or 0 to 270 volt range. Full power is available from 45 Hz to 550 Hz. The AC Power System is illustrated in Figure 1-1.

1-4 ACCESSORY EQUIPMENT/RACK SLIDES

1-5 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

1-6 SPECIFICATIONS

1-7 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.

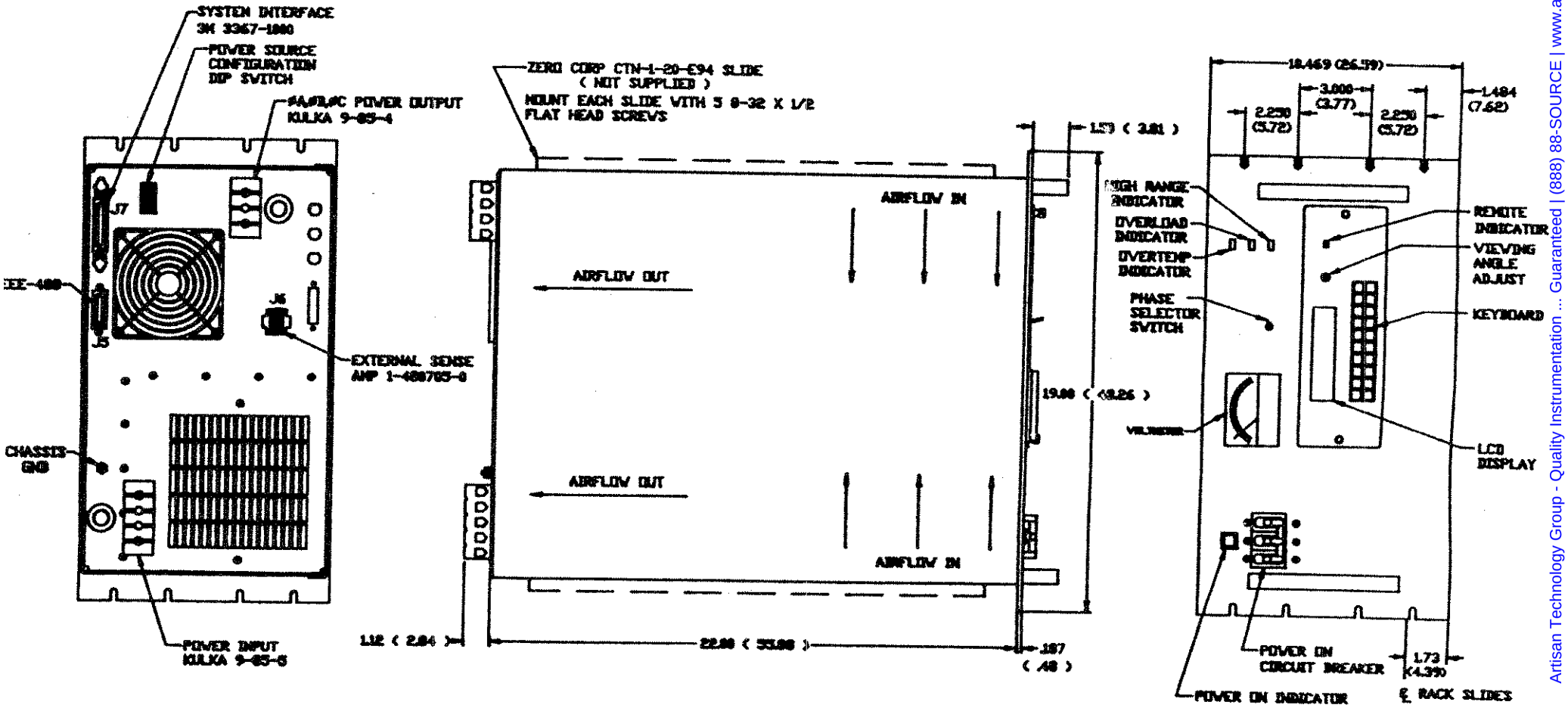


FIGURE 1-1
CALIFORNIA INSTRUMENTS 4503L

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TABLE 1-1

SPECIFICATIONS

(using remote sense inputs, 25 ±1 degree C, constant line and load conditions unless specified otherwise.)

OUTPUT POWER (At full scale voltage, 0 to 55 degrees C and from 0 to unity power factor. Derate linearly with voltage.)

1-PHASE: 4500 VA

3-PHASE: 1500 VA per phase

OUTPUT VOLTAGE

RANGES: 0 to 135 VRMS (Line-to-neutral)
0 to 270 VRMS (Line-to-neutral)

ACCURACY: (no load condition)
±0.135 VRMS from 5 to 135 VRMS (line-to-neutral)
±0.54 VRMS from 135 to 270 VRMS (line-to-neutral)

TEMPERATURE COEFFICIENT: ±0.02 volts per degree C average from 25 degrees C.

STABILITY: (At 25 ±1 degree C, constant line voltage and load)

±0.03% of full scale per 1000 hours

DEFAULT: 5.0 VRMS on 135.0 volt range.

OUTPUT CURRENT

	VOLTAGE RANGE 135	270
1-PHASE	33.33 amps	16.67 amps
3-PHASE	11.11 amps	5.56 amps per phase

CREST FACTOR: 2.5 maximum at 25 degrees C.

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OUTPUT FREQUENCY

RANGE:	45.00 to 550.0 Hz
RESOLUTION:	0.01 Hz from 45.00 to 99.99 Hz 0.1 Hz from 100.0 to 550.0 Hz
ACCURACY (25 ±1 degree C):	±0.001% of programmed value
TEMPERATURE COEFFICIENT:	±5 ppm/degree C from 25 degrees C
STABILITY (25 degrees C):	±15 ppm of programmed value per year
DEFAULT:	60 Hz

PHASE ANGLE PROGRAM

RANGE (phase B and C relative to phase A):		0 to ±999.9 degrees
DEFAULT:		
	Phase B:	240
	Phase C:	120
ACCURACY:		±1 degree with equal load on each phase

CURRENT LIMIT PROGRAM (all phases independent in 3-phase mode)

RANGE:	1-PHASE, 135 VOLT RANGE:	0 to 33.33 Amps
	1-PHASE, 270 VOLT RANGE:	0 to 16.67 Amps
	3-PHASE, 135 VOLT RANGE:	0 to 11.11 Amps/phase
	3-PHASE, 270 VOLT RANGE:	0 to 5.56 Amps/phase
DEFAULT:	3-PHASE	11.11 Amps on 135 volt range
	1-PHASE	33.33 Amps on 135 volt range

EXTERNAL SYNCHRONIZATION:

The output frequency may be synchronized to a 5 volt, 1.5 milliamp pulsed reference within the frequency range of 45 Hz to 550 Hz. The synchronization signal is optically isolated within the power source.

DISTORTION:	1% THD maximum for all harmonics and noise to 300 KHz.
LINE REGULATION:	±0.02% of full scale for a ±10% line voltage change.
LOAD REGULATION:	±0.05% of full scale from no load to full load.

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MEASUREMENTS: At 25 ±1 degree C unless specified otherwise)

VOLTAGE (True RMS method):
0.0 to 270.0 volts
0.1 volt resolution
±1.0 volt accuracy
±0.05 volts per degree C temperature coefficient

CURRENT (True RMS method):

3-PHASE:
0.00 to 20.00 Amps
0.01 amp resolution
±0.10 amp accuracy
±0.0016 amps per degree C temperature coefficient

1-PHASE:
0.0 to 60.0 amps
0.1 amp resolution
±1.5 amp accuracy
±0.016 amps per degree C temperature coefficient

POWER (True Power method):

3-PHASE:
0 to 2000 watts
1 watt resolution
±10 watt accuracy
±0.6 watt per degree C temperature coefficient

1-PHASE:
0.00 to 6.00 KW
0.01 KW resolution
±0.15 KW accuracy
±0.006 KW per degree C temperature coefficient

APPARENT POWER

3-PHASE:
0 to 2000 VA
1 watt resolution
±20 VA accuracy

1-PHASE:
0.00 to 6.00 KVA
0.01 KVA resolution
±0.3 KVA accuracy

POWER FACTOR
0.000 to 1.000

PHASE ANGLE (At full scale voltage):
0 to 360 degrees
0.1 degree resolution
±2.0 degree accuracy

FREQUENCY:
45.00 to 550.00 Hz
±0.02 Hz accuracy to 99.99 Hz
±0.2 Hz accuracy to 500.0 Hz
±0.5 Hz accuracy to 550.0 Hz

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INPUT POWER

VOLTAGE:	3-phase, 187 to 252V rms line-to-line
CURRENT:	20 Amps per phase
FREQUENCY:	47 to 440 Hz

TEMPERATURE RANGE

OPERATING:	0 to +55 degrees C at full power
STORAGE:	-40 to +85 degrees C

DIMENSIONS

WIDTH:	19 inches (48.3 cm)
HEIGHT:	11.5 inches (26.6 cm)
DEPTH (includes connectors):	23.1 inches (58.7 cm)
WEIGHT:	165 pounds (75.2 kg)

FRONT PANEL FINISH: Gray, 26440 per Federal Standard 595

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SECTION 2

INSTALLATION AND ACCEPTANCE

2-1 UNPACKING

2.2 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.

2-3 POWER REQUIREMENTS

2-4 The AC Power System has been designed to operate from 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 20 amps per phase and still supply a minimum of 187 volts line-to-line.

2-5 MECHANICAL INSTALLATION

2-6 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.

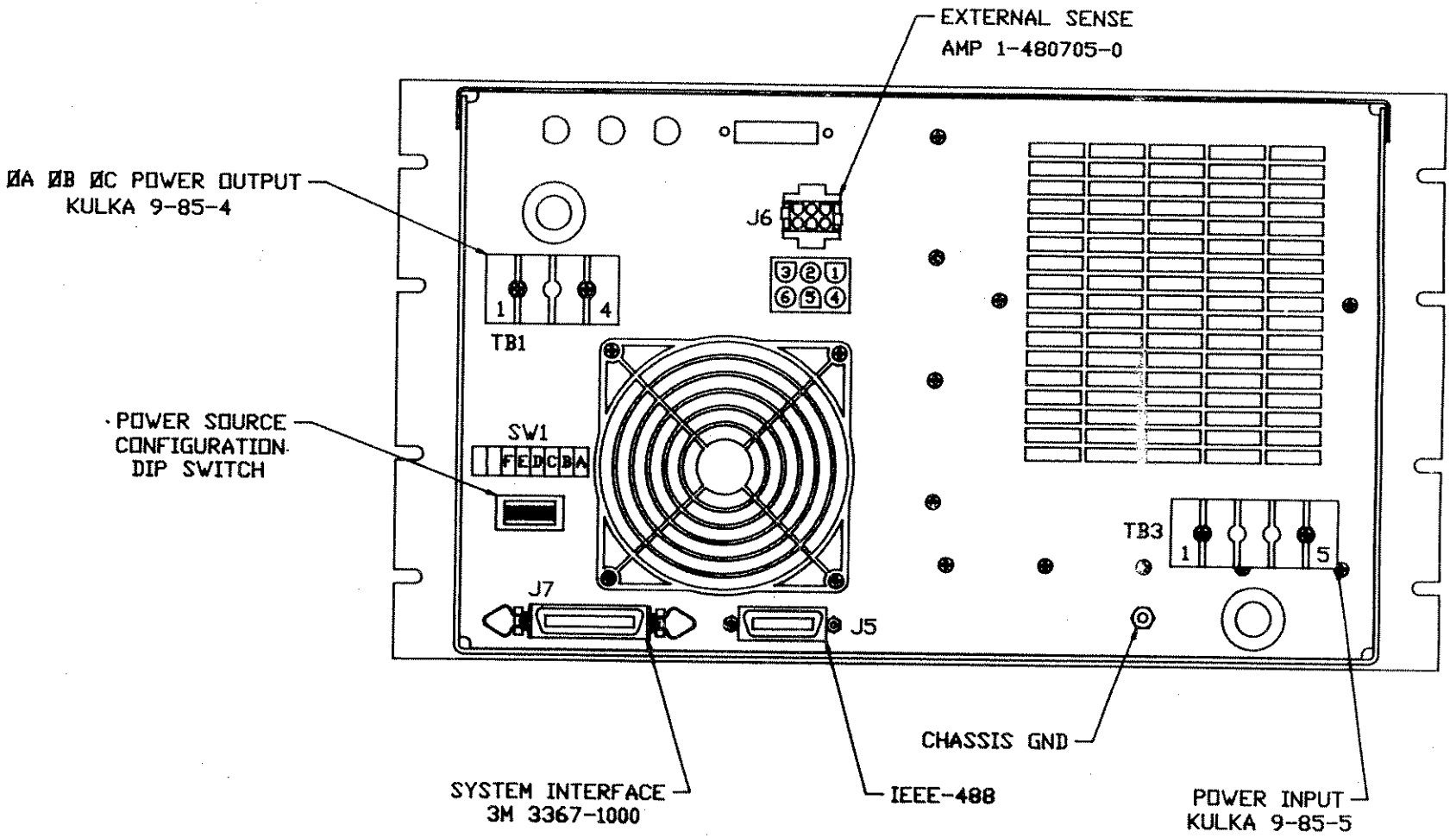
2-7 INPUT WIRING

2-8 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 Figure 2-1 for the input power connections.

2-9 OUTPUT CONNECTIONS

2-10 The output terminal block, TB1, is located at the rear of the power system. All load connections must be made at TB1. The remote sense inputs allow the power system output voltages to be monitored directly at the load and must be connected. The remote sense wires are connected at J6 on the rear panel.

2-11 The output power cables must be large enough to prevent a voltage difference greater than 3.5 VRMS between TB1 and the voltage between Remote Sense HI and LO input. Table 2-1 shows the maximum length of the output wires. The table assumes the Remote Sense input is connected at the load.



TB1

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

J6

PIN	FUNTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE

TB3

PIN	FUNTION
1	3 PHASE INPUT
2	
3	
5	GROUND

FIGURE 2-1
4503L REAR PANEL CONNECTIONS

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TABLE 2-1

MINIMUM WIRE SIZE

MODE	MAXIMUM OUTPUT CURRENT PER PHASE (AMPS)	WIRE GAGE (AWG)	MAXIMUM LENGTH (in feet) WIRE BETWEEN OUTPUT AND LOAD (BALANCE/UNBALANCED LOAD
3-phase	11.11	20	29/14
	11.11	14	119/59
	11.11	12	187/94
1-phase	33.33	14	10
	33.33	12	31

2-12 For a 1-phase power system the output power is available on TB1, pins 3 and 4.

2-13 The Remote Sense inputs must be connected or an AMP FAULT error message will be shown on the display and reported through the remote interface.

2-14 OUTPUT VOLTAGE RANGES

2-15 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 either the front panel keypad or through the GPIB input. All voltages are programmed line-to-neutral for 3-phase operation.

2-16 FUNCTION TEST

2-17 Refer to Figure 2-2 for the test setup. For the single phase load, the three loads used for the three-phase test may be used in parallel.

2-18 Perform the following test sequence.

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) With the front panel keypad program the 270 range with lthe following key sequences:

4 ENT .	To select the Range screen (RNG)
270 PRG ENT	To program the 270 range

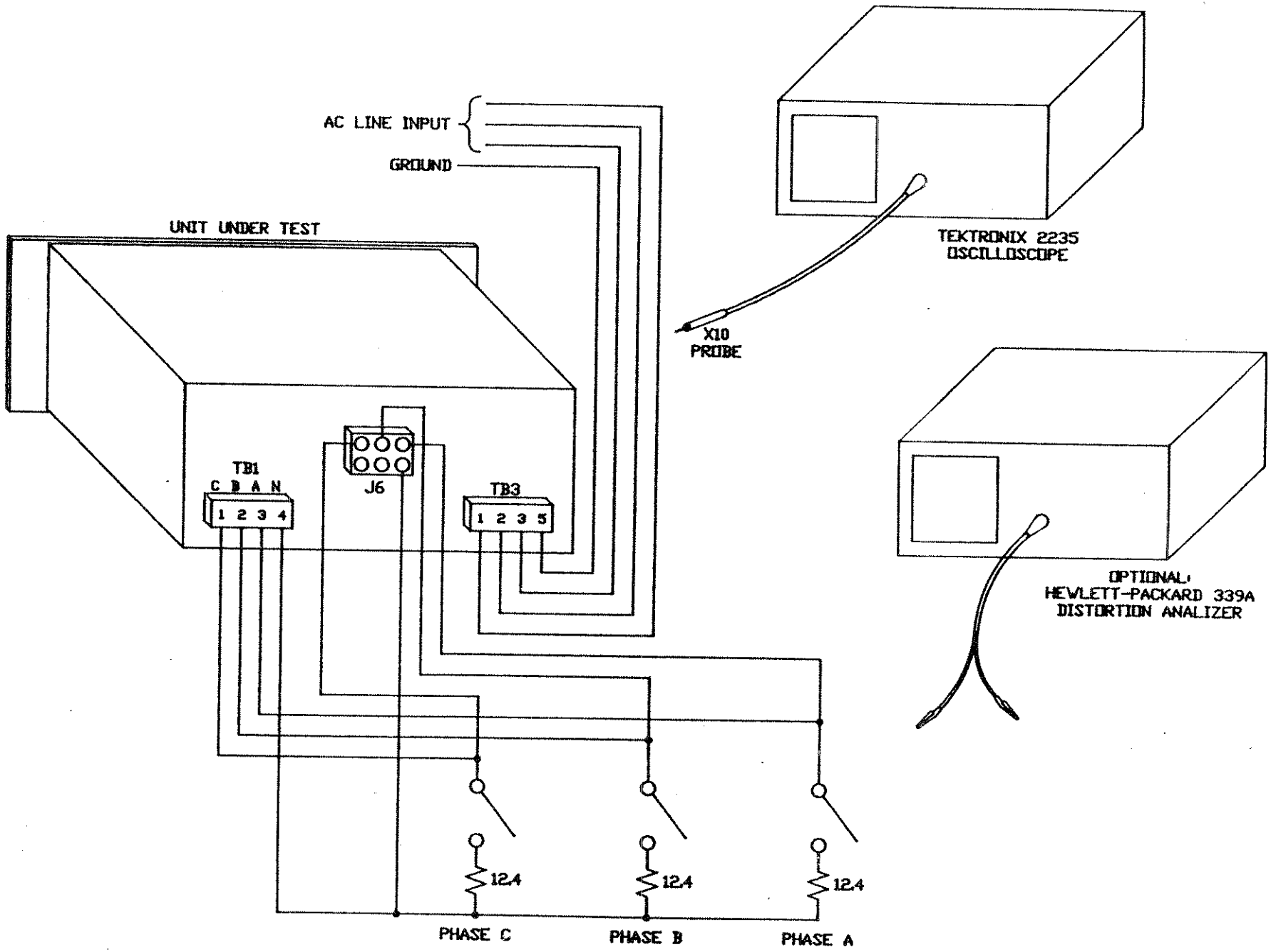


FIGURE 2-2
FUNCTION TEST SETUP

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4) Verify the HIGH RANGE lamp is lit.

5) Program the output to 270 volts with the following key sequences:

   Depress the MON key 1 time to select the Amplitude screen (AMP).

   270 PRG ENT To program the voltage to 270 volts

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) Program the AC Power System to the 135 volt range with the following keystrokes:

   4 ENT 135 PRG ENT

8) Program the output to 135 volts:

   5 ENT 135 PRG ENT

9) Observe each of the outputs with the oscilloscope or distortion analyzer. The outputs should be clean sine waves having less that 1.0% distortion.

10) Apply full loads to each phase (12.4 ohms, 1500 watts each). Verify that the voltage of each phase remains within 0.067 volts of the no-load voltage. The waveforms shall still appear clean on the oscilloscope and have less than 1% distortion. For a 1-phase system apply the three 12.4 ohm loads in parallel.

11) Program the Current Limit to 5.0 amps or 15.0 amps for a 1-phase system:

   8 ENT

   5 PRG ENT (15 PRG ENT for 1-phase)

12) The display should show the error message 'AMP ABC FAULT' for a 3-phase system. The error message may not, however, include all of the phases. The output will default to a programmed value of 5.0 volts with the output relays open.

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SECTION 3

OPERATION

3-1 GENERAL

3-2 The AC Power System may be programmed from the front panel or through the IEEE-488 remote interface. The rear panel of the AC Power System holds the power input and output terminals remote sense connector, system interface connector, IEEE-488 interface connector and the chassis ground stud.

3-3 FRONT PANEL CONTROLS

3-4 All front panel controls are shown in Figure 3-1. 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.

3-5 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.

3-6 The front panel has a subpanel with a keypad, remote lamp, LCD display and a viewing angle adjustment. The 20-key keypad allows the power source to be manually programmed at the front panel. The knob labeled VIEW ANGLE many be turned to adjust the contrast of the front panel display. The remote lamp illuminates when the AC Power System has been addressed through the IEEE-488 interface (GPIB).

3-7 FRONT PANEL INDICATORS

3-8 A lamp is located just above the input circuit breaker. It illuminates when power is applied and the circuit breaker is on.

3-9 An analog voltmeter, that indicates from 0 to 300 volts, 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.

3-10 An OVERTEMP 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.

3-11 An OVERLOAD lamp illuminates when the output current exceeds the programmed current limit value. The outputs will default to 5.0 volts and the output relays will open shortly after the condition occurs.

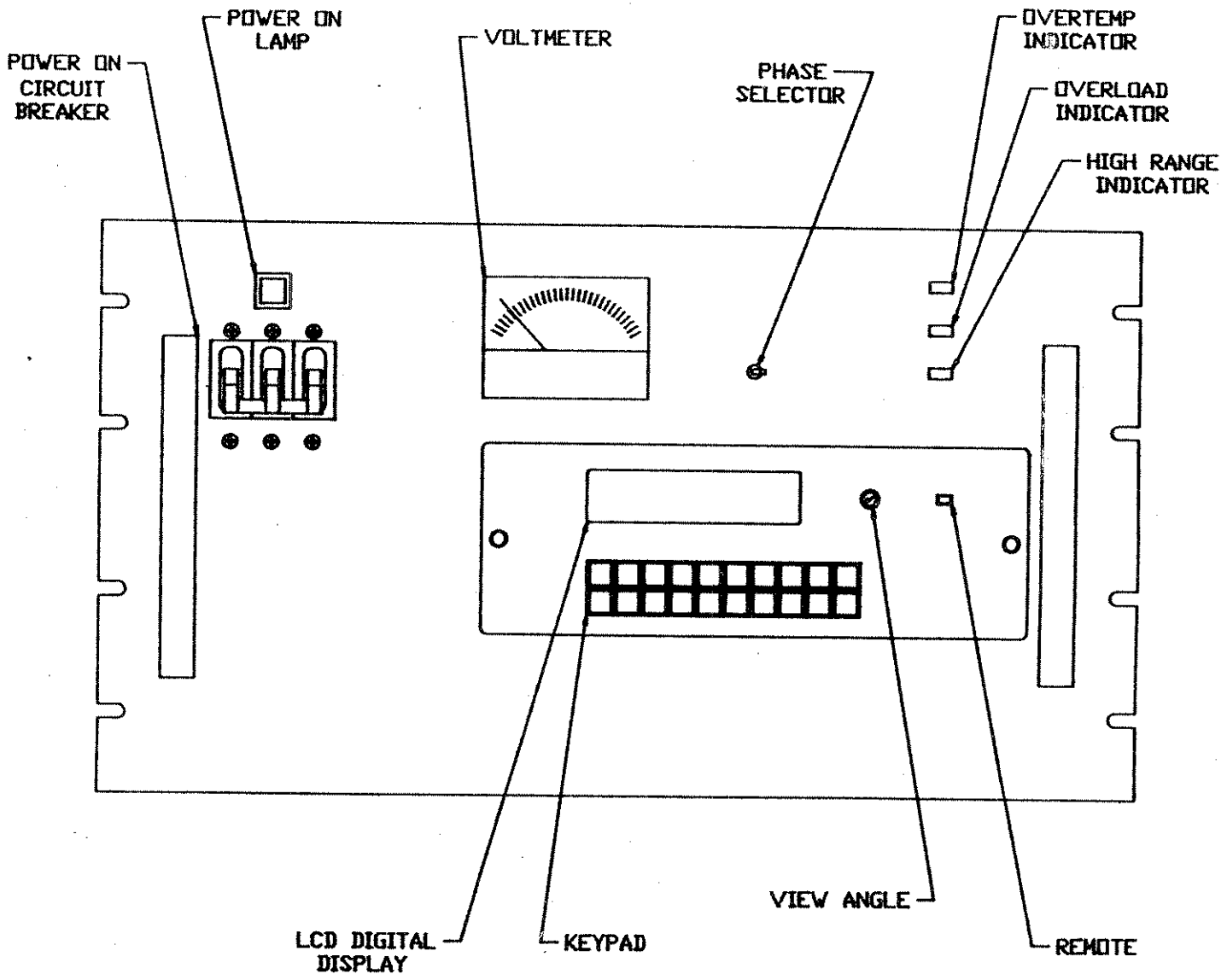


FIGURE 3-1
FRONT PANEL CONTROLS AND INDICATORS

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3-12 A HIGH RANGE lamp illuminates when the AC Power System is programmed to the high voltage range.

3-13 An LCD digital display shows the numeric value of all programmed output parameters. It also shows all error messages and measured values.

3-14 A REMOTE lamp illuminates when the AC Power System has been addressed from the IEEE-488 interface.

3-15 REAR PANEL CONNECTIONS

3-16 TB3 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.

3-17 TB1 is the power output terminal block. Refer to Table 3-1 for identification of the TB1 terminals. Terminal 3 and 4 are used for a 1-phase system.

TB1	DESCRIPTION
1	Phase C Output HI
2	Phase B Output HI
3	Phase A Output HI
4	Output Neutral

TABLE 3-1

3-18 J6 is the remote sense input connector. The remote sense input must be connected to the respective AC Power System output. If the inputs are not connected, an AMP FAULT error message will be generated. 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	No Connection	- - - - -
6	No Connection	- - - - -

TABLE 3-2

3-19 J5 is the IEEE-488 (GPIB) connector.

3-20 J7 is the System Interface connector. Table 3-3 identifies the pins of the System Interface connector.

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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, Not used
10	OVR TMP, Overtemperature indication
11	CNF, Output relay
12	FLT C, Phase C current limit fault
13	FLT A, Phase A current limit fault
14	F STB LO, Function Strobe output LO
15	EX SYNC LO, External Sync input LO
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	RNG HI, High Voltage range
29	REMOTE ON
30	FLT B, Phase B current limit fault
31	F STB HI. Function Strobe output HI
32	EX SYNC HI, External Sync input HI

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:

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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.

J7-9 RPV: This input is used for an optional Remote program of the output. With this option the output voltage may be controlled with a DC voltage.

J7-10 $\overline{\text{OVR TMP}}$: 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.

J7-12 FLT C: Make no connections.

J7-13 FLT A: Make no connections.

J7-14 F STB LO: Function Strobe Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.

J7-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J7-31.

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.

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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.

J7-26 CL A: A DC level from the oscillator used to set the current limit for phase A.

J7-27 D COM: Digital common.

J7-28 $\overline{\text{RNG HI}}$: 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.

J7-29 REMOTE ON: 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.

J7-30 FLT B: Make no connection.

J7-31 F STB HI: Function Strobe High signal. This is the collector lead of an optically isolated NON transistor. The internal power controller turns this transistor on the indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (<.4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC must be connected to J7, pin 31. J7, pin 14, is the common output. Refer to Figure 3-2.

J7-32 EX SYNC HI: External Sync Low signal. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 1.5 ma. The input should have a duty cycle 50 $\pm$10%. J7-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

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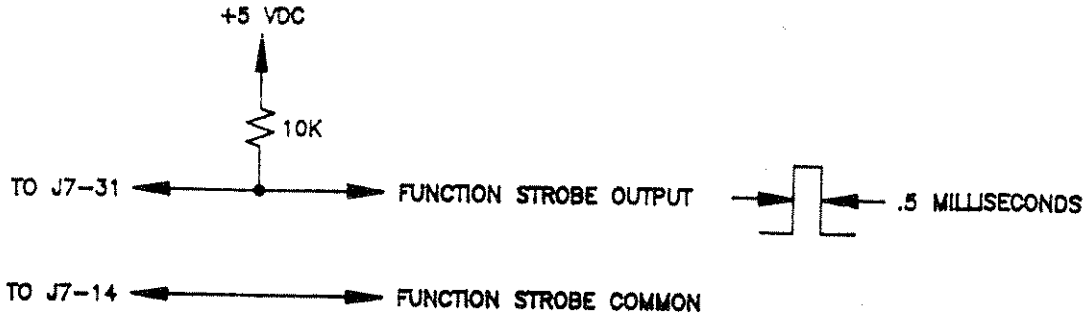


Figure 3-2

FUNCTION STROBE CONNECTIONS

3-21 FRONT PANEL PROGRAMMING

3-22 KEYPAD

3-23 The front panel keypad is enabled whenever the REMOTE light is not lit. The AC Power System may be manually programmed by using the keypad while observing the front panel LCD display.

3-24 Figure 3-3 shows the front panel keypad. Table 3-4 lists the key and a brief description. While viewing any Output Parameter screen (Ref. Table 3-5), the screens may be viewed in increasing order by depressing the MON key and in decreasing order by depressing the PRG key. While viewing the Measurement Screens, the MON and PRG keys work in a similar fashion. For example, if the AMP parameter screen is displayed, the FRQ screen may be displayed by pressing the MON key one time. The display will be switched back to the AMP screen by pressing the PRG key.

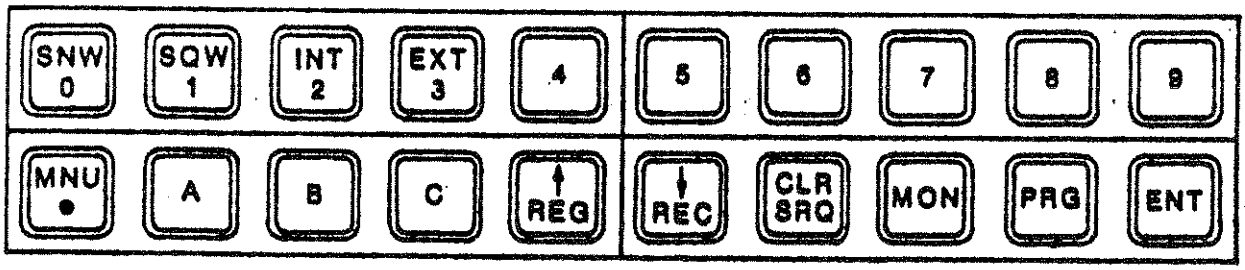


FIGURE 3-3

KEYPAD

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KEY	DESCRIPTION
SNW/0	Inputs the value "0" for all output parameters or to select screen "0" when followed by the ENT key. Also used to select the sine wave waveform.
SQW/1	Inputs the value "1" for all output parameters or to select screen "1" when followed by the ENT key. Also used to select the square wave waveform.
INT/2	Inputs the value "2" for all output parameters or to select screen "2" when followed by the ENT key. Also used to select the Internal Synchronize or Internal Clock modes of operation.
EXT/3	Inputs the value "3" for all output parameters or to select screen "3" when followed by the ENT key. Also used to select the External Synchronize or External Clock modes of operation.
4 through 9	Inputs the indicated numeric value for all output parameters or to select the corresponding screen when followed by the ENT KEY.
MNU/.	Selects the Menu screens that show all display screens and the corresponding numeric value. The decimal point function of this key is enabled after any numeric key is depressed.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
C	Used to direct any parameter change to phase C. Also used to update any quantity in the display identified as C=.
↑/REG	Used to increment the value in any output parameter screen or calibration screen. Also used to load the program register into any register identified by the preceeding numeric value.
↓/REC	Used to decrement the value in any output parameter screen or calibration screen. Also used to recall the program register identified by the preceeding numeric value.

TABLE 3-4

KEYPAD KEY DESCRIPTION

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KEY	DESCRIPTION
CLR/SRQ	Used to clear the numerical inputs for the display screen.
MON	Used to display programmed output parameter values. Used repeatedly, it will cause the display screens of increasing numeric numbers to be displayed.
PRG	Used to program setup values in the Program Register. Used repeatedly, it will cause the display screens of decreasing numeric numbers to be displayed.
ENT	Used to transfer the contents of the program register to the actual output parameters.

TABLE 3-4 (continued)

KEYPAD KEY DESCRIPTION

3-25 DISPLAY SCREENS

3-26 A display of data on the front panel LCD display is called a screen. There are four types of screens: menu, output parameter, measurement and configuration screens.

3-27 Menu screens display the screen abbreviation with its equivalent number. The numeric value for each item in a menu screen is the code that may be used to select the screen. Tables 3-5 through 3-8 show the numeric values for all screens. Without the aid of the tables the MNU key may be used. The menu screens will display only the programmable features that are enabled and their associated screen number.

3-28 Table 3-5 shows all of the available Output Parameter screens. While viewing any of the screens, the associated output parameter may be changed from the keyboard.

3-29 Table 3-6 shows all of the Measurement screens. When accessing some Measurement screens up to three seconds may be required to display the screen.

3-30 Table 3-7 shows all of the screens for calibrating the output and measurement functions. A special code is required to access these screens. Refer to Section 4, Calibration.

3-31 Table 3-8 shows all of the Configuration screens. The only value that is user programmable is the IEEE-488 (GPIB) Listen Address.

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NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for changing the output:				
1	SNC		INT, EXT	Selects phase A to be synchronized to an external input.
*2	CLK		INT, EXT	Selects the external clock mode of operation.
*3	WVF	A, B, C	SNW, SQW	Sets the output waveform.
4	RNG		Range limit	Selects the output voltage range. Range limit values of 135 and 270 are standard.
5	AMP	A, B, C	0-RNG limit	Sets the output voltage amplitude.
6	FRQ		45-550.0	Sets the output frequency.
7	PHZ	A, B, C,	0-±999.9	Sets the output phase angle.
8	CRL	A, B, C	0-33.33 or 0-11.11	Sets the output current limit.
9	RMP A	DLY	0.001-9999	Sets the Delay between ramp steps in seconds. Four decade resolution from 0.001 to 9999 seconds.
		STP		Sets the step size of ramp parameter.
		VAL		Sets the final value of the parameter ramped.
	RMP B	STP		Same as RMPA
		VAL		Same as RMPA

*Optional screen.

NOTE: RMPA and RMPB screens are not accessible until AMP, FRQ, CRL or PHZ are programmed (PRG) but not yet entered (ENT).

TABLE 3-5

OUTPUT PARAMETER SCREEN

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NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for measured values.				
11	ELT	H, M, S	Hrs,Min,Sec	Reports the total accumulated run time up to 99,999 hours.
21	VLT	A, B, C	0-300.0	Measures the TRMS output voltage.
22	CUR	A, B, C	0.0-100.0 or 0.00-20.00	Measures the TRMS output current in Amps. Range depends on maximum current per phase.
23	PWR	A, B, C	0.00-20.00KW or 0-2000 watts	Measures the True output power. Range depends on output VA per phase.
24	PWF	A, B, C	0-1.000	Measures the power factor of the load.
25	APW	A, B, C	0.00-20.00KVA or 0-2000 VA	Measures the apparent output power. Range depends on output VA per phase.
26	FQM		40-550.0	Measures the output frequency in hertz.
27	PZM	A, B, C	0-359.9	Measures the phase angle of the output voltage relative to phase A and phase A relative to an external input.

TABLE 3-6

MEASUREMENT SCREENS

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NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
12	CAL AMP	A, B, C	0-255	Calibrates the programmed output voltage
13	CAL VLT	A, B, C	Actual output voltage	Calibrates the measured voltage to be same as argument.
14	CAL CUR	A, B, C	Actual output current (amps)	Calibrates the measured current to be same as argument.
15	CAL PWR	A, B, C	Actual output power	Calibrates the measured power to be same as argument. The argument is in KW for power systems of more than 2000 VA per phase.
20	POF	A, B, C	0-$\pm$359.9	Calibrates the programmed output phase angle.

TABLE 3-7

CALIBRATION SCREEN

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NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
16	CFG	A(LSN)	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		B(CFG)	*28	Defines the features enabled for Power Source compatibility.
		C(PHZ)	*120	Defines the phase C initial value for power system configuration.
17	ALM	A(RNG)	*0	Code that defines the default voltage range.
		B(LLM)	*135	Defines the upper limit of the lower voltage range.
		C(HLM)	*270	Defines the upper limit of the higher voltage range.
18	FLM	A(FRQ)	*60	Defines the default frequency.
		B(LLM)	*45	Defines the low frequency limit.
		C(HLM)	*550	Defines the high frequency limit.
19	CLM	A(RNG)	*11.11	Defines the maximum current limit value.
		B(PRS)	*0	Defines the decimal point location for measured power.
		C(CRS)	*2	Defines the decimal point location for measured current.

*NOT USER PROGRAMMABLE. THE VALUES SHOWN ARE FOR A 3-PHASE SYSTEM OF 1500 VA PER PHASE. THE VALUES WILL BE DIFFERENT FOR OTHER SYSTEMS.

TABLE 3-8

CONFIGURATION SCREENS

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3-32 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP=5)

NOTE

The remote sense lines must be connected to J6 on the rear panel of the AC Power System. If they are not properly connected an AMP FAULT message will result when the output voltage amplitude is programmed above 5.0 volts. Refer to Figure 2-2.

3-33 Select the Amplitude (AMP) screen by entering keystrokes:

5 ENT

The display now shows the AMP parameter screen:

```
AMP MON    A = 5.0
B = 5.0    C = 5.0
```

NOTE: The B and C values are optional and they are only displayed with either a two or three-phase configuration.

Program all outputs to 115.5 volts with the keystrokes:

115.5 PRG ENT

Program phase A to 130.0, phase B to 110.0 and phase C to 90.0 volts.

130 A PRG 110 B PRG 90 C PRG ENT

Slowly increase the output amplitude of phase B only:

B PRG ↑ (Hold until desired value is obtained.)

3-34 TO PROGRAM FREQUENCY (FRQ=6)

3-35 Select the Frequency (FRQ) screen by entering the keystrokes:

6 ENT

Program the output to 60.23 hertz:

60.23 PRG ENT

To incrementally increase the output frequency to a desired value:

↑ (Hold until desired frequency is reached.)

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3-36 TO PROGRAM OUTPUT PHASE ANGLE (PHZ=7)

3-37 Select the Phase (PHZ) screen by entering:

7 ENT

Program phase C to .5 degree relative the phase A:

0.5 C PRG ENT

3-38 To enable the External Sync input and to program phase A to 90.0 degrees relative to the External Sync input, perform the following sequence:

1. Select the SNC screen:

   1 ENT

2. Program EXT:

   EXT PRG

At this point the phase screen must be accessed by repeatedly depressing either the MON or PRG keys. After the Phase (PHZ) screen is displayed, enter the following key sequence to simultaneously enable the External Sync and program phase A to 90 degrees:

9 0 A PRG ENT

The up (↑) and down (↓) keys may be used to increment or decrement any or all output phases.

NOTE

The PHZ A value is maintained in nonvolatile memory. The last programmed value is retained at power-up.

3-39 TO PROGRAM CURRENT LIMIT (CRL=8)

3-40 The Current Limit can be programmed independently or simultaneously for each phase of the AC Power system.

1. Select the Current Limit screen by entering:

   8 ENT

2. Program all phases to 5 amps:

   5 PRG ENT

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3-41 TO PROGRAM VOLTAGE RANGE (RNG=4)

3-42 The RNG screen has two purposes; to select a range defined by the range pair selected in the Amplitude Limit (ALM) screen and to select an upper voltage limit less than that specified by the ALM screen, LLM or HLM values. If the range pair 135/270 has been selected in the ALM screen with LLM=135 and HLM=270, the 135 range of the power source will be programmed by the RNG screen for any value of 135 or less. The value programmed will then be the maximum value allowed to be programmed in the Amplitude (AMP) screen.

3-43 To select the 270 range and set a program amplitude limit of 250 volts, perform the key sequence below:

4 ENT 250 PRG ENT

3-44 TO PROGRAM RAMP OR STEP FUNCTIONS (RMP=9)

3-45 The Ramp (RMP) function allows any programmable parameter (AMP, FRQ, PHZ, CAL or CRL) to be Stepped (STP) with a Delay (DLY) for each step to a final value (VAL). There are three types of programs that may be specified by the RMP screen; a ramp and two types of step programs.

3-46 The step function will program the output parameter value specified by a previous screen for the time specified for the DLY value in seconds. The parameter will then return to a final value specified by the VAL value.

4-47 The ramp function will step the output parameter value specified by a previous screen with the STP value, the DLY time per step and the final VAL setup in the RMP screen. The ramp will increment if the VAL value is larger than the parameter value. It will decrement if it is less than the parameter value.

NOTE

The DLY, STP or VAL parameters must be specified (A, B or C key depressed) before the number value for the parameter is entered.

3-48 When ramping frequency, an error message will result with an attempt to step the frequency with greater resolution than that possible by the initial or final values.

3-49 The step program may also be used to generate a dropout to zero volts on phase A at any point on the waveform. This type of program is selected by setting the AMP value to zero before setting the DLY and VAL parameters. The point on the waveform at which the dropout occurs is specified by the A value in the (PHZ) screen.

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3-50 The following key sequence will program 130V for 2.5 seconds and then return to a final value of 115V.

1. Select the AMP screen and enable 130 volts to be programmed:

   5 ENT 130 PRG (*)

2. Select the RMP screen, program a DLY of 2.5, a final VAL of 115 volts and run the program:

   9 ENT A 2.5 PRG C 115 PRG ENT

3-51 The next example will illustrate a ramp program. The following sequence will ramp the frequency from 60 hertz to 400 hertz in .1 hertz steps with a delay (DLY) for each step of .003 seconds. The total time for this ramp will be = [(VAL-FRQ)/STP]DLY or 10.2 seconds.

1. Select the FRQ screen and set the starting frequency of 60 Hz:

   6 ENT 60 PRG

2. Select the RMP screen, set a DLY of .003, set the STP of .1, set the final VAL of 400 and run the program:

   9 ENT A 0.003 PRG B 0.1 PRG C 400 PRG ENT

3-52 The following program will illustrate a dropout to zero volts. The program will drop the phase A amplitude to zero volt at 90 degrees for .002 seconds and return to 115 volts.

1. Select the AMP screen and program phase A to 115 volts:

   5 ENT 115 A PRG ENT

2. Select the PHZ screen and program A to 90:

   7 ENT 90 A PRG ENT

3. Select the AMP screen and program the dropout voltage of phase A to zero volt:

   5 ENT 0 A PRG

4. Select the RMP screen. Set a delay of .002 seconds and a return value of 115 volts:

   9 ENT A 0.002 PRG C 115 PRG

5. Execute the program by depressing the ENT key.

(*)If the ENT key is depressed at this point, the AMP would be programmed to and remain at 130 volts.

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3-53 Two output parameters may be ramped simultaneously. The parameter programmed just prior to entering the RMP A screen will be the independent parameter and will be identified in that screen. The parameter loaded prior to the independent parameter will be the dependent parameter.

3-54 The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen (dependent parameter) and program the start to 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen (independent parameter) and program the start frequency of 360 Hz:

   6 ENT 360 PRG

3. Select the RMPA screen and program the independent ramp parameters of STP = .2, and DLY = .2 and VAL = 440:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMPB screen and program the dependent (AMP) ramp parameters of STP = .5:

   10 ENT B 0.5 PRG

5. Start the program by pressing the ENT key.

3-55 The final value of the dependent parameter, AMP, will be determined by the number of steps of the independent parameter and the STP value, .5V specified in RMP B.

FINAL VALUE = INITIAL VALUE + (RMP B STP) (NO. STEPS)
NO. STEPS = (DEP. PAR.) (FINAL VALUE - INITIAL VALUE)/STEP SIZE

In this example:

NO. STEPS = (440 - 360)/.2 = 400

FINAL AMP VALUE = 10 + .5 X 400 = 210 Volts

If the final value exceeds the RNG value, an error message will be generated.

NOTE

Any ramp may be terminated at any time by depressing the ENT key.

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3-56 TO PROGRAM THE OUTPUT WAVEFORM (WVF=3)

3-57 The waveform selection is an option for the AC Power system. If the screen cannot be selected the option is not enabled.

3-58 The WVF screen displays the type of waveform selected, sine wave (SNW) or square wave (SQW), for each of the three outputs. To program a square wave, depress the SQW or any odd number key followed by any combination of the A, B or C key, the PRG key and ENT key. If no phase key is depressed, the new waveform will be programmed for all outputs.

3-59 To program phase A and C to square wave:

SQW A C PRG ENT

3-60 To select the sine wave waveform for any phase depress the SNW or any even number key followed by the key sequence described above.

3-61 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC=1)

3-62 The SNC screen displays whether the external or internal SNC mode of operation has been selected. While viewing this screen to select the external SNC mode depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

3-63 While operating in the EXT SNC mode, the FRQ screen will display the frequency of the External Sync signal. The signal must be between 45 Hz and 550 Hz.

NOTE

When viewing the SNC, CLK or WVF screens the MON or PRG keys must be used to sequence to another screen. The MNU key can also be used to return to the menu then followed by any screen selection.

3-64 To return to the internal SNC mode of operation, depress the INT key or any even numeric key followed by the PRG and ENT key while viewing the SNC screen.

Example: INT PRG ENT

3-65 If the External Sync signal is not between 45 Hz and 550 Hz, the message will be 'EXT SYNC ERROR'.

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3-66 In the EXT SNC mode the A value on the PHZ screen represents the angle of the A output leading the External Sync input. If the zero degree point of the power source does not match the zero degree point of the External Sync input, the POF screen may be used for calibration. Select the POF screen and enter a value for calibration.

3-67 TO PROGRAM THE EXTERNAL CLOCK (CLK=2)

3-68 The clock selection is an option for the AC Power System. The CLK screen displays whether the AC Power System is operating in the external (EXT) or internal (INT) CLK mode of operation. While viewing this screen to select the EXT CLK mode, depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

NOTE

Before selecting the External Clock mode, ensure that the AC Power System containing the oscillator has the proper clock and lock signals applied to the BNC connectors at the rear panel. Failure to have the proper clock and lock signals when the EXT CLK mode of operation is selected may result in an AMP FAULT error message. No output from the AC Power System will be available.

3-69 To return to the internal (INT) CLK mode of operation, depress the INT or any even numeric key followed by the PRG and ENT key while viewing the CLK screen.

Example: INT PRG ENT

3-70 TO PROGRAM REGISTERS AND RAMPS

3-71 The AC Power System has 16 registers that can be used to store setups. All of the data stored in the registers will be retained during power-down. Register operation may be chained to another register by adding the REC and register number to any setup sequence. The REC and REG keys are used for register operations. Any of the previous examples may be stored in a register by adding the extra step of entering the register number followed by depressing the PRG key. This extra step must be entered before the last ENT keystroke.

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3-72 The following program will program 135 volts and 60 hertz on all outputs for 10 seconds before reducing the output to 115 volts and store the test in register 0.

1. Select the FRQ screen and program 60 hertz:

   6 ENT 60 PRG

2. Select the AMP screen and program 135 volts:

   5 ENT 135 PRG

3. Select the RMP screen and program DLY = 10 and VAL = 115

   9 ENT A 10 PRG C 115 PRG

4. Store the program in register 0:

   0 REG

3-73 To recall and perform the register operation, simply enter the register number followed by depressing the REC and ENT keys.

3-74 REGISTER LINKING

3-75 Any number of registers may be linked together by using the REC key prior to loading the register operation.

3-76 The following program will ramp the voltage from 115 volts and 60 hertz to 135 volts with .1 volts per 10 millisecond steps, remain at 135 volts for 10 seconds, return to 115 volts at the same rate but at 62 Hz. Store the program in Registers 1 and 2.

1. Select the FRQ screen and program 60 Hz:

   6 ENT 60 PRG

2. Select the AMP screen and program 115 volts:

   5 ENT 115 PRG

3. Select the RMP screen and program DLY = 0.01, STP =0.1 and VAL = 135:

   9 ENT A 0.01 PRG B 0.1 PRG C 135 PRG

4. Link this program to Register 2:

   2 REC

5. Store this program in Register 1:

   1 REG ENT

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The second portion of the program will be stored in Register 2.

6. Select the FRQ screen and program 62 Hz:

   6 ENT 62 PRG

7. Select the AMP screen and program 135 volts:

   5 ENT 135 PRG

8. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 115:

9. Store this program in Register 2:

   2 REG ENT

To initiate the program:

1 REC ENT

3-77 TO PROGRAM SIMULTANEOUS RAMPS

3-78 Two outputs may be simultaneously ramped or stepped by enabling two parameter screens. The screen first selected will be the dependent parameter. The last parameter screen selected before entering the ramp (RMP) screen is the independent parameter. The independent parameter is used to specify the number of steps in a ramp. Since the dependent parameter has as many steps as the independent parameter, the step (STP) size must be calculated so the dependent parameter will not exceed its maximum value. The following example will specify frequency as the independent parameter and phase as the dependent parameter. Refer to paragraph 3-53 for more information.

3-79 The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen and specify the starting voltage of 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen and specify the starting frequency of 360 Hz.

   6 ENT 360 PRG

3. Select the RMP A screen and specify the ramp parameters of the independent parameter, FRQ, of DLY = .2 seconds, STP = .2 Hz and VAL = 440 Hz:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

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4. Select the RMP B screen and specify the ramp parameter of the dependent parameter, AMP, of STP = .5 volts:

   10 ENT B 0.5 PRG

5. At this point the program may be executed by depressing the ENT key or stored in a register.

3-80 ERROR MESSAGES

3-81 Table 3-9 shows all of the possible error messages displayed on the front panel display. The cause of the error message is also shown.

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ERROR MESSAGE	CAUSE
AMP (1) FAULT	Incorrect sense line connection. Overload on indicated output.
TEMP (1) FAULT	Amplifier overtemperature
CPU MEMORY FAULT	CPU failed self-test
DMA OVERFLOW	Remote message greater than 256 bytes.
EXT SYNC ERROR	No external sync input at System Interface connector. Signal is not between 45 and 550 Hz.
BUS LOCAL ERROR	Remote message sent while AC Power System is in local.
SYNTAX ERROR	Incorrect syntax received from IEEE-488 Remote Interface
AMP RANGE ERROR	Attempt to program AMP value greater than RNG value.
FRQ RANGE ERROR	Attempt to program FRQ less than 45 or greater than 550.
PHZ RANGE ERROR	Attempt to program PHZ greater than $\pm$999.9
CRL RANGE ERROR	Attempt to program CRL greater than 11.11 or 33.33.
RNG RANGE ERROR	Attempt to program RNG greater than 270.0 or other optional high voltage range.
RMPA RANGE ERROR	Attempt to program STP, DLY or VAL greater than the maximum.
DIV ERROR	Consult factory.
OVERFLOW ERROR	Consult factory.

(1) May be any combination of A, B or C.

FRONT PANEL DISPLAY ERROR MESSAGES

TABLE 3-9

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3-82 TO MEASURE THE OUTPUT

3-83 Seven measurement screens display the output voltage, current, power, apparent power, power factor phase and frequency. The phase A, B and C output values are shown simultaneously for 3-phase systems.

3-84 While viewing any measurement screen, except ELT, any other measurement screen may be displayed by repeatedly depressing either the MON or PRG key. The screen may also be displayed by entering its equivalent screen number followed by depressing the ENT key. Refer to Table 3-6 for all measurement screen numbers.

3-85 TO MEASURE THE OUTPUT VOLTAGE (VLT=21)

3-86 The voltage screen displays the actual TRMS output voltage with 0.1 volt resolution. This voltage is the voltage at the Remote Sense connector of the AC Power System. To access the voltage screen, depress the keys:

21 ENT

3-87 TO MEASURE THE OUTPUT CURRENT (CUR=22)

3-88 The current screen displays the actual TRMS load current. The resolution is 0.01 amp for AC Power Systems rated for less than 20 amps per phase. The resolution is 0.1 amp for AC Power Systems of more than 20 amps per phase.

3-89 TO MEASURE THE OUTPUT POWER (PWR=23)

3-90 The power screen displays the actual true power delivered to the load. The resolution is 1 watt for AC Power Systems rated for less than 2000 watts per phase. The resolution is 0.01 KW for AC Power Systems rated for more than 2000 watts per phase.

3-91 TO MEASURE THE OUTPUT POWER FACTOR (PWF=24)

3-92 This screen displays the power factor from 0 to 1.000 with 0.001 resolution. The PWF screen will read unity for loads less than 10 digits of apparent power on the Apparent Power (APW) screen. When this screen is displayed after another screen, it takes approximately two seconds to update the screen.

3-93 TO MEASURE THE OUTPUT APPARENT POWER (APW=25)

3-94 This screen is accessed by its screen number, 25. It displays VOLT-AMPERES with a resolution of 1 VA for AC Power Systems rated for less than 2000 VA per phase. The resolution is 0.01 KVA for AC Power Systems rated for more than 2000 VA per phase.

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3-95 TO MEASURE THE OUTPUT FREQUENCY (FQM=26)

3-96 This screen is accessed by its screen number, 26. It displays the output frequency with a resolution of 0.01 Hz or 0.1 Hz up to 99.99 Hz or 550.0 Hz, respectively.

3-97 TO MEASURE THE OUTPUT PHASE ANGLE (PZM=27)

3-98 This screen is accessed by its screen number, 27. It displays phase A relative to an external synchronizing input and phase B and C relative to phase A. The resolution is 0.1 degree.

3-99 ELAPSED TIME (ELT =11)

3-100 This screen displays the total run time accumulated on the AC Power System up to 99,999 hours.

H = Hours M = Minutes S = Seconds

3-101 REMOTE CONTROL

3-102 Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alpha-numeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-10. These abbreviations must not be confused with the device dependent abbreviations used to describe the AC Power System operating parameters (ex. FRQ=Frequency, etc.).

3-103 UNIT ADDRESS

3-104 This is the A value (LSN) set in the CFG screen. The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-11 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1 but may be changed by selecting the CFG Configuration screen and setting a new value.

3-105 To select the CFG screen repeatedly depress the MNU key until menu screen #1 is displayed as illustrated below:

```
SNC = 01        CLK = 02
WVF = 03        RNG = 04
```

Enter the key sequence: 959 ENT

Repeatedly depress the MNU key until the menu screen #5 is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

Enter the key sequence: 16 ENT

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The CFG screen will now be displayed. Depress the A key to display the present Unit Address. It may be changed to any value from 0 to 30 and will be stored in non-volatile memory. The new unit address will not be updated until power is shut off and reapplied to the power system.

The following key sequence will change the unit address to 16:

16 PRG ENT

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TABLE 3-10

COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states.
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End Or identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End Of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to remote when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to its Power-on state.

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TABLE 3-11

UNIT ADDRESS GROUP

LISTEN ADDRESS	HEX	BINARY						DECIMAL	ASCII
			A5	A4	A3	A2	A1		
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	,
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

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3-106 MESSAGE FORMAT

3-107 The message sent to the AC Power System must have the following format for each parameter:

HHHDXXX----------E±NND

where

H = Three letter mnemonic for each message header (except MODE).

D = Optional header extension (A, B or C) to specify output (ref. Table 3-5 through 3-8)

X = Alpha or numeric argument or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter, (CR) (LF) or (LF)

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

3-108 NUMERIC DATA FIELD

3-109 Parameter values may be sent as an unsigned value with a decimal point or a decimal point with an exponent. The phase value may be sent as a signed value.

3-110 The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts.

```
AMP115
AMP115.0
```

There may be any number of digits following the decimal point, not to exceed the 256 byte DAM buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is tenths of volts. The LSD for frequency is either hundredths or tenths for up to 99.99 Hz or 550.0 Hz respectively.

3-111 Any parameter's numeric value may be of a mixed form with a decimal point and exponent. The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 15 volts:

```
AMP1.15E2
AMP1.15E+2
AMP1.15E+02
AMP1150E-1
```

A positive exponent value is represented by either an ASCII "+" or an unsigned value.

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3-112 PROGRAM HEADERS

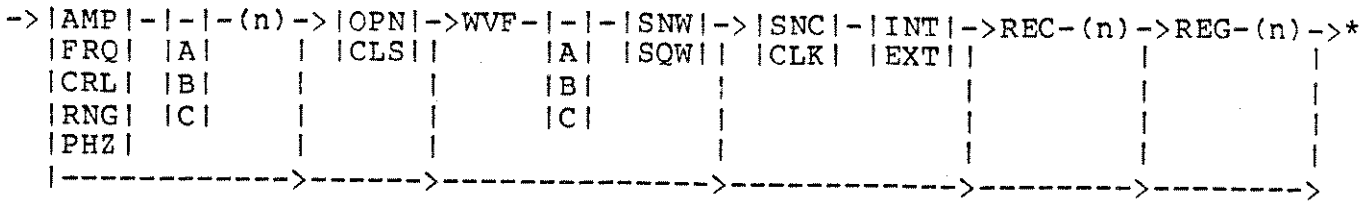
3-113 A Program Header is a mnemonic of a series of three ASCII characters used to select a function or identify the data it precedes. The header is an abbreviation of the program function it identifies. The header may be followed by a header extension to separately program each output (phase A, B or C) to different values. If an extension is not added to the header all outputs will be programmed to the header's argument. See Table 3-12 for the definition of the Program Headers and their related arguments.

3-114 Any header that is sent without an argument will cause the front display to show the corresponding screen. Refer the Figure 3-4 for a summary of all possible command sequences.

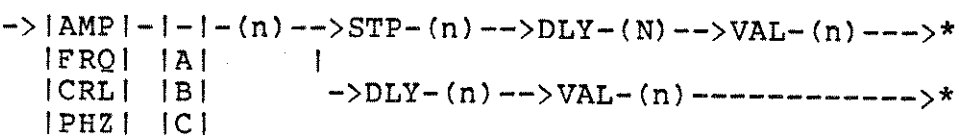
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IEEEE-488 PROGRAM SYNTAX

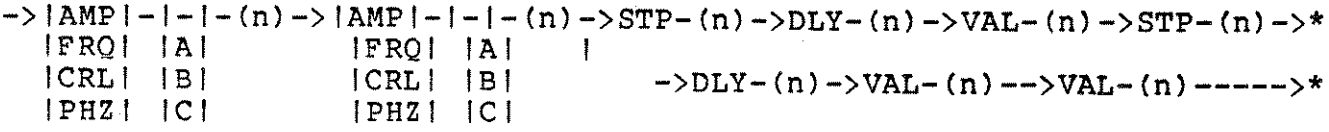
TO PROGRAM OUTPUT PARAMETERS:



TO RAMP OR STEP ONE OUTPUT PARAMETER:



TO RAMP OR STEP TWO OUTPUT PARAMETERS:



TO REQUEST TALKING OF CALIBRATION COEFFICIENTS:

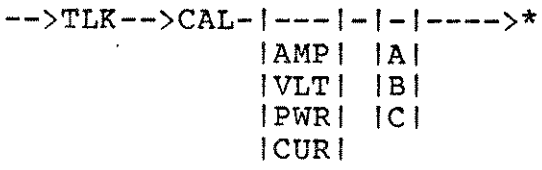
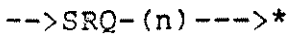


FIGURE 3-4

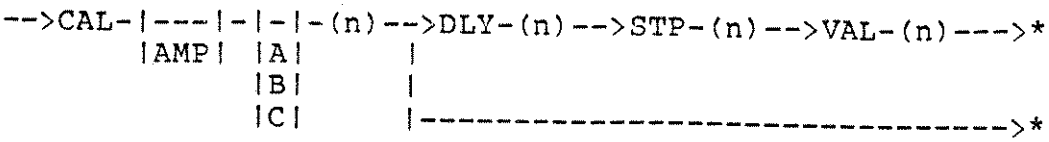
REMOTE COMMAND SEQUENCES

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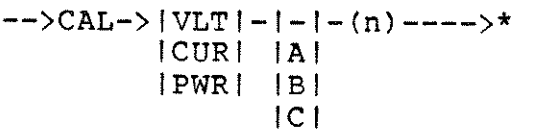
TO SPECIFY THE SERVICE REQUEST INTERRUPT:



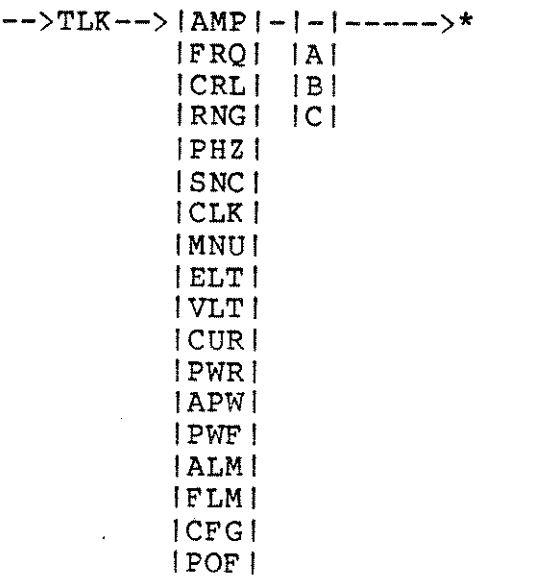
TO CALIBRATE OUTPUT:



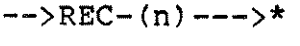
TO CALIBRATE MEASUREMENT:



TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:



TO RECALL A REGISTER:



* Represents either an IEEE-488 END or EOS message. The EOS message may be either an ASCII Carriage Return(CR), Line Feed(LF) or just LF.

n Represents a numeric value.

FIGURE 3-4 (continued)

REMOTE COMMAND SEQUENCES

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TABLE 3-12
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
AMP	A, B, C	# or numeric from 0.0 to RNG value.	Amplitude in volts.
CAL or CAL AMP	A, B, C	# or numeric data from 0.0 to 255	Calibration Coefficient for output voltage.
CAL VLT	A, B, C	Actual voltage	Calibrated measured voltage at remote sense point.
CAL CUR	A, B, C	Actual current	Calibrate measured current.
CAL PWR	A, B, C	Actual power	Calibrate measured power.
CLK		INT,EXT	Clock source
CRL	A, B, C	0 to maximum current per phase	Current limit in amps
DLY		0.000 to 9999 seconds	Delay in seconds used as a ramp parameter
FRQ		45.00 to 550.0	Frequency in hertz.
PHZ	A, B, C	0 to 999.0	Phase angle in degrees.
PRG		0 through 15	Load register with preceding data.
REC		0 through 15	Recall register or specify link register if it is preceded by program argument followed by PRG and register number.
REG		0 through 15	Register load
RNG	A, B, C	0.0 to 270 or other optional range value	Amplitude range and limit value in volts.
SNC		INT,EXT	Synchronize

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TABLE 3-12 (CONT.)
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program.
STP		From parameter minimum to maximum value	Define step size in ramp.
TLK		Any header	Set up to talk argument value or measured value when addressed to talk.
TRG			Execute (Trigger) set-up parameters on GPIB "GET" message.
VAL		From parameter minimum to maximum value	Final ramp or step value in volts, hertz, amps, degrees, sine wave or square wave.
WVF	A, B, C	SNW,SQW	Waveform
OPN			Open output relays
CLS			Close output relays
VLT	A, B, C		Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
CUR	A, B, C		Used with TLK to request measurement of the output load current.

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TABLE 3-12 (CONT.)
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
PWR	A, B, C		Used with TLK to request measurement of the True output power.
APW	A, B, C		Used with TLK to request measurement of the Apparent output power.
PWF	A, B, C		Used with TLK to request measurement of the output power factor.
PZM	A, B, C		Used with TLK to request measurement of the output phase angle.
FQM			Used with TLK to request measurement of the output frequency.

NOTE: If Extension does not follow the header, the argument will be applied to all phases.

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3-116 The AMP header with the optional A, B or C extension is used to identify the amplitude command. The argument is a numeric data field from 0.0 to the limit set by the RNG value. An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB.

3-117 The following ASCII strings will program the voltage given in the left column:

A,B,C 0.0 volts	AMP0	or	AMPA0AMPB0AMPC0			
A,B,C 10.5 volts	AMP10.5	or	AMP1.05E1	or	AMP105E-1	
A,B,C 100 volts	AMP100	or	AMP100.0	or	AMP1E2	
A,B = 110.5, C = 115	AMPA110.5AMPB110.5AMPC115 or AMP110.5AMPC115					

3-118 TO PROGRAM FREQUENCY (FRQ)

3-119 The FRQ header is used to identify the following numeric data as frequency.

3-120 The following string will program the frequency to 60.56 Hz.

```
FRQ 60.56
```

3-121 TO PROGRAM PHASE ANGLE (PHZ)

3-122 The PHZ header with the optional A, B or C extension is used to identify the following numeric data as phase. The PHZ header sent with no extension will program the B and C outputs in phase with phase A. The phase of the A output will lead the EXT SNC signal or EXT lock and clock signal by the value programmed.

3-123 The following example will program the phase A output to 90 degrees relative to an external sync signal when operating in the EXT SNC mode:

```
PHZA 90
```

3-124 The following example will program phase B to 240.5 degrees and phase C to 119.3 degrees leading phase A.

```
PHZB 240.5 PHZ C 119.3
```

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3-125 TO PROGRAM CURRENT LIMIT (CRL)

3-126 The CRL header with the optional A, B or C extension is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to the maximum rated current of the power system.

3-127 The following string will program a current limit of 10.5 amps for all three phases:

```
CRL 10.5
```

3-128 TO PROGRAM CALIBRATION (CAL)

3-129 The CAL header when used alone or followed by the header AMP, in addition to an A, B or C extension, is used to calibrate the programmed output voltage. The argument is a relative starting coefficient from 0 to 255 or the ASCII # symbol. The CAL ramp is terminated with the GPIB message Group Execute Trigger (GET). The CAL header can be used with a Delay (DLY) command to allow the external calibration AC DVM time to settle. Refer to Section 4 for additional information.

3-130 A CAL coefficient can be programmed without a ramp by using only the argument with the CAL header.

3-131 To program the CAL A coefficient to 55 use the following string:

```
CALA55
```

3-132 To calibrate phase A at 135.0 volts, start the CAL routine with a GPIB GET message with the CAL coefficient starting at 20 and with each step lasting 2 seconds use the following string:

```
AMP135.0 CALA20 DLY2 STP1 VAL255 TRG
```

In this example the output will program to 135.0 and start to change the output by stepping the CAL value after a "GET" message. The ramp will terminate after a second "GET" message.

3-133 To calibrate phase A at 135 volts and start the ramp with the existing CAL coefficient reducing the output with steps lasting one second:

```
AMP135.0 CALA# DLY1 STP1 VAL0
```

Again the ramp must be terminated with the bus "GET" message when the external AC calibration DVM indicates the correct voltage.

3-134 The CAL header is used with the headers VLT, CUR and PWR to calibrate the respective measurement function. An A, B or C extension follows the headers to designate a specific measurement channel. If the extension is omitted, the calibration

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coefficients for all measurement channels will be the same and will depend on only the value for phase A. The argument is a numeric value that represents the expected measured value. It should be equal to an external precision TRMS voltmeter, ammeter or power meter.

3-135 The following ASCII string will cause the current measurement for phase A to measure the value indicated by a TRMS ammeter standard, 10.12 amps:

```
CAL CUR A 10.12
```

3-136 TO PROGRAM RAMP OR STEP OPERATIONS

3-137 The DLY header is used with a parameter that has a numeric argument (ex. AMP, FRQ, PHZ, CRL, CAL) in a single step program. The numeric argument is in seconds with four decade resolution from 0.001 to 9999 seconds.

3-138 The STP header with VAL may be used with DLY to completely specify a ramp program.

3-139 The following string will first step the voltage to 125 volts for 2.55 seconds and return to 115 volts.

```
AMP 125 DLY 2.55 VAL 115
```

3-140 The following string will ramp the voltage from 10 volts to 115 volts with 1.5 volt/.5 sec. steps:

```
AMP 10 DLY .5 STP 1.5 VAL 115
```

3-141 When an AMP header with an argument of 0 is used, the waveform will stop and drop to zero volts at the point specified by the PHZ A value.

3-142 The following ASCII string will stop the waveform at 0 degrees for .01 seconds and return to 115 volts:

```
PHZ A 0 AMP 0 DLY .01 VAL 115
```

3-143 The STP header is used to identify the following argument numeric value as the increment or decrement value for a FRQ, CRL, AMP, PHZ or CAL ramp.

3-144 The following example will ramp all outputs from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

```
AMP130 DLY.5 STP1.5 VAL10
```

3-145 The header VAL is used to identify the following numeric argument as the final Value of a ramp or step. If the VAL argument is larger than the initial value for the parameter to be ramped, the ramp will increment with step size defined by STP and DLY. With the VAL argument less than the initial value, the

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ramp will decrement from the initial parameter.

3-146 A ramp or step operation can be stopped at anytime by the GPIB message Group Execute Trigger (GET).

3-147 The following example will decrement the output amplitude of phase A only from 120 in .1 volt/.2 sec steps to 100 volts after a Device Trigger.

```
AMP A 120 DLY.2 STP.1 VAL100 TRG
```

3-148 The following example will simultaneously ramp the Frequency from 400 to 5000 Hz at a rate of 10 Hz per second and the Amplitude from 5 volts in increments of .5 volts per step:

```
RNG270 AMP5 FRQ400 STP10 DLY1 VAL5000 STP.5
```

3-149 A GPIB Service Request will be generated at the end of a ramp if SRQ2 is included in the setup string.

3-150 TO PROGRAM A REGISTER (REG)

3-151 The REG header is used to load the register specified by the following numeric data with the preceding data. The numeric value is from 0 to 15. The PRG header is identical to the REG header and is included to standardize other AC power controllers.

3-152 The following example will load a ramp program that will step the voltage from 10 to 115 volts with 1 volt/.5 sec steps at 400 Hz into register 0.

```
FRQ400 AMP10 DLY.5 STP1 VAL115 REG0
```

3-153 TO RECALL A REGISTER (REC)

3-154 The REC header is used to recall previously loaded data from a register identified by the following register number (0 to 15).

3-155 The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3-152.

```
REC0
```

3-156 The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" message.

```
REC0 TRG
```

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3-157 The following is an example of register linking. The voltage and frequency is maintained at 115 volts and 60 Hz for 5 seconds and then the program contained in register 0 is recalled and executed. The program is stored in register 1.

```
FRQ60 AMP115 DLY5 VAL115 REC0 REG1
```

The program is initiated by the following ASCII string:

```
REC1
```

3-158 TO PROGRAM VOLTAGE RANGE (RNG)

3-159 The RNG header is used to select a range. The numeric value following the RNG header will also define the upper limit for the AMP value. The RNG value will select the higher range if the value is greater than the lower range value defined by the ALM screen which is 135 for the standard voltage range. If the range and voltage amplitude are to be programmed by the same data string the RNG header and argument must precede the AMP header or a syntax error will be generated.

3-160 The following example will select the 270 range from the 135/270 range pair with an upper amplitude limit of 210 volts.

```
RNG210
```

3-161 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC)

3-162 The SNC header is used with the EXT argument to synchronize the phase A output to an external sync input. The phase A output will be phase referenced to the sync input with the displacement equal to the PHZ A value.

3-163 The following ASCII string will program the phase A output to 0 degree relative to the external sync input and select the external sync mode.

```
PHZA0 SNC EXT
```

3-164 Sending the ASCII string SNC INT will disable the sync input.

3-165 TO PROGRAM EXTERNAL CLOCK (CLK) (optional)

3-166 The CLK header has an argument of either EXT or INT. The CLK header with the EXT argument will make one AC Power System a slave to another system. The slave will operate at the same frequency as the master. Phase A of the slave will be related to phase A of the master by the PHZ A value of the slave.

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NOTE

The clock option is only available for the if the associated power systems have the LK option.

3-167 The following ASCII string will enable the CLOCK and LOCK inputs to the associated slave AC Power System:

```
CLK EXT
```

NOTE

If there is no signal at the CLOCK input at the rear panel of the associated power system, the output will go to zero volts.

The ASCII string CLK INT will return the slave AC Power System to its programmed frequency.

3-168 TO TRIGGER AN OPERATION (TRG)

3-169 The TRG header has no argument. When the TRG mnemonic is included in a setup string, it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller. The TRG header may also be used to trigger register operations by including the TRG header with the string used to recall a register. The following example will delay execution of the program in register 1 until an IEEE-488 Device Trigger is received:

```
REC1 TRG
```

3-170 The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The setup values will then be programmed in the remote mode when the Device Trigger is received.

3-171 TO PROGRAM TO OUTPUT WAVEFORM (WVF) (Optional)

3-172 The header WVF with the optional A, B or C extension is used to identify the following argument as the Sine Wave (SNW) or Square Wave (SQW) function of the Waveform.

3-173 The following example will program all outputs to the square wave function.

```
WVF SQW
```

3-174 The following example will program only output B to the square wave function:

```
WVFB SQW
```

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3-175 TO OPEN (OPN) AND CLOSE (CLS) THE OUTPUT RELAY

3-176 The OPN and CLS headers open and close the output relays in the power source. There is no argument associated with these headers. When the OPN or CLS headers is received the output voltage will be programmed to zero volts for 50 milliseconds before the output relays open or close.

3-177 TO TALK (TLK) MEASURED AND PROGRAMMED DATA

3-178 The TLK header will setup the AC Power System to talk data. The TLK header will setup the AC Power System to report a programmed output parameter if the program header is the argument for the TLK header.

3-179 To setup the AC Power System to report a measured value, attach a measurement header as the TLK argument. The measurement headers are VLT, CUR, PWR, APW and PWF with an A, B or C extension and FQM with no extension.

3-180 The following string will setup the AC Power System to measure the phase A power output when it is talk addressed:

```
TLK PWR A
```

3-181 All arguments for the TLK header are shown in Table 3-13. Table 3-14 shows an example response for all TLK arguments with no A, B or C extension. For 1-phase systems, all responses will only include the phase A value. For 3-phase systems, if the TLK argument includes the A, B or C extension, the response message will be only for the indicated phase.

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TABLE 3-13

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
ALM	A	0000	Default voltage range code
	B	*135.0	Low voltage range.
	C	*270.0	High Voltage range
AMP	A,B,C	0 to 270.0	Programmed voltage Amplitude value in volts.
APW	A,B,C	0 to 2000 or 0.00 to 20.00	Output VA Output KVA
CFG	A	0 to 30	IEEE-488 Listen address
	B	* 28	Configuration code
	C	* 120	Phase C initial value
CLM	A	11.11 or 33.33	Defines the maximum current per phase
	B	0 or 2	Defines the power decimal point
	C	2 or 1	Defines the current decimal point
CRL	A, B, C	0 to 11.11 or 0 to 33.33	Programmed output current limit
CUR	A, B, C	0.00 to 20.0 or 0.0 to 100.0	Measured output current
ELT	A	0000 to 9999	Total accumulated hours (H)
	B	00 to 59	Accumulated minutes (M)
	C	00 to 59	Accumulated seconds (S)
FLM	A	60	Default frequency
	B	45	Low frequency limit
	C	550	High frequency limit
FQM	None	45.00 to 550.0	Measured output frequency
FRQ	None	45.00 to 550.0	Programmed frequency

(*) Standard values shown. Values will be different for other ranges, output power and options.

NOTE: If the A. B or C Extension is not sent with the argument all phases will be reported.

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TABLE 3-13 (continued)

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
CLK	None	INT or EXT	Programmed clock source
SNC	None	INT or EXT	Programmed external sync mode
WVF	A, B, C	INT or EXT	Programmed waveform
PHZ	A, B, C	0.0 to 359.9	Programmed output phase angle
PWR	A, B, C	0 to 2000	Output watts
		or	
		0.00 to 20.00	Output KW
PZM	A, B, C	0.0 to 359.9	Measured phase B and C output phase angle relative to A. A is always 0.0
REG	0 to 15	Contents of Reg	Talk contents of register
RNG	None	0 to 270.0	Programmed range and limit
SRQ	None	0, 1 or 2	Programmed SRQ status
VLT	A, B, C	0.0 to 270.0	Measured output voltage

NOTE: If the A. B or C Extension is not sent with the argument all phases will be reported.

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TABLE 3-14

EXAMPLE TALK RESPONSE (3-PHASE SYSTEM)

ASCII STRING SENT		RESPONSE AFTER ADDRESSED TO TALK		
TLK	ALM	ALMA0000	B135.0	C270.0
TLK	AMP	AMPA005.0	B005.0	C005.5
TLK	APW	APWA1003	B0985	C1507
TLK	CFG	CFGA0001	B0028	C0120
TLK	CRL	CRLA11.11	B11.11	C11.11
TLK	CUR	CURA06.14	B05.12	C06.71
TLK	ELT	ELTH0147	M0051	S0033
TLK	FLM	FLMA0060	B0045	C0550
TLK	FQM	FQM59.97		
TLK	FRQ	FRQ60.00		
TLK	CLK	CLK INT (*)		
TLK	SNC	SNC INT		
TLK	PHZ	PHZA000.0	B240.0	C120.0
TLK	PWF	PWFA1.000	B1.000	C1.000
TLK	PWR	PWRA0.737	B0.620	C0.806
TLK	PZM	PZMA000.0	B242.1	C118.9
TLK	REG0	ACTUAL CONTENTS OF REGISTER 0		
TLK	RNG	RNGA 135.0	B135.0	C.135.0
TLK	VLT	VLTA120.1	B119.8	C120.0
TLK	WVF	WVFA SNW	B SNW	C SNW (*)

(*) If function is not enabled a Syntax Error message will be generated.

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3-182 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK VLT)

3-183 VLT may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output voltage with 0.1 volt resolution.

3-184 When VLT is used as a header in a string with no argument, it will cause the front panel to display the measured output voltage.

3-185 TO TALK THE MEASURED OUTPUT CURRENT (TLK CUR)

3-186 CUR may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output current in amps with 0.01 amp resolution. The resolution is 0.1 amps for power systems capable of more than 20 amps per phase.

3-187 When CUR is used as a header in a string with no argument, it will cause the front panel to display the output current.

3-188 TO TALK THE MEASURED OUTPUT POWER (TLK PWR)

3-189 PWR may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output power in watts with 1 watt resolution. The power is measured in kilowatts with 0.01 KW resolution for power systems capable of more than 2000 watts per phase.

3-190 When PWR is used as a header in a string with no argument, it will case the front panel to display the output power.

3-191 TO TALK THE MEASURED OUTPUT POWER FACTOR (TLK PWF)

3-192 PWF may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output power factor from 0 to 1.000.

3-193 When PWF is used as a header in a string with no argument, it will cause the front panel to display the output power factor.

3-194 TO TALK THE MEASURED OUTPUT APPARENT POWER (TLK APW)

3-195 APW may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the Apparent Power output in VA with 1 VA resolution. The apparent power is measured in KVA with 0.01 KVA resolution for power systems capable of more than 2000 VA per phase.

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3-196 When APW is used as a header in a string with no argument, it will cause the front panel to display the measured output Apparent Power.

3-197 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)

3-198 FQM may be used as an argument to the header TLK. There are no extensions for this argument. When FQM is used as an argument, it will set up the AC Power System to measure the output frequency in hertz.

3-199 When FQM is used as a header, it will cause the front panel to display the measured output frequency.

3-200 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM)

3-201 PZM may be used as an argument with an extension A, B or C for the header TLK. When used as an argument, PZM will set up the AC Power System to measure the phase angle of phase B and C relative to phase A. The measurement is made at the Remote Sense terminals. Phase A is the reference phase and will always be reported as 000.0 degrees unless the AC Power System is operating in the external sync mode.

3-202 When PZM is used as a header, it will cause the front panel to display the phase measurement screen.

3-203 MESSAGE SEPARATORS

3-204 A complete message consists of a header and an argument. Since more than one message can be sent in a setup string, message separators included in the string between the message will make it more readable to the human operator. Three message separators are recognized: the comma (,), semicolon (;) and a space. Since these separators are ignored, they may be dispersed throughout a setup string.

3-205 The following are two examples of ASCII strings with separators:

```
PHZA90;FRQ60;AMP115

CRL,90;FRQ50;AMP,120
```

3-206 SERVICE REQUEST

3-207 After power-up the GPIB Service Request (SRQ) will be generated after any error (example. syntax, output fault, etc.). This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1. Sending SRQ2 causes an SRQ to be generated after the execution of a setup string. The setup string can be of any type: ramp, calibration, etc.

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3-208 The following example disables GPIB SRQ.

```
SRQ0
```

3-209 SERIAL POLL STATUS BYTE

3-210 Once the bus controller has detected the SRQ, it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. The Status Byte values for various faults are given in Table 3-15.

3-211 END OF STRING

3-212 The End of String (EOS) delimiter recognized by the AC Power System is the ASCII Line Feed (LF). Carriage Return (CR) followed by Line Feed may also be used for EOS. The End or Identify (EIO) IEEE-488 message END will also be recognized. The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

3-213 ERROR MESSAGES

3-214 Table 3-15 shows all of the possible error messages that can be generated by the AC Power System. These messages will also be displayed on the front panel of the AC Power System.

3-215 GROUP EXECUTE TRIGGER

3-216 The trigger mode is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected, it will delay execution of the new setup values until the GPIB Device Trigger is sent by the bus controller.

3-217 A GPIB Device Trigger will also terminate a programmed ramp or other program.

3-218 The following setup string will recall the values from register 9 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. (See Table 3-10).

```
REC9TRG
```

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TABLE 3-15

STATUS BYTE VALUES

STATUS BYTE SRQ = 1	REPORTED MESSAGE	CAUSE
64	AMP A FAULT	Overload or sense line fault
65	AMP B FAULT	Overload or sense line fault
66	AMP AB FAULT	Overload or sense line fault
67	AMP C FAULT	Overload or sense line fault
68	AMP AC FAULT	Overload or sense line fault
69	AMP BC FAULT	Overload or sense line fault
70	AMP ABC FAULT	Overload or sense line fault
72	TEMP A FAULT	Amplifier overtemperature
73	TEMP B FAULT	Amplifier overtemperature
74	TEMP AB FAULT	Amplifier overtemperature
75	TEMP C FAULT	Amplifier overtemperature
76	TEMP AC FAULT	Amplifier overtemperature
77	TEMP CB FAULT	Amplifier overtemperature
78	TEMP ABC FAULT	Amplifier overtemperature
90	RNG RANGE ERROR	RNG value greater than 270.0
91	AMP RANGE ERROR	AMP value greater than RNG value
92	FRQ RANGE ERROR	FRQ value is less than 45 or greater than 550.0
93	PHZ RANGE ERROR	PHZ value greater than ±999.0
94	CRL RANGE ERROR	CRL value greater than maximum value
95	RMPA RANGE ERROR	DLY, STP or VAL values wrong
96	SYNTAX ERROR	Wrong string SYNTAX
97	BUS LOCAL ERROR	Remote message sent while i local mode
98	EXT SYNC ERROR	No external sync input or signal not between 45 and 550 Hz
99	CPU MEMORY FAULT	CPU failed self-test
100	DMA OVERFLOW ERROR	Remote message greater than 256 bytes
101	CAL RANGE ERROR	Unable to calibrate output
127		The response after SRQ2 is included in a setup string and the execution of the string has been completed.
<64	STA OK	No problems

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TABLE 3-16
HP SERIES 80 CONTROLLER STATEMENTS

STATEMENT	DESCRIPTION
CLEAR 7	Universally sets all instruments to their power-on states by sending the GPIB message DCL
CLEAR 701	Sets only instrument with listen address "1" to its power-on state by sending the GPIB message SDC.
LOCAL 7	Universally sets all instruments into their local control mode by deasserting REN.
LOCAL 701	Sets only instrument with listen address "1" to its local control mode by sending the GTL message.
REMOTE 7	Sets REN true.
REMOTE 701	Sets instrument with listen address "1" to remote.
ABORTIO 7	Clears all instrument interfaces to unlisten and untalk by toggeling IFC.
RESUME 7	Sets ATN false.
OUTPUT 701; "AMP"; V	Sends the data string AMP followed by the numerical value of variable V to the instrument with listen address "1".
STATUS 7,1;A	This statement reads the SR1 register of the series 80 controller for the interrupt cause. This statement is necessary to clear the Service Request flag in the controller.
ENABLE INTR 7; 8	This statement allows the series 80 controller program to be interrupted when a GPIB instrument generates an SRQ.
ON INTR 7 GOSUB100	This statement will cause the program to go to an interrupt subroutine at 100.
TRIGGER 7	This statement triggers all addressed instruments by sending the GET message.
TRIGGER 701	This statement will trigger only the instrument with listen address "1" by sending the GET message.
A=SPOLL (7)	Sets variable A equal to the decimal value of the Status Byte of an instrument previously addressed to talk.
A=SPOLL (701)	Sets variable A equal to the decimal value of the Status Byte of the instrument with listen address "1".

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3-219 HEWLETT PACKARD SERIES 80 PROGRAM EXAMPLES

3-220 For the following program examples, the listen address is "1" and the controller interface is select code "7".

3-221 Table 3-16 lists some of the Series 80 Controller statements that may be useful in programming the AC Power System on the GPIB. For additional statements and their descriptions refer to the Hewlett Packard I/O Programming Guide for the Series 80 Computer.

3-222 The following program will step the program voltage from 0 volt to 130 volts in .1 volt steps:

```
10 REMOTE 7
20 FOR V=0 TO 130 STEP .1
30 OUTPUT 701; "AMP"; V
40 NEXT V
50 END
```

The following program will load the parameters of 115 volts and 400 hertz. The Model AC Power System will output the parameters only after the K1 special function key of the Series 80 Controller is depressed to send the GET message.

```
10 REMOTE 701
20 OUTPUT 701 ; "AMP115 FRQ 400 TRG"
30 ENABLE KBD 32+64 ! ENABLE PAUSE AND SPECIAL FUNCTION KEYS
40 ON KEY # 1 GOTO 100 ! USE KEY K1 FOR DEVICE TRIGGER
50 GOTO 40

100 TRIGGER 701
110 END
```

The program example for SRQ uses the statements STATUS, ON INTR, ENABLE INTR, AND SPOLL.

The STATUS statement in line 20 is necessary to clear the Controller status register from any possible previous Service Request (SRQ) interrupts. The HP I/O Programming Manual is not clear on the use of the STATUS statement but it must be used after every SRQ and before enabling or reenabling the SRQ interrupt to prevent false SRQ indication. Line 30 causes the program to go to the interrupt subroutine at line 100.

The ENABLE INTR statement in line 40 enables the SRQ to generate an interrupt. A setup string in line 60 causes an SRQ to be generated. The SRQ interrupt subroutine is between lines 100 and 150.

The STATUS statement in line 120 clears the SRQ.

Line 130 generates a Status Byte from the AC Power System with listen/talk address "1".

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```
10  REMOTE 701 ! PUT INSTRUMENT#1 INTO REMOTE
20  STATUS 7,1,;Z! READ STATUS TO CLEAR HP SERIES 80 STATUS
    REGISTER.
30  ON INTR 7 GOSUB 100! ON SRQ GO TO ROUTINE AT LINE 100.
40  ENABLE INTR 7;8! ENABLE HP SERIES 80 FOR SRQ INTERRUPT.
50  ! THE FOLLOWING SETUP STRING WILL GENERATE AN SRQ AFTER COM-
    PLETION.
60  OUTPUT 701; AMP105 DLY10 VAL115 SRQ2.
70  WAIT 20000!
80  DISP "SETUP STRING DIDN'T GENERATE AN SRQ".
90  END
100 ! SERVICE REQUEST FOR DEVICE 1
110 ! USE SERIAL POLL TO DETERMINE STATUS BYTE
120 STATUS 7,1;Z ! READ STATUS TO CLEAR SRQ
130 A=SPOLL (701)
```

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SECTION 4

CALIBRATION PROCEDURE

4-1 GENERAL

4-2 The calibration is divided into two categories; a periodic and a nonperiodic calibration. The periodic calibration should be performed at a 1 year interval. The nonperiodic calibration should only be performed if the periodic calibration cannot be performed or if an adjustable subassembly is replaced.

4-3 The following is a listing of paragraphs that may be performed to fix an indicated problem. Any AC Power System with a 1-phase output or that has more than one chassis will have paralleled amplifiers.

PARAGRAPH	TITLE
4-8	OUTPUT VOLTAGE CALIBRATION
	This is a periodic calibration of the output voltage.
4-12	MEASUREMENT CALIBRATION
	This is a periodic calibration of the measurements of output voltage, current and power.
4-16	REMOTE MEASUREMENT CALIBRATION
4-21	REMOTE OUTPUT VOLTAGE CALIBRATION
4-27	OUTPUT FREQUENCY CALIBRATION
	This is a nonperiodic calibration of the output frequency.
4-26	GAIN ADJUSTMENTS FOR 1-BOX 3-PHASE SYSTEM
4-36	GAIN ADJUSTMENTS FOR 1-BOX 1-PHASE SYSTEM
	These are nonperiodic adjustments of the Current Limit Board, assembly 4009-702. The adjustments may have to be performed for the following reasons:

1. An output amplifier, assembly 4009-404-1, is replaced.

2. Unable to obtain rated output current from AC Power System with paralleled amplifiers.

A 1-box, 3-phase system has a 3-phase output with 1500 to 2000 VA per phase. A 1-box, 1-phase system has a 1-phase output with 4500 to 6000 VA.

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4-39 CURRENT TRANSFORMER ADJUSTMENTS FOR 1-BOX 3-PHASE SYSTEM

4-41 CURRENT TRANSFORMER ADJUSTMENTS FOR 1-BOX 1-PHASE SYSTEM

These are nonperiodic adjustments. The adjustments are required if it is impossible to perform the current or power measurement calibration (Ref. Paragraph 4-12).

4-43 SINGLE-PHASE ADJUSTMENTS FOR 1-BOX SYSTEM

This is a nonperiodic adjustment. The adjustment is required if the rated output current is not available from 1-phase AC Power Systems or other systems with paralleled amplifiers.

4-45 CURRENT LIMIT CALIBRATION

This is a nonperiodic calibration. The calibration is required if the available output current is not equal to the programmed current limit value. The available output current may exceed the programmed value by 10%.

4-47 OUTPUT PHASE ANGLE CALIBRATION

This is a nonperiodic calibration. The calibration is required if there is an error in the phase B or C output phase angle relative to phase A.

4-4 TEST EQUIPMENT

4-5 The following equipment or their equivalents are required to completely test the AC Power System.

TEST EQUIPMENT FOR PERIODIC CALIBRATION

1. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent.

2 100 Amp Current Transformer: Pearson Model 3468

3. Three Resistive Loads: 15 to 12.1 ohms, 1500 Watts

ADDITIONAL TEST EQUIPMENT

1. Two additional Digital Voltmeters

2. Frequency Counter: Philips PM 6671

3. Phase Angle Meter: Krohn-Hite 6500A

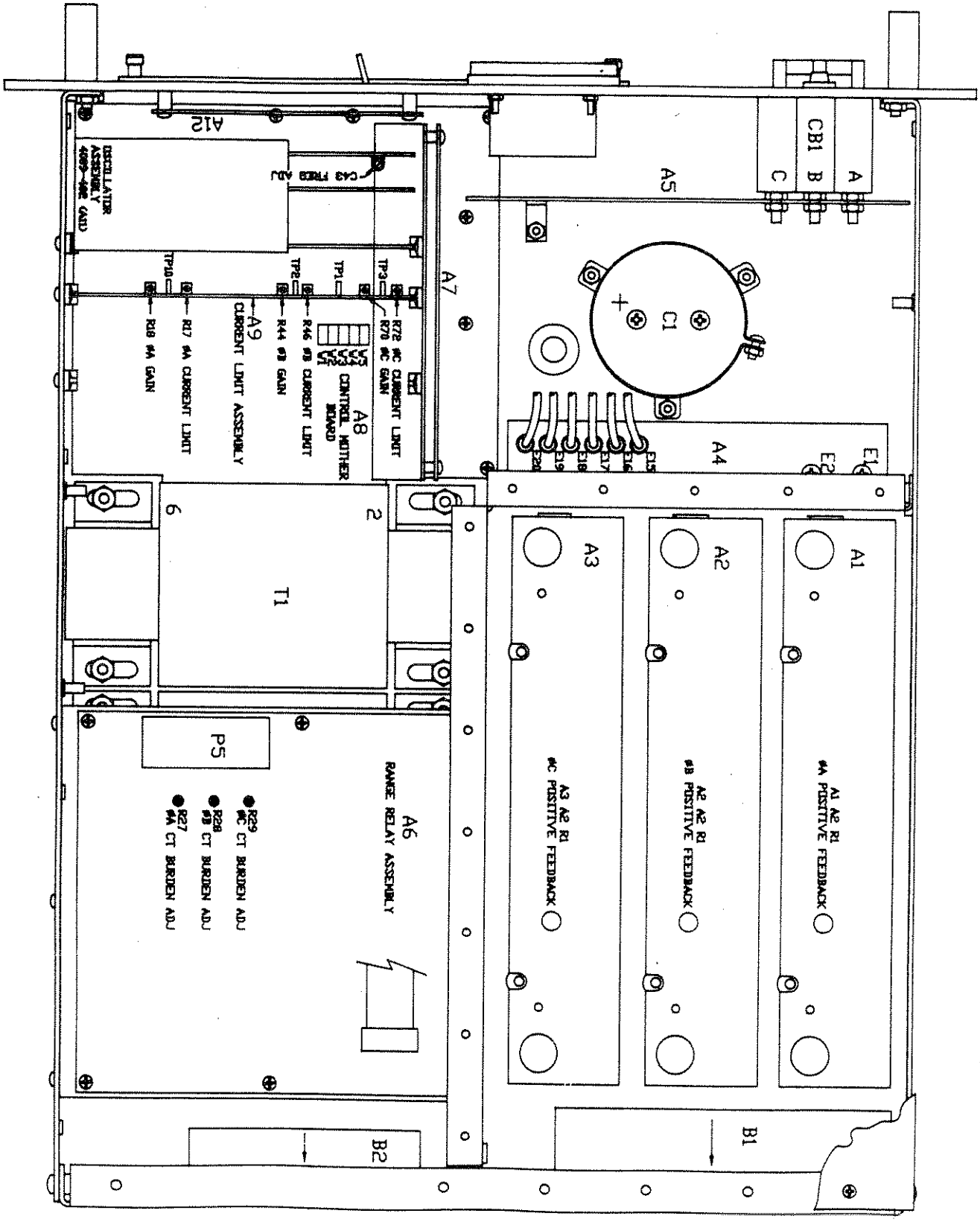


FIGURE 4-1

INTERNAL ADJUSTMENTS AND JUMPER LOCATIONS

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4-6 PERIODIC CALIBRATION

4-7 The following periodic calibration adjustments should be performed on a 1 year interval.

4-8 OUTPUT VOLTAGE CALIBRATION

4-9 Apply power to the AC Power System and allow at least fifteen minutes for temperature stabilization. Program the output to 60 Hz, 135 volts and perform the following steps:

1. Connect the AC voltmeter to the phase to be calibrated.

2. Depress the MNU key several times until the first menu screen is displayed as illustrated below.

```
 SNC = 01        *CLK = 02
*WVF = 03         RNG = 04
```

*May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

5. Select the CAL screen with the key sequence: 12 ENT

6. Depress the A, B or C key for the output phase to be calibrated. Verify that the other phases are in the MON mode. The A, B or C keys will switch the respective phase between the MON and PRG mode. If the output voltage is greater than the programmed output, depress and hold the ↓ key until the correct output voltage has been reached. The ↑ key is used if the output is less than the programmed value.

7. Repeat step 6 for the other outputs to be calibrated.

4-12 MEASUREMENT CALIBRATION

4-13 For calibration of voltage measurement first perform the output voltage calibration and then perform the followings steps:

1. Remove the load from the AC Power System and program 60 Hz and 135.0 volts.

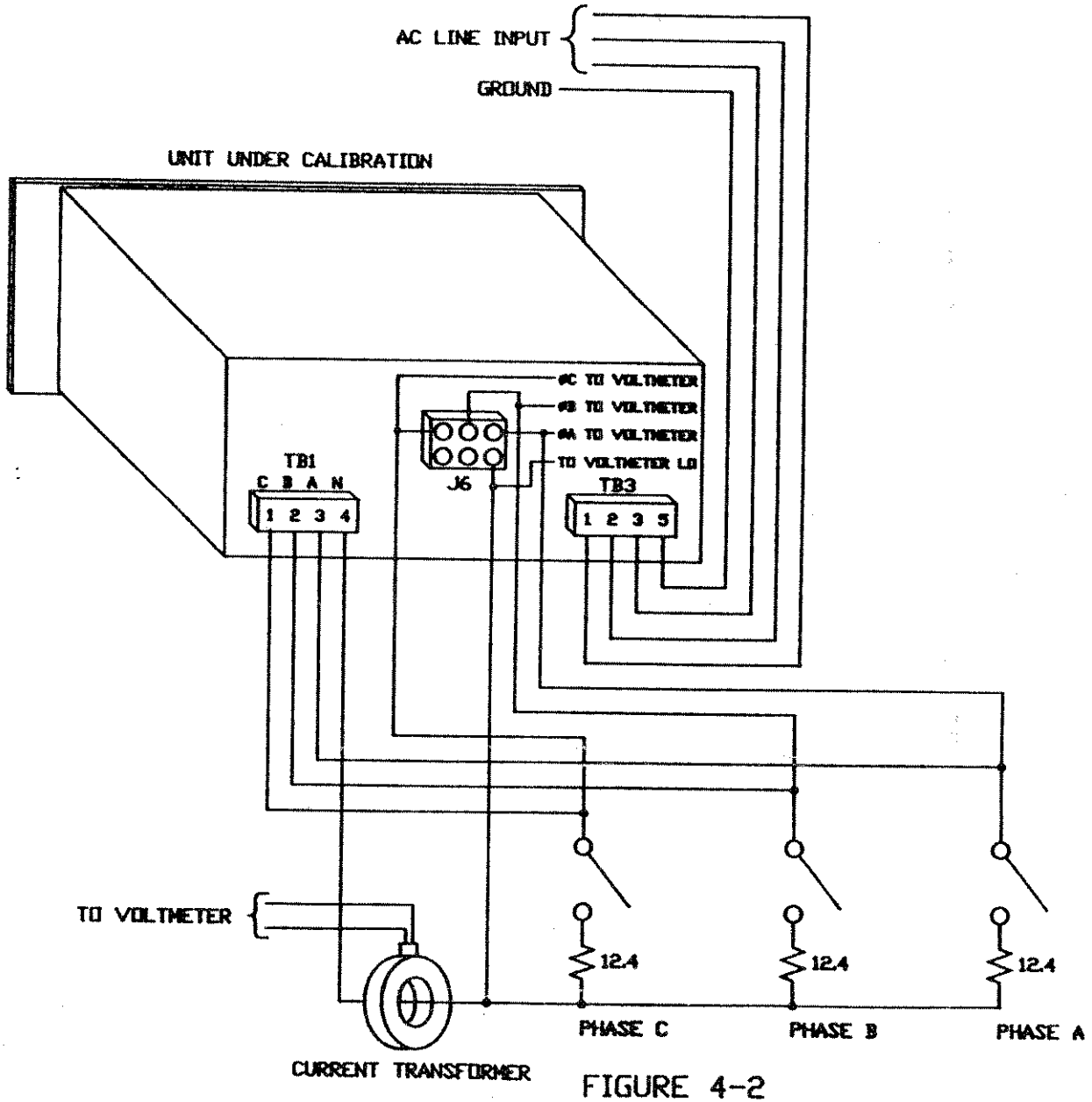


FIGURE 4-2
EQUIPMENT HOOKUP FOR
PERIODIC CALIBRATION

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2. Depress the MNU key several times until the Menu screen is displayed as illustrated below:

```
 SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

*May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT.

4. Depress the MNU key several times until the configuration menu screen is displayed.

```
CFG = 16          ALM = 17
FLM = 18          CLM = 19
```

5. Enter the key sequence 13 ENT to access the CAL VLT screen.

6. If all phases of the voltage measurement are to be calibrated to 135.0, enter the key sequence:

   135 PRG ENT

   After about 5 seconds, the volt measurement function will be calibrated for all three phases.

   If only one phase is to be calibrated to 135.0 volts (ex., phase A) enter the key sequence:

   135 A PRG ENT

4-14 For calibration of current measurement perform the following steps:

1. Program 60 Hz and 130.0 volts.

2. If any calibration screen is already displayed, the Current Calibration screen (CAL CUR) may be displayed by repeatedly depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, press the MNU key several times until the screen shown below is displayed:

```
 SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed.

5. Enter the key sequence: 14 ENT to access the CAL CUR screen.

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6. Apply the 12.3 to 15 ohm load to the phase A output. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer. If the AC Power Source in the system is configured to a 1-phase output (>2 KVA per phase) the three 12.3 to 15 ohm loads must be connected in parallel and connected to the phase A output.

7. On the keypad enter the key sequence:

   (Measured phase A current. Example 11.05) A PRG ENT

   After about 5 seconds the current measurement function for phase A will be calibrated.

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B current) B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

    (Measured phase C current) C PRG ENT

4-15 For calibration of power measurement perform the following steps:

1. Program 60 Hz and 145.0 volts.

2. If any calibration screen is already displayed, the Power Calibration screen (CAL PWR) may be displayed by depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, depress the MNU key several times until the screen shown below is displayed:

```
  SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as shown below:

```
CFG = 16          ALM = 17
FLM = 18          CLM = 19
```

5. Enter the key sequence 15 ENT to access the CAL PWR screen.

6. Apply the 12.3 or 15 ohm load to the phase A output. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer. Measure the phase A voltage from the phase A sense to neutral sense. Multiply the voltage and current values to determine the power value. (Note:

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The load must be resistive for the correct power value.) If the AC Power Source in the system is configured for a 1-phase output (>2 KVA per phase) the three 12.3 to 15 ohm loads must be connected in parallel to the phase A output.

7. On the keypad enter the key sequence:

   (Measured phase A power) A PRG ENT

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B phase) B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

    (Measured phase C power) C PRG ENT

4-16 REMOTE MEASUREMENT CALIBRATION

4-17 The measurement function of the AC Power System may be remotely calibrated. The equipment hookup is the same as before except an IEEE-488 Controller must be used to program the AC Power System. The values for the VLT, CUR and PWR strings must be derived from the external AC Digital Voltmeters and Current Transformer.

4-18 To calibrate the measured voltage, first program the AC Power System to 135.0 volts and 60 Hz. Send the following calibration string:

CAL VLT (1) (Measured voltage value for phase (1))

4-19 To calibrate the measured current send the following string:

CAL CUR (1) (Measured current value for phase (1))

4-20 To calibrate the measured power value send the following string:

CAL PWR(1) (Measured power value for phase (1))

4-21 REMOTE OUTPUT VOLTAGE CALIBRATION

4-22 The ASCII # symbol can be used with remote calibration to greatly reduce the calibration time. The ASCII # is used in place of a calibration coefficient to start the CAL ramp to start at the existing CAL coefficient and ramp up or down for a VAL argument of 255 or 0 respectively.

NOTE: (1) May include an A, B or C extension.

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4-23 The following string will cause the CAL coefficient to ramp down with a delay of .2 seconds per step:

```
CAL # DLY.2 VAL0
```

4-24 Figure 4-3 is a Flow Diagram for the Remote Calibration program that follows. The program was written in HP Basic for an HP Series 80 computer.

4-25 NONPERIODIC CALIBRATION

4-26 If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power System will have to be removed. A nonperiodic calibration will only be required if a related assembly is replaced or if the performance is out of specification.

4-27 OUTPUT FREQUENCY CALIBRATION

4-28 Connect the Frequency Counter to the phase A output. Program the output to 135.0 volts and 400.0 Hz. Engage the low-pass filter on the Frequency Counter to obtain the output frequency.

4-29 If the Frequency Counter does not indicate 400.000 $\pm$0.001 Hz, adjust C43 for the correct frequency. Refer to Figure 4-1.

4-30 GAIN ADJUSTMENTS FOR 1-BOX 3-PHASE SYSTEM

4-31 If the AC Power System has amplifiers operating in the parallel mode, skip to paragraph 4-36.

4-32 Remove all loads from the power source output and disconnect the Remote Sense inputs. Connect the AC DVM to the phase A output. Program the output to 100.0V rms and 60 Hz. Hold the ENT to prevent the output from defaulting to its initial condition.

4-33 Adjust A9R18 for a DVM indication of 110.0 $\pm$1V rms.

4-34 Repeat step 4-32 for phase B and C. Make the adjustments shown in Table 4-1.

4-35 Reconnect the Remote Sense lines.

PHASE	DVM CONNECTION	ADJUSTMENT OF CURRENT LIMIT ASSY	ADJUST FOR
A	Phase A	A9R18	110.0 $\pm$1.00 Vrms
B	Phase B	A9R44	110.0 $\pm$1.00 Vrms
C	Phase C	A9R70	110.0 $\pm$1.00 Vrms

TABLE 4-1

1-BOX 3-PHASE GAIN ADJUSTMENTS

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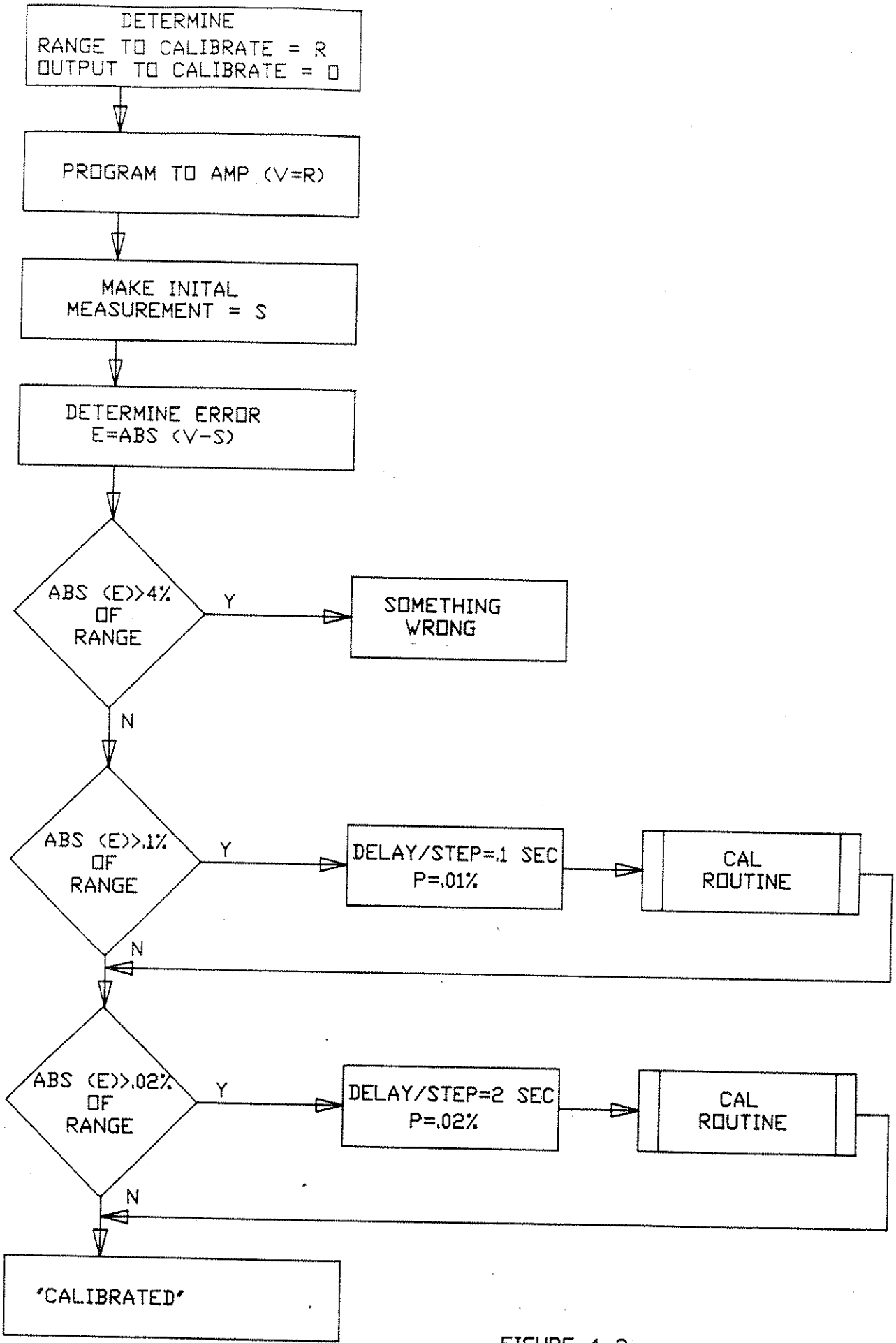


FIGURE 4-3

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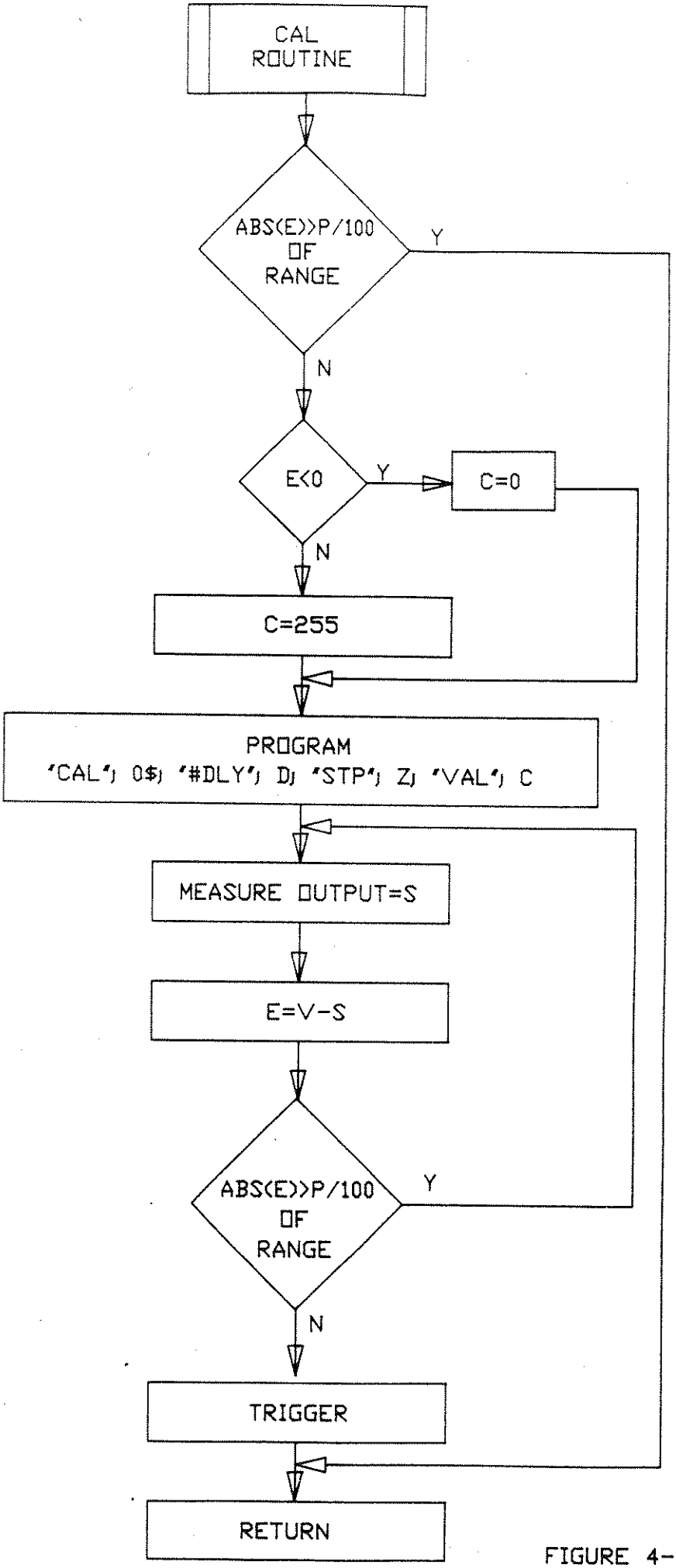


FIGURE 4-3 (CONTINUED)

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```
10  ! CAL
20  SET TIMEOUT 7;5000 ! SET BUS TIMEOUT TO 5SEC
30  ! CLEAR 7! SEND DEVICE CLEAR
40  CLEAR
50  ABORTIO 7
60  R=135
70  0$="A"
80  DISP "THE AC POWER SYSTEM ADDRESS MUST BE 1 AND "
90  DISP "THE 8506A AC DVM ADDRESS MUST BE 4."
100 DISP "PRESS K1 TO CONTINUE"
110 ON KEY# 1 GOTO 140
120 GOTO 120
130 OFF KEY#
140 DISP "WHAT VOLTAGE RANGE TO CAL 135 OR 270.DEFAULT IS ";R
150 INPUT C$
160 IF C$ <> "" THEN R=VAL (C$)
170 CLEAR
180 IF R=135 THEN DISP "WHAT CAL. VOLTAGE FROM 60 TO 135? THE
    DEFAULT IS 135"
190 IF R=270 THEN DISP "WHAT CAL. VOLTAGE FROM 120 TO 270? THE
    DEFAULT IS 270."
200 INPUT V$
210 IF V$ <> "" THEN V=VAL (V$) ELSE V=R
212 ON TIMEOUT 7 GOTO 2000
214 IF V>125 THEN OUTPUT 704 ;"VAR7,"
216 IF V>40 AND V<= 125 THEN OUTPUT 704 ;"VAR6,"
218 IF V<= 40 THEN OUTPUT 704 ;"VAR5,"
220 DISP "WHICH OUTPUT TO CAL(DEFAULT IS ";O$;")"
230 INPUT P$
240 IF P$ <> "" THEN 0$=P$
250 CLEAR
260 DISP "CONNECT THE 8506A AC DVM TO OUTPUT ";O$;"."
270 DISP "PRESS K1 TO CAL."
280 ON KEY# 1 GOTO 300
290 GOTO 290
300 OFF KEY#
310 GOSUB 1000
320 ! OUTPUT CALIBRATED TO WITHIN .02%
330 DISP "OUTPUT ";O$;" CALIBRATED. CAL ANOTHER OUTPUT(Y/N)"
340 INPUT A$
350 IF POS (A$,"Y")=1 THEN GOTO 220
360 LOCAL 7
370 END
500 ! CAL SUBROUTINE
510 ! DETERMINE IF OUTPUT IS WITHIN P% OF R
512 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
515 GOSUB 800
520 IF ABS (E)<P/100*R THEN GOTO 600
530 ! DETERMINE DIRECTION OF CAL COEFF. RAMP
540 IF E<0 THEN C=0 ELSE C=255
545 ON TIMEOUT 7 GOTO 3000
550 OUTPUT 701 ; "CAL AMP";O$;"#DLY";D;"STP";Z;"VAL";C
560 X=255
562 GOSUB 800
564 IF ABS (E)>ABS (X)+.005 THEN GOTO 590
```

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```
566 IF ABS (E)<P/100*R THEN GOTO 590
568 WAIT D*1000
570 X=E
580 GOTO 562
590 TRIGGER 701 ! STOP CAL RAMP WITH DEVICE TRIGGER
600 RETURN
800 ! MEASURE ROUTINE
810 OUTPUT 704 ; "?"
820 ENTER 704 ; 6
830 E=V-S
840 RETURN
1000 ! GEN CAL
1010 ! PROGRAM TO SELECTED RANGE AND AMPLITUDE
1020 OUTPUT 701 ;"FRQ400RNG";R;"AMP";V
1030 WAIT 2000
1040 ON TIMEOUT 7 GOTO 2000
1042 WAIT 2000
1050 GOSUB 800
1070 UF ABS (E)>,04*R THEN GOTO 3000 ! NOT AT EXPECTED OUTPUT
1080 D=1 @ P=.1 @ Z=10 ! DLY=.1SEC FOR CAL TO APPROX. .1%
1090 GOSUB 500
1100 D=1 @ P=.02 @ Z=1 ! DLY=1SEC FOR CAL TO .02%
1110 GOSUB 500
1120 RETURN
2000 DISP "DVM IS INACTIVE. INSURE ADDRESS IS 4."
2010 GOTO 360
3000 DISP "CHECK THAT THE ADDRESS IS 1."
3010 DISP "THE MEASURED OUTPUT IS ",S
3020 GOTO 360
```

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4-36 GAIN ADJUSTMENTS FO 1-BOX 1-PHASE SYSTEM

4-37 Before making the Gain adjustments, turn off the power to the AC Power System. Remove the Current Limit Assembly. Refer to Figure 4-1. Remove plug jumper W2 and reinstall the assembly.

4-38 Remove all loads from the output and disconnect the Remote Sense lines. Turn on the power to the system and perform the following adjustment on the
current Limit Assembly:

1. Connect the AC DVM to the phase A output. Program 100.0 VRMS and 60 Hz. Hold the ENT key to prevent the output from defaulting.

2. Connect the AC DVM to the phase A output. Adjust A9R18 for a DVM indication of 100.0 ±0.1 VRMS.

3. Connect the AC DVM to the phase B output. Adjust A9R44 for the phase A output voltage ±0.02 VRMS.

4. Connect the AC DVM to the phase C output. Adjust A9R70 for the phase A output voltage ±0.02 VRMS.

5. Turn off the power and reinstall jumper W2 on the Current Limit Assembly. Reconnect the Remote Sense lines.

4-39 CURRENT TRANSFORMER ADJUSTMENTS FOR 1-BOX 3-PHASE SYSTEM

4-40 If the AC Power System has amplifiers operating in the parallel mode, skip to paragraph 4-41 otherwise perform the following steps:

1. Monitor the phase A output current with the Current Transformer and AC DVM. Measure the phase A voltage between TP10 and TP1 on the Current Limit Assembly. Refer to Figure 4-1.

2 Turn on the AC input to the AC Power System. Program 135.0 VRMS and 60 Hz.

3. Apply the resistive load to the phase A output. Adjust R27 on the Range Relay assembly for the correct voltage at TP10 for the load current: (1 volt = 10 amps). Remove the load before loading the next phase to be calibrated.

4. Repeat steps 1 through 3 for phase B and C. Refer to Table 4-2 for the adjustments and test points.

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TABLE 4-2

CURRENT TRANSFORMER ADJUSTMENTS

PHASE	ADJUSTMENT (Range Relay Assy)	TEST POINTS (Current Limit Assy)
A	R27	TP10, TP1
B	R28	TP2, TP1
C	R29	TP3, TP1

4-41 CURRENT TRANSFORMER ADJUSTMENTS FOR 1-BOX 1-PHASE SYSTEM

4-42 The adjustments for this system identical to those in paragraph 4-30 except jumper W2 on the Current Limit Assembly must first be removed. After the jumper is removed and the Current Limit Assembly is reinstalled, turn on the power and follow the steps in paragraph 4-40. After the adjustments have been made, reinstall the jumper.

4-43 SINGLE-PHASE ADJUSTMENTS FOR 1-BOX SYSTEM

4-44 Three resistive loads must be used for the following adjustments. The resistance must be between 12.3 and 15 ohms. Three external AC DVMS must be used. The DVMs must be connected to test points on the Current Limit Assembly, A9. The input LO for all DVMs must be connected to TP1. The input HI of the 1st DVM must be connected to TP10, phase A. The input HI of the 2nd DVM must be connected to TP2, phase B. The input HI of the 3rd DVM must be connected to TP3, phase C. Perform the following steps:

1. Remove power from the AC Power System and remove jumper W2 from the Current Limit assembly. Reinstall the assembly and turn on the AC input power.

2. Remove all loads from power source output. The Remote Sense input must be disconnected.

3. With the DVM monitor the phase A output voltage.

4. Program output to 110 VRMS and 60 Hz. Record the output voltage.

5. Apply one 12.3 to 15 ohm load to the phase A output. Allow 15 seconds for load to stabilize.

6. Adjust A1-A2-R1 until the output voltage is 2.0 VRMS lower than the voltage recorded in step 4.

7. Turn off the AC Power System. Remove the Current Limit assembly and install jumper W2. Reinstall the Current Limit assembly and reconnect the Remote Sense lines. Turn on the input circuit breaker.

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8. Program the output to 135.0 volts and 60 Hz.

9. Apply one resistive load to the phase A output terminal. Monitor the phase A, phase B and phase C amplifier currents by measuring the voltages on TP10, TP2 and TP3 respectively on the Current Limit assembly. Adjust A2-A2-R1 and A3-A2-R1 so the voltages on TP2 and TP3 are equal to the voltage on TP10 ±0.02 VRMS.

10. Apply the three loads in parallel. Verify that the voltages at TP2 and TP3 are within ±0.05 VRMS of TP10. If the voltages are incorrect, adjust A2-A2-R1 and A3-A2-R1 until the voltages on TP2 and TP3 are equal to TP10 ±0.02 VRMS.

4-45 CURRENT LIMIT CALIBRATION

4-46 For the Current Limit Calibration perform the following steps:

1. If this is a 1-box, 1-phase system the jumper W2 will normally be installed on the Current Limit Assembly. This jumper must be removed for the following adjustments.

2. Program the Current Limit to 9.0 amps or 27.0 amps for a 1-phase system.

3. Monitor the output current with the external Current Transformer and AC voltmeter.

4. Program the output voltage to 115 volts and 60 Hz.

5. Apply one load resistor to the phase A output. If the output faults turn A9R17 on the current Limit Assembly counterclockwise and reprogram 115 volts.

6. Increase the output amplitude slowly until the external AC current transform indicates 10.0 amps. Slowly turn A9R17 on the Current Limit Assembly in a clockwise direction until the output faults.

7. Repeat steps 4 and 5 for phase B and C. Adjust A9R46 for phase B and A9R72 for phase C.

8. For a 1-phase system reinstall jumper W2.

4-47 OUTPUT PHASE ANGLE CALIBRATION

4-48 The phase calibration values for phases B and C are entered on the Phase Offset (POF) screen.

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4-49 To calibrate the output phase angle, connect either a Phase Meter or an oscilloscope between the phase to be calibrated and the phase A output. Program the phase B or C value to be calibrated from the Phase screen (PHZ). If an oscilloscope is used the calibration is best performed with a programmed angle of 0 degrees.

4-50 To calibrate the output phase angle, program 120.0 volts and 60 Hz.

4-51 To access the POF screen perform the following key sequences:

1. Access the Phase screen (PHZ).

2. Depress the MNU key several times until the following screen is displayed:

SNC = 01	CLK = 02
WVF = 03	RNG = 04

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the Configuration menu screen is displayed:

CFG = 16	ALM = 17
FLM = 18	CLM = 19

5. To display the POF screen enter the key sequence: 20 ENT

4-52 If an oscilloscope is used and the respective phase is programmed to 0 degrees and 200 Hz, a 3 degree error is represented by 41 microseconds of the 0 volt point of the two signals.

4-53 The POF values may be either a positive or negative value. A negative value is entered by depressing the . key two times after the numerical value is entered before the PRG key is depressed.

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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

5-3 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).

5-4 The Programmable Oscillator assembly (A11) generates the oscillator waveforms and power source control and measurement signals. The oscillator assembly is connected to the rest of the power source through the Control Mother Board, A10.

5-5 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.

5-6 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.

5-7 The board assemblies are described in more detail in the following paragraphs.

5-8 INPUT POWER SUPPLY

5-9 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.

5-10 The Input Power Supply also has circuits that generate the DC voltages identified as $\pm$18V, $\pm$15VSW, +8VSW and +8V.

5-11 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 and +8VSW supplies are used for the three Amplifier Modules.

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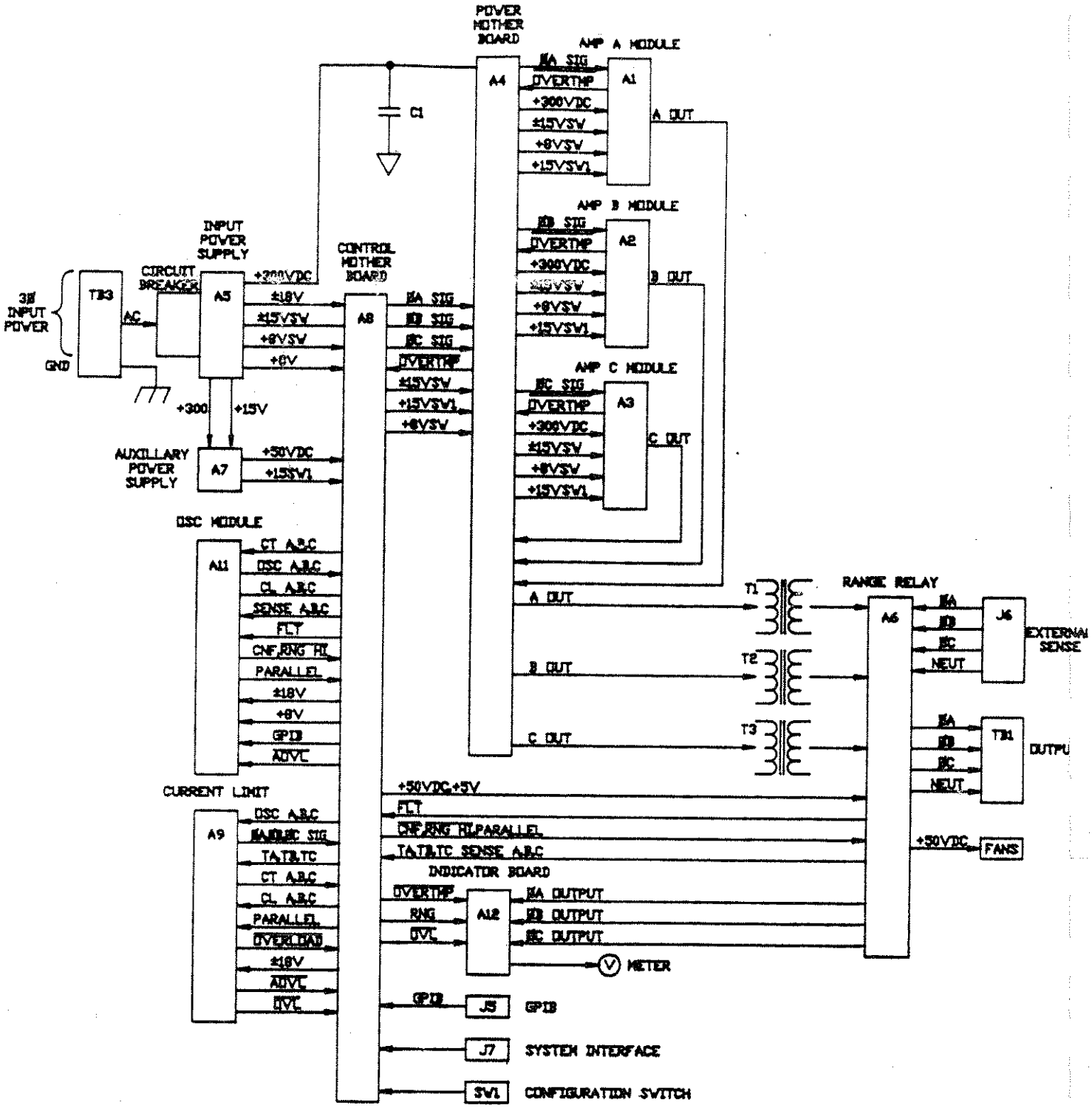


FIGURE 5-1
AC POWER SYSTEM BLOCK DIAGRAM

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5-12 AUXILIARY POWER SUPPLY

5-13 The Auxiliary Power Supply receives the +300 supply voltage from the Input Power Supply. The +300 supply voltage us 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.

5-14 CURRENT LIMIT BOARD

5-15 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.

5-16 The current limit circuits are also located on the Current Limit Board. These circuits receive a DC signal form the Oscillator Module, CLA, B and C, that is proportion 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.

5-17 The Current Limit Board has analog switches and summing amplifiers that are used for current measurements. The outputs from the summing amplifiers, CT A, B and C, are routed to the Oscillator Module for measurement. In the 1-phase mode the current from all 3 output current transformers are summed together for measurement. This signal is identified as CT A.

5-18 INDICATOR BOARD

5-19 The Indicator Board has the reference designator, A12. This board has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

5-20 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.

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5-21 RANGE RELAY BOARD

5-22 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.

5-23 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.

5-25 AMPLIFIER MODULES

5-26 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.

5-27 The Amplifier Modules operate in a switch mode to obtain high efficiency. These switchmode amplifiers operate at 200 KHz.

5-28 Each Amplifier Module obtains its input signal from the Current Limit Board. These three input signals are identified as ØA SIG ØB SIG and ØC SIG. A 4.6 VRMS input signal will generate a full scale output voltage at the output of the AC Power System and 90.0 VRMS on the primary of the output transformer.

5-29 Each Amplifier Module requires +300 DC, ±15 VSW, +8 VSW and the +15 VSW1 supplies. The +300 VDC supply comes from the Input Power Supply through a 10 amp fuse on the Power Mother Board.

5-30 The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100 degrees C, a control signal is sent to the Oscillator Module. A logic low on the OVER TMP control line will cause the error message TEMP FAULT to be generated.

5-31 OSCILLATOR MODULE

5-32 The Oscillator Module is identified with the reference designator, A11. The module consists of three printed circuit assemblies. These three assemblies are interconnected with a small mother board, A11A2. The oscillator Display Assembly connects to the Oscillator Module with a short ribbon cable. The Display Assembly is mounted on the front panel. The block diagram of the Oscillator Module is shown in Figure 5-2.

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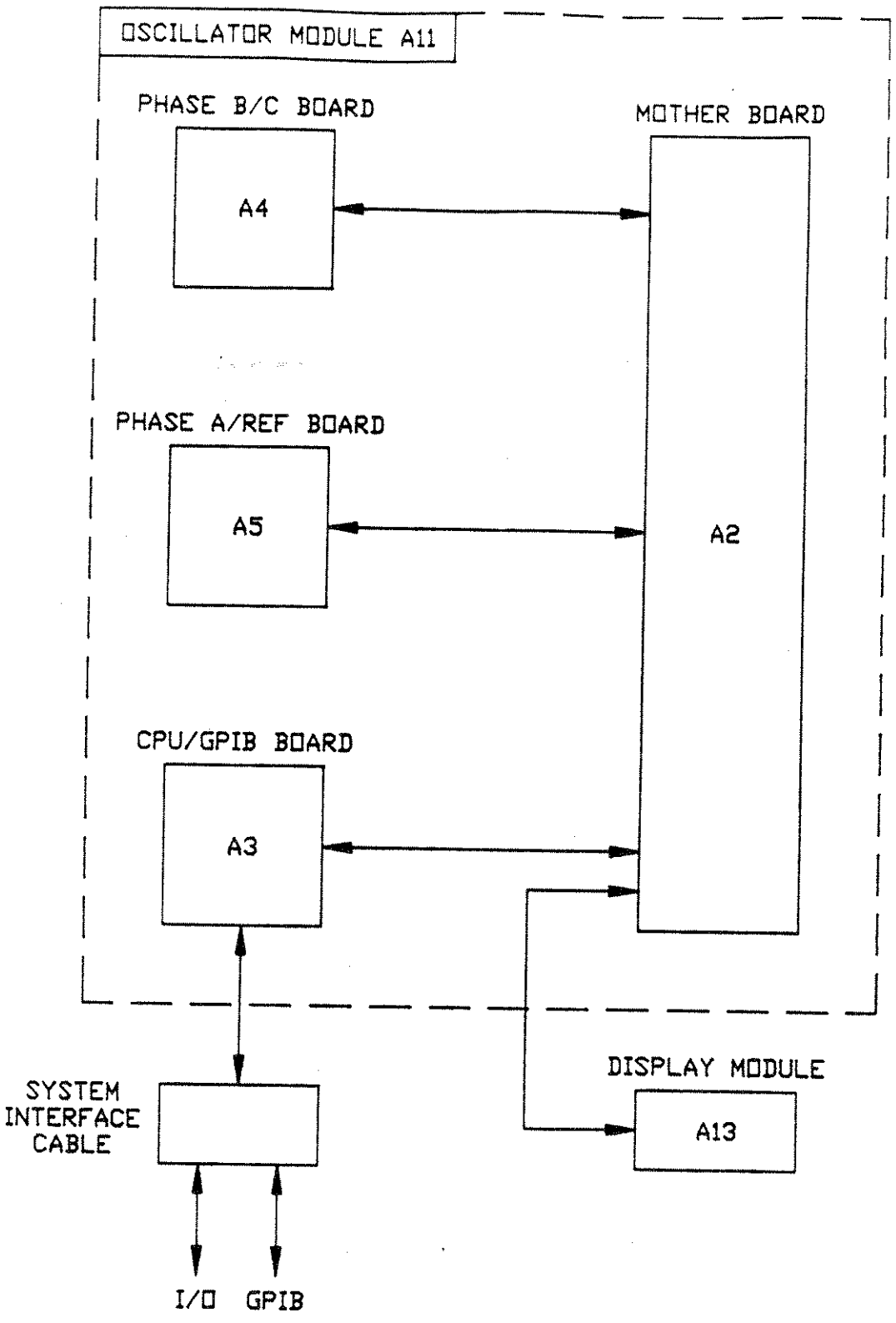


FIGURE 5-2
PROGRAMMABLE OSCILLATOR MODULE

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5-33 CPU/GPIB BOARD

5-34 The CPU/GPIB board, A11A3, provides the control and measurement functions of the module. A microprocessor circuit accepts commands from the GPIB or the front panel keyboard. It sends digital programming information to set the output parameters of the power source. Data from measurement circuits are accepted and reported to the display and GPIB. Measurement calibration coefficients are stored in a memory backed up by a battery. The battery has a 10 year life expectancy.

5-35 Measurement circuits on the CPU/GPIB board monitor voltage, current, power, frequency, and phase angle. Voltage from the rear panel sense connector is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

5-36 Current sensed by internal current transformers is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

5-37 The scaled voltage and current waveforms are applied to the inputs of a multiplier. The multiplier output is filtered to a DC level and digitized by the analog-to-digital converter.

5-38 Frequency is computed from the measured time intervals between zero crossings of the Phase A waveform. Phase is computed from the differences of measured zero crossings between the Phase A signal and the Phase B or Phase C signal.

5-39 A digital-to-analog converter on the CPU/GPIB board sets the DC voltages that are used for the programmable current limit function.

5-40 PHASE A/REF BOARD

5-41 The Phase A/Ref Board, A11A5, serves several purposes. A programmable clock sets the output frequency of the power source. Digital-to-analog converters program references to set the output amplitude of Phases A, B and C. A sine wave generator creates a 1024 step waveform which is filtered to provide the Phase A oscillator signal. A remote sense amplifier controls the Phase A output amplitude.

5-42 PHASE B/C BOARD

5-43 The Phase B/C Board, A11A4, uses the DC voltage references and programmable clock from the Phase A/Ref board to generate the Phase B and C oscillator waveforms. Remote sense circuits control the Phase B and C output amplitudes.

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5-44 DISPLAY MODULE

5-45 The Display Board, A11A13, is held to the power source by a small panel and is connected through a short ribbon cable. It holds the 20 button keyboard and a 32 character LCD display. A knob on the board allows the display viewing angle to be adjusted.

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SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6-1 GENERAL

6-2 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
6-3	Poor Voltage Accuracy	89
6-5	Poor Output Voltage Regulation	89
6-7	Overtemperature Lamp On	90
6-9	Overload Lamp On	90
6-11	Can't Program AC Power System on GPIB	91
6-13	Distorted Output	91
6-15	No Output	91

6-3 POOR VOLTAGE ACCURACY

6-4 If the power source exhibits poor programmed voltage accuracy, the following item may be at fault:

1. The calibration is incorrect.

   SOLUTION: Calibrate the output. Refer to Paragraph 4-8.

6-5 POOR OUTPUT VOLTAGE REGULATION

6-6 If the AC Power System exhibits poor voltage regulation the following item may be at fault:

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

   SOLUTION: Connect AC voltmeter to Remote Sense lines.

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6-7 OVERTEMPERATURE LAMP ON

6-8 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.

6-9 OVERLOAD LAMP ON

6-10 The OVERLOAD lamp comes on when the output load current has exceeded the programmed current limit value. In the 1-phase mode the lamp may come on prematurely if either the amplifier gain adjustment or 1-phase adjustment is incorrect. 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 programmable current limit level is set too low for the load being driven.

   SOLUTION: Compute and reprogram the correct programmable current limit level.

3. The programmable current limit is incorrectly calibrated.

   SOLUTION: Perform the calibration in paragraph 4-45.

4. In the 1-phase mode the amplifier load share is incorrect.

   SOLUTION: Perform the adjustments in paragraph 4-43 and 4-36.

5. Incorrect AC Power Source configuration. Check the ELT screen. It should show more than 24 hours of operation. If it shows less than 24 hours consult the factory.

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6-11 CAN'T PROGRAM AC POWER SYSTEM ON GPIB

6-12 If the power source does not respond to IEEE-488 GPIB programming, the following items may be at fault:

1. The power source unit address is wrong.

   SOLUTION: Update address. See paragraph 3-103.

2. GPIB cable is loose at power source rear panel.

   SOLUTION: Check connection, tighten jack screws.

3. The oscillator has failed.

   SOLUTION: Replace the oscillator. See Paragraph 6-19.

6-13 DISTORTED OUTPUT

6-14 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 program 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 program the current limit to a higher value.

6-15 NO OUTPUT

6-16 If the AC Power System has no output at the rear panel terminal block, TB1, the following items may be at fault:

1. If the Remote Sense lines are not connected correctly, there will be no output. The error message AMP FAULT will also be generated.

   SOLUTION Correctly connect the sense lines. Refer to Paragraph 2-9.

2. When the output is overloaded an error message will be generated and the output relays will open. The error message would be AMP FAULT.

   SOLUTION: Remove the overload. Observe the output power capabilities. Refer to Section 1.

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

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

   Program 135.0 volts on the 135 volt range. The three signals should be 4.74 ±0.5 VAC.

   SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6-17.

   SOLUTION: If the signal at the System Interface connector is greater than 4.74 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6-21.

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 6-21.

6-17 MODULE REMOVAL

6-18 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.

6-19 OSCILLATOR MODULE REMOVAL/REPLACEMENT

6-20 If a fault is found that requires the replacement of the Oscillator Module (assembly 4009-402-1) 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 Keyboard/Display assembly by loosening the two captive screws on its front panel.

4. Unplug the ribbon cable from the Keyboard/Display assembly.

5. Remove the Oscillator Module, A11, by pulling up the package of PC assemblies.

6. The module is now removed. To replace the module follow these steps in reverse order. Make sure the ribbon cable that plugs into the Keyboard/Display assembly runs between PC assembly, A12, and the front panel.

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6-21 AMPLIFIER REMOVAL/REPLACEMENT

6-22 If a fault has been found that indicates the failure of an amplifier module (assembly 4009-404), 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.

6-23 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 and 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.

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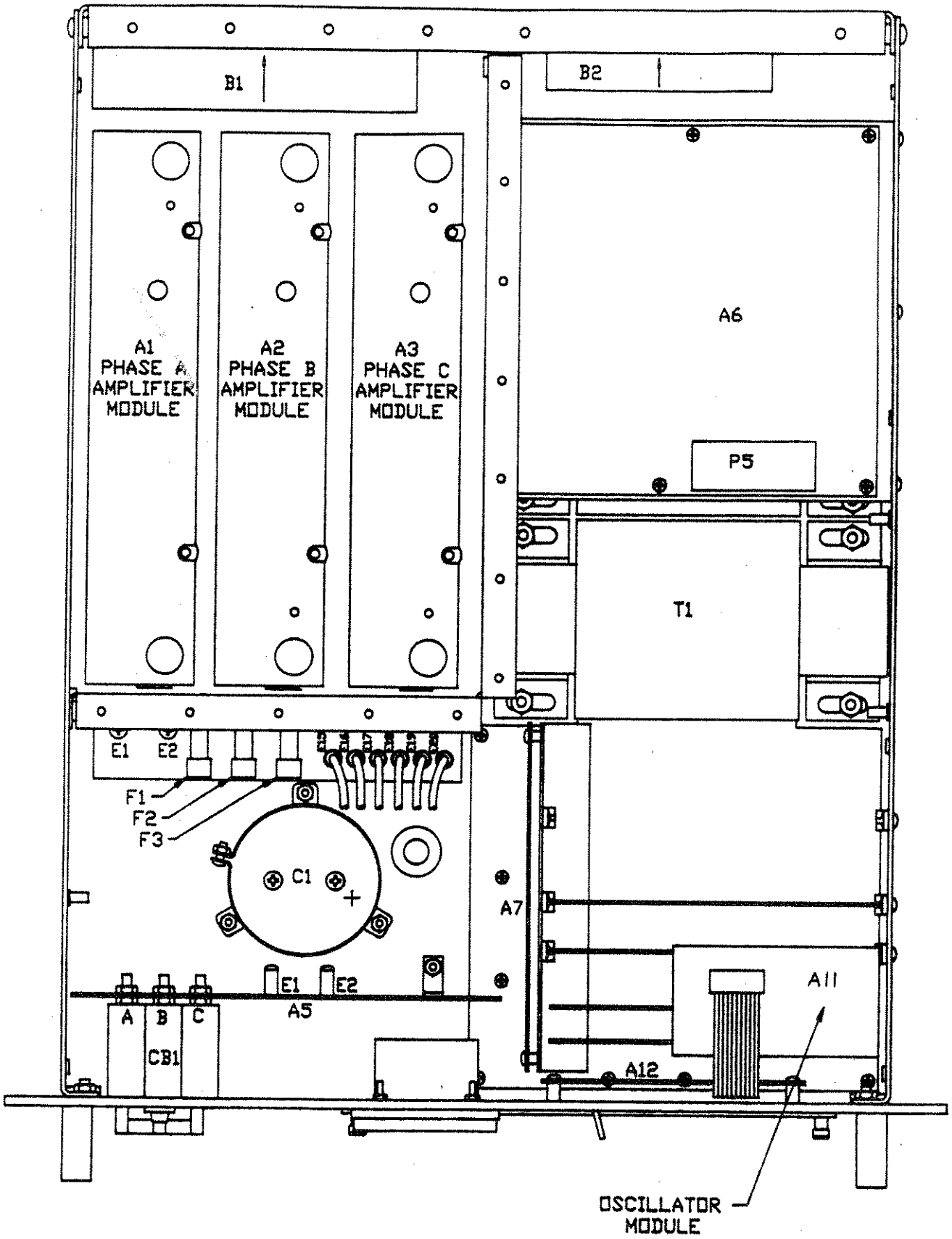


FIGURE 6-1
MODULE LOCATION

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SECTION 7

REPLACEABLE PARTS

7-1 GENERAL

7-2 This section contains ordering information and a list of replaceable parts. The list includes the parts description and California Instruments part numbers.

7-3 ORDERING INFORMATION

7-4 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 the component is located. (PARENT ITEM NO.)

c. Component reference designator. (SEQ NO.)

d. Component description.

e. Component manufactures' FSCM number. (VENDOR)

f. California Instruments' part number (COMPONENT ITEM NO.)

All replaceable part orders should be addressed to:

California Instruments
Attention: Customer Service
5125 Convoy Street
San Diego, California 92111

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TOP ASSEMBLY REPLACEABLE PARTS
FOR 4503L-4132
TOP ASSEMBLY NO: 4009-400-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4009-404-1	HEATSINK ASSY, SW AMP	16067	1.0
A2	4009-404-1	HEATSINK ASSY, SW AMP	16067	1.0
A3	4009-404-1	HEATSINK ASSY, SW AMP	16067	1.0
A4	4009-704-1	PC ASSY, MOTHER	16067	1.0
A5	4009-706-1	PC ASSY, POWER SUPPLY	16067	1.0
A6	4009-716-2	PC ASSY, RANGE	16067	1.0
A7	4009-711-1	PC ASSY, AUX POWER SUPPLY	16067	1.0
A8	4009-710-1	PC ASSY, MOTHER, CTRL	16067	1.0
A9	4009-702-2	PC ASSY, CURRENT LIMIT	16067	1.0
A11	4009-402-1	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	241180	FAN, 4", 48VDC	23936	1.0
C1	611295	CAP, AL, 3900UF, 400V	80031	1.0

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Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waudon,Surrey	GB
0000S(28564)	OPCDA (Potac Elect. Corp.)	Winsted	CT
0000W	Milton Road Co.	Southampton	PA
0000X(527455)	Tinca	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(551112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	Lafrance	Philadelphia	PA
000AH(543433)	Jan Crystal	Ft. Myers	CA
000AL(534955)	Data Components, Inc.	Gardena	CA
000AN	Kraus & Neimer	Santa Monica	CA
000AM	Ritz Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(626433)	United Chem-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(618371)	Semi Processes, Inc.	San Jose	CA
000AW	Mirosa	Chatsworth	CA
000AX(638703)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(612771)	Fujitsu	Santa Clara	CA
000BA(619643)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshima America, Inc.	Tustin	CA
000BD(559982)	Electronic Essentials	Woodside	NY
000BE(579561)	Kel-Am	Eldon	MO
000BF(553285)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(561186)	Micro Power Systems	Santa Clara	CA
000BJ(067761)	Robinson Nugent	New Albany	IN
000BL(131158)	Beau Products (Vernitron)	Laconia	NH
000BM(591725)	Corebinder (Gerard AJ & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secme	Bagnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Gow Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc. Use Code 472116	Des Plains	IL
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stanton, Wyte Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06778	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Keivin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Bitcher Corporation	Los Angeles	CA
07556	Unitrack Celabra Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IMC Incorporated Use Code 115818	Burrington	IA
07910	Loctite (Auto & Consumer Grp)	Mtn View	CA
08028	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08057	Accurate Rubber and Plastics	San Diego	CA
08065	Spectra Strip (Amphenol)	Garden Grove	
08261	Allan Deibert Co.	Pomona	CA
08289	Bristol Co. of Canada	Toronto, Ont	Canada
08353	Oatby & Barton (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09153	C & K Components	Newton	MA
09322	Burndy Corp.	Norwalk	CT
10189	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12406	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13606	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Sentron Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Ametek Ent (Rodan Div)	Anaheim	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amelco Teledyne, Inc.	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Ompco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scambe Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18725	Voltronics Corp.	Danever	NJ
19040	Rosiaom Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23916	Fametor, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Inc.	Tempe	AZ
24796	Paralea, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Ischier, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27338	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27681	Vero, Inc.	St. Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28626	Schlak Ltd.	Readale Ont.	Canada
29372	Raymond Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segundo	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Dorann Company	Sylmar	CA
30983	Electra/Midland (Repco/ Electra)	San Diego	CA
31827	Buddig Mfg. Co.	Pomona	CA
31951	Trididge, Inc.	Pittsburg	PA
31993	Interail	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33135	Logic Dynamics, Inc.	Gardena	CA
33716	Kingsdacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Caliber Corp.	Irvington	NJ
34218	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn, Ind. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Mouser Corp.	Santee	CA
51147	Acies Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Hatley	WI
51705	ICC/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Kintex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Towards Sheet Metal Works	Fredericktown	OH
54407	PowerOne Co.	Camarillo	CA
55322	Santek, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	NCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kel-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milpitas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Densitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74868	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Leviton Mfg. Co.	Little Neck	NY
75915	Littelfuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77068	Panel Inp. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Fetwin Div	Watertury	CT
77342	Potter and Bluefield Div, AMF	E. Princeton	IN
78189	Shakeproof Div. IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79136	Johns-Manville Products Corp	Chicago	IL
79963	Waldes Kohinoor Inc.	Long Island City	NY
80031	Elerick Mfg. Corp.	New Rochelle	NY
80223	Repco/Electra	Morristown	NJ
80294	United Transformer Co.	New York	NY
80495	Bourns, Inc.	Riverside	CA
81095	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81312	Triad Transformer Corp.	Venice	CA
81348	Winchester Electronics (Fed. Specs) Promulgated by Administration Washington DC	Oakville	CT
81349	General Services Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Raco Products Co.	Chicago	IL
81631	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82189	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
85440	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91947	National Tel-Tronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94696	Magnecraft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95967	Wechesser Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Tech, Inc.	Gardena	CA
98291	Sealetb Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IEMC	Burbank	CA
99017	Protective Closures Co., Inc. (Caplugs Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delavan	WI
99743	Permacell	New Brunswick	NJ
99763	IMC	Haywood	CA
99800	Delevan Electronics Corp.	Aurora	NY

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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.

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MANUAL ADDENDUN

4503L-4174

GENERAL:

The 4503L-4174 is identical to the standard 4503L except the output is limited to 1750 VA per phase at 35 degrees C. The initial frequency is also 400 Hz.

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