



**Advanced Test Equipment Rentals**

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**INSTRUCTION  
MANUAL  
751L-P/1501L-P/2001L-P**



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# Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.

	<p><b>Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment. Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.</b></p>
	<p><b>The equipment used contains ESD sensitive ports. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.</b></p>

Only *qualified personnel* who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.

Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment *must* be grounded properly for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.

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## SAFETY SYMBOLS



WARNING  
Risk of Electrical Shock



CAUTION  
Refer to Accompanying Documents



Off (Supply)



Direct Current (DC)



Standby (Supply)



Alternating Current (AC)



On (Supply)



Three-Phase Alternating Current



Protective Conductor Terminal



Earth (Ground) Terminal



Fuse



Chassis Ground

## Product Family: California Instruments Model 2003RP

Warranty Period: One Year

### WARRANTY TERMS

AMETEK Programmable Power, Inc. ("AMETEK"), provides this written warranty covering the Product stated above, and if the Buyer discovers and notifies AMETEK in writing of any defect in material or workmanship within the applicable warranty period stated above, then AMETEK may, at its option: repair or replace the Product; or issue a credit note for the defective Product; or provide the Buyer with replacement parts for the Product.

The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product or any part thereof:

- is damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- is damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- is installed or operated contrary to the instructions of AMETEK;
- is opened, modified or disassembled in any way without AMETEK's consent; or
- is used in combination with items, articles or materials not authorized by AMETEK.

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

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1. Request a Return Material Authorization (RMA) number from the repair facility (**must be done in the country in which it was purchased**):
  - **In the USA**, contact the AMETEK Repair Department prior to the return of the product to AMETEK for repair:  
Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)  
858-450-0085, ext. 2295 or ext. 2463 (direct)
  - **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, [www.programmablepower.com](http://www.programmablepower.com), by clicking Support and going to the Service Centers tab.
2. When requesting an RMA, have the following information ready:
  - Model number
  - Serial number
  - Description of the problem

**NOTE:** Unauthorized returns will not be accepted and will be returned at the shipper's expense.

**NOTE:** A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

## SAFETY SUMMARY

**This power source contains high voltage and current circuits which are potentially lethal. Because of its size and weight, mechanical stability must be ensured. The following safety guidelines must be followed when operating or servicing this equipment. These guidelines are not a substitute for vigilance and common sense. California Instruments assumes no liability for the customer's failure to comply with these requirements.**

### BEFORE APPLYING POWER

1. Verify the correct voltage is applied to the unit.
2. The chassis and cabinet of this power source must be grounded to minimize shock hazard. A chassis ground is provided at the input terminal block. This is located at the back of the cabinet on the lower right hand side. The chassis ground must be connected to an electrical ground through an insulated wire of sufficient gauge.

### FUSES

Use only fuses of the specified current, voltage, and protection speed (slow blow, normal blow, fast blow) rating. Do not short out the fuse holder or use a repaired fuse.

### DO NOT OPERATE IN A VOLATILE ATMOSPHERE

Do not operate the power source in the presence of flammable gases or fumes.

### DO NOT TOUCH ENERGIZED CIRCUITS

Disconnect the power cable before servicing this equipment. Even with the power cable disconnected, high voltage can still exist on some circuits. Discharge these voltages before servicing. Only qualified service personnel may remove covers, replace components or make adjustments.

### DO NOT SERVICE ALONE

Do not remove covers, replace components, or make adjustments unless another person, who can administer first aid, is present.

### DO NOT EXCEED INPUT RATINGS

Do not exceed the rated input voltage or frequency. Additional hazards may be introduced because of component failure or improper operation.

### DO NOT MODIFY INSTRUMENT OR SUBSTITUTE PARTS

Do not modify this instrument or substitute parts. Additional hazards may be introduced because of component failure or improper operation.

### MOVING THE POWER SOURCE

When moving the power source, observe the following:

- Use two people to prevent injury.

### SURFACE STABILITY

1. Operate the power source only on a level surface.
2. Verify that the floor will support the weight of the power source.

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## 1. INTRODUCTION

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### 1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the California Instruments Model 2001L-P/1501L-P and 751L-P. The 2001L-P/1501L-P and 751L-P will hereafter be referred to as the AC Power Source. The difference between the 2001L-P/1501L-P and 751L-P will be detailed throughout the manual.

### 1.2 GENERAL DESCRIPTION

This instrument is a high efficiency power source that provides a low distortion sine wave output. The AC Power Source can supply up to 2000VA for the 2001L-P, 1667 VA for the 1501L-P and 835 VA for the 751L-P. See the following table for the full output VA rating.

<u>MODEL</u>	<u>OUTPUT VA</u>	
	35° C	50° C
2001L	2000	1800
1501L	1667	1500
751L	835	750

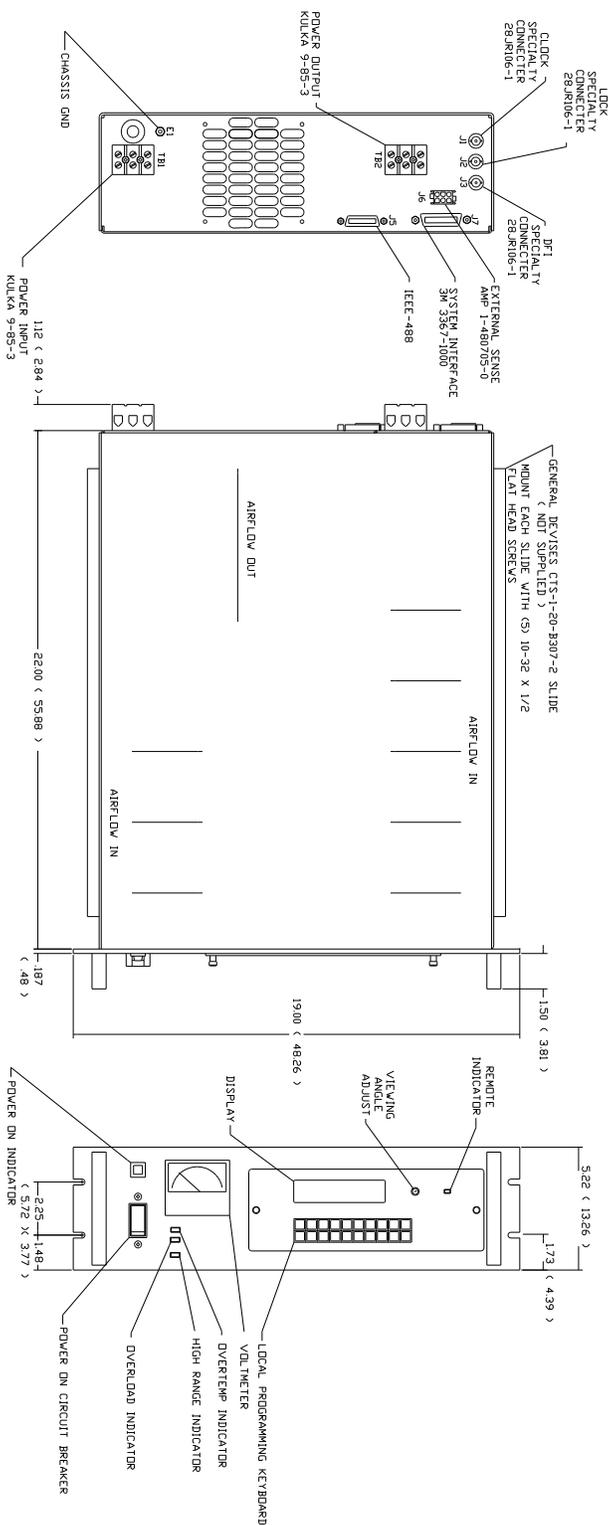
Full power is available at the maximum output voltage on either of two voltage ranges. The standard voltage ranges are 135 and 270. Three optional voltage range pairs are available: 67.5/135, 156/312 and 200/400.

Full power is available from 45 Hz to 5 KHz except for the 200/400 volt range (EHV option). The upper limit for the EHV range is 1000 Hz. The AC Power Source is illustrated in Figure 1-1.

### 1.3 ACCESSORY EQUIPMENT/RACK SLIDES

General Devices Model CTS-1-20-B307-2 rack slides may be attached to the sides of the power source using 10-32 X 1/2 flat head screws.

Figure 1-1: 751L-P/1501L-P/2001L-P



**1.4 SPECIFICATIONS**

Table 1-1 contains the operation specifications of the AC Power Source. 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.

**2001L/1501L /751L-P SPECIFICATIONS**

**ELECTRICAL SPECIFICATIONS**

All specification apply using external sense, 25±1° C, constant line and load condition, after 15 minute warm up unless other wise specified.

**OUTPUT**

Model	POWER, VA		CURRENT, 135V		CURRENT, 270V	
	35°C	50°C	35°C	50°C	35°C	50°C
2001L	2000	1800	14.8A	13.33A	7.4A	6.66A
1501L	1667	1500	12.34A	11.12A	6.18A	5.56A
751L	835	750	6.18A	5.56A	3.09A	2.78A

All other Voltage Ranges: Current = Power/Voltage Range

- Power factor: 0 to 1.0
- Peak Repetitive Current:
  - 2001L = 4.0 times maximum current at 50°C
  - 1501L = 5.0 times maximum current at 50°C
  - 751L = 6.0 times maximum current at 50°C
- Peak Non-repetitive (20 ms) Current:
  - 2001L = 4.0 times maximum current at 50°C
  - 1501L = 5.0 times maximum current at 50°C
  - 751L = 6.0 times maximum current at 50°C
- Voltage range:
  - 135/270 volts STD
  - 67.5/135 volts LV option
  - 156/312 volts HV option
  - 200/400 volts EHV option
- Total Distortion (to 300 KHz) with a linear load.
  - 1% up to 2 KHz,
  - 2% up to 5 KHz.
- Line regulation: 0.02% of full scale for ±10% of input line voltage.
- Load regulation: 0.05% of full scale from no load to full load.

Voltage accuracy (at no load):

$\pm 0.135$  volts from 5 to 135 volts  
 $\pm 0.54$  volts from 135 to 312 volts

Voltage accuracy (below 45 Hz)

Add 2% of programmed value.

Voltage accuracy (EHV option only 45 Hz to 1000 Hz)

$\pm 1.5$  volts 5 to 200 volts.  
 $\pm 3.0$  volts 200 to 400 volts.

Frequency range:

45 Hz to 5 KHz at 50°C max. current.  
45 Hz to 2 KHz at 35°C max. current.  
45 Hz to 1 KHz for EHV option.

Frequency accuracy:  $\pm 0.001\%$  of programmed value.

## PROTECTION

Output overload: Default to initial volts and open output relay, no recovery.

Output short circuit: Default to initial volts and open output relay, no recovery.

Sense Line Fault: Default to initial volts and open output relay if applicable, no recovery.

Overtemperature: Default to initial volts and open output relay if applicable, no recovery.

## MEASUREMENTS

Voltage accuracy:  $\pm 1.0$  Volt.  
Voltage resolution: 0.1 Volt.  
Current accuracy:  $\pm 0.1$  Amps.  
Current resolution: 0.01 Amps.  
True power accuracy:  $\pm 10$  Watts.  
True power resolution: 1 Watt.  
Apparent power resolution: 1 VA  
Power factor resolution: 0.001.  
Frequency accuracy:  $\pm 0.02$  Hz to 99.99 Hz,  
 $\pm 0.2$  Hz to 499.9 Hz,  
 $\pm 0.5$  Hz to 999.9 Hz,  
 $\pm 10$  Hz to 5000 Hz.  
Measurement Accuracy:  
below 45 Hz add 2% of reading.

**2001L/1501L /751L-P SPECIFICATIONS(continued)**

**SUPPLEMENTAL SPECIFICATIONS**

**ELECTRICAL**

**Input**

Line voltage: 103 - 127 VAC.

187 - 253 VAC.

Current, worst case (pf=0.6, eff=75%, volt=103, full load): 36 Amps (2001L)

Line frequency: 47 - 440 Hz.

Efficiency: 75% typical.

Surge current (turn-on) 185 amps peak at 253 VAC input voltage.

**Output**

Output noise (20 KHz to 1 MHz at full load)

160 mv rms (typical)

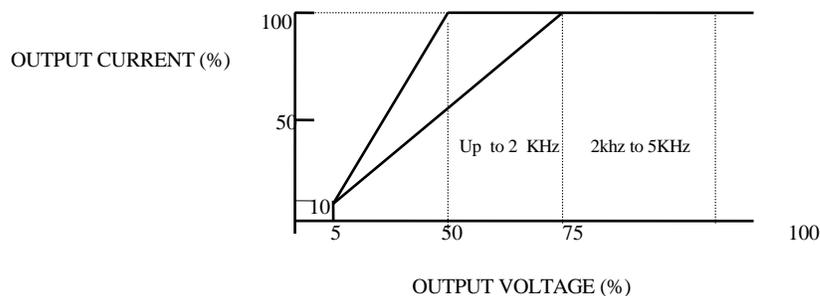
Voltage temperature coefficient:

$\pm 0.02$  of full scale/ $^{\circ}$  C.

Voltage stability (24 hours):

$\pm 0.015\%$  of full scale under constant load, line and temp.

Full Current Range: (See graph below)



Steady state output impedance:

= (voltage range \* 0.0005)/load current.

**Voltage settling Time:**

(from start of voltage change from 5.0 V rms or higher voltage within 2% of final value)

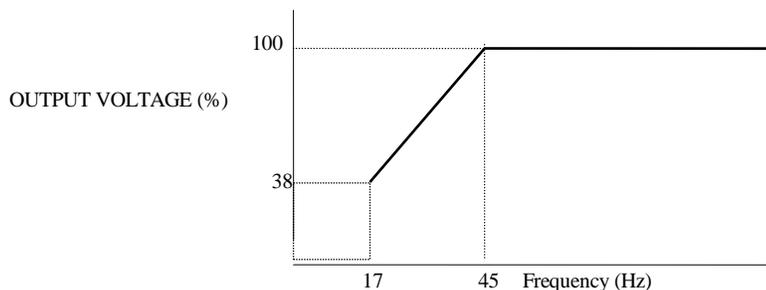
No load: 16 msec.

Full load: 0.3 sec.

(16 msec to within 15% of final value)

**Frequency Range:**

At less than Full-scale Voltage: (Refer to graph below)

**Frequency temperature coefficient:**

±5 ppm per degree C.

**Frequency Stability:**

±15 ppm per year.

**Isolation:**

500 Volts rms input to output.

**CONTROL****Front panel controls:**

- Power on/off circuit breaker with indicator.
- Key Keypad.  
Bus: IEEE 488.
- Subsets: SH1, AH1, T6, L3, SR1, RL2, DC1, DT1.
- Codes and formats:
  - Numeric NR1, NR2, or NR3.
  - Headers: HR1 or HR2.
  - Message separators: SR1.
- Data transfer rate 200K bytes/ second. DMA mode.
- Language: California Instruments language that is upward compatible from other C.I. products.

**Functions****Voltage:**

Range: 0 to voltage Range

Resolution: 0.1 Volt

Initialization: 5.0 Volts STD

**Voltage Range:**

Range: 135/270

Resolution: 0.1 Volt.

Initialization: Low Volt Range.

Frequency:

Range: 45 to 5000 Hz (1000Hz EHV).

Resolution: 0.01 Hz from 45 to 99.99 Hz,  
0.1 Hz from 100 to 999.9 Hz,  
1 Hz from 10x to 5000 Hz.

Initialization: 60 Hz STD

Current Limit:

Range:

2001L 0 TO 14.8 Amp on 135V range.  
0 to 7.4 Amp on 270V range.

1501L 0 to 12.34 Amp on 135V range  
0 to 6.18 Amp on 270V range

751L 0 to 6.18 Amp on 135V range  
0 to 3.09 Amp on 270V range.

For other Voltage Ranges:

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

Accuracy: -0 to +15% of programmed value

Resolution: 0.01 Amp

Initialization: Maximum value of range

Phase Angle: (to external sync only)

Range: 0 to 999.9 degree

Resolution: 0.1 degree

Initialization: Last setup value

Sync:

Range: Internal/External

Initialization: Internal

Clock: (Option only)

Range: Internal/External

Initialization: Internal

Waveform: (Option only)

Range: Sine wave/square wave

Initialization: Sine wave.

Drop Period:

Range: 1 to 5 cycles  
Drop Point 0 to 360 degrees

Sweep/step:

Of voltage, frequency, current up to two functions simultaneously.

Calibrations:

Of output voltage and Measurement functions

Service request:

Remote function only with option to enable and disable after errors, faults, and end of measurements.

Status:

Remote Status Byte and Status Message.  
Display Status Message only.

Group Execute Trigger:

Remote function only, Trigger setups and terminate programs.

Registers and Register Linking:

16 Register will store programmable parameter with abilities to link them to each other.

## FEATURES

Remote shut down:

A logic low input program, the output to initial volt and open the output relay if applicable.

Output Relay:

Normally open at power up. In local control, relay will close with the first programmable function. Output Relay can be controlled remotely.

Function Sync:

400usec low logic output level when voltage and frequency is programmed.

External Sync:

A TTL logic level with a frequency of 45 Hz to 5 KHz as an input. The output will track the frequency and phase of the input.

Remote Sense:

Will compensate for 10% drop in output voltage wiring loss.

Indicators:

Power on, high voltage range, overtemperature, output overload, and 2 lines 16 character each LCD type display.

Elapse Time Indicator:

Display the accumulated Power-on time.

**MECHANICAL**

Dimensions: 5.25 inches (13.3 cm)high,  
23 inches (58.4 cm) deep,  
19 inches (48.3 cm) wide

Weight: 2001L - 75 lbs (34 kg)  
1501L - 75 lbs (34 kg)  
751L - 75 lbs (34 kg)

Material: Aluminum front panel, steel chassis.

Finish: Gray 26440 per Fed Std 595.

Air intake/exhaust: Sides/rear.

Modularity: Modules interconnected with motherboard.

Connectors: Input - Kulka 9-85-3.  
Output - Kulka 9-85-3.  
Sense - Amp 1-480705-1.  
Interface - 3M3367-1000.

Chassis slides: Zero Manufacturing CTN-1-20-E94.

**ENVIRONMENTAL AND QUALITY**

Operating temperature: 0 to 50°C.

Storage temperature: -40 to 85°C.

Operating altitude: 0 to 6000 feet.

**OPTIONS:**

Output Voltage Ranges:

High Voltage: 156/312 V

Low Voltage: 67.5/135 V

Extra High voltage: 200/400 V

Master:

Must use LK Option

Slave:

Must use LK Option

Square Wave:

Rise Time: 40usec(10% to 90%).

Droop: 10%

Overshoot: 20% (resistive load)

MATE:

Use CIIL language with Confidence Test. (1501L only)

MIL704D:

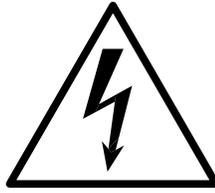
Performs all sections of MIL704D

RTCA/DO-160C (DO-160C Option)

Performs all sections of RTCA/DO-160C

**SYSTEMS**

None



## CAUTION

Voltages up to 400 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.



## DEATH

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

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## 2. INSTALLATION AND ACCEPTANCE

---

### 2.1 UNPACKING

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

### 2.2 POWER REQUIREMENTS

#### 2.2.1 AC LINE VOLTAGE

The AC Power Source has been designed to operate from either of the following AC line voltage ranges:

- 1) 103 to 127 volts
- 2) 187 to 253 volts

---

**CAUTION:** *The AC Power Source will be damaged if it is operated at an input voltage that is outside its configured input range.*

---

The input voltage range is set at the factory. Section 2.3 gives the procedure to change the input voltage range.

#### 2.2.2 LINE FREQUENCY OPERATING RANGE

The AC Power Source has been designed to operate with a line frequency from 47 Hz to 440 Hz.

#### 2.2.3 INPUT POWER

The input power to the AC Power Source depends upon line and load conditions and may be as high as 2650 watts. (2001L)

### 2.3 INPUT VOLTAGE RANGE SELECTION

---

**WARNING:** *Voltages up to 360 VDC and 400 VAC are present in certain sections of this power source. This equipment generates potentially lethal voltages.*

---

---

**DEATH:** *On contact may result if personnel fail to observe safety precautions. Do not touch electric circuits when power is applied. Servicing should only be performed by trained personnel.*

---

The input voltage range is configured by two wires and eight jumpers. See Figure 2-2 or Figure 2-3 for the location of the A6 board (DC Supply) where the jumpers are located.

### **2.3.1 LOW INPUT VOLTAGE RANGE CONFIGURATION (103-127V) Figure 2-2**

In order to change the voltage range configuration:

1. Turn off the input circuit breaker.
2. Disconnect AC input power at TB1.



3. Remove the AC Power Source top cover by removing (13) #6-32 x 5/16" FLH screws.



4. Remove the (2) #6-32 x 1" PHN screws and lock washers that hold the amplifier module from the far end opposite the connector.



5. Remove the (2) #6-32 x 3/8" PHN screws and lock washers located near the connector, attaching the red insulator to the center bracket.

6. Remove the amplifier by lifting its end up and disconnecting from the connector.



7. Locate and remove the (2) #8-32 x 1/2" FLH screws on the outside of the chassis which attaches the perforated support bracket to the chassis, and lift perforated support bracket up and out of unit.

The low input voltage range is set by making the following connections inside the power source:

Wire W5 4005-050-005 From CB1B-LN to A6-E2.

Wire W11 4005-050-011 From DS1 to A6-E7.

Jumper A6-J1 From 2 to 5.

Jumper A6-J1 From 3 to 4.

Jumper A6-J2 From 2 to 5.

Jumper A6-J2 From 3 to 4.

Jumper A6-J3 From 2 to 5.

Jumper A6-J3 From 3 to 4.

Jumper A6-J4 From 2 to 5.

Jumper A6-J4 From 3 to 4.

**2.3.2 HIGH INPUT VOLTAGE RANGE CONFIGURATION (187- 253V) Figure 2-3**

In order to change the voltage range configuration:

1. Turn off the input circuit breaker.
2. Disconnect AC input power at TB1.
3. Remove the AC Power Source top cover by removing (13) #6-32 x 5/16" FLH screws.
4. Remove the (2) #6-32 x 1" PHN screws and lock washers that hold the amplifier module from the far end opposite the connector.
5. Remove the (2) #6-32 x 3/8" PHN screws and lock washers located near the connector, attaching the red insulator to the center bracket.
6. Remove the amplifier by lifting its end up and disconnecting from the connector.
7. Locate and remove the (2) #8-32 x 1/2" FLH screws on the outside of the chassis which attaches the perforated support bracket to the chassis, and lift perforated support bracket up and out of unit.

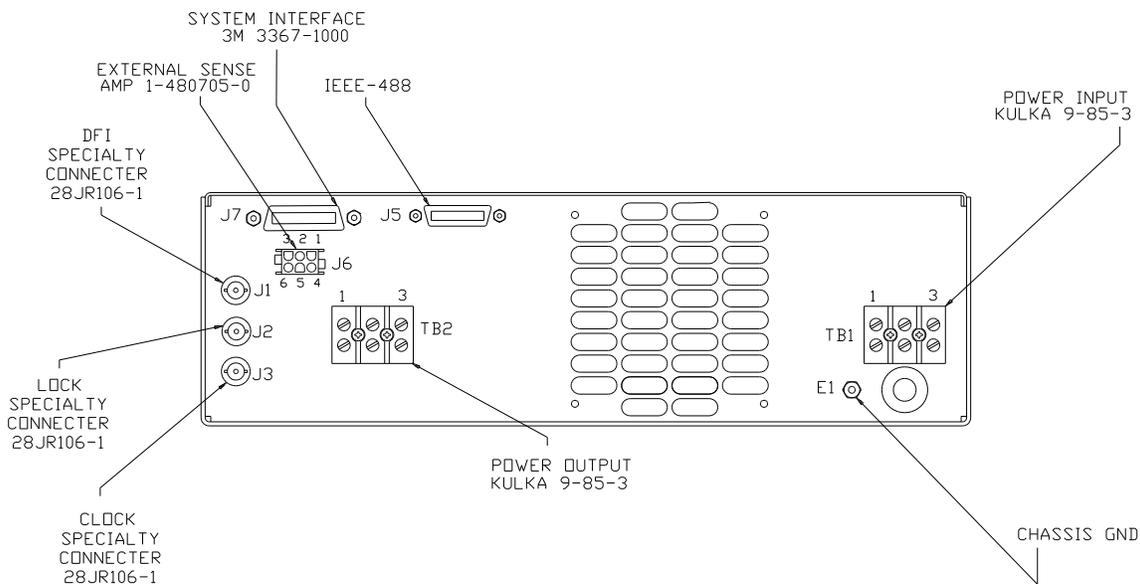
The high input voltage range is set by making the following connections inside the power source:

Wire W5 4005-050-005 From CB1B-LN to CR1-AC.

Wire W11 4005-050-011 From DS1 to A6-E4.

- |              |              |
|--------------|--------------|
| Jumper A6-J1 | From 1 to 6. |
| Jumper A6-J1 | From 2 to 3. |
| Jumper A6-J2 | From 1 to 6. |
| Jumper A6-J2 | From 2 to 3. |
| Jumper A6-J3 | From 1 to 6. |
| Jumper A6-J3 | From 2 to 3. |
| Jumper A6-J4 | From 1 to 6. |
| Jumper A6-J4 | From 2 to 3. |

Figure 2-1: 751L-P/1501L-P/2001L-P Rear Panel Connections

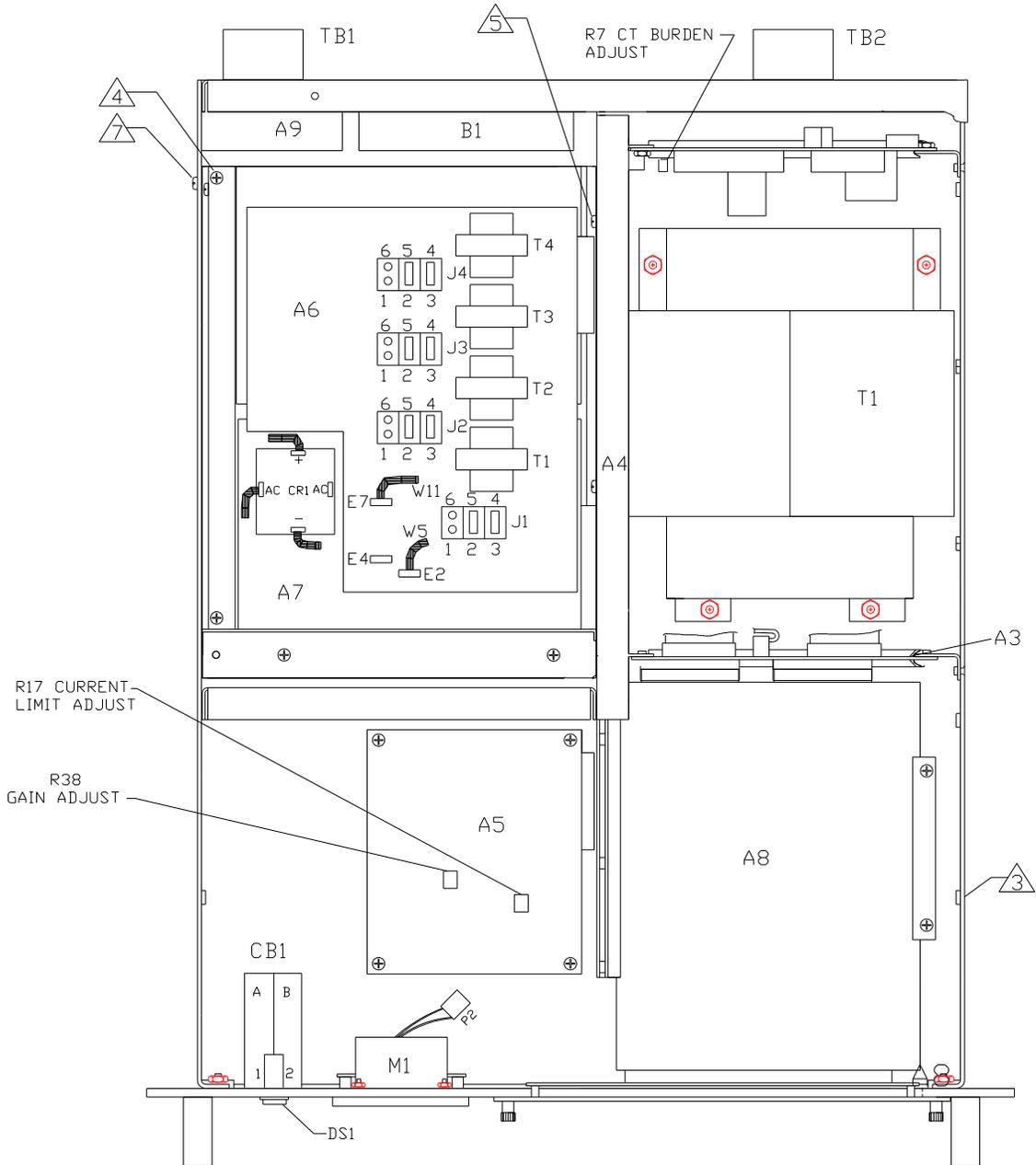


TB1	
PIN	FUNCTION
1	HI INPUT
2	LO INPUT
3	GND

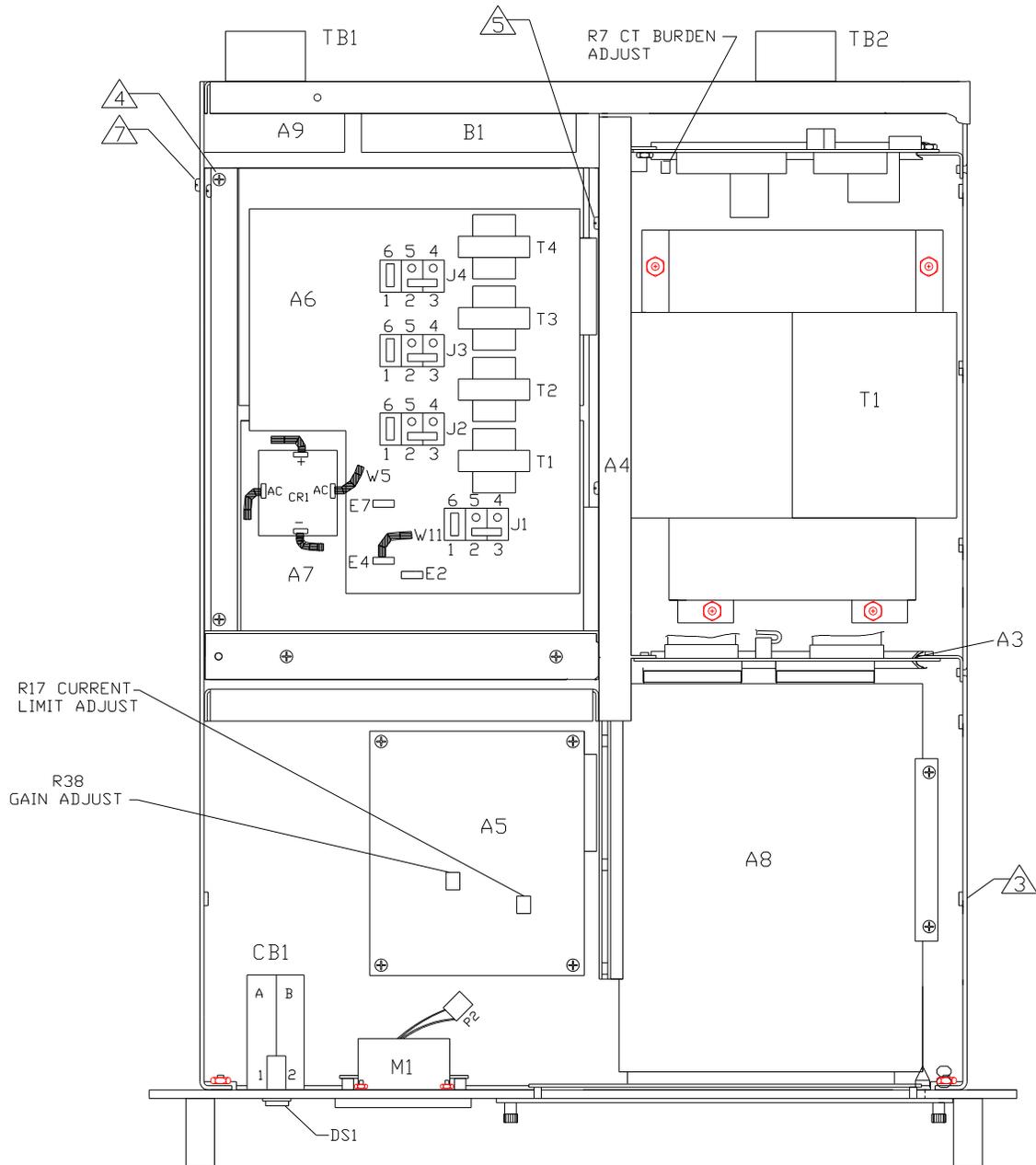
J6	
PIN	FUNCTION
1	∅ C SENSE
2	∅ B SENSE
3	∅ NEUT SENSE
4	∅ A SENSE

TB2	
PIN	FUNCTION
1	HI OUTPUT
2	LO OUTPUT
3	GND

**Figure 2-2: Internal Adjustments and Jumper Locations for Input Line Voltage 103 to 127 Volts**



**Figure 2-3: Internal Adjustments and Jumper Locations for Input Line Voltage 187 to 253 Volts**



## 2.4 MECHANICAL INSTALLATION

The power source 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 1.3. 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. Special consideration of overall air flow characteristics and the resultant internal heat rise must be allowed for with systems installed inside enclosed cabinets to avoid self heating and over temperature problems.

## 2.5 INPUT WIRING

The AC Power Source must be operated from a three-wire single phase service. The mains source must have a current rating greater than or equal to 35 amps for the 2001L and 1501L ,or 20 Amps for the 751L if used on the low input range. Connect AC mains to TB1. Refer to Figure 2-1 for the input power connections.

## 2.6 OUTPUT CONNECTIONS

The output terminal block, TB2, is located at the rear of the power source. All load connections must be made at TB2. The remote sense inputs allow the power source 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.

The output power cables must be large enough to prevent a voltage difference greater than 10% of the programmed value between TB2 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.

**Table 2-1: Minimum Wiring Size**

MAXIMUM OUTPUT CURRENT IN AMPS	WIRE GAUGE (AWG)	MAXIMUM LENGTH (IN FEET) WIRE BETWEEN OUTPUT AND LOAD
14.8	14	46
14.8	12	73
14.8	10	117

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.

## 2.7 OUTPUT VOLTAGE RANGES

The standard voltage ranges for this AC Power Source 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.

## **2.8 FUNCTION TEST**

Refer to Figure 2-3 for the test setup.

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 the following key sequences:

4 ENT	To select the Range screen (RNG)
270 PRG ENT	To program the 270 range
- 4) Verify the HIGH RANGE lamp is lit.
- 5) Program the output to 270 volts with the following key sequences:

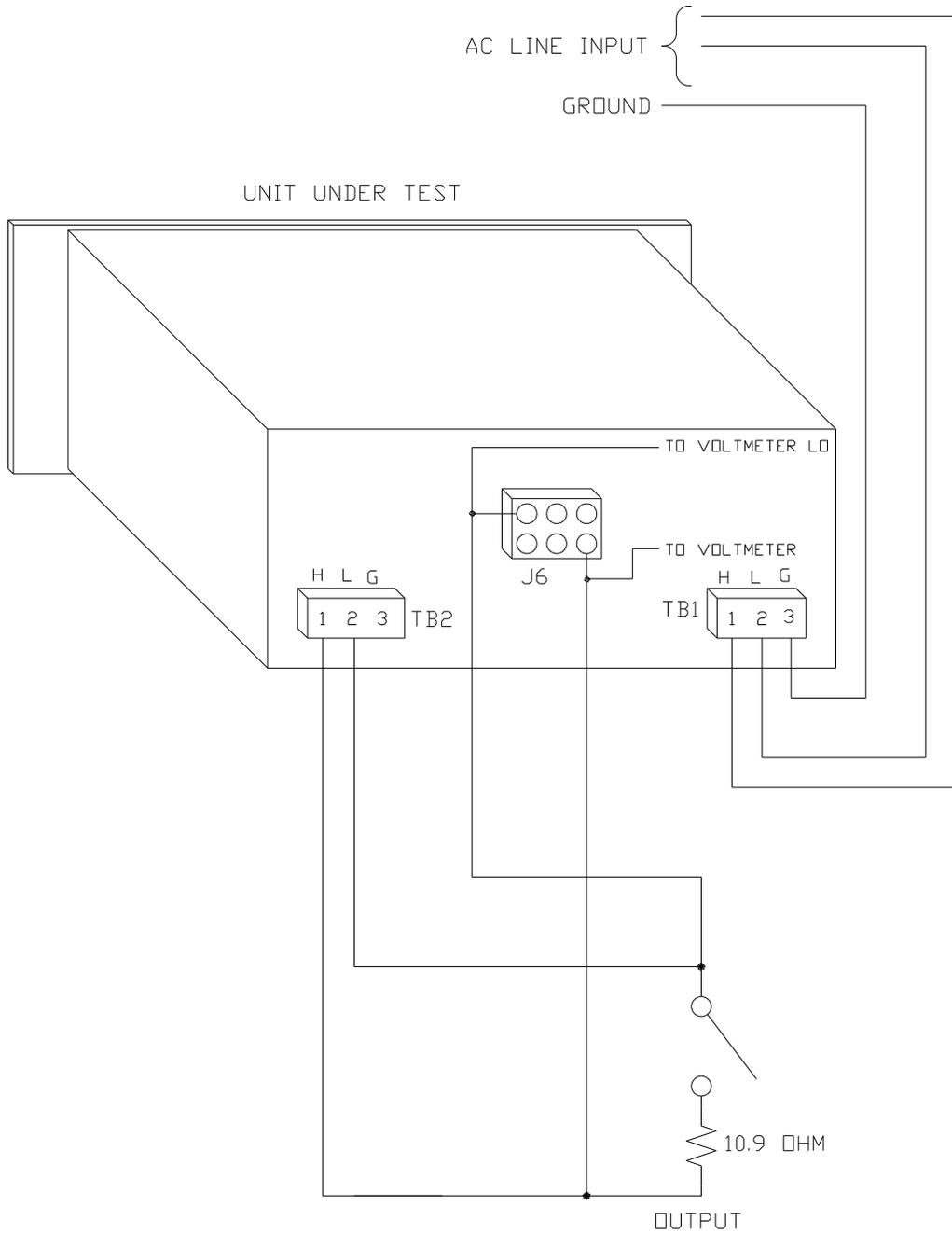
Depress the MON key 1 time to select the Amplitude screen (AMP).	
270 PRG ENT	To program the voltage to 270 volts
- 6) Verify that the front panel voltmeter indicates approximately 270 volts.
- 7) Program the AC Power Source to the 135 volt range with the following keystrokes:

4 ENT 135 PRG ENT
-------------------
- 8) Program the output to 135 volts:

5 ENT 135 PRG ENT
-------------------
- 9) Observe the output with the oscilloscope or distortion analyzer. The output should be a clean sine wave having less than 1.0% distortion.
- 10) Apply a full load (9.1  $\Omega$ , 2000W FOR 2001L, 10.9  $\Omega$ , 1667 W for 1501L and 21.8  $\Omega$ , 835 W for the 751L). Verify that the output voltage 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.
- 11) Program the Current Limit to 5.0 amps:

8 ENT
5 PRG ENT
- 12) The display should show the error message 'AMP FAULT'. The output will default to its initial voltage value with the output relay open .

Figure 2-4: Test Setup





### **3. OPERATION**

---

#### **3.1 GENERAL**

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

#### **3.2 FRONT PANEL CONTROLS**

All front panel controls are shown in Figure 3-2. A voltmeter is located at the left side of the front panel.. The voltmeter shows the output volt status.

A 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.

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 may be turned to adjust the contrast of the front panel display. The remote lamp illuminates when the AC Power Source has been addressed through the IEEE-488 interface (GPIB).

#### **3.3 FRONT PANEL INDICATORS**

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

An analog voltmeter, that indicates from 0 to 300 volts, shows the actual output voltage.

An OVERTEMP lamp illuminates when the temperature of the power amplifier heatsink has surpassed a maximum set level. When the fault is detected, the output is disabled and must be reprogrammed after the overtemperature condition has been eliminated.

An OVERLOAD lamp illuminates when the output current exceeds the programmed current limit value. The output will default to the initial value and the output relay will open shortly after the condition occurs .

A HIGH RANGE lamp illuminates when the AC Power Source is programmed to the high voltage range.

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

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

### 3.4 REAR PANEL CONNECTIONS

TB1 is the terminal block for the three input AC wire. Terminals 1 and 2 connect to the High and Low respectively. Terminal 3 is the chassis connection which should be connected to the input main ground.

TB2 is the power output terminal block. Refer to Table 3-1 for identification of the TB1 and TB2 terminals.

**Table 3-1: Terminal Identification**

TB1	DESCRIPTION	TB2	DESCRIPTION
1	Input HI	1	Output HI
2	Input LO	2	Output LO
3	Chassis Ground	3	Chassis Ground

J6 is the remote sense input connector. The remote sense input must be connected to the respective AC Power Source output. If the inputs are not connected, an AMP FAULT error message will be generated. Table 3-2 identifies the pins of connector J6.

**Table 3-2: Pin Connection**

J6	DESCRIPTION	CONNECT TO:
1	Do not connect	
2	Do not connect	
3	Sense LO	Output LO
4	Sense HI	Output HI
5	No Connection	
6	No Connection	

J5 is the IEEE-488 (GPIB) connector.

J7 is the System Interface connector.

Figure 3-1: Front Panel Controls and Indicators

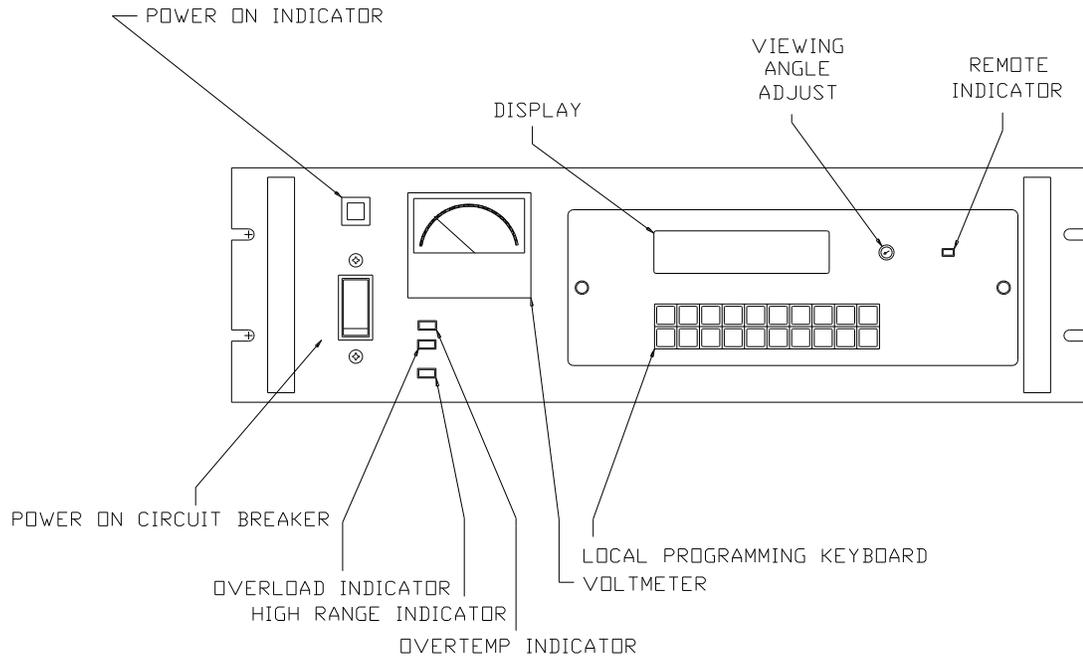
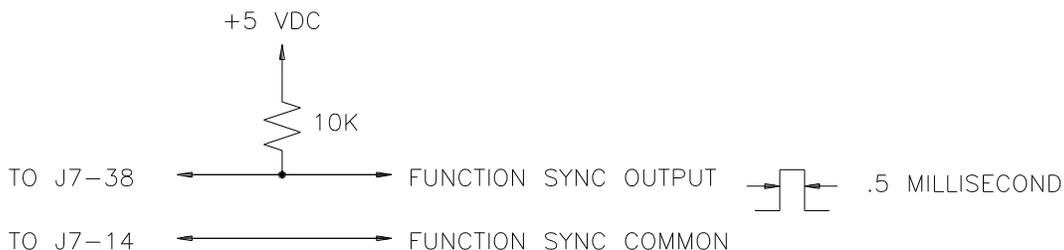


Table 3-3: System Interface Connector J7

J7	Description
J7-1	ANALOG COMMON: This is the common for all analog signals on the connector.
J7-3	ANALOG COMMON: See J7-1.
J7-5	CT COMMON:
J7-7	ANALOG COMMON: See J7-1.
J7-9	RPV: Not used.
J7-10	$\overline{\text{OVR TMP}}$ : A logic low output to indicate an over temperature 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.
J7-13	FLT A: Make no connections.
J7-14	F STB LO: a Function Strobe 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 opto coupler. Refer to J7-31.
J7-16	No connection.
J7-17	No connection.
J7-18	No connection.
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.
J7-22	CS A: Current sum for the phase A output. Make no connection to this pin.
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.
J7-26	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 Range 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.
J7-31	F STB HI: Function Strobe High signal. This is the collector lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to 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 3-1.
J7-32.	EX SYNC HI: External Sync High signal. This is an input that can be

<b>J7</b>	<b>Description</b>
	used to synchronize the outputs of the AC Power Source. This input requires a logic high level of at least +4.5 VDC at 1.5 ma. The input should have a duty cycle of 50 %. J7-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen
J7-36	<b>REMOTE SHUTDOWN:</b> 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 (DCOM) will simulate a logic low state.

**Figure 3-2: Function Sync Connections**



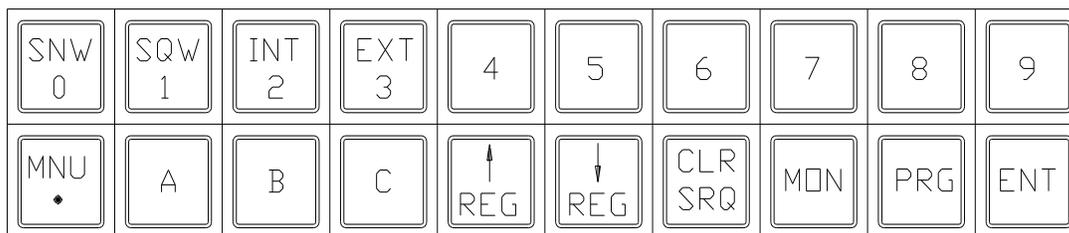
### 3.5 FRONT PANEL PROGRAMMING

#### 3.5.1 KEYPAD

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

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**



**Table 3-4: Keypad Key Description**

<b>KEY</b>	<b>DESCRIPTION</b>
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.
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
4 THRU 9	Inputs the indicated numeric value for all output parameters or to select the corresponding through screen when followed by the ENT KEY
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
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 preceding 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 preceding numeric value.
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.

### 3.5.2 DISPLAY SCREENS

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.

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.

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.

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.

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.

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

**Table 3-5: Output Parameter Screen**

<u>NO</u>	<u>SCREEN NAME</u>	<u>EXT.</u>	<u>ARGUMENT</u>	<u>ACTION TAKEN</u>
: The following are for changing the output				
1	SNC.		INT, EXT	Selects the output to be synchronized to an external input
*2	CLK		INT, EXT	Selects the external clock mode of operation
3	WVF		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		0-RNG limit	Sets the output voltage amplitude
6	FRQ		45-5000	Sets the output frequency.
8	CRL		0 to maximum current	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
28	DRP		1-5	Drops the amplitude by the number of

cycles defined by the argument.

\*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 3-6: Measurement Screen**

<u>NO</u>	<u>SCREEN NAME</u>	<u>EXT.</u>	<u>ARGUMENT</u>	<u>ACTION TAKEN</u>
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		0-400.0	Measures the TRMS output voltage
22	CUR		0.00-20.00	Measures the TRMS output current in Amps.
23	PWR		0-2000 watts	Measures the True output power.
24	PWF		0-1.000	Measures the power factor of the load.
25	APW		0-2000 VA	Measures the apparent output power.
26	FQM		40-5000	Measures the output frequency in hertz.
27	PZM		0-359.9	Measures the phase angle of the output voltage relative to an external input.

**Table 3-7: Calibration Screen**

<u>NO</u>	<u>SCREEN NAME</u>	<u>EXT.</u>	<u>ARGUMENT</u>	<u>ACTION TAKEN</u>
12	CAL AMP		0-255	Calibrates the programmed output voltage.
13	CAL VLT		Actual output voltage	Calibrates the measured voltage to be same as argument.
14	CAL CUR		Actual output current	Calibrates the measured current to be same as (amps) argument.
15	CAL PWR		Actual output power	Calibrates the measured power to be same as argument. The argument is in watts
20	POF		0-±359.9	Calibrates the programmed output phase angle relative to external reference if used.

**Table 3-8: Configuration Screen**

<u>NO</u>	<u>SCREEN NAME</u>	<u>EXT.</u>	<u>ARGUMENT</u>	<u>ACTION TAKEN</u>
16	CFG	A(LSN)	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		B(CFG)	*60	Defines the features enabled for Power Source compatibility.
		C(PHZ)	0	Defines the phase C initial value for power system configuration.
17	ALM	A(RNG)	0	<sup>1</sup> 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)	*5000	Defines the high frequency limit.
19	CLM	A(RNG)	*Max Current	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.
29	INI	A(AMP)	0-5	Defines the initial voltage output.
		C(CRL)	0-Max Current	Defines the initial current limit.

---

***\*NOT USER PROGRAMMABLE. THE VALUES SHOWN ARE FOR A 1500 VA POWER SOURCE. THE VALUES WILL BE DIFFERENT FOR OTHER SOURCES DEPENDING ON REQUIREMENTS.***

---

<sup>1</sup>A code of 0 defines the Low Voltage Range. A code of 8 defines the High Voltage Range.

### 3.5.3 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 Source. If they are not properly connected an AMP FAULT message will result when the output voltage amplitude is programmed above the default value. Refer to Figure 2-2.*

---

Select the Amplitude (AMP) screen by entering keystrokes:

5 ENT

The display now shows the AMP parameter screen:

AMP MON A = 5.0 (or the initial value)

Program the output to 115.5 volts with the keystrokes:

115.5 PRG ENT

Program output to 130.0 volts.

130 PRG ENT

Slowly increase the output amplitude:

↑ (Hold until desired value is obtained.)

The output frequency can be programmed below 45 Hz down to 17 Hz. For operation between these frequencies, the output voltage Amplitude is limited to values described by the following formula:

$$\text{AMP} = \text{VOLTAGE RANGE} * \text{FREQUENCY}/45$$

### 3.5.4 TO PROGRAM FREQUENCY (FRQ=6)

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.)

### **3.5.5 TO PROGRAM THE OUTPUT PHASE ANGLE (PHZ=7)**

Output phase can be programmed relative to external sync. To program External Sync refer to paragraph 3.5.10. To program output phase to 90 degrees relative to External Sync perform the following sequence:

1. Select the phase (PHZ) screen by entering:  
7 ENT
2. Program phase to 90 degree relative to External Sync by entering:  
90 PRG ENT

### **3.5.6 TO PROGRAM CURRENT LIMIT (CRL=8)**

1. Select the Current Limit screen by entering:  
8 ENT
2. Program the current limit to 5 amps:  
5 PRG ENT

### **3.5.7 TO PROGRAM VOLTAGE RANGE (RNG=4)**

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.

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

4 ENT 250 PRG ENT

### **3.5.8 TO PROGRAM RAMP OR STEP FUNCTIONS (RMP=9)**

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.

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. 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.***

---

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.

The step program may also be used to generate a dropout to zero volts 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 value in the (PHZ) screen.

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

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

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

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

The following program will illustrate a dropout to zero volts. The program will drop the 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 PRG ENT

2. Select the PHZ screen and program to 90:

7 ENT 90 PRG

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

5 ENT 0 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.

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.

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 = .5:1

0 ENT B 0.5 PRG

5. Start the program by pressing the ENT key.

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.

$$\begin{aligned} \text{FINAL VALUE} &= \text{INITIAL VALUE} + (\text{RMP B STP}) (\text{NO. STEPS}) \\ \text{NO. STEPS} &= (\text{DEP. PAR.}) (\text{FINAL VALUE} - \text{INITIAL VALUE}) / \text{STEP} \\ &\text{SIZE} \end{aligned}$$

In this example:

$$\text{NO. STEPS} = (440 - 360) / .2 = 400$$

$$\text{FINAL AMP VALUE} = 10 + .5 \times 400 = 210 \text{ Volts}$$

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.*

---

### 3.5.9 TO PROGRAM THE OUTPUT WAVEFORM (WVF=3)

The waveform selection is an option for the AC Power Source. If the screen cannot be selected the option is not enabled.

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 the PRG key and ENT key.

To program the output to square wave:

SQW PRG ENT

To select the sine wave waveform depress the SNW or any even number key followed by the key sequence described above.

### 3.5.10 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC=1)

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

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.*

---

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

If the External Sync signal is not between 45 Hz and 5000 Hz, the message will be 'EXT SYNC ERROR'.

In the EXT SNC mode the value on the PHZ screen represents the angle of the 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.

### 3.5.11 PROGRAM THE EXTERNAL CLOCK (CLK=2)

The clock selection is an option for the AC Power Source. The CLK screen displays whether the AC Power Source 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 Source 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 Source will be available.*

---

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

### 3.5.12 TO PROGRAM THE DROP PERIODS (DRP=29)

Select the phase (PHZ) screen by entering keystrokes: 7 ENT. The display will show the PHZ parameter screen:

PHZ MON A = 0.0

To drop the output waveform starting at 90 degrees, enter the keystrokes: 90 PRG ENT.

Select the DROP (DRP=29) screen by entering the keystrokes:

2 ENT

The display will show the DRP parameter screen

DRP MON A = 0

To drop the output waveform for 3 cycles, enter the keystrokes:

3 PRG ENT

### **3.5.13 TO PROGRAM REGISTERS AND RAMPS**

The AC Power Source 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.

The following program will program 135 volts and 60 hertz on the output 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 60 hertz:

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 ENT

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

### **3.5.14 REGISTER LINKING**

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

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

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

### 3.5.15 TO PROGRAM SIMULTANEOUS RAMPS

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 3.5.8 for more information.

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

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.

### 3.5.16 TO PROGRAM INITIALIZATION PARAMETER

Several screens will control the initialization parameter of the power source. To access any of the following screens, the following procedures must be completed.

1. Press the menu key until you reach the first menu screen:

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

\*These are options and may not appear on the screen if options are not available.

2. Enter the numeric value of 959 followed by the ENT key.

3. Press the menu key until you reach menu screen five. This screen should appear as follows:

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

### **3.5.17 TO PROGRAM THE INITIAL VOLTAGE RANGE**

*First perform paragraph 3.5.16*

1. Enter the value 17 followed by the ENT key
2. Press the A value. If this value is less than 8, the unit will initialize at the low voltage range.
3. Add 8 to the value shown and enter the new value followed by the PRG key and ENT key. The unit will initialize at the high voltage range.
4. If the value is greater than 7, subtract 8 from the value and enter the new value followed by the PRG key and ENT key. This will initialize the unit to the low voltage range. Note: any other values entered will generate a syntax error.

### **3.5.18 TO PROGRAM FREQUENCY INITIAL VALUE**

*First perform paragraph 3.5.16*

1. Enter the value 18 followed by the ENT key.
2. Select the A key. Enter the desired initial frequency value. This value must be within the frequency range of the power source or a range error will be generated.

### **3.5.19 TO PROGRAM AMPLITUDE INITIAL VALUE**

*First perform paragraph 3.5.16*

1. Enter the value 29 followed by the ENT key.
2. Select the A key. Enter the desired initial voltage value between 0 and 5 volts followed by the PRG and ENT key. A value less than 5 volts may cause a fault condition when the output is programmed to a low value above 5 volts.

### **3.5.20 TO PROGRAM CURRENT LIMIT INITIAL VALUE**

*First perform paragraph 3.5.16*

1. Enter the value 29 followed by the ENT key.
2. Select the C key. Enter the desired initial current limit value. This value cannot be greater than the maximum output current of the power source.

### 3.5.21 ERROR MESSAGES

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.

**Table 3-9: Front Panel Display Error Messages**

<b><u>ERROR MESSAGE</u></b>	<b><u>CAUSE</u></b>
AMP FAULT	Incorrect sense line connection. Overload on indicated output.
TEMP 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 Low Frequency Limit and High Frequency Limit.
BUS LOCAL ERROR	Remote message sent while AC Power Source 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 Low Frequency Limit or greater than High Frequency Limit.
CRL RANGE ERROR	Attempt to program CRL greater than 11.11.
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.

### **3.5.22 TO MEASURE THE OUTPUT**

Seven measurement screens display the output voltage, current, power, apparent power, power factor phase and frequency.

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.

### **3.5.23 TO MEASURE THE OUTPUT VOLTAGE (VLT=21)**

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 Source. To access the voltage screen, depress the keys:

21 ENT

### **3.5.24 TO MEASURE THE OUTPUT CURRENT (CUR=22)**

The current screen displays the actual TRMS load current. The resolution is 0.01 amp for the AC Power Source.

### **3.5.25 TO MEASURE THE OUTPUT POWER (PWR=23)**

The power screen displays the actual true power delivered to the load. The resolution is 1 watt.

### **3.5.26 TO MEASURE THE OUTPUT POWER FACTOR (PWF=24)**

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.

### **3.5.27 TO MEASURE THE OUTPUT APPARENT POWER (APW=25)**

This screen is accessed by its screen number, 25. It displays VOLT-AMPERES with a resolution of 1 VA.

### **3.5.28 TO MEASURE THE OUTPUT FREQUENCY (FQM=26)**

This screen is accessed by its screen number, 26. It displays the output frequency with a resolution of 0.01 Hz, 0.1 Hz or 1 Hz up to 99.99 Hz, 999.9 Hz or 5000 Hz, respectively.

### 3.5.29 TO MEASURE THE OUTPUT PHASE ANGLE (PZM=27)

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

### 3.5.30 ELAPSED TIME (ELT =11)

This screen displays the total run time accumulated on the AC Power Source up to 99,999 hours.

H = Hours      M = Minutes      S = Seconds

## 3.6 REMOTE CONTROL

Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alphanumeric 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 Source operating parameters (ex. FRQ=Frequency, etc.).

### 3.6.1 UNIT ADDRESS

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.

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

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

---

**NOTE (\*):** *These screens will only be shown if the Square Wave and External Clock options are installed.*

---

**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.
LLO	Local Lockout. A GPIB message, when asserted, will inhibit the instrument from going to local if the CLR/LOC key is pressed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to local when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to it Power-on state.

Table 3-11: Unit Address Group

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

### 3.6.2 MESSAGE FORMAT

The message sent to the AC Power Source 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.

### 3.6.3 NUMERIC DATA FIELD

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

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 DMA 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 5000 Hz respectively.

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.

### 3.6.4 PROGRAM HEADERS

A Program Header is a mnemonic of a series of 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 segment of the header to different values. See Table 3-12 for the definition of the Program Headers and their related arguments.

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.



**Figure 3-4: Remote Command Sequences (continued)**  
**IEEE-488 PROGRAM SYNTAX**

TO SPECIFY THE SERVICE REQUEST INTERRUPT:

-->SRQ - (n) ---> \*

TO CALIBRATE OUTPUT:

-->CAL -		----		-		-		-(n)---	>DLY - (n) -->	STP - (n) -->	VAL - (n) ---->
		AMP						*			
						A					
						B					
						C					
											-----> *

TO CALIBRATE MEASUREMENT:

-->CAL ->		VLT		-		-		-(n)---	> *
		CUR				A			
		PWR				B			
						C			

TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:

-->TLK ->		AMP		-		-		----->	*
		FRQ				A			
		CRL				B			
		RNG				C			
		PHZ							
		SNC							
		THD							
		DRP							
		MNU							
		ELT							
		VLT							
		CUR							
		PWR							
		APW							
		PWF							
		ALM							
		FLM							
		CFG							
		POF							
		HLD							
		INI							

TO RECALL A REGISTER:

-->REC - (n) ---> \*

Table 3-12: Program Headers

HEADER	EXTENSION	ARGUMENT	DEFINITION
AMP		# or numeric from 0.0 to RNG value.	Amplitude in volts
CALor CAL AMP		# or numeric data from 0.0 to 255	Calibration Coefficient for output voltage
CAL VLT		Actual voltage	Calibrated measured voltage at remote sense point.
CAL CUR		Actual current	Calibrate measured current
CAL PWR		Actual power	Calibrate measured power.
CLK		INT, EXT	Clock source
CRL		0 to maximum current	Current limit in amps
DLY		0.000 to 9999 seconds	Delay in seconds used as a ramp parameter
DRP		0 to 5	Number of Drop cycles
FRQ		45.00 to 5000	Frequency in hertz.
PHZ		0 to 999.9	Output phase angle relative to external sync.
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		0.0 to 270 or other optional range value	Amplitude range and limit value in volts
SNC		INT,EXT	Synchronize
INI A		0 to 5.0	Voltage initial value.
C		0 to maximum	Current limit initial value current
ALM A		0 to 15	Select initial voltage range. See programming for details.
FLM A		0 to freq. range	Set initial frequency.
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program and measurements.
STP		From parameter minimum to maximum value	Define step size in ramp.

Table 3-12: Program Headers(continued)

HEADER	EXT.	ARGUMENT	DEFINITION
TLK		Any header	Set up to talk argument value or measured value when addressed to talk.
TRG			Execute (Trigger) setup 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		SNW,SQW	Waveform
OPN			Open output relays (2001L,1501L, 751L if option installed)
CLS			Close output relays (2001L,1501L, 751L if option installed)
VLT			Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
CUR			Used with TLK to request measurement of the output load current.
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.

### 3.6.5 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP)

The AMP header 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.

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

0.0 volts	AMP0
10.5 volts	AMP10.5 or AMP1.05E1 or AMP105E-1
100 volts	AMP100 or AMP100.0 or AMP1E2

### 3.6.6 TO PROGRAM FREQUENCY (FRQ)

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

The following string will program the frequency to 60.56 Hz.

FRQ 60.56

### 3.6.7 TO PROGRAM PHASE ANGLE (PHZ)

The PHZ header is used to identify the following numeric data as phase. The phase output will lead the external sync signal by the value programmed.

The following example will program the output phase angle to 90 degrees relative to external sync if it was operating in the external sync mode.

PHZ 90

### 3.6.8 TO PROGRAM CURRENT LIMIT (CRL)

The CRL header 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.

The following string will program a current limit of 10.5 amps.

CRL 10.5

### 3.6.9 TO PROGRAM CALIBRATION (CAL)

The CAL header when used alone or followed by the header AMP 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.

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

To program the CAL coefficient to 55 use the following string:

```
CAL55
```

To calibrate the output 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 CAL20 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. To calibrate the output at 135 volts and start the ramp with the existing CAL coefficient reducing the output with steps lasting one second:

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

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

The CAL header is used with the headers VLT, CUR and PWR to calibrate the respective measurement function. 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.

The following ASCII string will cause the current measurement for the output to measure the value indicated by a TRMS ammeter standard, 10.12 amps:

```
CAL CUR 10.12
```

### 3.6.10 TO PROGRAM RAMP OR STEP OPERATIONS

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.

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

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
```

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
```

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 value.

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

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

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.

The following example will ramp the output from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

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

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 ramp will decrement from the initial parameter.

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

The following example will decrement the output amplitude from 120 in .1 volt/.2 sec steps to 100 volts after a Device Trigger.

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

The following example will 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
```

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

### **3.6.11 TO PROGRAM A REGISTER (REG)**

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.

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
```

### **3.6.12 TO RECALL A REGISTER (REC)**

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

The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3.6.11.

REC0

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

REC0 TRG

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

### **3.6.13 TO PROGRAM VOLTAGE RANGE (RNG)**

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.

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

RNG210

### **3.6.14 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC)**

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

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

PHZ0 SNC EXT

Sending the ASCII string SNC INT will disable the sync input.

### **3.6.15 TO PROGRAM EXTERNAL CLOCK (CLK) (optional)**

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

---

***NOTE: The clock option is only available if the associated power systems have the LK option.***

---

The following ASCII string will enable the CLOCK and LOCK inputs to the associated slave AC Power Source:

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 Source to its programmed frequency.

### **3.6.16 TO PROGRAM A NUMBER OF DROP PERIODS (DRP)**

The DRP header is used to identify the drop command. The argument is a numeric data field from 1 to 5 that sets the number of Drop periods. The start angle of the Drop is defined by the value of phase A angle.

The following ASCII string will Drop the output voltage for 5 cycles starting at 90° angle of the sinewave.

PHZ 90 DRP 5

### **3.6.17 TO PROGRAM INITIAL VOLTAGE RANGE (ALMA)**

The ALM header is used to identify the Amplitude Range value. It must be followed by extension A. The argument is a numeric value. This value must have the range 0 to 15. The only acceptable value that does not generate a Range Error is the value equal  $\pm 8$  from the existing value.

If ALMA = 0, the following string will initialize the power source to the high voltage range at power up.

ALMA8

### **3.6.18 TO PROGRAM INITIAL FREQUENCY VALUE (FLMA)**

The FLM header is used to identify the initial frequency if it is followed by extension A and numeric value within the frequency range of the power source.

The following string will cause the power source to initialize at 400 Hz at power up.

FLMA400

### **3.6.19 TO PROGRAM INITIAL AMPLITUDE VALUE (INIA)**

The INI header is used to identify the initial Amplitude values if it is followed by extension A. The initial value is limited from 0 to 5 volts. The following string will program the power source to initialize at 5 volts at power up.

INIA 5.0

### **3.6.20 TO PROGRAM INITIAL CURRENT LIMIT VALUE (INIC)**

The INI header is used to identify the initial Current Limit value if it is followed by extension C. The initial value must be within the current limit of the power source. The following string will program the power source to initialize its Current Limit to 5.5 Amps at power up.

INIC 5.5

### **3.6.21 TRIGGER AN OPERATION (TRG)**

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

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.

### **3.6.22 TO PROGRAM TO OUTPUT WAVEFORM (WVF) (Optional)**

The header WVF is used to identify the following argument as the Sine Wave (SNW) or Square Wave (SQW) function of the Waveform.

The following example will program the output to the square wave function.

WVF SQW

The following example will program the output to the sine wave function:

WVF SNW

### **3.6.23 TO OPEN (OPN) AND CLOSE (CLS) THE OUTPUT RELAY**

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 initial value for 50 milliseconds before the output relays open or close.

### **3.6.24 TO TALK (TLK) MEASURED AND PROGRAMMED DATA**

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

To setup the AC Power Source to report a measured value, attach a measurement header to the TLK argument. The measurement headers are VLT, CUR, PWR, APW, PWF and FQM.

The following string will setup the AC Power Source to measure the power output when it is talk addressed:

TLK PWR A

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.

**Table 3-13: TLK Arguments**

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
ALM	A B C	0000 *135.0 *270.0	Default voltage range code Low Voltage Range High Voltage Range
AMP		0 to 270.0	Programmed voltage Amplitude value in volts.
APW		0 to 2000	Output VA
CFG	A B C	0 to 30 *28 *0	IEEE-488 Listen Address Configuration Code Phase C initial Value - output configures.
CLM	A B C	Maximum 35°C Current 0 2	Defines the maximum current Defines the power decimal point Defines the current decimal point
CRL	A,B,C	0 to Max. Current	Programmed output current limit.
CUR	A,B,C	0.00 to 20.0	Output current
ELT	A B C	0000 to 9999 00 to 59 00 to 59	Total accumulated hours (H) Accumulated minutes (M) Accumulated seconds (S)
FLM	A B C	60 45 5000	Default frequency Low frequency limit High frequency limit
FQM	None	45.00 to 5000	Measured output frequency
FRQ	None	45.00 to 5000	Programmed frequency
INI	A C	0.0 TO 5.0 0 to CLMA	Default voltage Default current limit

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

TABLE 3-13 TLK ARGUMENTS (CONTINUED)

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
CLK	None	INT or EXT	Programmed clock source
SNC	None	INT or EXT	Programmed external sync mode
WVF		INT or EXT	Programmed waveform
PHZ		0.0 to 359.9	Programmed output phase angle
PWR		0 to 2000	Output watts
PZM		0 to 359.9	Measured phase A angle relative to external sync
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		0.0 to 270.0	Measured output voltage

Table 3-14: Example Talk Response

ASCII STRING	SENT	RESPONSE AFTER	ADDRESSED TO TALK
TLKALM	ALMA0000	B135.0	C270.0
TLKAMP	AMPA005.0		
TLKAPW	APWA1003		
TLKCFG	CFGA0001	B0028	C0120
TLKCRL	CRLA12.34		
TLKCUR	CURA06.14		
TLKELT	ELTH0147	M0051	S0033
TLKFLM	FLMA0060	B0045	C0550
TLKFQM	FQM59.97		
TLKFRQ	FRQ60.00		
TLKCLK	CLK INT (*)		
TLKSNC	SNC INT		
TLKPHZ	PHZA000.0		
TLKPWF	PWFA1.000		
TLKPWR	PWRA0.737		
TLKPZM	PZMA000.0		
TLKREG0	ACTUAL CONTENTS OF REGISTER 0		
TLKRNG	RNGA 135.0		
TLKVLT	VLTA120.1		
TLKWVF	WVFA SNW		
TLKINI	INIA005.0	C012.34	

(\*) If function is not enabled, a syntax Error message will be generated

### **3.6.25 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK VLT)**

VLT may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output voltage with 0.1 volt resolution.

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.

### **3.6.26 TO TALK THE MEASURED OUTPUT CURRENT (TLK CUR)**

CUR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output current in amps with 0.01 amp resolution.

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

### **3.6.27 TO TALK THE MEASURED OUTPUT POWER (TLK PWR)**

PWR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output power in watts with 1 watt resolution.

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

### **3.6.28 TO TALK THE MEASURED OUTPUT POWER FACTOR (TLK PWF)**

PWF may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output power factor from 0 to 1.000.

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.

### **3.6.29 TO TALK THE MEASURED OUTPUT APPARENT POWER (TLK APW)**

APW may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the Apparent Power output in VA with 1 VA resolution.

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.

### **3.6.30 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)**

FQM may be used as an argument to the header TLK. When FQM is used as an argument, it will set up the AC Power Source to measure the output frequency in hertz. When FQM is used as a header, it will cause the front panel to display the measured output frequency.

### **3.6.31 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM)**

PZM may be used as an argument for the header TLK. When used as an argument, PZM will set up the AC Power Source to measure the phase angle of phase A relative to external sync. The measurement is made at the Remote Sense terminals. Phase A will always be reported as 000.0 degrees unless the AC Power Source is operating in the external sync mode.

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

### **3.6.32 MESSAGE SEPARATORS**

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.

The following are two examples of ASCII strings with separators:

PHZA90;FRQ60;AMP115

CRL,90;FRQ50;AMP,120

### **3.6.33 SERVICE REQUEST**

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.

The following example disables GPIB SRQ.

SRQ0

### **3.6.34 SERIAL POLL STATUS BYTE**

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.

### **3.6.35 END OF STRING**

The End of String (EOS) delimiter recognized by the AC Power Source 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.

### **3.6.36 ERROR MESSAGES**

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

### **3.6.37 GROUP EXECUTE TRIGGER**

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.

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

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

Table 3-15: Status Byte Values

STATUS BYTE SRQ = 1	REPORTED MESSAGE	CAUSE
64	AMP A FAULT	Overload or sense line fault
72	TEMP A 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 5000
93	PHZ RANGE ERROR	PHZ value greater than $\pm 999.0$
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 in local mode
98	EXT SYNC ERROR	No external sync input or signal not between 45 and 5000 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.
40	STA OK	No problems

### 3.7 REMOTE OPERATION WITH MATE CIIL

When the AC Power Source is configured to operate with CIIL as the principal language, the alternate language is APE. Refer to Figure 3-4 for information on the APE program syntax. Using CIIL, the 1501L will accept OP codes, the noun ACS (AC SIGNAL) and noun modifiers to program the operating parameters of voltage, frequency, phase and current limit in a setup string. In addition, a number of OP codes cause the AC Power Source to perform a specific task such as reset and confidence testing. Figure 3-5 is a summary of the CIIL program syntax.

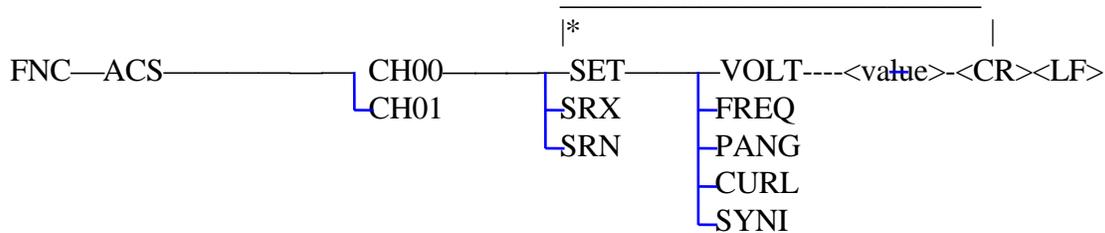
#### 3.7.1 CIIL ELEMENTS

The Control Interface Intermediate Language (CIIL) elements are:

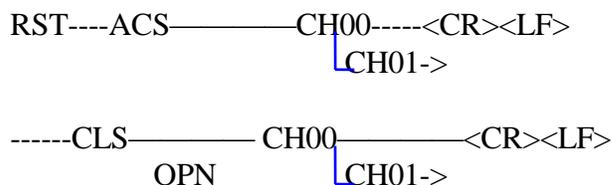
OP-CODES:	FNC, SET, SRX, SRN, CLS, OPN, RST, CNF, IST, INX, FTH, STA, GAL
NOUN	ACS
NOUN MODIFIERS:	VOLT, FREQ, PANG, CURL, SYNI, POWR, APOW, CURR, TRSC
CHANNEL DESIGNATORS	:CH00, :CH01

The only noun recognized by the 1501L is ACS for AC Signal. The only non-operational code (no-op) in a string is an ASCII space. Numeric expressions may be represented by explicit decimal values (e.g., 115.0) or exponential values (e.g., 0.115E3). The exponent field may be either a one-digit or two-digit form (e.g., E1 or E01) signed or unsigned with a range from E-24 to E+24.

**Figure 3-5: CIIL Program Syntax  
STIMULUS STRING**



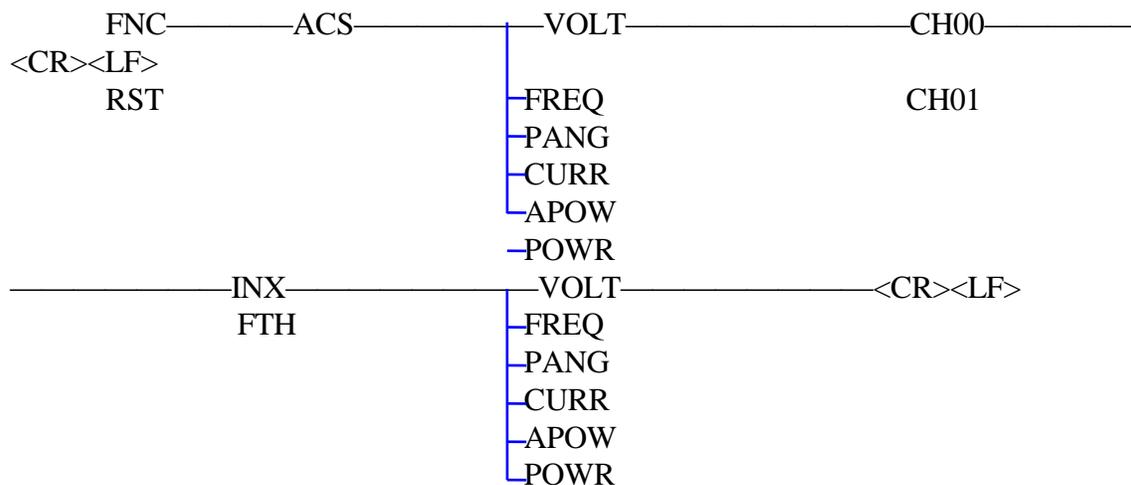
\*NOTE: There is no value for SET SYNI



**GENERAL CIIL STRINGS**



**SENSOR STRINGS**



### 3.7.2 CHANNEL DESIGNATORS

The channel designator consists of a colon (:) followed by the syntax CH and a single-digit or two-digit channel number. The general form for the channel designator is CHnn and may be any of the following;

:CH00 Designates output.

:CH01 Designates output.

Channel designators and their applicable noun modifiers are listed in Table 3-16.

### 3.7.3 OP-CODES

Each of the OP-codes listed is described in following paragraphs.

### 3.7.4 FNC

All set-up strings must begin with OP-code FNC followed by the noun ACS, and the channel designator :CHnn (e.g., FNC ACS :CH01).

### 3.7.5 SET

The SET (set-up) OP-code must be sent when a characteristic included in the output string is to be programmed. The noun modifiers that may follow the SET OP-code are VOLT, FREQ, SYNI, CURL, TRSC and PANG. A SET OP-code is always followed by a noun modifier. A SET string has the following string elements:

FNC ACS :CHnn SET<NOUN-MOD><NUMERIC> <CR> <LF>

An example of a setup string where the output is set to 115.0 volts as follows:

FNC ACS :CH01 SET VOLT 115.0 <CR><LF>

---

**Note:** All strings end with ASCII <CR><LF>. The AC Power Source is configured to recognize this series of ASCII characters as indicating end-of-string (EOS).

---

**Table 3-16: Channel Design & Noun Modifier**

CHANNEL DESIGNATOR	MODIFIER	FUNCTION
:CH00	VOLT	Set output amplitude.
:CH01	VOLT	Set output amplitude.
:CH00	FREQ	Set Frequency.
:CH01	FREQ	Set Frequency.
:CH00	PANG	Syntax error with :CH00.
:CH01	PANG	Set output phase angle relative to external sync.
:CH00	CURL	Set output current limit.
:CH01	CURL	Set output current limit.
:CH00	CYNI	Set sync to external signal.
:CH00	POWR	Send power measurement data for output to Bus Controller.
:CH01	POWR	Send power measurement data for output to Bus Controller.
:CH00	APOW	Send apparent power measurement data for output to Bus Controller.
:CH01	APOW	Send apparent power measurement data for output to Bus Controller.
:CH00	CURR	Send apparent power measurement data for output to Bus Controller.
:CH01	CURR	Send output current measurement data for output to Bus Controller.
		Send output current measurement data for output to Bus Controller.

### 3.7.6 SRX AND SRN OP-CODES

The SRX (set maximum) OP-code sets the maximum value of the programmable noun modifiers VOLT, FREQ, PANG and CURL. It is always accompanied by a noun modifier. An example of setting the maximum output amplitude to 135 volts and the output to 115 volts follows:

```
FNC ACS :CH00 SRX VOLT 135 SET VOLT 115.0 <CR> <LF>
```

The SRN OP-code sets the minimum value. For example, to set the minimum value of the output amplitude to 5.0 volts and the output to 20 volts, the following string is transmitted:

```
FNC ACS :CH00 SRN VOLT 5 SET VOLT 20 <CR> <LF>
```

### 3.7.7 OPN AND CLS

The CLS (Close) OP-code closes the relay between the amplifier outputs and the output connector. The CLS Op-code must be followed by a valid channel designator. (:CH00, :CH01). A programmed amplitude will not be generated at the output until the relay has been closed.

CLS :CH00 <CR> <LF> Closes relay

If an output voltage been programmed prior to the CLS OP-code, the output will appear after CLS has been sent.

The OPN (open) OP-code opens the relay at the power source output. Prior to opening the relay, the output of the AC Power Source is reduced to zero.

OPN :CH00 <CR> <LF> Opens relay

### 3.7.8 RST

The RST (reset) OP-code resets the AC Power Source to its default values as follows:

Output Amplitude	5.0 Volts
Frequency	Selected default frequency
Output Phase Angle	0Degrees*
Sync	Internal
Current Limits	Maximum current of power system
Power Source Relays	Open

\*Relative to External Sync.

In addition, all non-catastrophic error messages (SYNTAX and RANGE errors) are cleared. All other error messages are not affected.

OP-code RST must be followed by ACS and any one of the valid channel designators :CH00 and :CH01 (e.g., RST ACS :CH00 <CR> LF>).

### 3.7.9 CNF AND IST

The CNF (confidence) OP-code instructs the 1501L to perform a confidence test of the entire power system. The OP-Code stands by itself. The confidence test flow diagram is shown in Figure 3-6. If confidence testing detects a fault, an appropriate message is transmitted to the Bus Controller on receipt of an STA OP-code (see paragraph 3.7.3.9). The output relays of the power source are opened during confidence testing.

During confidence testing, the AC Power Source generates the following:

Amplitude	115 Volts
Frequency	400 Hz
Current Limit	Maximum and 5% of Maximum

The 1501L compiles a message after the confidence test and the receipt of a STA OP-code. The AC Power Source responds with the appropriate message as shown in Figure 3-6.

The IST (internal self test) OP-code produces the same response described for CNF.



### 3.7.10 INX

The INX (initialize) OP-code is a request for data from the AC Power Source. A request for the time required to measure the voltage of all phases consists of the following strings:

```
FNC ACS VOLT :CHnn <CR> <LF>
```

```
INX VOLT <CR> <LF>
```

The AC Power Source then responds with:

```
<SP> 5 <CR> <LF>
```

The AC Power Source response indicates that 5 seconds will be required to perform the measurement.

---

**Note:** *The INX OP-code must be preceded by an FNC OP-code string containing the noun modifier for which INX will request data.*

---

### 3.7.11 FTH

The FTH (fetch) OP-code function fetches data from the AC Power Source for the parameter indicated by the noun modifier of the previous string. For example, the following FNC string is first sent:

```
FNC ACS VOLT :CH01 <CR> <LF>
```

Then the measurement value is requested with:

```
FTH VOLT <CR> <LF>
```

Assuming that the output is 115.5 volts, the AC Power Source responds with:

```
<SP> 115.5 <CR> <LF>
```

The FTH OP-code may be repeated for the same FNC noun modifier.

An INX string may be inserted between the two strings as described in 3.7.3.7 if the time to accomplish the measurement is required.

### 3.7.12 STA

The STA (status) OP-code instructs the AC Power Source to transfer its output message to its output buffer. The message is then transmitted to the Bus Controller when the AC Power Source is addressed to talk. Table 3-17 lists all of the possible status messages generated outside of confidence testing. All confidence testing messages are shown in Figure 3-6. If the power source is operating correctly and the following OP-code is sent:

STA <CR> <LF>

The AC Power Source responds with:

<SP> <CR> <LF>

### 3.7.13 GAL

The GAL (go to alternate language) OP-code instructs the AC Power Source to discontinue use of the CIIL language and start accepting commands in the Abbreviated Plain English (APE) language. While operating in the APE language mode, sending ASCII characters CIIL will return operation to the CIIL language. When power is removed and then restored, the AC Power Source reverts to the native language.

**Table 3-17: Non-CF Status Messages**

CONDITION	DEVICE RESPONSE
Loaded output Fault	F07ACS01 <SP> (DEV): <SP> OUTPUT CH01 VOLT FAULT <CR><LF>
Source Temperature Fault	F07ACS01 <SP> (DEV): <SP> SOURCE CH01 TEMPERATURE <CR><LF>
Program out of range for VOLT, FREQ, PANG or CURL	F07ACS01 <SP> (MOD): <SP>VOLT/FREQ/PANG CURL RANGE ERROR <CR><LF>
Unrecognizable OP-code or missing OP-code	F07ACS01 <SP> (MOD): <SP>SYNTAX ERROR <CR><LF>
Good Status	<SP><CR><LF>

### 3.7.14 NOUN MODIFIERS

Noun modifiers are a CIIL mnemonic indicating the characteristic of the signal to be described.

### 3.7.15 VOLT

The VOLT (voltage) noun modifier may be contained in a string as an instruction to the AC Power Source with SET, SRX or SRN. Depending on the OP-code, an output voltage (or voltages) may be programmed or set as an upper or lower limit in 0.1-volt increments up to the range limit. The number which follows the modifier in the string determines the amplitude to be programmed. For example, to set the output voltage to 110 volts, the following string is transmitted:

```
FNC ACS :CH00 SET VOLT 110 <CR> <LF>
```

The noun modifier may also be used in a string that uses the sensor (measurement) capability of the AC Power Source. An example of requesting the measurement of power source output voltage follows. Note that the noun modifier precedes the channel indicator.

```
FNC ACS VOLT :CH01 <CR> <LF>
```

```
FTH VOLT <CR> <LF>
```

When the output voltage is 110.0 the AC Power Source responds with:

```
<SP> 110.0 <CR> <LF>
```

### 3.7.16 FREQ

The FREQ (frequency) noun modifier may be contained in a string as an instruction to the AC Power Source with SET, SRX or SRN. Either of the two channel indicators may be used in the string. The number which follows the modifier in the string determines the frequency to be programmed. For example, to program to 440 Hertz, the following string is transmitted:

```
FNC ACS :CH00 SET FREQ 440 <CR><LF>
```

The FREQ modifier may also be used to instruct the AC Power Source to measure the output frequency as follows. Note that the noun modifier precedes the channel indicator:

```
FNC ACS FREQ :CH00 <CR><LF>
```

Followed by string:

```
FTH FREQ <CR> <LF>
```

The response from the AC Power Source when the frequency is 380.0 Hz is then:

```
<SP> 380.0 <CR> <LF>
```

### 3.7.17 PANG

The PANG (phase angle) noun modifier may be contained in a string as an instruction to the AC Power Source with SET, SRX or SRN. Depending on the OP-code, an output phase angle may be programmed or the upper or lower limit set in one-tenth degree increments. The number which follows the modifier in the string determines the phase angle to be programmed.

```
FNC ACS :CH01 SET PANG90 <CR> <LF>
```

As with the FREQ and VOLT modifiers, the INX OP-code may be used to request time for PANG measurement:

```
FNC ASC PANG :CH01 <CR><LF>
```

```
INX PANG :CH01 <CR> <LF>)
```

When addressed to talk, the AC Power Source responds with the maximum time required to make the measurement in seconds:

```
<SP> 5 <CR> <LF>
```

When operating in the external sync mode, the phase angle of the output relative to the external sync input may be programmed as follows:

```
FNC ASC :CH01 SET PANG90 SET SYNI <CR><LF>
```

The output will still track the SYNC input, but will be offset by 90 degrees.

### 3.7.18 CURL

The CURL (current limit) noun modifier may be contained in a string as an instruction to the AC Power Source with SET, SRX or SRN. Depending on the OP-code, an output current limit (or limits) may be programmed or set as to upper or lower limit in 0.01 ampere increments up to the power source maximum current. The number which follows the modifier in the string determines the current limit to be programmed.

```
FNC ACS :CH00 SET CURL 2.5 <CR> <LF>
```

### 3.7.19 SYNI

SET SYNI enables the external SYNC input. The AC Power Source returns to the internal sync mode in the absence of the SYNI noun modifier from any set-up string. Any channel indicator may be used in the set-up string that includes SYNI. SYNI may be used with PANG to program the output phase angle relative to the sync signal. The following string enables the AC Power Source to track the frequency and phase of the external sync signal:

FNC ACS :CH00 SET SYNI <CR> <LF>

---

*Note: Other noun modifiers may be included in the above string.*

---

While operating in the external synchronize mode, the AC Power Source racks the frequency and phase of the external signal. Note that its phase may be offset from the SYNC input. The frequency of the external signal is reported with the following set of strings:

(L) FNC ACS FREQ :CH00 <CR> <LF>

(L) INX FREQ <CR> <LF>

(T) <SP> "default time-out value reported" <CR> <LF>

(L) FTH FREQ <CR> <LF>

(T) <SP> "measured value of external sync frequency reported"  
<CR> <LF>

In the above, (L) indicates the AC Power Source is listen addressed and (T) that it is talk addressed. The INX OP-code in the above series of strings may be omitted if the time data is not required.

### 3.7.20 CURR

The CURR (current measurement) noun modifier's single function is to measure current. The strings to initiate the current measurement of the output are as follows:

FNC ACS CURR :CH01 <CR> <LF>

FTH CURR <CR> <LF>

### 3.7.21 POWR

Noun modifier POWR (power measurement) is included in a string to instruct the AC Power Source to measure the power output of the power source. The strings to initiate the power measurement are as follows:

FNC ACS POWR :CH01 <CR> <LF>

FTH POWR <CR> <LF>

The response from the AC Power Source is:

<SP> 80.5 <CR> <LF>

The foregoing assumes an output power of 80.5 watts.

### 3.7.22 APOW

Noun modifier APOW (apparent power measurement) included in a string instructs the AC Power Source to measure the apparent power output of the power source in volt-amperes (VA). The strings to initiate the measurement are as follows:

```
FNC ACS APOW :CH01 <CR> <LF>
FTH APOW <CR> <LF>
```

The response from the AC Power Source is:

```
<SP> 65.5 <CR> <LF>
```

The foregoing assumes an apparent output power of 65.5 VA.

### 3.7.23 NORMAL CONDITION RESPONSES

All normal condition responses of the AC Power Source to requests from the bus controller (either status or measurement requests) begin with an ASCII space <SP>. In the following examples of bus controller/AC Power Source exchange, (L) indicates the AC Power Source is listen addressed and (T) indicates it is talk addressed.

When the AC Power Source is requested to measure one of the parameters identified by a noun modifier (e.g., VOLT), the following strings are sent and received by the bus controller:

```
(L) FNC ACS VOLT :CH01 <CR> <LF>
(L) INX VOLT <CR> <LF>
(T) <SP> "default time out" <CR> <LF>
(L) FTH VOLT <CR> <LF>
(T) <SP> 115.5 <CR> <LF>
```

When the AC Power Source receives an STA OP-code after a CNF OP-code, its normal response is an ASCII space <SP>. An example of the strings transmitted and received is:

```
(L) CNF <CR> <LF>
(L) STA <CR> <LF>
(T) <SP> <CR> <LF>
```

The AC Power Source accepts the STA OP-code after any string which is sent to it. For example:

```
L) FNC ACS :CH00 SET VOLT115 SRX VOLT 135 SRN VOLT5 <CR><LF>
(L) STA
(T) <SP> <CR> <LF>
```

### 3.7.24 ABNORMAL CONDITION RESPONSE

When an abnormal condition has been detected by the AC Power Source, its response to the STA OP-code will begin with an ASCII F. The abnormal condition may be in the power source or specified in the power source controller. In the examples that follow, (MOD) is an abbreviation for MODULE and refers to the power controller; (DEV) is an abbreviation for DEVICE and refers to the power source excluding the power controller. The response string for an abnormal condition is:

```
F07ACS01 <SP> (DEV): <SP> "message"<CR> <LF>
```

The status contained in "message" may be similar to the following:

```
OUTPUT CH01 TEMPERATURE FAIL  
CONTROLLER CH01 FREQ FAIL
```

When an STA OP-code is transmitted after any string, the complete abnormal response may be similar to:

```
F07ASC01 <SP> (MOD) : <SP>"message"<CR> <LF>
```

The status contained in "message" may be any of the following for non-CNF messages:

```
SYNTAX ERROR  
VOLT RANGE ERROR  
FREQ RANGE ERROR  
CURL RANGE ERROR  
PANG RANGE ERROR
```

The response of the AC Power Source under a short circuit condition is as follows:

```
F07ACS01<SP>(DEV): <SP> OUTPUT CH01 VOLT FAULT <CR> <LF>
```

A setup string can always be followed by another string with the TA OP-code. In the event of a syntax, range or system error, an error message will be returned to the bus controller when the AC Power Source is addressed to talk. The value of the last parameter in a setup string is the one displayed on the front panel of the AC Power Source.

### 3.7.25 DISCRETE FAULT INTERRUPT

A discrete fault condition is one that would pose a hazard to equipment or personnel. A Discrete Fault Interrupt (DFI) is supplied with the MT power source option. The DFI relay contacts are connected to the BNC connector, J8, on the AC Power Source rear panel. Under normal operating conditions, the DFI relay contacts are open; when a fault is detected, the contacts close. The user may connect any type of indicator or alarm circuit to the DFI connector provided the applied signal is limited to 0.1 amps and 26 volts.

The conditions which will cause the discrete fault interrupt are listed in Table 3-18.

**Table 3-18: Discrete Fault Interrupt Conditions**

FAULT	CONDITION
OVERLOAD OUTPUT	The full rated power capability is exceeded on any phase where programmed output voltage is not maintained.
PROGRAMMABLE CURRENT	The load draws more current than the programmed current limit point on any phase.
OVERTEMPERATURE	Excess heatsink temperature in power supply or output amplifier due to high ambient temperature or internal component failure.
CONTROLLER FAILURE	The AC Power Controller has a CPU failure which is monitored by a watch dog timer.
POWER OFF	Power remains off - input breaker off.

### 3.7.26 PROGRAM EXAMPLES

Table 3-19 lists some typical CIIL strings. Each one illustrates the versatility in programming which is a feature of the AC Power Source. The strings listed transmit the information with the fewest possible characters. Decimal points need not be included when followed by zeros. Spaces may not be included anywhere in the string.

**Table 3-19: Sample Programming Strings**

PROGRAM	STRING
The output to 115 volts and current limit to 2 amperes and enable external sync.	FNC ACS :CH00 SET CURL2 SET FREQ400 SET VOLT 115 SET SYNI <CR><LF>
The output to 100 volts and current limit to 2 amps.	FNC ACS :CH01 SET CURL.2E1 SET FREQ4ED SET VOLT100 <CR><LF>
To power-up state open relay.	RST ACS :CH00 <CR><LF>
Output phase to 90 degrees.	FNC ACS :CH01 SET PANG90 <CR><LF>
Freq. to 65.23 Hz.	FNC ACS :CH00 SET FREQ65.23 <CR><LF>
The output current to 2.5 amps peak current limit.	FNC ACS :CH00 SET CURL2.5 <CR><LF>
Output current limit to 2 amps peak	FNC ACS :CH01 SET CURL2 <CR><LF>
Confidence test.	CNF <CR><LF>
For status msg.	STA <CR><LF>
Output relay closed.	CLS :CH00 <CR><LF>
To measure output voltage only of Phase A	FNC ACS VOLT :CH01 <CR><LF>
Output relay opened.	OPN :CH00 <CR><LF>
To measure Freq.	FNC ACS FREQ :CH00 <CR><LF> FTH FREQ <CR><LF>
To measure output voltage	FNC ACS VOLT <CR><LF>
Query time of measurement of voltage	FNC ACS VOLT <CR><LF> INX VOLT <CR><LF>



## **4. CALIBRATION PROCEDURE**

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### **4.1 GENERAL**

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.

The following is a listing of paragraphs that may be performed to fix an indicated problem.

<b><u>PARAGRAPH</u></b>	<b><u>TITLE</u></b>
4.3.1	OUTPUT VOLTAGE CALIBRATION  This is a periodic calibration of the output voltage.
4.3.2	VOLTAGE MEASUREMENT CALIBRATION  This is a periodic calibration of the measurements of output voltage, current and power.
4.3.3	CURRENT MEASUREMENT CALIBRATION
4.3.4	POWER MEASUREMENT CALIBRATION
4.3.5	REMOTE MEASUREMENT CALIBRATION
4.4.1	OUTPUT FREQUENCY CALIBRATION  This is a nonperiodic calibration of the output frequency.
4.4.2	GAIN ADJUSTMENTS  These are nonperiodic adjustments of the Current Limit Board, assembly A5. The adjustments may have to be performed for the following reasons:  1. An output amplifier, assembly A7 is replaced.
4.4.3	CURRENT TRANSFORMER ADJUSTMENTS  These are nonperiodic adjustments. The adjustments are required if it is impossible to perform the current or power measurement calibration. (Ref. Paragraph 4.3.3 and 4.3.4).

#### 4.4.4 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%.

### ***4.2 TEST EQUIPMENT***

The following equipment or their equivalents are required to completely test the AC Power Source.

#### **4.2.1 TEST EQUIPMENT FOR PERIODIC CALIBRATION**

1. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent.
2. 50 Amp Current Transformer: Pearson Model 110
3. Resistive Load: Refer to Table 4-1 for load values.

#### **4.2.2 ADDITIONAL TEST EQUIPMENT**

1. Frequency Counter: Philips PM 6671

### ***4.3 PERIODIC CALIBRATION***

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

#### **4.3.1 OUTPUT VOLTAGE CALIBRATION**

Apply power to the AC Power Source 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 output 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

Figure 4-1: Internal Adjustments and Jumper Locations

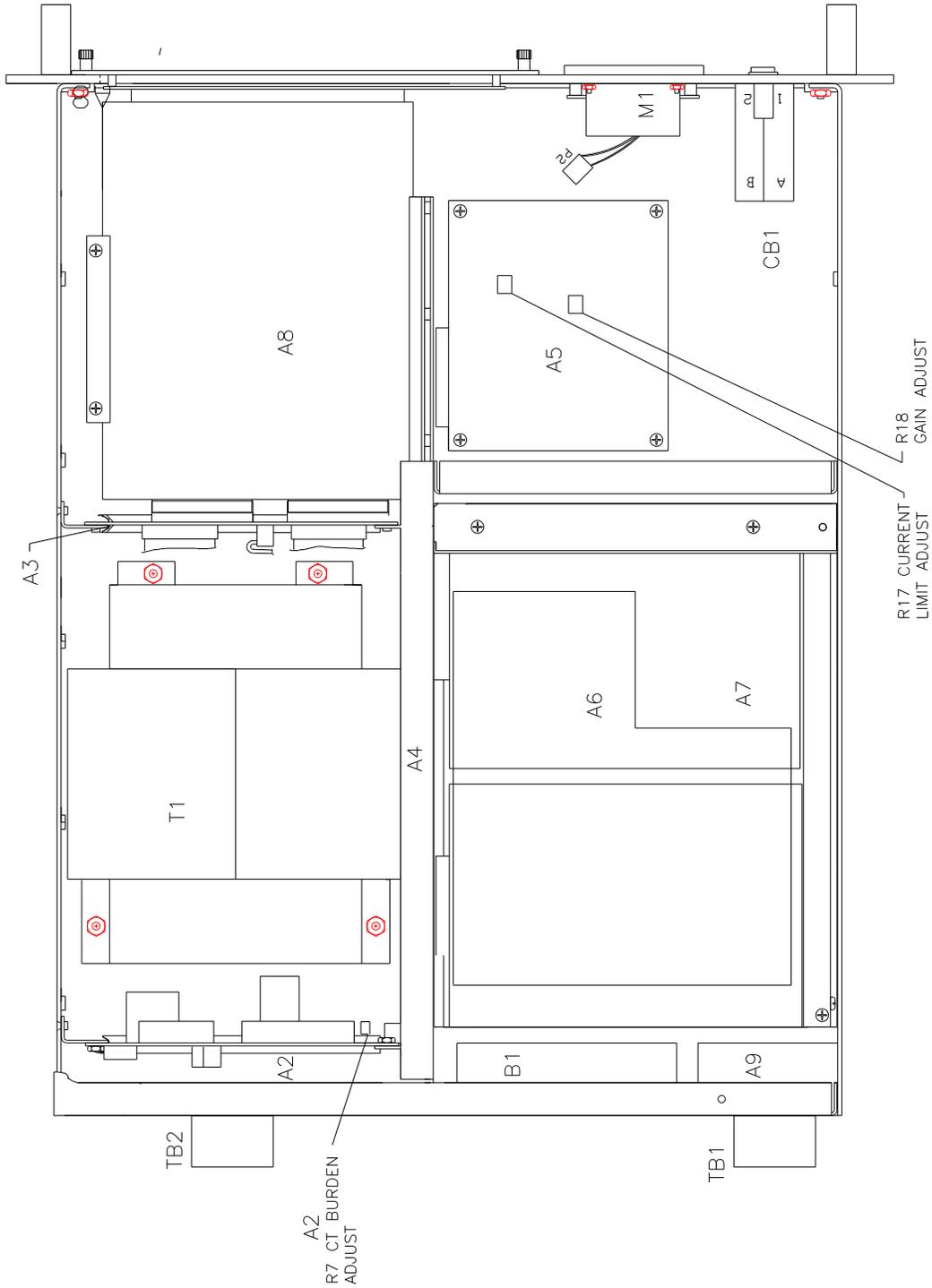
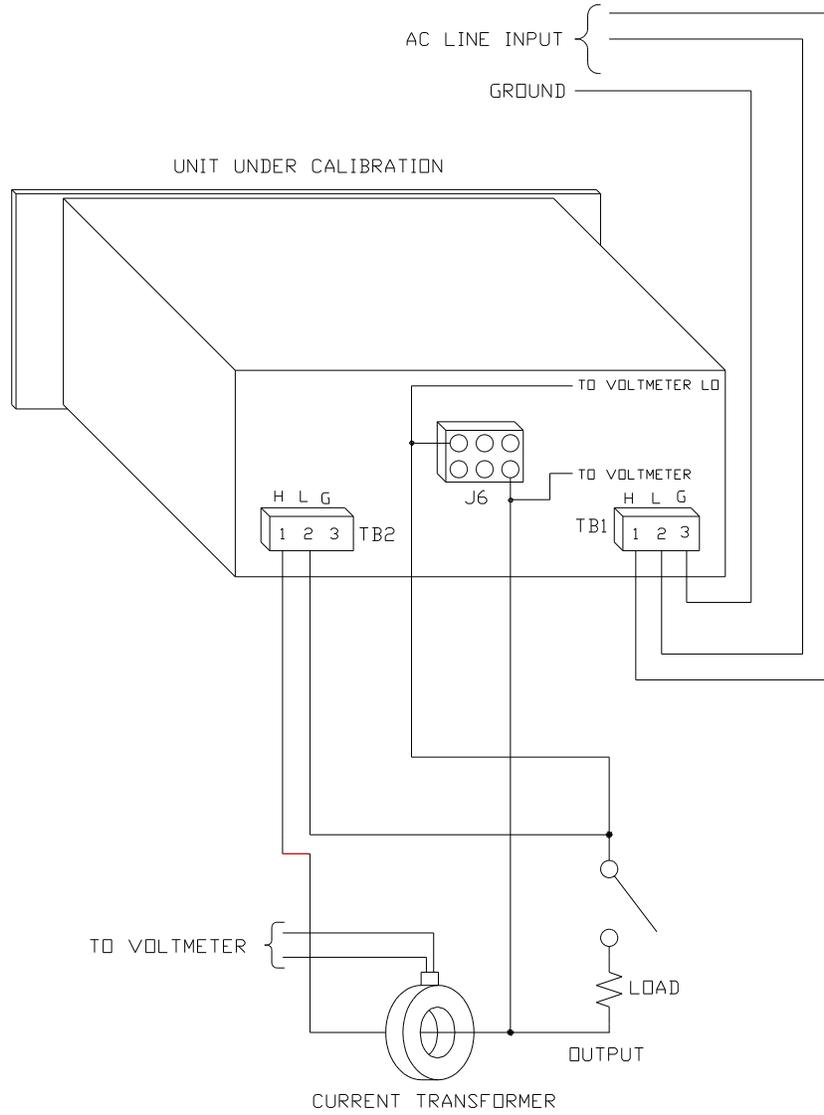


Figure 4-2: Equipment Hookup for Periodic Calibration



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. 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.

### 4.3.2 VOLTAGE MEASUREMENT CALIBRATION

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.
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. Enter the key sequence:

135 PRG ENT

After about 5 seconds, the volt measurement function will be calibrated.

**Table 4-1: Configuration and Setup Values**

MODEL	STANDARD	LV	HV	EHV	
VOLTAGE RANGE	135/270	67.5/135	156/312	200/400	
LOAD	2001L	9.1Ω	2.3Ω	12.2Ω	20Ω
	1501L	10.9Ω	2.73Ω	14.59Ω	24Ω
RESISTORS	751L	21.8Ω	5.45Ω	29.1Ω	47.9Ω
CLM A	2001L	14.8	29.6	12.8	10
(MAXOUTPUT)		12.34	24.70	10.68	8.34
1501L		6.18	12.37	5.36	4.17
AMPS					
751L					
PROGRAM VALUE		12	24	10	9
2001L		10	20	7.4	6.6
	1501L	15	10	3.7	3.3
FOR CAL.	751L				
CURRENT LIMIT		12.6	25.2	10.5	9.5
2001L		10.7	21.4	8	7
	1501L	5.4	10.7	4	3.5
SET POINT	751L				

### 4.3.3 CURRENT MEASUREMENT CALIBRATION

For calibration of current measurement perform the following steps:

1. Program 60 Hz, 135.0 volts and the maximum Current Limit value.
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, as shown below:

CFG = 16    ALM = 17

FLM = 18    CLM = 19

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

Determine the full load resistive value from the LOAD RES value in Table 4-1.

6. Apply the full load to the output. For other voltage ranges consult Table 4-1. Measure the output current with the AC Digital Voltmeter and Current Transformer.

7. On the keypad enter the key sequence:

Measured current. PRG ENT

Example: "12.1 PRG ENT"

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

#### 4.3.4 POWER MEASUREMENT CALIBRATION

For calibration of power measurement perform the following steps:

1. Program 60 Hz and 135.0 volts and the maximum Current Limit value.

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 LOAD RES value from Table 4-1 to the output. Measure the output current with the AC Digital Voltmeter and Current Transformer. Measure the voltage from the sense HI to neutral sense. Multiply the voltage and current values to determine the power value.

---

*(Note: The load must be resistive for the correct power value.)*

---

7. On the keypad enter the key sequence:

(Measured power) PRG ENT

### **4.3.5 REMOTE MEASUREMENT CALIBRATION**

The measurement function of the AC Power Source 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 Source.

The values for the VLT, CUR and PWR strings must be derive from the external AC Digital Voltmeters and Current Transformer.

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

CAL VLT (Measured output voltage value)

To calibrate the measured current send the following string:

CAL CUR (Measured output current value)

To calibrate the measured power value send the following string:

CAL PWR (Measured output power value)

## **4.4 NONPERIODIC CALIBRATION**

If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power Source 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.

### **4.4.1 OUTPUT FREQUENCY CALIBRATION**

Connect the Frequency Counter to the 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.

If the Frequency Counter does not indicate  $400.000 \pm 0.004$  Hz, adjust C43 on the A8 Assembly for the correct frequency. Refer to Table 4-1.

### **4.4.2 GAIN ADJUSTMENTS**

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

Adjust A5R38 for a DVM indication of 115.0 +1V rms.

Reconnect the Remote Sense lines.

#### 4.4.3 CURRENT TRANSFORMER ADJUSTMENTS

1. Monitor the output current with the Current Transformer and AC DVM. Measure the output voltage between TP10 and TP1(GND) on the Current Limit Assembly (5). Refer to Figure 4-1.
2. Turn on the AC input to the AC Power Source. Program 135.0 V rms and 60 Hz.
3. Apply the resistive load to the output. Adjust R7 on the Range Relay assembly, A2, for the correct voltage at TP10 for the load current: (1 volt = 10 amps). Remove the load.

#### 4.4.4 CURRENT LIMIT CALIBRATION

1. Program the Current Limit to 10.0 amps. (1501IL)
2. Monitor the power system phase A output current with the external current transformer and AC DVM. Connect an oscilloscope to the output.
3. Program the output voltage to 110 volts and 60 Hz.
4. Apply the LOAD RES to the output. If the output faults turn A5R17 on the Current Limit Assembly clockwise and reprogram 110 volts.
5. Increase the output amplitude slowly until the external AC current transformer indicates 10.7 amps. Slowly turn A5R17 on the Current Limit Assembly in a counterclockwise direction until the output OVERLOAD indicator starts to illuminate.

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## 5. THEORY OF OPERATION

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### 5.1 GENERAL

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

### 5.2 OVERALL DESCRIPTION

Input power at the rear panel is routed through the EMI filter and circuit breaker to the high current rectifier and the Power Supply Assembly, A6. The various DC supply outputs then go to the Mother Board, A4, then are directed to other modules.

The Programmable Oscillator Assembly, A8, generates the oscillator waveforms, power source controls and measurement signals. The oscillator assembly is connected to the rest of the power source through the Oscillator Interface Board, A3.

The Amplifier Module, A7, takes its DC supply voltages and input signal from the Mother Board, A4. It produces the high power output for the primary of the output transformer, T1. The output is routed through the Mother Board to the output transformer.

The Range Relay Board is identified as A2. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The output from the AC Power Source is taken from the Range Relay Board.

The Current Limit Board is identified by A5. This board controls the amplifier gain and the programmable current limit.

### 5.3 INPUT POWER SUPPLY

This assembly is identified as A6. It generates the high power +300 VDC supply.

The input power supply also has circuits that generate auxiliary DC voltages identified as  $\pm 18V$ ,  $\pm 15VSW$ ,  $+8VSW$  and  $+8V$ .

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

The input power supply also generates 50 VDC and 15VSW1 from the 300 volt DC supply. The 50 VDC is used for fan and relay operation,  $+15VSW1$  is used for the gate drive signal in the Amplifier Module.

#### ***5.4 CURRENT LIMIT BOARD***

The Current Limit Board receives the oscillator signal from the Oscillator Module. The signal is directed to the input of the power amplifier. A gain adjustment is located on the board.

The current limit circuit is also located on the Current Limit Board. The circuit receives a DC signal from the Oscillator Module that is proportional to the current limit value. The DC signal is compared to the output current.

If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power Source to operate at a constant current. If the output current limits the output voltage to 90% of the programmed voltage, an amplitude fault will be generated.

#### ***5.5 INDICATOR BOARD***

The Indicator Board, A1, has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

#### ***5.6 RANGE RELAY BOARD***

The Range Relay Board has all of the AC Power Source relays. These relays are operated from +50 VDC. The output relay is controlled by the CNF Logic Line. The range relay is controlled by RNG HI line.

There is a current transformer on the Range Relay Board. This transformer generates an AC voltage that is proportional to the output current. A 10 amp load current is represented by 1.00 VAC at the output of the current transformer.

#### ***5.7 AMPLIFIER MODULE***

The AC Power Source has a switchmode amplifier module to obtain high efficiency. The switchmode amplifier operates at 200 KHz.

The Amplifier Module obtains its input signal from the Current Limit Board. A 5.0 VRMS input signal will generate a full scale output voltage at the output of the AC Power Source and 100.0 VRMS on the primary of the output transformer.

The Amplifier Module requires a 300 VDC,  $\pm 15$ VSW, +8VSW and +15VSW1 supplies. The +300 VDC supply comes from the input power supply through a 15 amp fuse.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature exceeds 100 degrees C, the amplifier shuts down and sends an OVT signal to the oscillator module. A logic low on the OVT control line will cause the error message TEMP FAULT to be generated.

### **5.8 OSCILLATOR MODULE**

The Oscillator Module is designated A8. The module consists of two printed circuit assemblies.

These assemblies are interconnected with a small Mother Board. The Oscillator Display Assembly is mounted to the small Mother Board and is connected to the Oscillator Module with a short ribbon cable. The Oscillator Module is a plug-in module from the AC Power Source front panel.

### **5.9 CPU/GPIB BOARD**

The CPU/GPIB board, A8A3, 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.

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.

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.

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.

Frequency is computed from the measured time intervals between zero crossings of the output waveform. Phase is computed from the differences of measured zero crossings between the output signal and the external sync signal, if it is enabled.

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

### **5.10 PHASE A/REF BOARD**

The Phase A/Ref Board, A8A5, 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. A sine wave generator creates a 1024 step waveform which is filtered to provide the output oscillator signal. A remote sense amplifier controls the output amplitude.

### ***5.11 DISPLAY MODULE***

The Display Board, A8A13, 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.

Figure 5-1: AC Power System Block Diagram

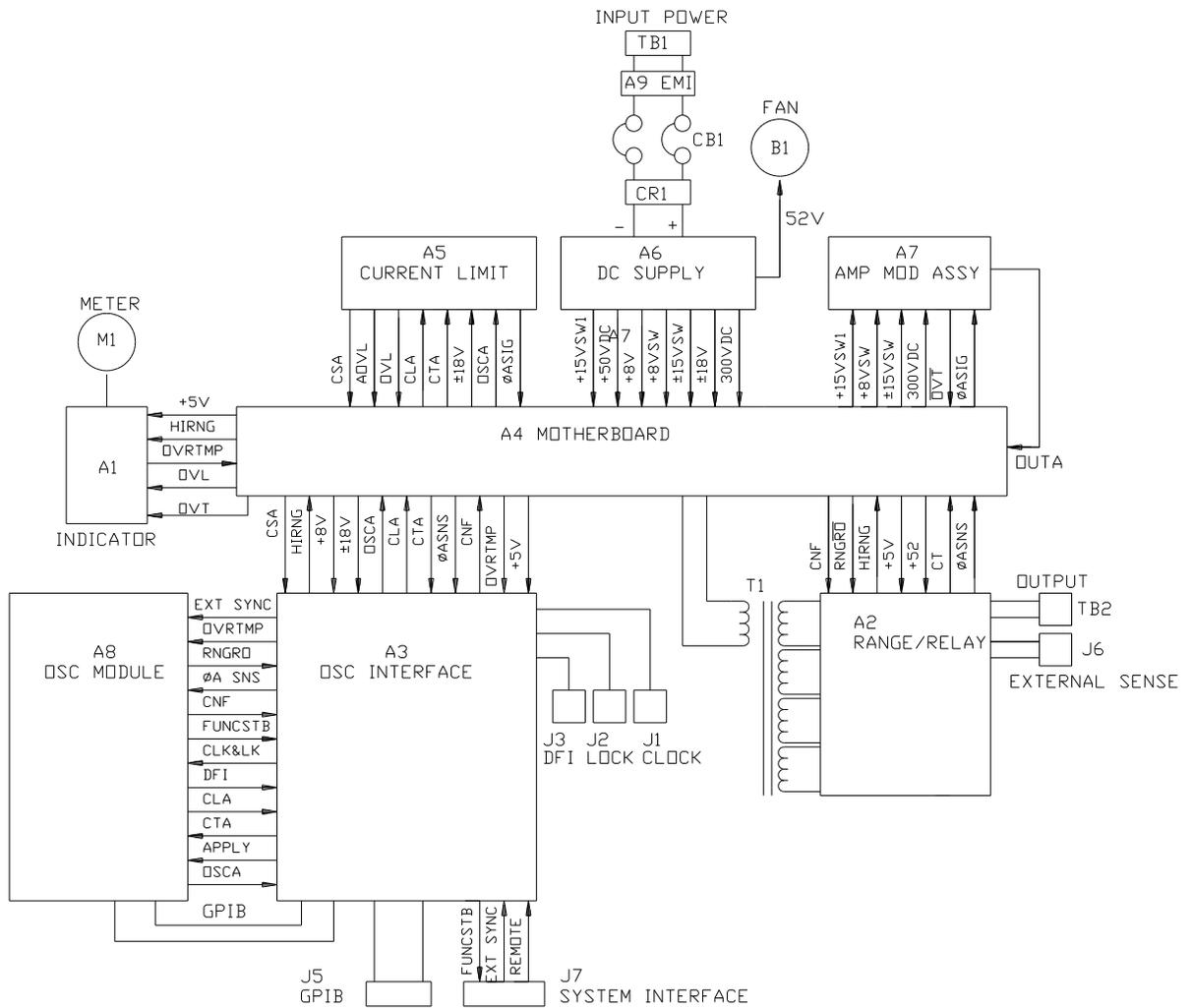
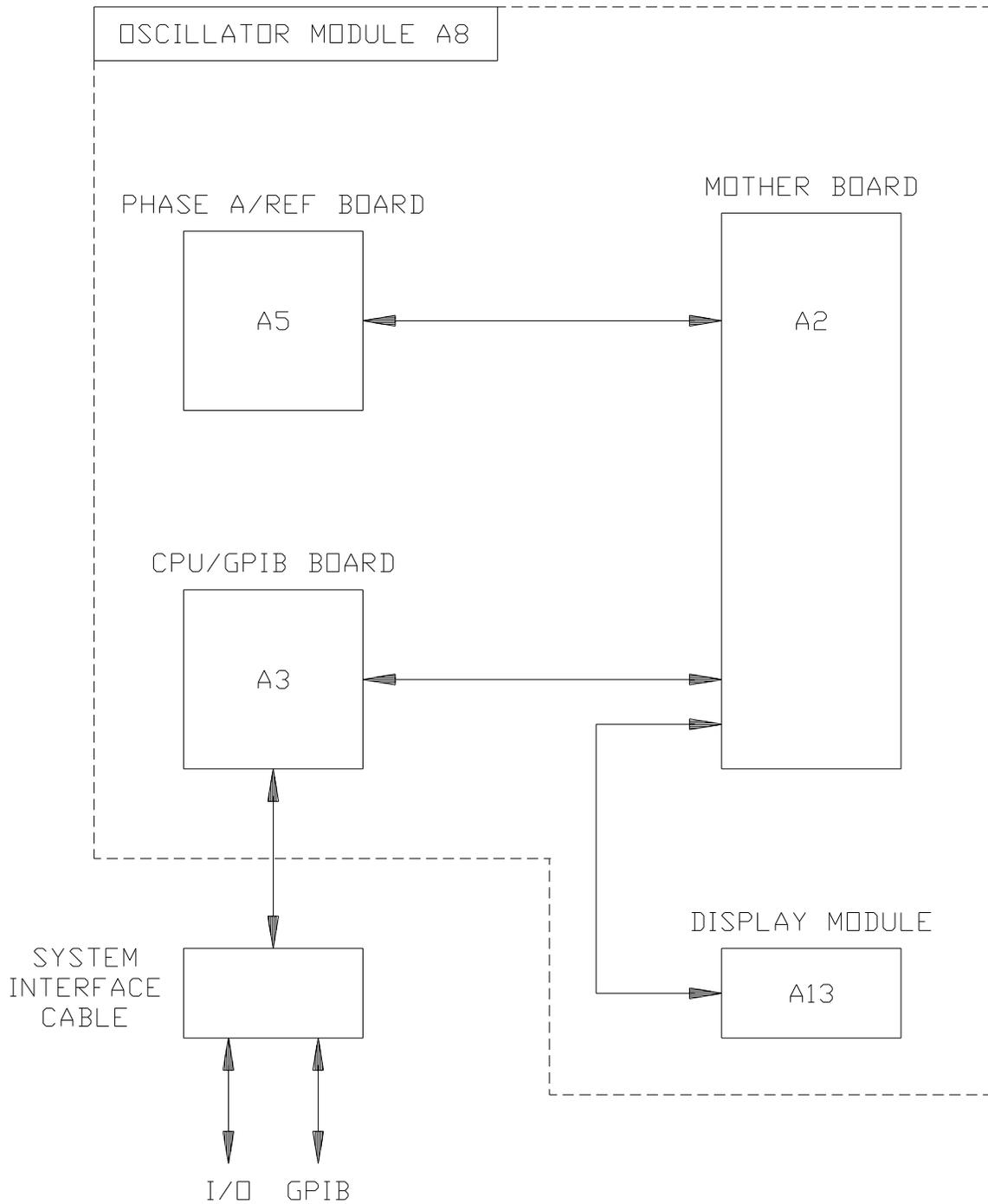


Figure 5-2: Programmable Oscillator Module



## **6. MAINTENANCE AND TROUBLESHOOTING**

---

### **6.1 GENERAL**

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power Source 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 Titles and Page Numbers for Troubleshooting**

<b><u>PARAGRAPH</u></b>	<b><u>PROBLEM</u></b>	<b><u>PAGE</u></b>
6.2	Poor Voltage Accuracy	99
6.3	Poor Output Voltage Regulation	99
6.4	Overtemperature Lamp On	100
6.5	Overload Lamp On	100
6.6	Can't Program AC Power Source on GPIB	101
6.7	Distorted Output	101
6.8	No Output	101

### **6.2 POOR VOLTAGE ACCURACY**

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 4.3.1.

### **6.3 POOR OUTPUT VOLTAGE REGULATION**

If the AC Power Source 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.

#### **6.4 OVERTEMPERATURE LAMP ON**

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

1. Ambient temperature is too high.

SOLUTION: Operate power source between 0 and 50°C.

2. Fan or ventilation holes are blocked.

SOLUTION: Remove obstructions.

3. Fan not working.

SOLUTION: Replace fan. Consult factory.

#### **6.5 OVERLOAD LAMP ON**

The OVERLOAD lamp comes on when the output load current has exceeded the programmed current limit value. If the AC Power Source 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 4.4.4.

4. 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.

### **6.6 CAN'T PROGRAM AC POWER SYSTEM ON GPIB**

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 incorrect.

SOLUTION: Update address. See paragraph 3.6.1.

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 6.10.

### **6.7 DISTORTED OUTPUT**

The AC Power Source 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 4.0. 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.

### **6.8 NO OUTPUT**

If the AC Power Source 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 2.6.

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.

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

J7-24 Oscillator Signal

J7-7 Oscillator common/return

Program 135.0 volts on the 135 volt range. The signal should be  $5.74 \pm 0.5$  VAC.

SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6.10.

SOLUTION: If the signal at the System Interface connector is greater than 5.74 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6.11.

4. The internal amplifier fuse, F2, has failed.

SOLUTION: Replace the fuse.

## **6.9 MODULE REMOVAL**

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Module, A7, with the insulator removed.

### 6.9.1 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the Oscillator Module (assembly A8) follow the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker. Remove the input power to the rear panel terminal block.
2. Remove the Keyboard/Display assembly (Oscillator Module front panel) by loosening the two captive screws on its front panel.
3. Unplug the Oscillator Module, A8, by sliding out the package of PC assemblies with the front panel display.
4. The module is now removed. To replace the module follow these steps in reverse order.

### 6.9.2 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that indicates the failure of the amplifier module (assembly A7), check the condition of the +300 VDC fuse before replacing the amplifier. Refer to Figure 6-1 for the location of the fuse.

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

1. Turn off the input circuit breaker.
2. Disconnect AC input power to the rear panel.



Remove the AC Power Source top cover by removing (13) #6-32 x 5/16" FLH screws.



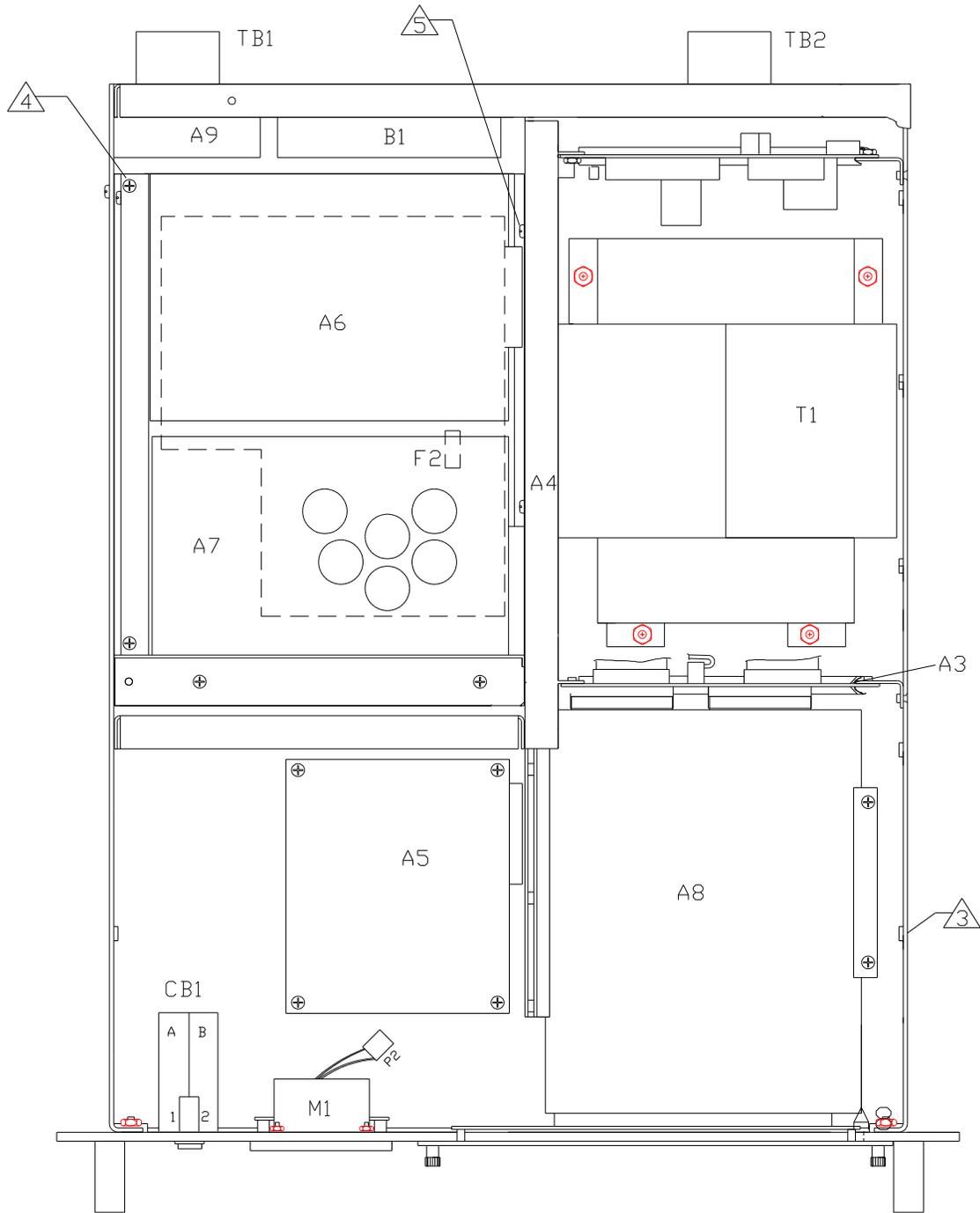
Remove the (2) #6-32 x 1" screws and lock washers that hold the amplifier module from the far end opposite the connector.



Remove (2) #6-32 x 3/8" screws and lock washers located near the connector, attaching the red insulator to the center bracket.

6. Remove the amplifier by lifting its end up and disconnecting from the connector.
7. The amplifier may be replaced by following this procedure in reverse order.
8. Check the amplifier 15 amp fuse (F2) located on the DC Supply Board, A6, and replace it if necessary.
9. After an amplifier has been replaced, readjust its gain. Refer to Section 4.

Figure 6-1: Module Location



## **7. REPLACEABLE PARTS**

---

### **7.1 GENERAL**

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

### **7.2 ORDERING INFORMATION**

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

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

All replaceable part orders should be addressed to:

**California Instruments  
Attention: Customer Service  
9689 Towne Centre Drive  
San Diego, California 92121**

**TOP ASSEMBLY REPLACEABLE PARTS  
FOR 2001L, 1501L, 751L  
TOP ASSEMBLY NO: 4005-411-1**

<b>SEQ NO.</b>	<b>COMPONENT ITEM NO.</b>	<b>DESCRIPTION</b>	<b>VENDOR</b>	<b>QTY</b>
A1	4005-700-1	PC ASSY, INDICATOR,LIMIT	16067	1.0
A2	4005-705-1	PC ASSY, RANGE/RELAY	16067	1.0
A3	4005-702-1	PC ASSY, OSCILLATOR INTERFACE	16067	1.0
A4	4005-708-1	PC ASSY, MOTHER	16067	1.0
A5	4005-709-1	PC ASSY, CURRENT LIMIT	16067	1.0
A6	4008-712-1	PC ASSY, DC SUPPLY	16067	1.0
A7	4009-423-8	PC ASSY, HEATSINK, SW AMP	16067	1.0
A8	4005-404-5	PC ASSY, MODULE OSC.	16067	1.0
A9	4005-710-1	PC ASSY, EMI FILTER	16067	1.0
B1	241175	FAN, 4", 48 VDC	23936	1.0
F2	270167	FUSE,15A,250V	71400	1.0

## 8. MIL-STD-704D

---

### 8.1 GENERAL

The MIL-704D option is capable of performing all sections of MIL-STD-704D. It will perform all tests in the order listed below or part of the test. There is a 5 second delay between tests to allow the operator to evaluate the result of the test.

### 8.2 INITIAL SETUP

Nominal parameters for the AC Power Source shall be as follows:

OUTPUT VOLTAGE: 115 L-N  
OUTPUT FREQUENCY: 400 Hz

### 8.3 TEST PERFORMED

---

**NOTE:** *All figures applied for single phase only.*

---

#### 8.3.1 Steady state test. (Refer to MIL-704D Doc. Table 1)

1. Voltage per Figure 1, page 118.
2. Voltage unbalance per Figure 2, page 118.  
(Does not apply to 751L, 1501L or 2001L.)
3. Voltage phase difference per Figure 3, page 118.  
(Does not apply to 751L, 1501L or 2001L.)
4. Waveform distortion factor per Figure 4, page 118.
5. Frequency per Figure 5, page 118.

#### 8.3.2 Transient

1. Voltage Transient (Refer to MIL-704D Doc. Figure 5.)  
  
High voltage Transient per Figure 6, page 119.  
Low voltage Transient per Figure 7, page 119.
2. Frequency Transient (Refer to MIL-704D Doc. Figure 6)  
  
High frequency Transient per Figure 8, page 120.  
Low frequency Transient per Figure 9, page 120.

### 8.3.3 Abnormal operation

1. Abnormal voltage (Refer to MIL-704D Doc. Figure 7).  
Overvoltage per Figure 10, page 121.  
Undervoltage per Figure 11, page 121.
2. Abnormal frequency (Refer to MIL-704D Doc. Figure 8)  
Overfrequency per Figure 12, page 122.  
Underfrequency per Figure 13, page 122.

### 8.3.4 Emergency operation (Refer to MIL-704D Doc. 5.2.5)

1. Voltage per Figure 14, page 123.
2. Frequency per Figure 15, page 123.

## 8.4 **KEYPAD ENTRY** (Refer to page 116 for Keyboard flow chart)

To perform a test from the key board, the following key sequence is required:

704 ENT

The following screen will appear:

```
MIL704D:SelA  
ENT=all CLR=EXIT
```

Pressing the A, B, C or any combination selects the phase in test. Press ENT without the phase select for simultaneous three-phase test.

The following screen appears for a short time.

```
TEST A  
CLR to Reselect
```

The next screen is:

```
Apply Nom Output  
Press ENT
```

When ENT is selected the following screen appears:

Press MNU to  
Select Test

The MNU screen has two lines of selection shown at a time.

There are 3 different types of operations that can be selected from a MENU screen. If the word MENU appears for the item selected, another MENU screen will be displayed. If the word TEST appears for the item selected, the test will start. The display will return to the previous screen if the word RETURN appears for the item selected.

The Main Menu will appear as follows:

1=Steady St Menu  
2=Transient Menu  
3=Abnormal Menu  
4=Emergency Menu  
5=MIL704D Test  
6=Return

If key 1 is selected "Steady State: from the Main Menu, the following Menu will appear:

1=Voltage Test  
2=Unbalance Test (This test is not applicable to 751L, 1501L or 2001L.)  
3=Phase dif Test (This test is not applicable to 751L, 1501L or 2001L.)  
4=Wave dist Test  
5=Frequency Test  
6=Steady St Test  
7=Return

If key 2 is selected "Transient" from the Main Menu, the following Menu will appear:

1=Volt Trns Menu  
2=Freq Trns Menu  
3=Transient Test  
4=Return

If key 1 is selected from the Transient Menu the following Menu will appear:

1=High Volt Test  
2=Low Volt Test  
3=Volt Trns Test  
4=Return

If key 2 is selected from the Transient Menu the following Menu will appear:

- 1=High Freq Test
- 2=Low Freq Test
- 3=Freq Trns Test
- 4=Return

If key 3 is selected "Abnormal" from the Main Menu, the following Menu will appear:

- 1=Abnl Volt Menu
- 2=Abnl Freq Menu
- 3=Abnormal Test
- 4=Return to Main Menu

If key 1 is selected from the "Abnormal" Menu, the following Menu will appear:

- 1=Overvolt Test
- 2=Undervolt Test
- 3=Abnl Volt Test
- 4=Return

If key 2 is selected from the "Abnormal" menu, the following Menu will appear:

- 1=Overfreq Test
- 2=Underfreq Test
- 3=Abnl Freq Test
- 4=Return

If key 4 is selected "Emergency" from the Main Menu, the following Menu will appear:

- 1=Emrg Volt Test
- 2=Emrg Freq Test
- 3=Emergency Test
- 4=Return

### 8.5 GPIB OPERATION (Refer to page 116 for syntax diagram)

The following command will be used to execute the appropriate part of all of the test.

```
MIL704D Test all MIL704D Sections
MIL704D :STEady state
MIL704D :STEady state :VOLTage
MIL704D :STEady state :WAVEform :DISTortion
MIL704D :STEady state :FREQuency

MIL704D :TRANsient
MIL704D :TRANsient :VOLTage
MIL704D :TRANsient :VOLTage :HIGH
MIL704D :TRANsient :VOLTage :LOW
MIL704D :TRANsient :FREQuency
MIL704D :TRANsient :FREQuency:HIGH
MIL704D :TRANsient :FREQuency:LOW

MIL704D :ABNormal
MIL704D :ABNormal :VOLTage
MIL704D :ABNormal :VOLTage :OVER
MIL704D :ABNormal :VOLTage :UNDer
MIL704D :ABNormal :FREQuency
MIL704D :ABNormal :FREQuency :OVER
MIL704D :ABNormal :FREQuency :UNDer

MIL704D :EMERgency
MIL704D :EMERgency :VOLTage
MIL704D :EMERgency :FREQuency
```

*All lower case letters are option.*

### 8.6 STEADY STATE

1. Steady state voltage test (Figure 1).

```
MIL704D :STEady state :VOLTage
```

This test will change the output voltage simultaneously from 115 volts to 108 volts for 5 seconds to 118 volts for 5 seconds.

2. Steady state voltage unbalance test (Figure 2).

```
MIL704D :STEady state :VOLTage :UNBalance
```

This test has no meaning for 751L, 1501L or 2001L and should not be executed.

3. Steady state voltage phase difference test (Figure 3).

MIL704D :STEady state :PHASe :DIFFerence

This test has no meaning for 751L, 1501L or 2001L and should not be executed.

4. Steady state waveform distortion (Figure 4).

MIL704D :STEady state :WAVEform :DISTortion

This test will generate a 5% distortion on the selected phase for 5 seconds.

5. Steady state frequency test (Figure 5).

MIL704D :STEady state :FREQuency

This test will change the programmed frequency from 400 Hz to 393 Hz for 5 seconds then to 407 Hz for 5 seconds.

6. Steady state test

MIL704D :STEady state

This test will perform all the above five tests in the same order above. A 5 second pause between tests is asserted.

### 8.6.1 TRANSIENT

1. Transient high voltage test (Figure 6).

MIL704D :TRANSient :VOLTage :HIGH

This test requires a 180 volts range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for range change and after 5 seconds the test will begin.

The output will go to 180 volts for 10 msec and will drop gradually to 115 volts in 81.25 msec. After 5 seconds, a range change will take place to the original setup.

2. Transient low voltage test (Figure 7).

MIL704D :TRANSient :VOLTage :LOW

The output voltage will drop to 80 volts for 10 msec. It will gradually rise to 115 volts in 81.25 msec.

3. Transient voltage test

MIL704D :TRANSient :VOLTage

This test will combine High voltage transient and Low voltage transient. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts, the High voltage transient test will not take place.

4. Transient high frequency test (Figure 8).

MIL704D :TRANSient :FREQUENCY:HIGH

This test will step up the frequency from 400 Hz to 425 Hz. The frequency will step down to 400 Hz in the following sequence:

425 Hz for 1 second  
420 Hz for 4 seconds  
410 Hz for 5 seconds  
407 Hz for 4 seconds

5. Transient low frequency test (Figure 9).

MIL704D :TRANSient :FREQUENCY:LOW

This test will step down the frequency from 400 Hz to 375 Hz. The frequency will step up to 400 Hz in the following sequence:

375 Hz for 1 second  
380 Hz for 4 seconds  
390 Hz for 5 seconds  
393 Hz for 4 seconds

6. Transient frequency test

MIL704D :TRANSient :FREQUENCY

This test will combine the high frequency transient and the low frequency transient. There is a pause of 5 seconds between tests.

### 8.6.2 ABNORMAL

1. Abnormal overvoltage test (Figure 10).

MIL704D :ABNormal :VOLTage :OVER

This test requires a 180 volt range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for the range change and after 5 seconds the test will begin.

The output will go to 180 volts for 50 msec and will drop gradually to 125 volts in 450 msec. The output voltage will remain at 125 volts for 9.5 seconds before it drops to 115 volts. After 5 seconds, a range change will take place to the original setup.

2. Abnormal undervoltage test (Figure 11).

MIL704D :ABNormal :VOLTage :UNDer

The output voltage will drop to 0 volts for 7 seconds. It step up to 100 volts for 3 seconds before it will go to 115 volts.

3. Abnormal voltage test

MIL704D :ABNormal :VOLTage

This test will combine Abnormal overvoltage and Abnormal undervoltage. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts the Abnormal overvoltage test will not take place.

4. Abnormal overfrequency test (Figure 12)

MIL704D :ABNormal :FREQuency :OVER

This test will step up the frequency from 400 Hz to 480 Hz. The frequency will step down to 400 Hz in the following sequence:

480 Hz for 5 seconds

425 Hz for 5 seconds

5. Abnormal underfrequency test (Figure 13)

MIL704D :ABNormal :FREQuency :UNDer

This test will step down the frequency from 400 Hz to 0 Hz. The frequency will step up to 400 Hz in the following sequence:

0 Hz for 5 seconds

375 Hz for 5 seconds

6. Abnormal frequency test

MIL704D :ABNormal :FREQuency

This test will combine the Abnormal overfrequency and the Abnormal underfrequency .  
There is a pause for 5 seconds between tests.

### 8.6.3 EMERGENCY

1. Emergency voltage test (Figure 14).

MIL704D :EMERgency :VOLTagE

This test will step down the voltage to 104 volts for 5 seconds. Also it will step up the voltage to 122 volts for another 5 seconds.

2. Emergency frequency test (Figure 15).

MIL704D :EMERgency :FREQuency

This test will step down the frequency to 360 Hz for 5 seconds then will step up the frequency to 440 Hz for 5 seconds.

3. Emergency test

MIL704D :EMERgency

This test will combine the voltage emergency test and the frequency emergency test. A pause of 5 seconds between tests is asserted.

### 8.6.4 MIL704D TEST

MIL704D

This test will combine all the tests listed above in one test in the sequence listed. A 5 second time delay separate the parts of the test. Tests will be performed on the selected phases only.

Figure 8-1: Flow Diagram

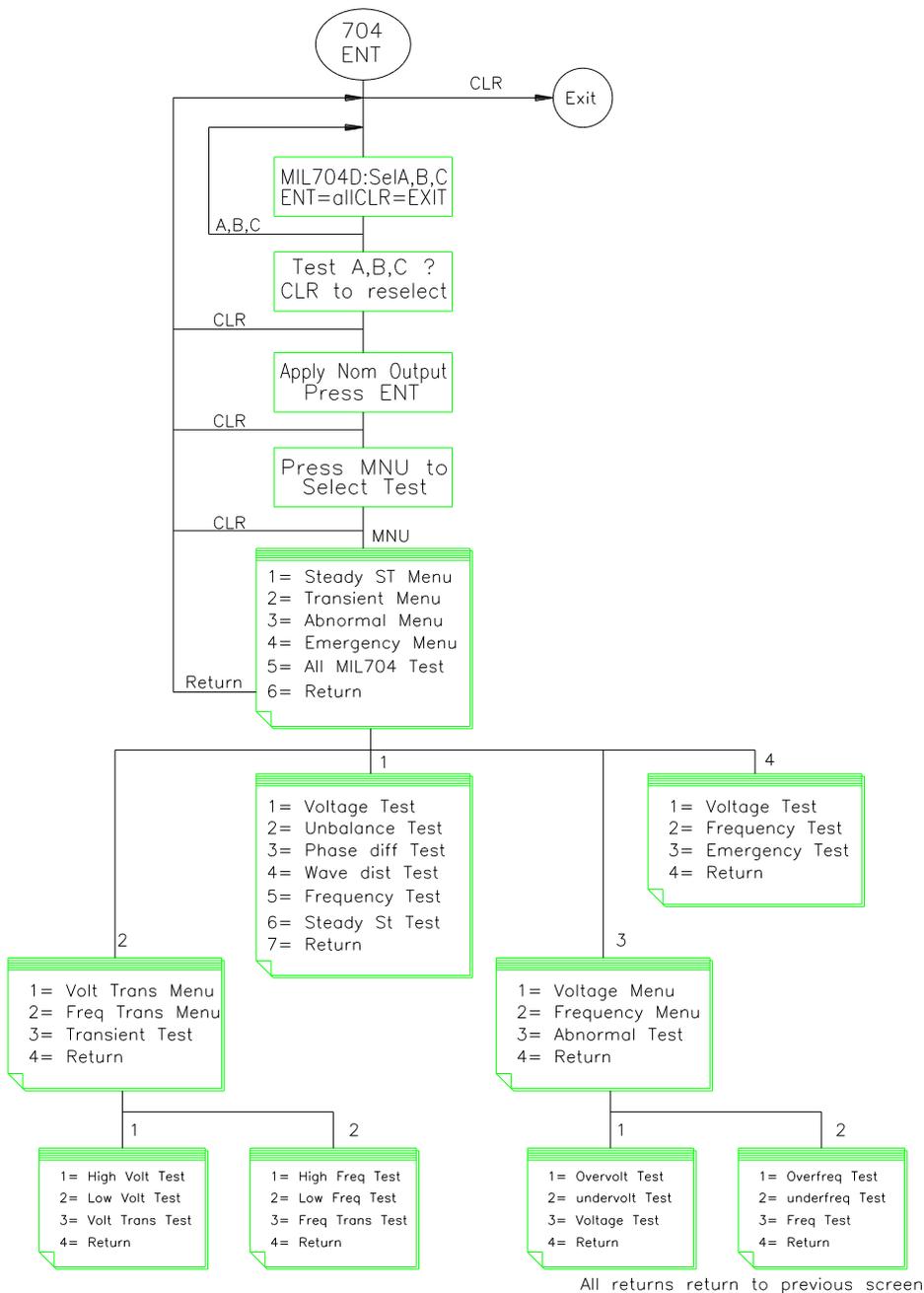
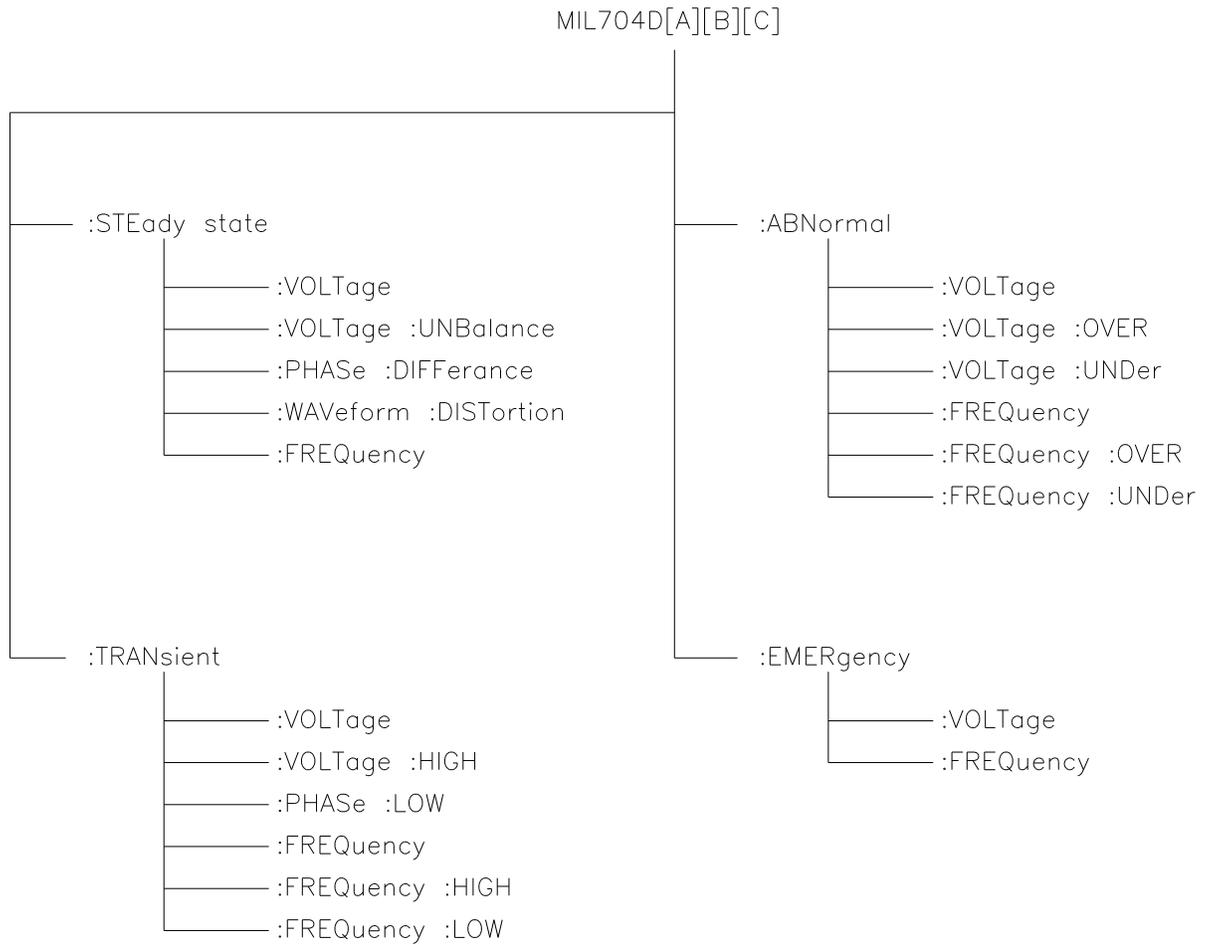


Figure 8-2: Syntax Flow



MIL704D SYNTAX FLOW

Figure 8-3: Figure 1,2,3,4,5

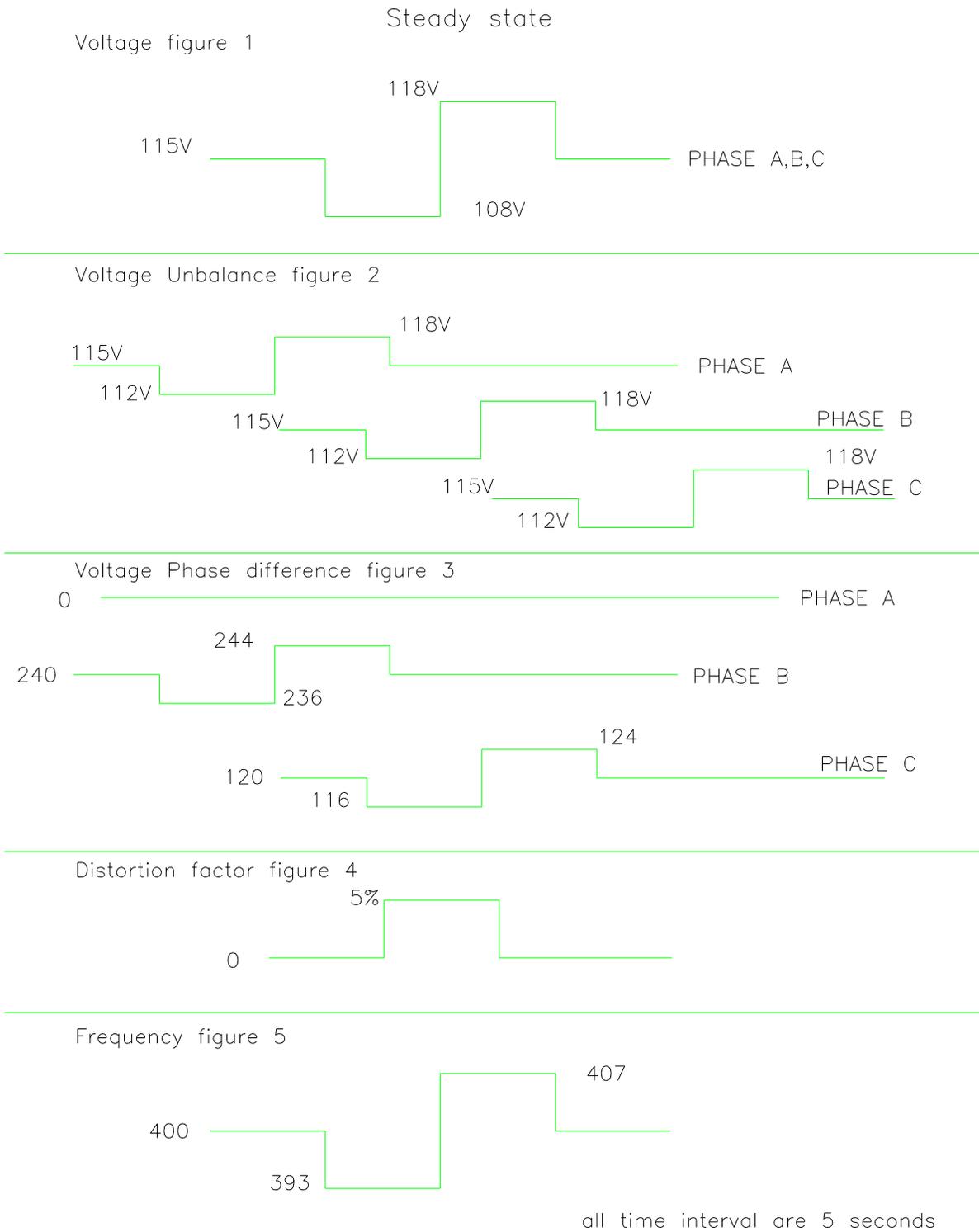


Figure 8-4: Figure 6,7

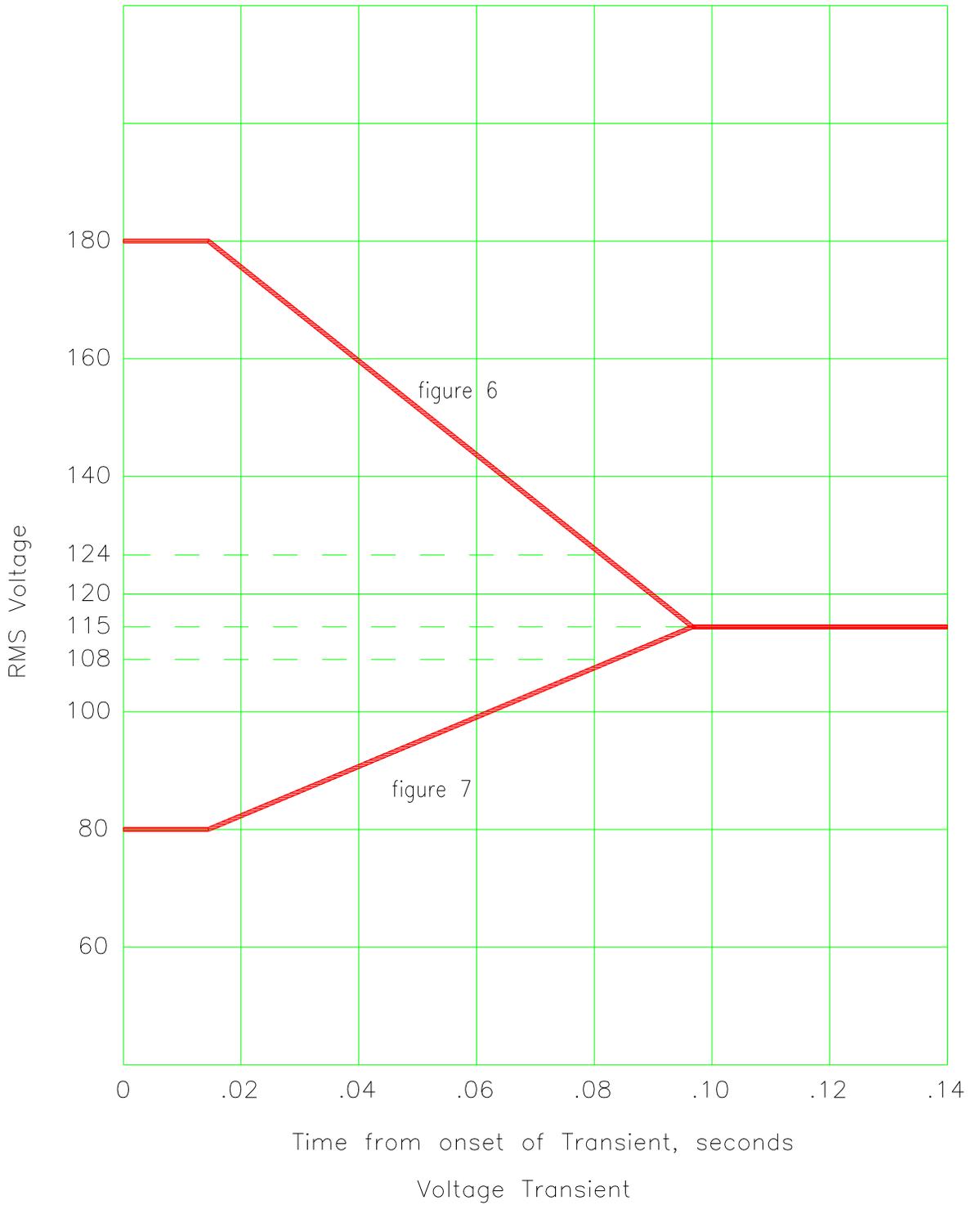


Figure 8-5: Figure 8,9

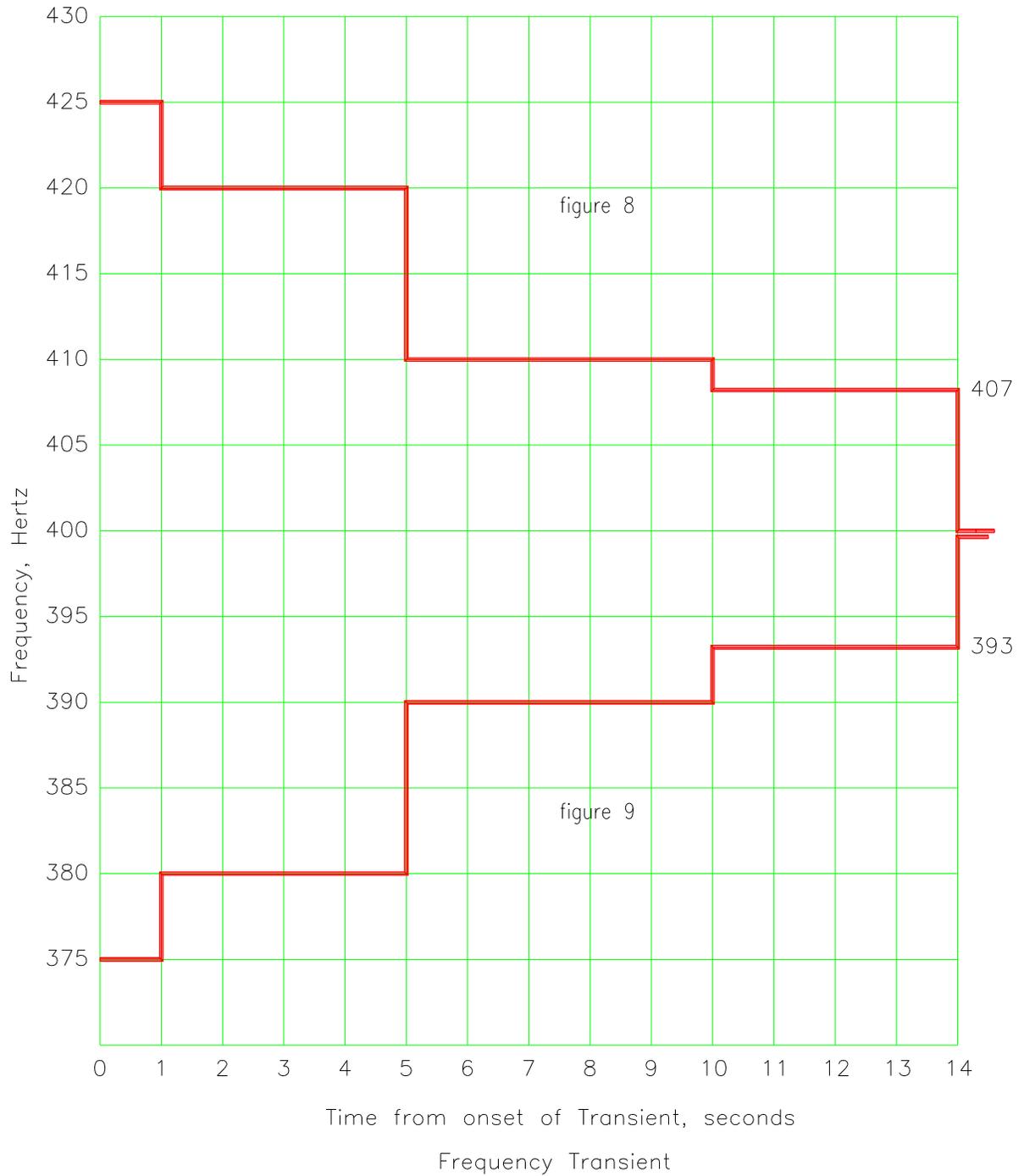


Figure 8-6: Figure 10,11

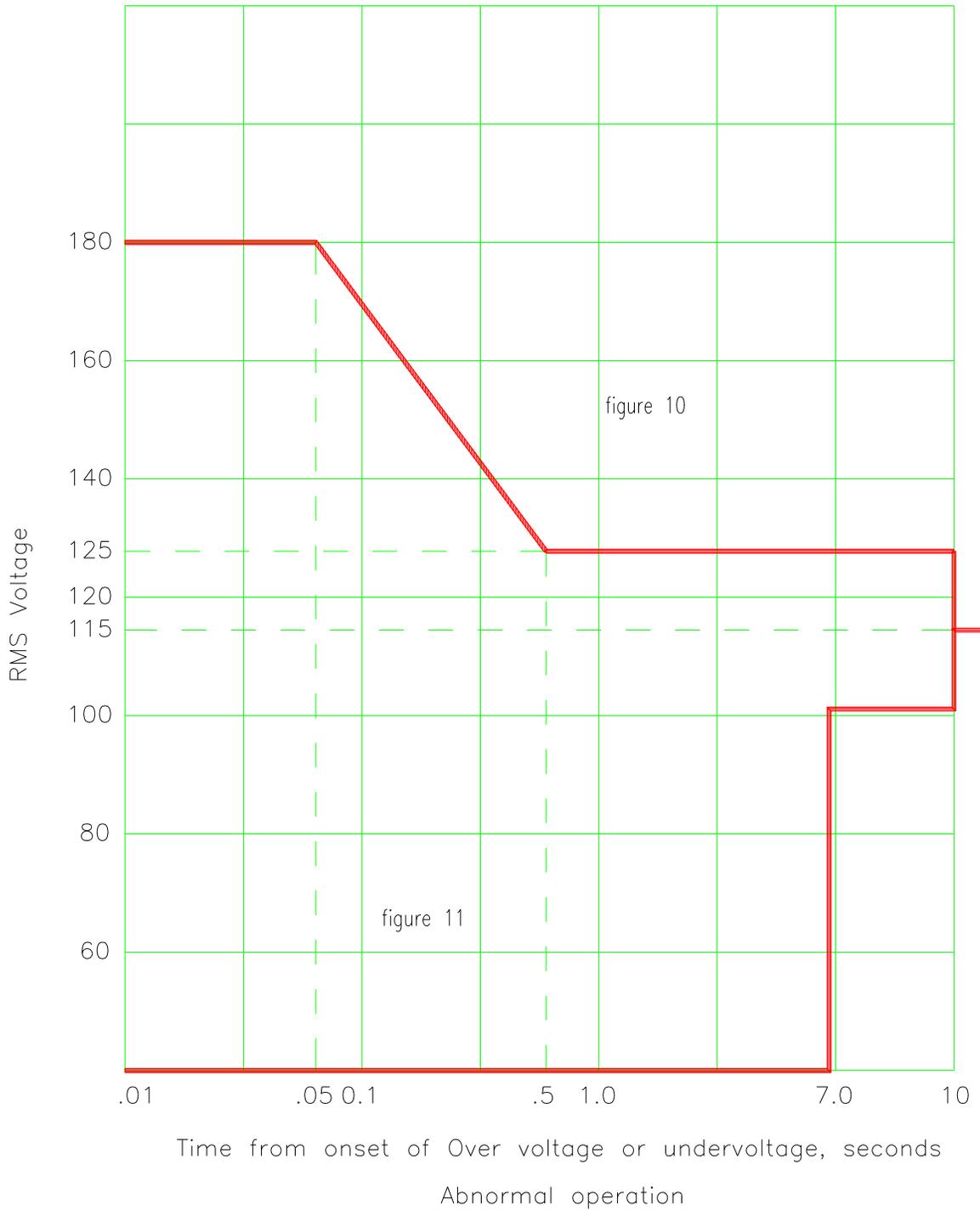
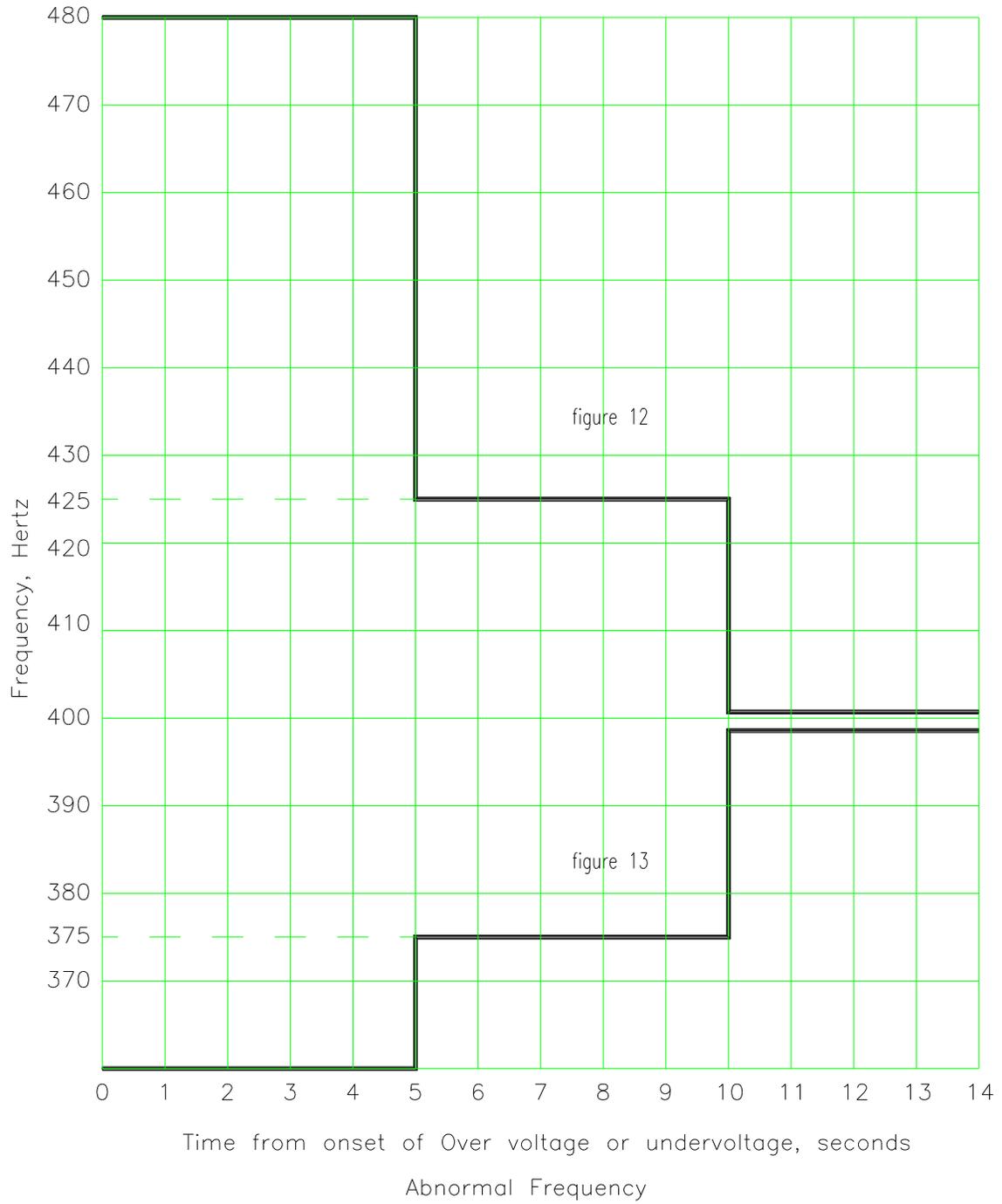
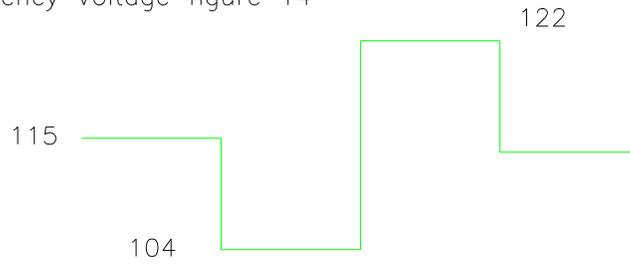


Figure 8-7: Figure 11,12



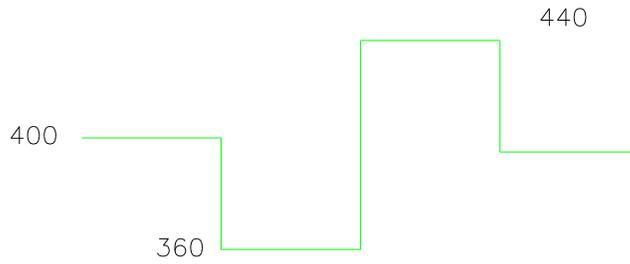
**Figure 8-8: Figure 14,15**

Emergency Voltage figure 14



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Emergency Frequency figure 15



all time interval are 5 seconds

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## **9. RTCA/DO-160C**

---

### **9.1 GENERAL**

The RTCA/DO-160C option is capable of performing all sections of RTCA/DO-160C for the AC Source signal.

### **9.2 INITIAL SETUP**

Nominal parameters for the AC Power source shall be as follows:

Output Voltage	115V L-N
Output Frequency	400 Hz

### **9.3 TEST PERFORMED**

#### **9.3.1 NORMAL STATE**

1. Normal State Voltage and Frequency test
2. Waveform Distortion test
3. Voltage Modulation test
4. Frequency Modulation test
5. Momentary Power Interrupt (Undervoltage) test
6. Voltage Surge (Overvoltage) test

#### **9.3.2 EMERGENCY TEST**

1. Emergency Voltage and Frequency test

#### **9.3.3 ABNORMAL TEST**

1. Abnormal Voltage and Frequency test
2. Momentary Undervoltage test
3. Voltage Surge test

### **9.4 KEYPAD ENTRY (Refer to Figure 1 for Keyboard Flow Chart)**

To perform a test from the keyboard, the following key sequence is required:

160 ENT

The following screen will appear:

```
DO160C: SelA
ENT=all CLR=EXIT
Press the ent key. No phase selection is required.
```

The following screen appears for a short time:

Test A  
CLR to Reselect

The next screen is:

Apply Nom output  
Press ENT

When ENT is selected the following screen appears;

Press MNU to  
Select Test

The MNU screen has two lines of selection shown at a time.

There are three different types of operations that can be selected from the MENU screen. If the word MENU appears for the items selected, another MENU screen will be displayed. If the word Test appears for the item selected, the test will start. The display will return to the previous screen if the word RETURN appears for the item selected.

The Main Menu will appear as follows:

1 = Normal Menu  
2 = Emergency Menu  
3 = Abnormal Menu  
4 = Return

If Key 1 is selected "Normal Menu" from the Main Menu, the following Menu will appear:

1 = Volt/Freq Menu  
2 = Unbalance Test (three-phase only)  
3 = Volt Mod Test  
4 = Power Int Test  
5 = Volt Surge Test  
6 = Wave Dist Test  
7 = Freq Mod Test  
8 = Return

If Key 2 is selected "Emergency Menu" from the Main Menu, the following Menu will appear:

1 = Emg V/F Menu  
2 = Emg Unbal Test (three-phase only)  
3 = Return

If Key 3 is selected "Abnormal Menu" from the Main Menu, the following Menu will appear:

- 1 = Ab Volt Menu
- 2 = Ab Vunder Test
- 3 = Ab Vsurge Test
- 4 = Return

If Key 1 is selected "Volt/Freq Menu" from the Normal Menu, the following Menu will appear:

- 1 = Under Volt Test
- 2 = Over Volt Test
- 3 = Return

If Key 1 is selected "Volt/Freq Menu" from the Emergency Menu, the following Menu will appear:

- 1 = Emg Vunder Test
- 2 = Emg Vover Test
- 3 = Return

If Key 1 is selected "Volt Menu" from the Abnormal Menu, the following Menu will appear:

- 1 = Ab Vunder Test
- 2 = Ab Vover Test
- 3 = Return

If Key 3 or Key 7 is selected from the "Normal Menu", another screen will appear as follows:

Enter Modulation  
Rate in Hz and ENT.  
The numeric value must be within the limits for the test performed. See Figure 2 and Figure 3.

If Key 4 is selected from the "Normal Menu", the following screen will appear as follows:

Enter Test  
Number 1 to 15 and ENT (see Table 1)

## 9.5 GPIB OPERATION

The following command will be used to execute the appropriate section of DO-160C.

Remote Command

***Items contained within square brackets [ ] are optional***

DO160 :NORMAl state :VOLT\_FREQ :MINimum  
DO160 :NORMAl state :VOLT\_FREQ :MAXimum  
DO160 :NORMAl state :WAVE form :DISTortion  
DO160 :NORMAl state :VOLTage :MODulation <numeric>  
DO160 :NORMAl state :FREQUENCY :MODulation <numeric>  
DO160 :NORMAl state :VOLTage :UNDer<numeric>  
DO160 :NORMAl state :VOLTage :OVER

DO160 :EMERgency :VOLT\_FREQ :MINimum  
DO160 :EMERgency :VOLT\_FREQ :MAXimum  
DO160 :EMERgency :VOLTage :UNBalance

DO160 :ABNormal stage :VOLTage :MINimum  
DO160 :ABNormal stage :VOLTage :MAXimum  
DO160 :ABNormal stage :VOLTage :UNDer  
DO160 :ABNormal stage :VOLTage :OVER

## 9.6 TEST SPECIFICATION

### 9.6.1 NORMAL STATE

#### 9.6.1.1 Normal State Minimum Voltage and Frequency Test

DO160 :NORMAl state :VOLT\_FREQ :MINimum

This test will change the output voltage for single phase from 115V to 104V and for three-phase from 115V to 105.5V and the frequency from 400 Hz to 380 Hz. The test will last for 30 minutes. The CLR Key in local operation will terminate the test at any time. Group execute trigger will terminate the test remotely. The unselected phases will remain at 115 volts.

### ***9.6.1.2 Normal State Maximum Voltage and Frequency Test***

DO160 :NORMAl state :VOLT\_FREQ :MAXimum

This test will change the output voltage for single phase from 115V to 122 volts and from 115V to 120.5 volts for three-phase and the frequency from 400 Hz to 420 Hz. The test will last for 30 minutes. The CLR Key in local operation will terminate the test at any time. Group execute trigger will terminate the test remotely. The unselected phase will remain at 115 volts.

### ***9.6.1.3 Normal State Waveform Distortion***

D0160 :NORMAl state :WAVE form :DISTortion

This test will generate a 5% distortion on the selected phase. The test will last for 30 minutes. This test can be terminated at any time.

### ***9.6.1.4 Normal State Voltage Modulation***

DO160 :NORMAl state :VOLTage :MODulation <numeric>

This test requires a numeric value equal to the modulation rate in Hz. See Figure 2. The amplitude modulation is calculated based on the modulation rate. This test will last for 2 minutes.

### ***9.6.1.5 Normal State Frequency Modulation***

DO160 :NORMAl state :FREQency :MODulation <numeric>

This test requires a numeric value equal to the modulation rate in Hz. See Figure 3. The frequency modulation is calculated based on the modulation rate. This test will last for two minutes.

### ***9.6.1.6 Normal State Power Interrupt***

DO160 :NORMAl state :VOLTage :UNDer<numeric>

This test requires a numeric value equal to the test number. There are 15 tests. See Table 1.

### ***9.6.1.7 Normal State Voltage Surge***

DO160 :NORMAL state :VOLTage :OVER

This test requires a power source with 160 volt output. If the power source has a dual voltage range, the test will select the high voltage range to complete the test.

The output voltage will remain at 115 volts for 5 minutes before it rises to 160 volts for 30 msec then stays for 5 seconds at 115 volts then drops to 60 volts for 30 msec before returning to 115 volts for 5 seconds. The above sequence will repeat itself three times.

## **9.6.2 EMERGENCY TEST**

This test could be performed in addition to the Normal State test for equipment designed to operate under emergency electrical system.

### ***9.6.2.1 Emergency State Minimum Voltage and Frequency Test***

DO160 :EMERgency :VOLT\_FREQ :MINimum

This test is similar to the test at 9.6.1.1 except the output frequency changes from 400 Hz to 360 Hz.

### ***9.6.2.2 Emergency State Maximum Voltage and Frequency Test***

DO160 :EMERgency :VOLT\_FREQ :MAXimum

This test is similar to the test at 9.6.1.2 except the output frequency changes from 400 Hz to 440 Hz.

## **9.6.3 ABNORMAL STATE**

### ***9.6.3.1 Abnormal State Minimum Voltage***

DO160 :ABNormal stage :VOLTage :MINimum

This test will drop the output to 97 volts for 5 minutes

### ***9.6.3.2 Abnormal State Maximum Voltage***

DO160 :ABNormal state :VOLTage :MAXimum

This test will raise the output voltage from 115 volts to 135 volts for 5 minutes.

### ***9.6.3.3 Abnormal State Undervoltage***

DO160 :ABNormal stage :VOLTage :UNDER

This test will drop the output voltage from 115 volts to 60 volts for 7 seconds.

**9.6.3.4 Abnormal State Voltage Surge**

DO160 :ABNormal state :VOLTage :OVER

This test requires an output voltage range of 180 volts. If the power source is a dual voltage range, this test will select the upper voltage range if the lower voltage ranges is less than 180 volts.

The output voltage will rise to 180 volts for 100 msec and will drop to 148 volts for 1 sec before it returns to 115 volts.

Figure 9-1: Figure 1

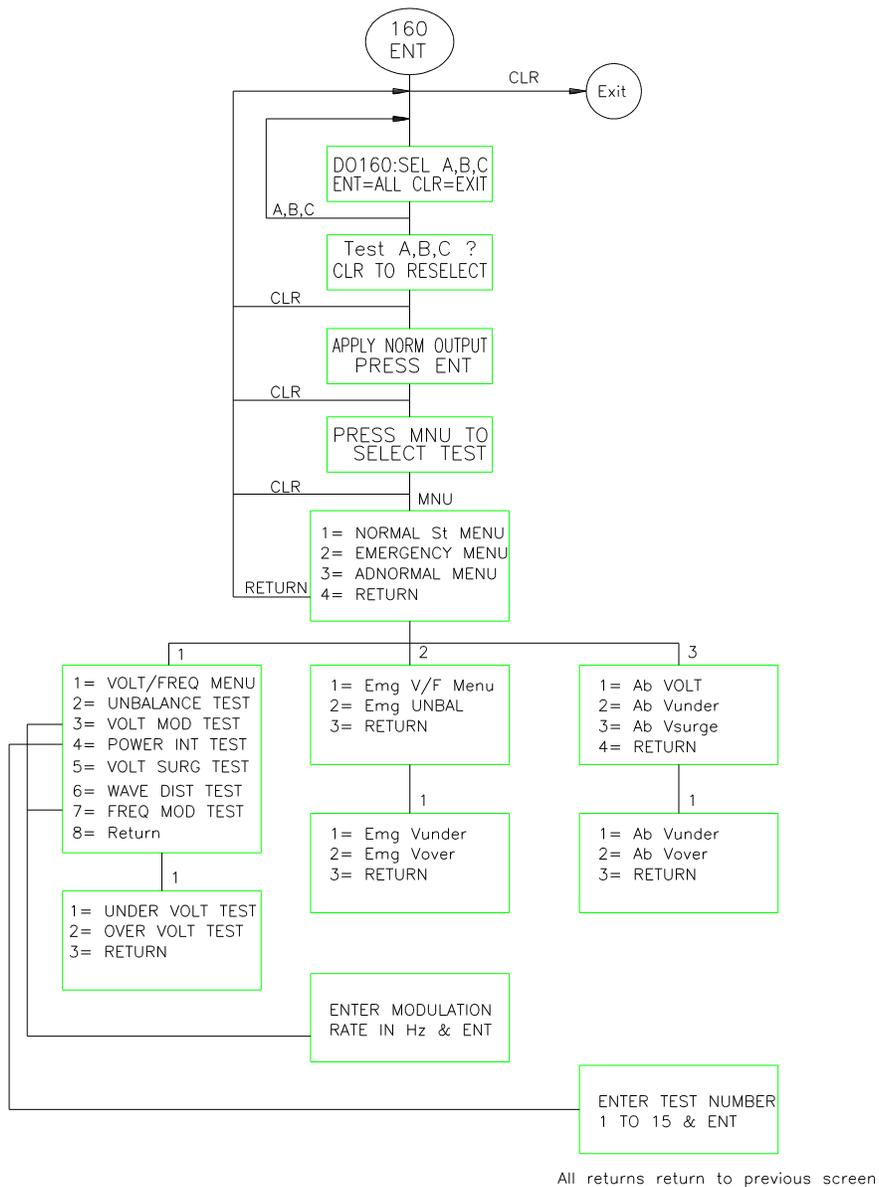
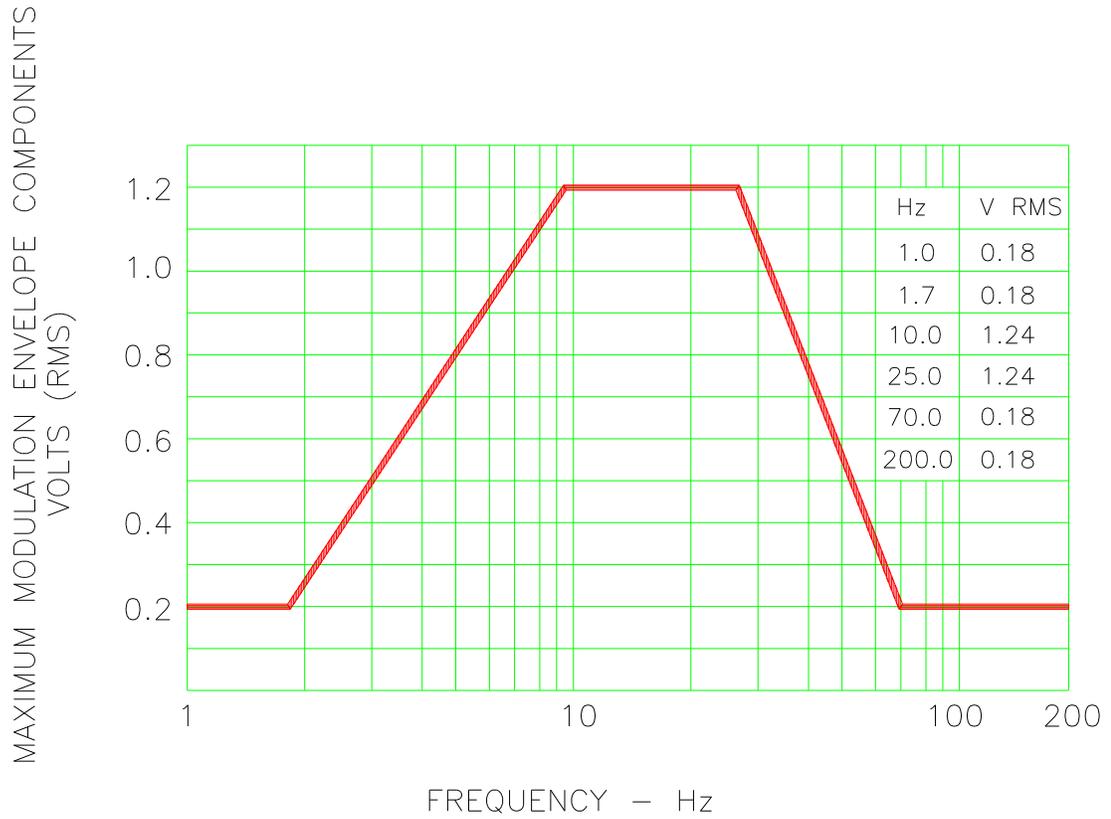
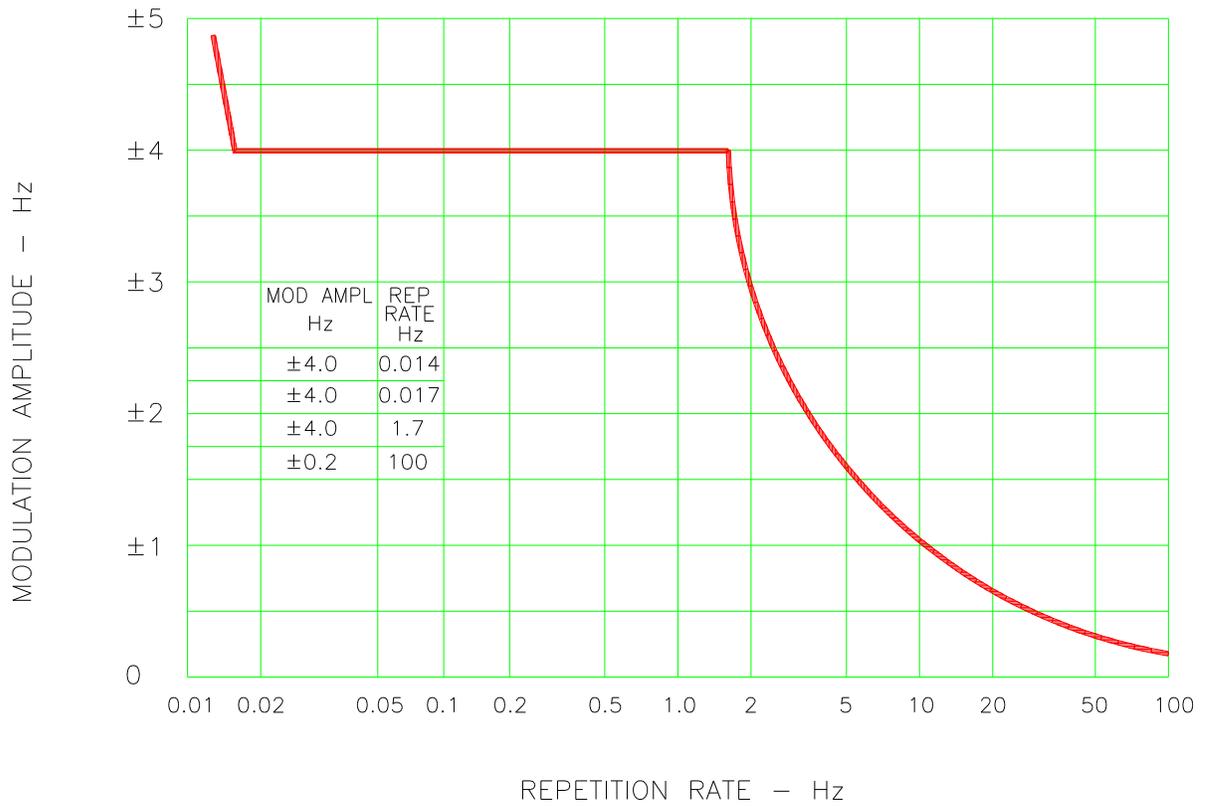


Figure 9-2: Figure 2



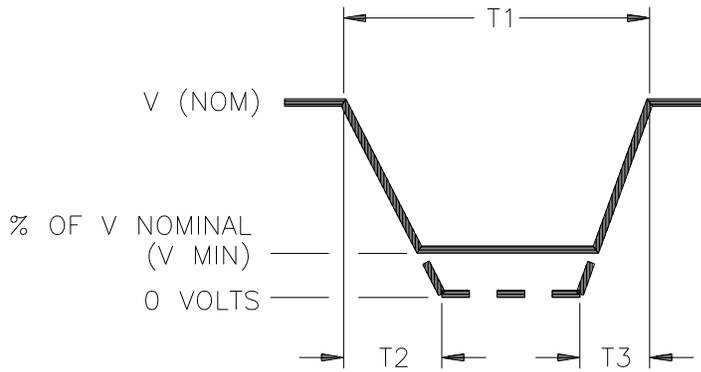
FREQUENCY CHARACTERISTICS OF AC VOLTAGE MODULATION ENVELOPE

Figure 9-3: Figure 3



CHARACTERISTICS OF AC FREQUENCY MODULATION

Table 9-1: Table 1



NOTES: 1. Definitions

T1 – Power interrupt time.

T2 – Time it would take for the applied voltage to decay from V (nom) to zero volts

T3 – Time it would take for the applied voltage to rise from zero to V (nom) volts.

V MIN – The minimum level (expressed as a percentage of V NOMINAL) to which the applied voltage is permitted to decay.

2. Tolerance to T1, T2 and V MIN = ±10%

TEST CONDITION NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1 (MILLISECONDS)	2	10	25	50	75	100	200	1000	10	25	50	75	100	200	1000
T2 (MILLISECONDS)	<1	20*	20	20	20	20	20	20	50*	50*	50	50	50	50	50
T3 (MILLISECONDS)	<1	5	5	5	5	5	5	5	20	20	20	20	20	20	20
% OF V NOMINAL (V MIN)	0	50	15	10	5	0	0	0	20	50	0	15	5	0	0

\* VOLTAGE WILL NOT REACH ZERO IN THIS TEST CONDITION.

## 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 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 number 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 when 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.