California Instruments

**Revision C**
**June 2000**

**P/N 7000-978**

# iM-Series AC Power Source User Manual

User's Manual
AC Power Source
California Instruments
Models :

- 3001iM
- 5001iM
- 5001iM-400
- 10001iM
- 10001iM-400
- 15001iM
- 15001iM-400
- 15003iM
- 15003iM-400

# 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. If the power source is used in a manner not specified by California Instruments the protection provided by the equipment may be impaired.**

**BEFORE APPLYING POWER**

1. Verify that correct voltage is applied to the unit, e.g. 240V.

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:

1. Remove all AC power to unit.

2. Use two people to prevent injury.

**ALLOW CAPACITORS TO DISCHARGE**

Capacitors in the power source may hold a hazardous electrical charge even if the power source has been disconnected from the mains supply. Allow capacitors to discharge to a safe voltage before servicing internal circuits or touching exposed pins of mains supply connectors.

SAFETY SYMBOLS:



THIS SYMBOL INDICATES DIRECT CURRENT

THIS SYMBOL INDICATES ALTERNATING CURRENT

THIS SYMBOL INDICATES BOTH DIRECT AND ALTERNATING CURRENT

THIS SYMBOL INDICATES THREE–PHASE ALTERNATING CURRENT

THIS SYMBOL INDICATES EARTH (GROUND) TERMINAL

THIS SYMBOL INDICATES PROTECTIVE CONDUCTOR TERMINAL

THIS SYMBOL INDICATES FRAME OR CHASSIS TERMINAL



THIS SYMBOL INDICATES ON (SUPPLY)

THIS SYMBOL INDICATES OFF (SUPPLY)

THIS SYMBOL INDICATES CAUTION, RISK OF ELECTRIC SHOCK

THIS SYMBOL INDICATES CAUTION (REFER TO ACCOMPANYING DOCUMENTS)

# 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 9689 Towne Centre Drive, San Diego, CA 92121. 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.

## Table of Contents

## List of Figures



## List of Tables

# 1. Introduction

This instruction manual contains information on the installation, operation, calibration and maintenance of all power systems that use the 3001iM and 5001iM power sources with the manual controller.

## 1.1 General Description

The 3001iM and 5001iM are high efficiency, light weight AC power sources that provide a low distortion output. The output has two sets of ranges, either 0-135V/0-270V or 0-150/0-300. Full power is available at the maximum output voltage of any range. Two or three 5001iM units can be configured into a single-phase system of 10 kVA or 15 kVA respectively with one master and the other unit(s) as auxiliaries. Three 5001iM units can be connected as a three phase system with one controller operating all three sources.

# 2. Specifications

## 2.1 Electrical

### 2.1.1 Input

| | |
|---|---|
| Line Voltage: | |
| 3001iM | 208-240 ±10% VAC single phase |
| 5001iM | 208-240 $V_{LL}$ ±10% , 400-440 $V_{LL}$ ±10% or 400-480 $V_{LL}$ ±10%<br>3 phase, 3 wire + ground |
| Line VA: | |
| 3001iM | 5000 VA |
| 5001iM | 8000 VA |
| Line Current: | |
| 3001iM | 25 A RMS max. |
| 5001iM | 23 A RMS max. at 208-240 VAC |
| | 12 A RMS max. at 400-440 VAC and 400-480 VAC |
| Line Frequency: | 50-60 Hz ±10% |
| Efficiency: | 80% (typical) depending on line and load |
| Power Factor: | |
| 3001iM | 0.7 (typical) |
| 5001iM | 0.9 (typical) |
| Inrush Current: | 100 $A_{pk}$ for 100 μs at 208-240V |
| | 50 $A_{pk}$ for 100 μs at 400-440 VAC and 400-480 VAC |
| Hold-Up Time: | 15 ms |
| Isolation Voltage: | 2200 VAC input to output<br>1350 VAC input to chassis |

### 2.1.2 Output

| | |
|---|---|
| Voltage Ranges: | Switch selectable - 0 to 135/150 volts or 0 to 270/300 volts |
| Total Power: | |
| 3001iM | 3000 VA maximum at full scale voltage either range. |
| 5001iM | 5000 VA maximum at full scale voltage either range. |
| Power Factor: | 0 to 1 |
| Current: | |
| 3001iM | 22.2 A RMS max. for 135 V range<br>20.0 A RMS max. for 150 V range<br>11.1 A RMS max. for 270 V range<br>10.0 A RMS max. for 300 V range |
| 5001iM | 37.0 A RMS max. for 135 V range<br>33.3 A RMS max. for 150 V range<br>18.5 A RMS max. for 270 V range<br>16.7 A RMS max. for 300 V range<br>(Derat linearly from 100% of maximum current at 50% of voltage range to 10% of maximum current at 5% of voltage range). |
| Peak Repetitive Current: | 110 A for 135/150 V range<br>92 A for 270/300 V range |
| Harmonic Distortion: | 1% max. at 50/60 Hz linear load<br>2% max. at 400 Hz linear load<br>4% max. at 60 Hz, 110 A peak repetitive load |
| Output Noise: | 400 mV RMS low range |
| (20 kHz to 1 MHz) | 800 mV RMS high range |
| Line and Load Reg: | 1% total for 10% line change, full load change, and initial accuracy |
| Frequency Range: | 16 Hz to 500 Hz |
| DC Offset Voltage: | Less than 50 mV with resistive or symmetrical load |
| Isolation Voltage: | 1350 VAC, output to chassis<br>2200 VAC, input to output |

### 2.1.3 Unit Protection

| | |
|---|---|
| Input Overcurrent: | Circuit breaker |
| Input Overvoltage: | Automatic shunt trip of input circuit breaker |
| Input Overvoltage Transients: | Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels |
| Output Overcurrent: | Adjustable level constant current mode with a maximum set point at 3.5% +/-3.5% above rated current |

| | |
|---|---|
| Output Short Circuit: | Peak current limit at 110 amps, foldback with automatic recovery |
| Overtemperature: | Automatic shutdown and recovery |

## 2.2 Mechanical

| | |
|---|---|
| Dimensions: | 19” (482.6 mm) width x 7” (177.8 mm) height x 24” (609.6 mm) depth chassis size which is available in a rack mounted or stand-alone configuration |
| Unit Weight: | 61 lb/28 kg |
| Material: | Aluminum chassis, panels and cover |
| Finish: | Light textured painted external surfaces with front and rear panels semi-gloss polyurethane color no. 26440 (medium gray) and top, bottom and sides semi-gloss polyurethane color no. 26622 (light gray) |
| Cooling: | Fan cooled with air intake from the sides and exhaust to the rear |
| Internal Construction: | Modular sub assemblies |
| Rear Panel Connections: | (see Section 4 for description of all connections) |
| | Input terminal block with cover |
| | Output terminal block with cover |
| | Remote voltage sense terminal block |
| | System interface (not for table top use, use only in rack enclosed systems) |
| | Clock and Lock (not for table top use, use only in rack enclosed systems) |

## 2.3 Environmental

| | |
|---|---|
| Operating Temp: | 0 degrees to +40 degrees Celsius |
| Storage Temp: | -40 degrees to +85 degrees Celsius |
| Altitude: | <2000m |
| Relative Humidity: | 80% maximum for temperatures up to 31°C decreasing linearly to 50% at 40°C. |
| Installation/Overvoltage | |
| Category: | II |
| Pollution Degree: | 2 |
| Indoor Use Only | |
| Vibration: | Design to meet NSTA 1A transportation levels |
| Shock: | Design to meet NSTA 1A transportation levels |

## 2.4 Regulatory

| | |
|---|---|
| Electromagnetic Emissions and Immunity: | Designed to meet EN50081-2 and EN50082-2 European Emissions and Immunity standards as required for “CE” marking |

| | |
|---|---|
| Acoustic Noise:<br>(@ 1 meter) | 65 dBA max. at 0% to approximately 50% load<br>75 dBA max. greater than approximately 50% to 100% load |
| Safety: | Designed to meet EN61010-1 European safety standards as required for “CE” marking |

## 2.5 Front Panel Controls

Frequency range select switch
Frequency select switches
Voltage range switch
Output on/off switch
Current limit adjustment knob
Voltage amplitude knob
Power on light
Overload light
High range light
Overtemperature light
Output on/off light
Output voltmeter

## 2.6 Special Features and Options

| | |
|---|---|
| Parallel Operation: | Can parallel up to three units in a single phase configuration (with one master controller and one or two auxilary units) |
| Three Phase Output: | Able to connect three units in a three phase configuration using system interface connection between sources |
| Rack Mount/Handles Version: | Available rack mounting kit with slides and handles. Handles also available as a separate option. |
| Output Relay: | Standard to isolate AC source from the load. |
| Output On/Off Control: | Front panel output on/off control via switch on controller models or remote command through the system interface connections. |
| Remote Programming Voltage (RPV) Option | Remote program voltage from 0 to +10VDC. Sets output from 0 to 100% of range. |

# 3. Unpacking and Installation

## 3.1 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.

***WARNING: This power source weighs 61 lb (28kg). Obtain adequate help when moving or mounting the unit.***

## 3.2 Power Requirements

The 5001iM AC power source has been designed to operate from a three phase AC line voltage. Two different models are available. One model operates from 208 to 240 volt input line and the other model operates from 400 to 480 volt line. The 3001iM power source operates from a 208 to 240 volt single phase line.

***CAUTION: Do not connect 400-480V into the 208-240V unit, the result could be a severely damaged unit.***

**Figure 3-1: The 5001iM Power source**

## 3.3 Mechanical Installation

The 3001iM and 5001iM are completely self contained power sources. They can be used free standing on a bench top or rack mounted using the optional rack mount/handle kit. The units are fan cooled, drawing air in from the sides and exhausting at the rear. The sides of the units must be kept clear of obstruction and a 6" clearance must be maintained to the rear. See Figure 3-1.

## 3.4 Input Wiring

The input terminal block, TB1, is located at the rear of the unit. The 5001iM AC power source must be operated from a three wire, three phase service with ground. The 3001iM AC power source must be operated from a two wire, single phase service with ground. The ground (earth) wire must be connected to the chassis of the AC power source. The mains source must have a current rating equal to or greater than the input circuit breaker and the input wiring must be sized to satisfy the applicable electrical codes.

***CAUTION: Capacitors in the power source may hold a hazardous electrical charge even if the power source has been disconnected from the mains supply. Allow capacitors to discharge to a safe voltage before touching exposed pins of mains supply connectors.***

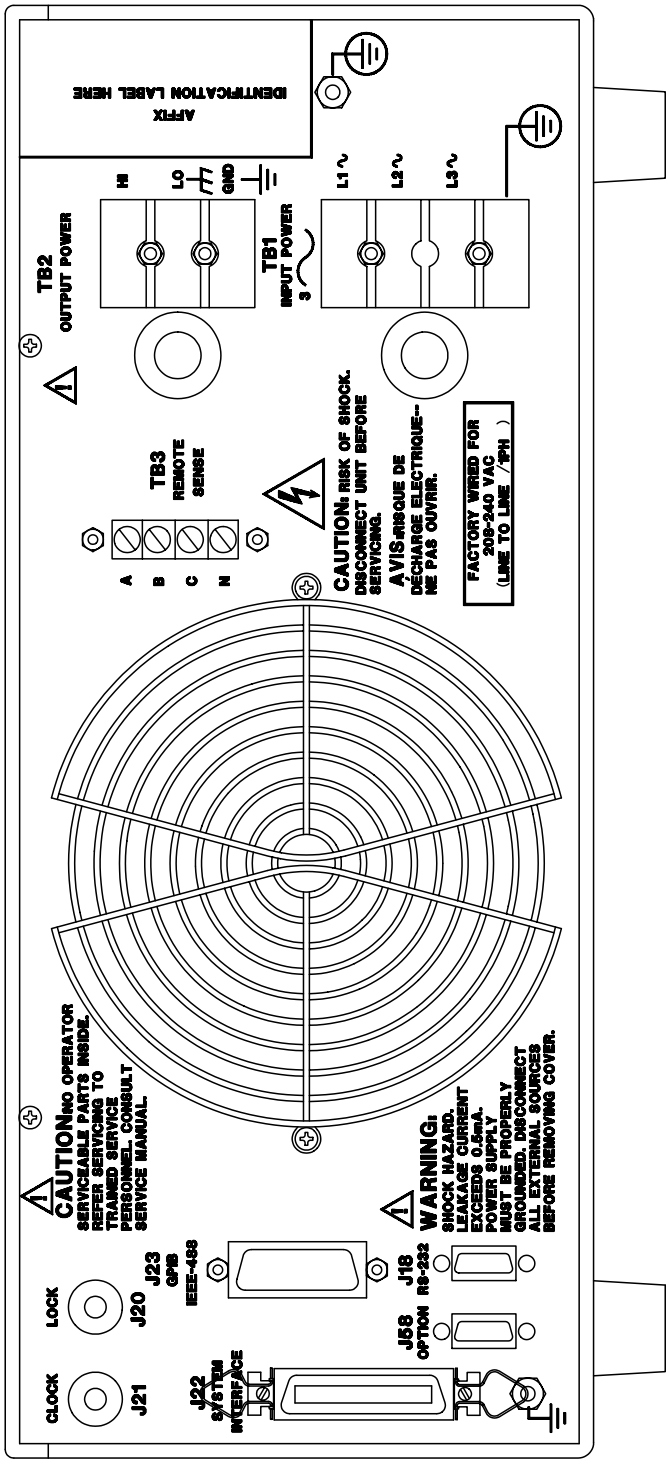
## 3.5 Output Connections

### 3.5.1 Output Wiring

The output terminal block, TB2, is located at the rear of the unit. The external sense inputs allow the power system output voltages to be monitored directly at the load and ***must be connected either at TB2 or the load at all times***. The external sense wires are to be connected to TB3 on the rear panel and should be run as a twisted pair for short lengths. Sense leads over 3 feet long (0.9 meter) should be run as a twisted shielded pair. Refer to Figure 3-2 for all connections.

The output of the power source may be grounded or left floating.

**Figure 3-2: Rear Panel View**



The output power cables must be large enough to prevent a total voltage drop exceeding 1% of the rated output voltage between the power source and the load. Table 1 shows the AWG size of the cables that may be used. Cable lengths must not exceed 25 feet (7.6 meters). For lengths greater than 25 feet (7.6 meters), calculate the voltage drop from the following formula:

2 x distance x cable resistance per length x current = volt drop

Table 1: Wire Sizes

| LOAD CURRENT | WIRE GAGE | |
|---|---|---|
| 22 AMPS | 10 AWG | (5.2 $mm^2$) |
| 37 AMPS | 8 AWG | (8.4 $mm^2$) |
| 74 AMPS | 4 AWG | (21.6 $mm^2$) |
| 111 AMPS | 2 AWG | (33.7 $mm^2$) |

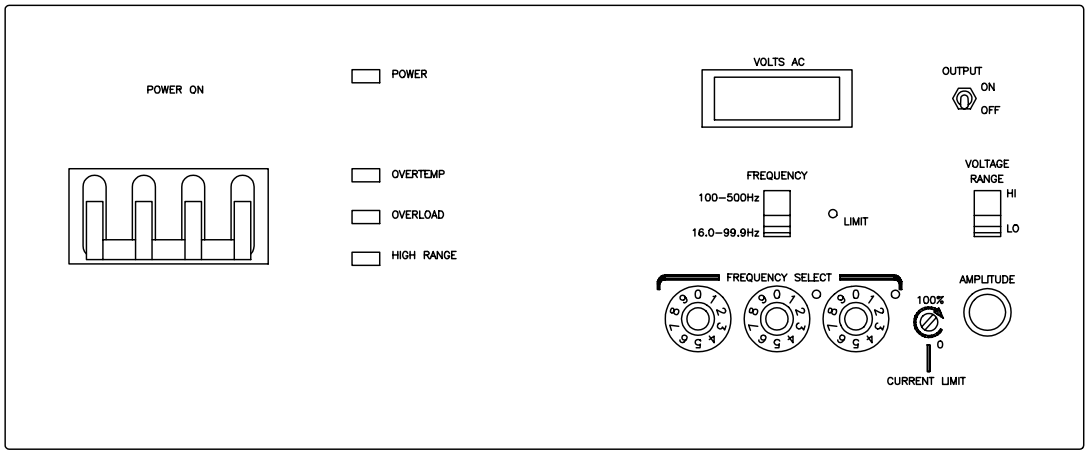
### 3.5.2 Single-Phase and Three Phase System Configurations

**Three Phase System:**
The three phase system will be configured ready for use when ordered as such from the factory. One unit will be identified as the master and the other two units will be identified as auxiliaries. The master will control the two auxiliary units via the system interface cable. The LO outputs of all three sources must be connected together so that they share a common reference.

**Single Phase System:**
In a multi-box single phase system there will be one master and one or two auxiliary units. The master will control the auxiliary units via the system interface cable. The HI output on TB2 of all sources must be connected. The LO output on TB2 of all sources must be connected. See Table 1 for cable sizing.

The appropriate jumpers have all been installed at the factory before shipment. If it becomes necessary to change the system to three phase please consult the factory.

**Figure 3-3: Front Panel View**




FRONT PANEL VIEW

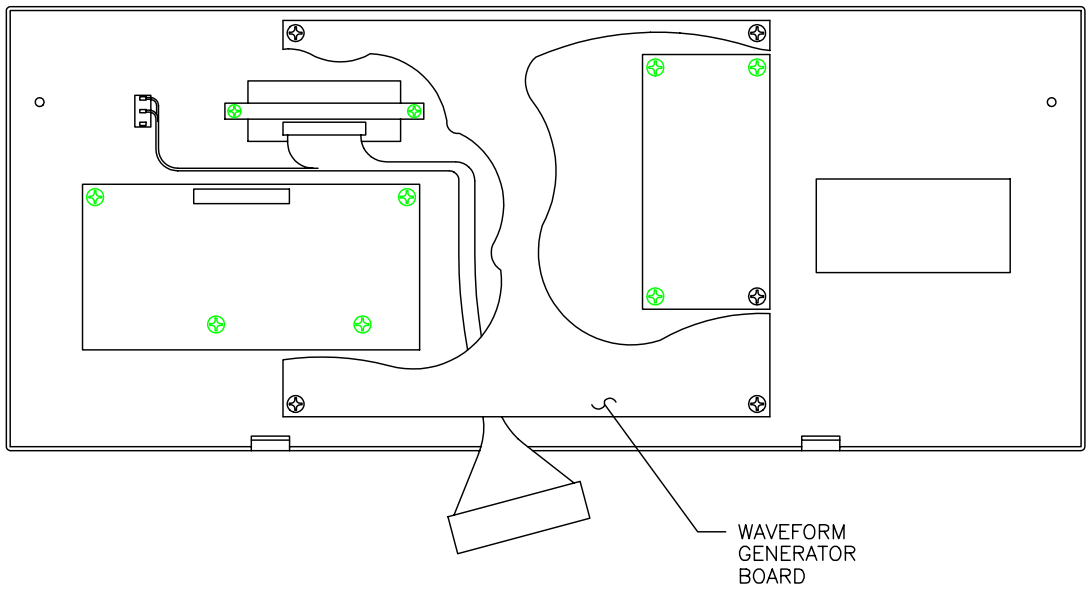
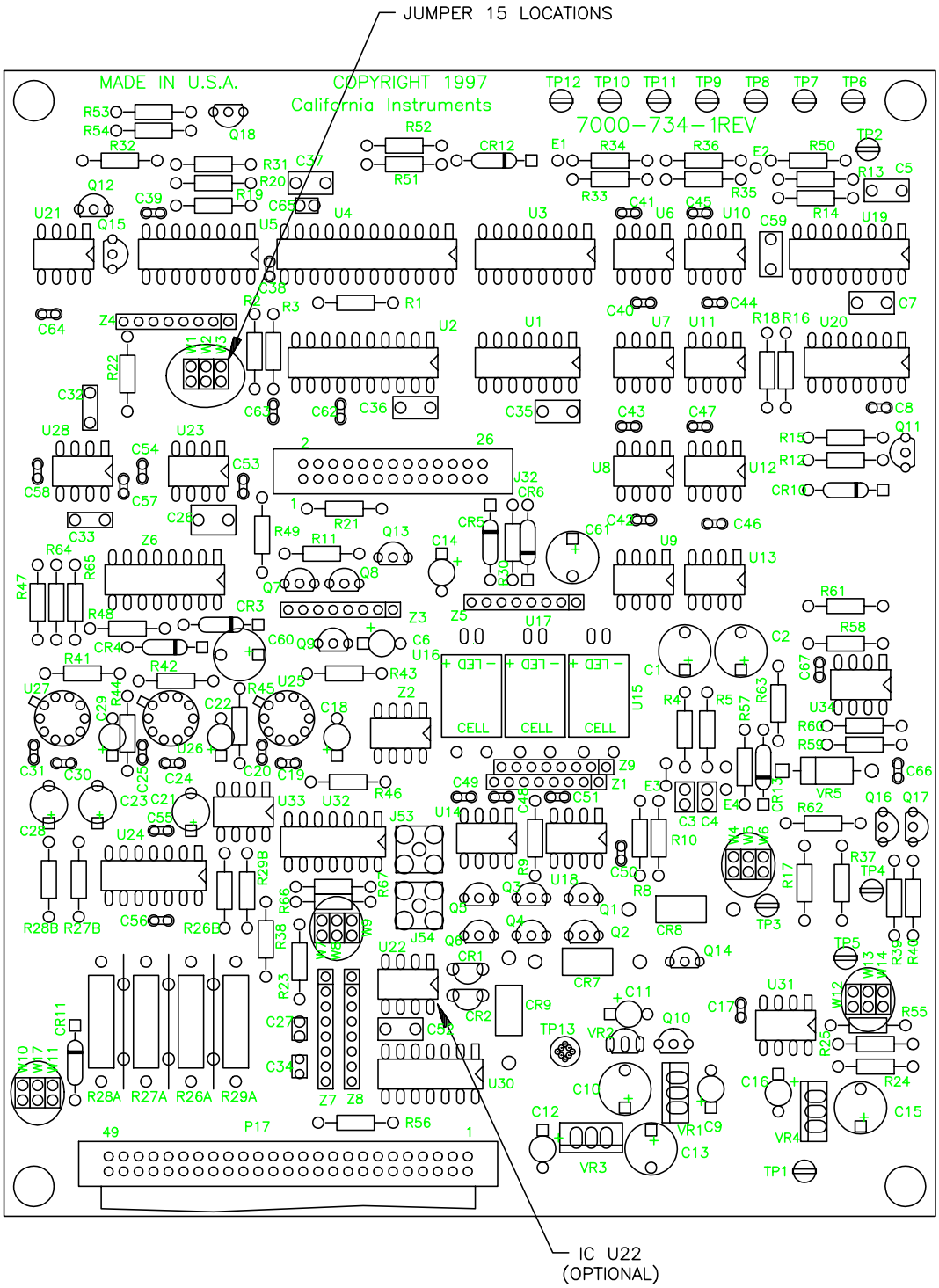


**Figure 3-4: Waveform Generator Board**



## 3.6 Output Voltage Ranges

The 3001iM and 5001iM power sources have four voltage ranges: 0 to 135, 150, 270 or 300 volts. These ranges are organized in two pairs. The low range includes 0 to 135/150 volts. The high range includes 0 to 270/300 volts. Voltage amplitude control is continuous on either range, but when the voltage magnitude increases above 135 volts on the low range or 270 volts on the high range, the current limit is automatically reduced by 10%.

## 3.7 Functional Test

Refer to Figure 3-5 for the test set up.

1. Apply AC line power and turn on the front panel circuit breaker. The output on/off switch should be in the off position.
2. Verify that the POWER ON lamp is lit.
3. Set the frequency to 60 Hz and adjust the amplitude knob for 135 VAC on the front panel meter. The accuracy of the front panel meter is +/- 2% and is only to be used as an indicator.
4. Connect an oscilloscope or distortion analyzer to the output. Enable the output with the output on/off switch. The output should be a clean sine wave having less than 1% (at 60 Hz) distortion.
5. Apply full load (22A/6.1Ω for 3001iM or 37A/3.6Ω for 5001iM) to the output and verify the output voltage remains within 2% using an external DVM. The output should still be clean and the distortion should still be less than 1% (at 60 Hz).
6. Set the current limit knob to half scale. The output will go into current limit, the output voltage will start to fall and the overload light will start to glow. Return the current limit knob to full scale, and turn the output off.
7. Switch the range switch to HI-RANGE and adjust the output to 270V. The green high range light on the front panel should now be lit.
8. Repeat tests 3 through 6 for the 270V range. Full load is 11A/24.3Ω for 3001iM 18.5A/14.6Ω for 5001iM at 270V.

In the unlikely event the power source does not pass the functional test, refer to the calibration procedure in Section 6.

**Figure 3-5: Functional Test Setup**

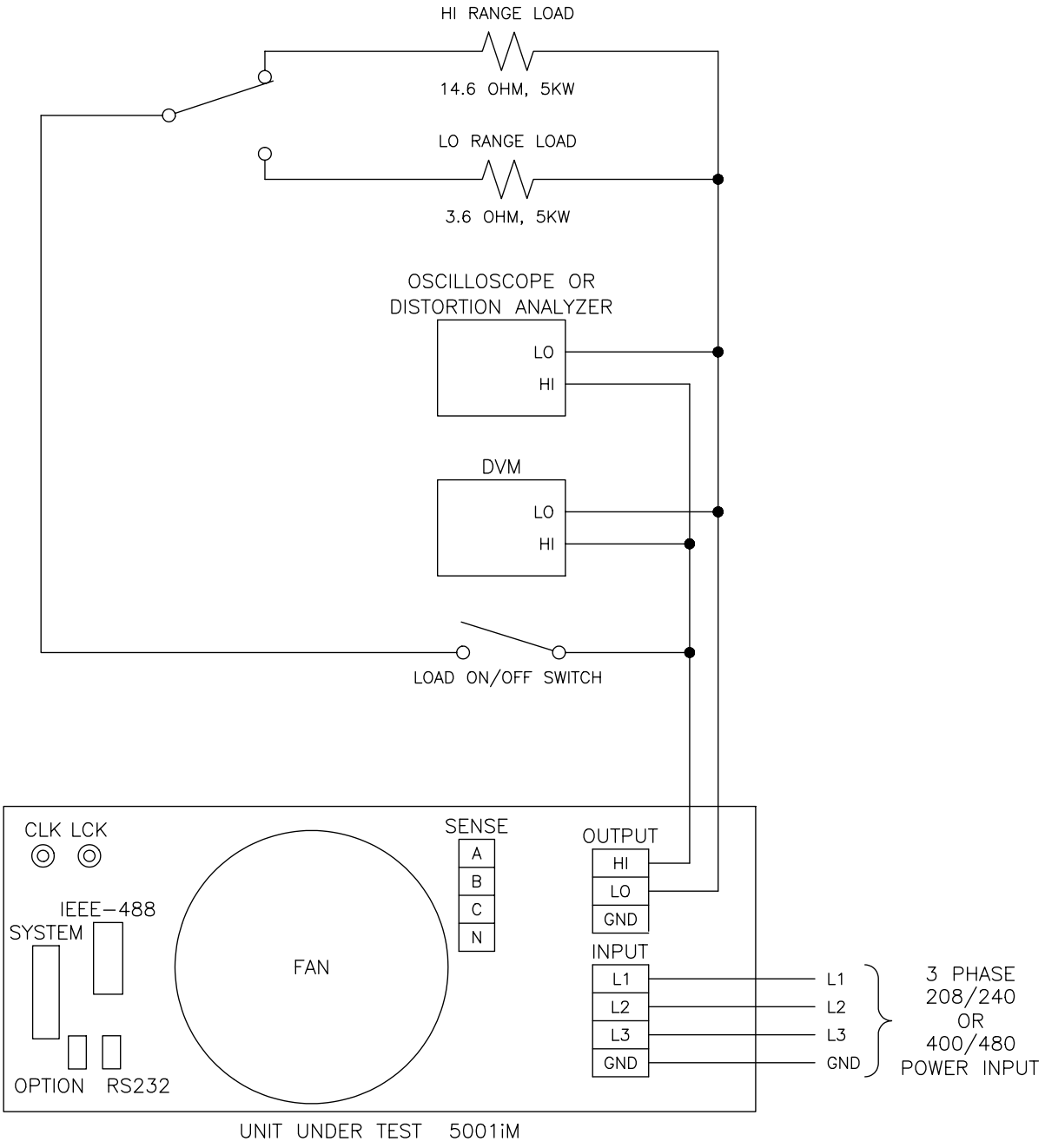


**Figure 3-6: Three Phase System**

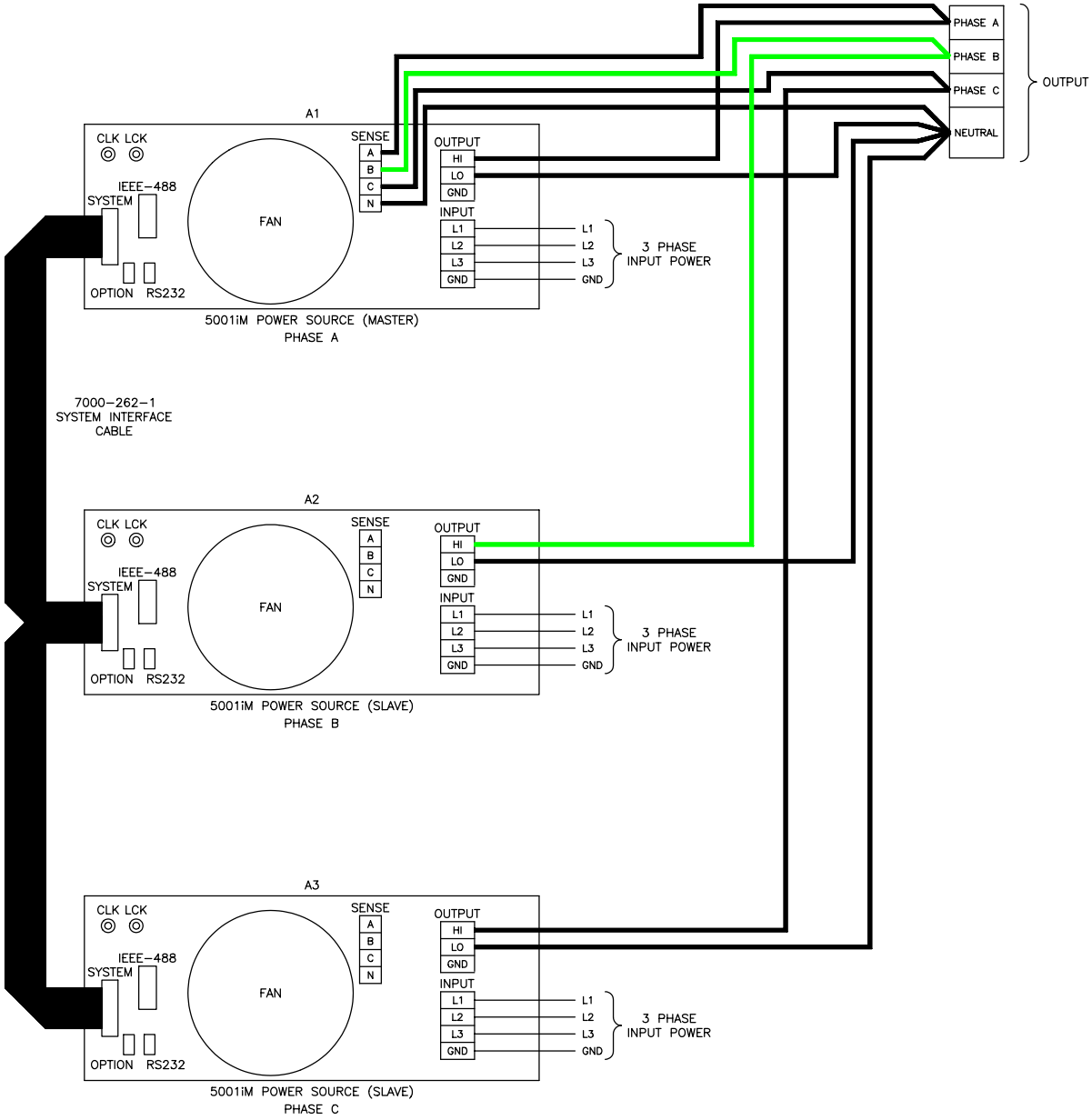


**Figure 3-7: Single Phase System**

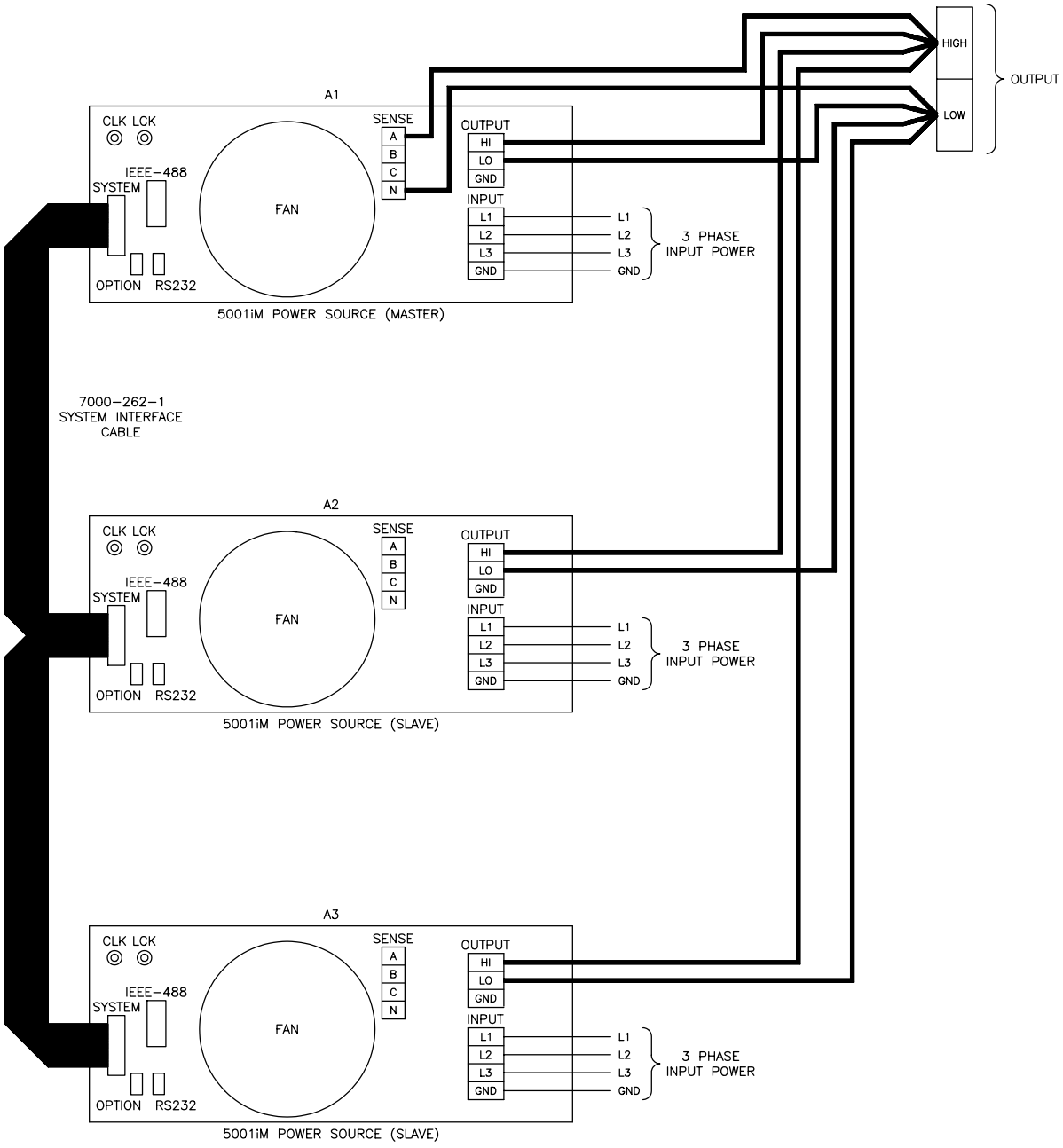
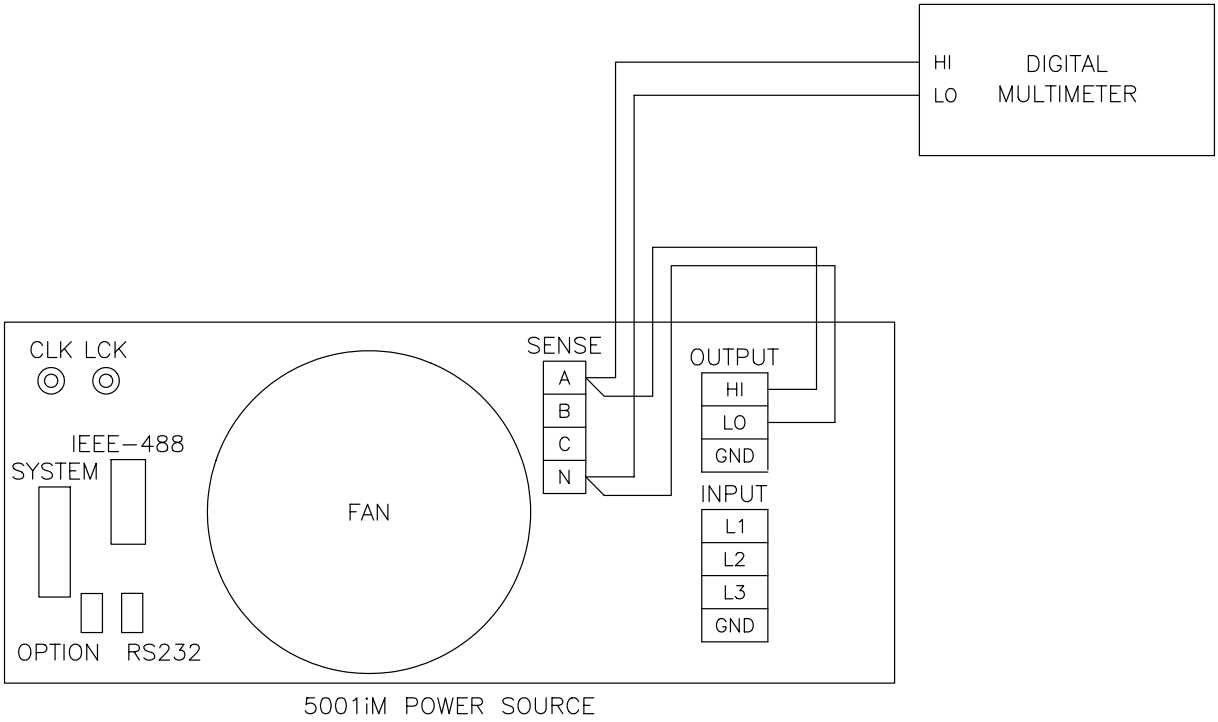


**Figure 3-8: 5001iM Power System**



# 4. Front Panel Operation

## 4.1 General

The 3001iM and 5001iM power sources have on the front panel all the controls required to set the voltage, frequency, and current limit.

## 4.2 Front Panel Controls

A circuit breaker is located on the left side of the front panel and is used to control power to the unit. (See Figure 3-1and Figure 3-3)

| | |
|---|---|
| FREQUENCY SELECT DIALS: | The three dials set the output frequency within the range determined by the frequency range select switch. When in the 16 to 99.9 Hz range, an LED decimal point is lit between the second and third dials to give 0.1 Hz resolution. When in the 100 to 500 Hz range an LED is lit after the third dial to indicate 1 Hz resolution. If a frequency is selected outside this range, the red frequency limit light will be lit and the output will go to zero volts. |
| FREQUENCY RANGE SELECT: | This two position switch selects which of the two ranges the frequency select dials will use. The lower position selects the 16.0 Hz to 99.9 Hz range. The upper position selects the 100 Hz to 500 Hz range. |
| VOLTAGE AMPLITUDE KNOB: | The output voltage is set by the amplitude control knob. |
| CURRENT LIMIT CONTROL: | This knob sets the programmable current limit. Turning the knob fully counterclockwise sets the current limit to zero amps. Fully clockwise sets the current limit to the maximum capability of the selected voltage range. The knob sets the limit linearly between the two extremes. When the output voltage is increased above 135 volts on the low voltage range or above 270 volts on the high voltage range, the current limit is automatically reduced by 10%. |
| OUTPUT ON/OFF SWITCH: | The output ON/OFF switch controls a relay that isolates the output from the power source in the off position. |
| VOLTAGE RANGE SWITCH: | This switch will change the output between the 0-135/150V range and the 0-270/300V range. |

## 4.3 Front Panel Indicators

The front panel has the following indicators: POWER ON, OVERTEMP, OVERLOAD, HI RANGE, LIMIT, OUTPUT ON, and a digital voltmeter.

| | |
|---|---|
| POWER ON | The lamp is illuminated when mains power is present and the circuit breaker is on. |
| OVERTEMP | This lamp is illuminated to indicate an overtemperature condition in the power section. This condition could occur if the fan is blocked or not operating, or if the power system has been overloaded. |
| OVERLOAD | The lamp is illuminated when the current capability of the unit is exceeded. If the overload is severe enough, this will result in a decrease in output voltage as the unit goes into constant current mode. |
| HI-RANGE | The indicator is lit when the high voltage range has been selected. |
| LIMIT | This lamp is lit when the controller is limiting the oscillator drive signal. This occurs for a very short time when power is initially applied. The LED stays on indefinitely if a frequency is selected outside of the normal output range, OUTPUT OFF is selected or while the REMOTE SHUTDOWN line is held low. |
| OUTPUT | The lamp is ON when the output relay is closed and power is applied to the load |
| DVM | The digital voltmeter indicates the voltage on the sense lines. When the output is switched off, the sense lines are switched to sense internally and the source is still active internally. The power source voltage can then be adjusted before the OUTPUT ON is selected. |

## 4.4 Rear Panel Connections

For an overview of the rear panel and the location of the rear panel connections refer to Figure 3-2.

### 4.4.1 Power Input

TB1 is the terminal block for the input voltage. For the 5001iM, terminals L1, L2, and L3 connect to respective legs of the 3 phase input, and the terminal marked with the ground symbol connects to the input mains safety ground. The 3001iM only uses L1, L2 and ground for its single phase input.

### 4.4.2 Power Output

TB2 is the power output terminal block. If one side of the output must be grounded, it is preferable to ground the LO side.

### 4.4.3 External Sense

TB3 is the external sense input connector. The external sense must be connected to the AC power output. If the sense lines are not connected, the output voltage regulation will be poor.

***NOTE: The power source is shipped with sense lines connected to output TB2. For best regulation, connect external sense lines (shielded twisted pair) from source to load observing proper phase connections.***

### 4.4.4 System Interface

***WARNING: The system interface connector and Clock and Lock connectors may be at hazardous voltages. These connections may not be used in table top applications. In table top applications the safety cover must be in place. These connections may only be used when the equipment is enclosed in a rack, only within one rack, only with California Instruments supplied cables, and only between California Instruments equipment.***

J22 is the system interface connector. Table 2 identifies the pins of the system interface connector. The system interface connector allows the input of external signals to control or modify the operation of the power source, such as REMOTE PROGRAMMING VOLTAGE (RPV), REMOTE ON, etc. It also allows for coordinated operation when up to three units are connected in a system.

**Table 2: System Interface Connector**

| J22 | Description |
|---|---|
| 1 | Analog Common: analog signal common |
| 2 | MR B: Phase B master signal |
| 3 | Analog Common |
| 4 | CS B: Phase B current sum |
| 5 | CT Common: Current transformer common |
| 6 | OSC B: Phase B oscillator output |
| 7 | Analog Common |
| 8 | CL B: Phase B current limit reference |
| 9 | RPV: Remote Programming Voltage/External modulation input. This pin normally serves as and external modulation input. A 0.0 to +/- 10 VDC input provides 0 to +/- 10% modulation. The pin may optionally be configured as a remote programming voltage input. In this case a 0.0 to 10 VDC input signal provides 0 to 100% of full scale output voltage with the amplitude control set fully clockwise. |
| 10 | $\overline{\text{OVR TEMP}}$ : A logic low output to indicate an overtemperature condition. |
| 11 | $\overline{\text{CNF}}$ : Output relay state: Logic HI = open, LOW = closed. |
| 12 | FLT C: Phase C current limit fault control |
| 13 | FLT A: Phase A current limit fault control |
| 14 | F STB LO: Not used |
| 15 | EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J22-32. |

| J22 | Description |
|---|---|
| 16 | AMP SHARE B |
| 17 | PARALLEL |
| 18 | CL ENA |
| 19 | MR C: Phase C master signal |
| 20 | MR A: Phase A master signal |
| 21 | CS C: Phase C current sum |
| 22 | CS A: Phase A current sum |
| 23 | OSC C: Phase C oscillator output |
| 24 | OSC A: Phase A oscillator output |
| 25 | CL C: Phase C current limit reference |
| 26 | CL A: Phase A current limit reference |
| 27 | D COM: Digital Common |
| 28 | RNG HI: Voltage range state: Logic HI = high range, LOW = low range |
| 29 | $\overline{\text{OVL}}$ : Overload |
| 30 | FLT B: Phase B current limit fault control |
| 31 | F STB HI: Not used. |
| 32 | EX SYNC HI, External Sync input HI. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 5 mA. The input should have a duty cycle 50 ±30%. J22-15 is the common input. The External Sync input is optically isolated. Consult factory for details. |
| 33 | AMP SHARE C |
| 34 | AMP SHARE A |
| 35 | FLICKER / $\overline{\text{BYPASS}}$ |
| 36 | REMOTE ON: This is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0.0 volts and the output relays to open. A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J22-27 (D COM) will simulate a logic low state. |

### 4.4.5 Clock and Lock Connectors

***WARNING: The system interface connector and Clock and Lock connectors may be at hazardous voltages. These connections may not be used in table top applications. In table top applications the safety cover must be in place. These connections may only be used when the equipment is enclosed in a rack, only within one rack, only with California Instruments supplied cables, and only between California Instruments equipment.***

J21 and J20 are the Clock and Lock connectors and are used to synchronize controllers with other California Instruments power sources.

### 4.4.6 GPIB IEEE-488 Interface

J23 is not used in a manual controller power system.

### 4.4.7 RS-232 Interface

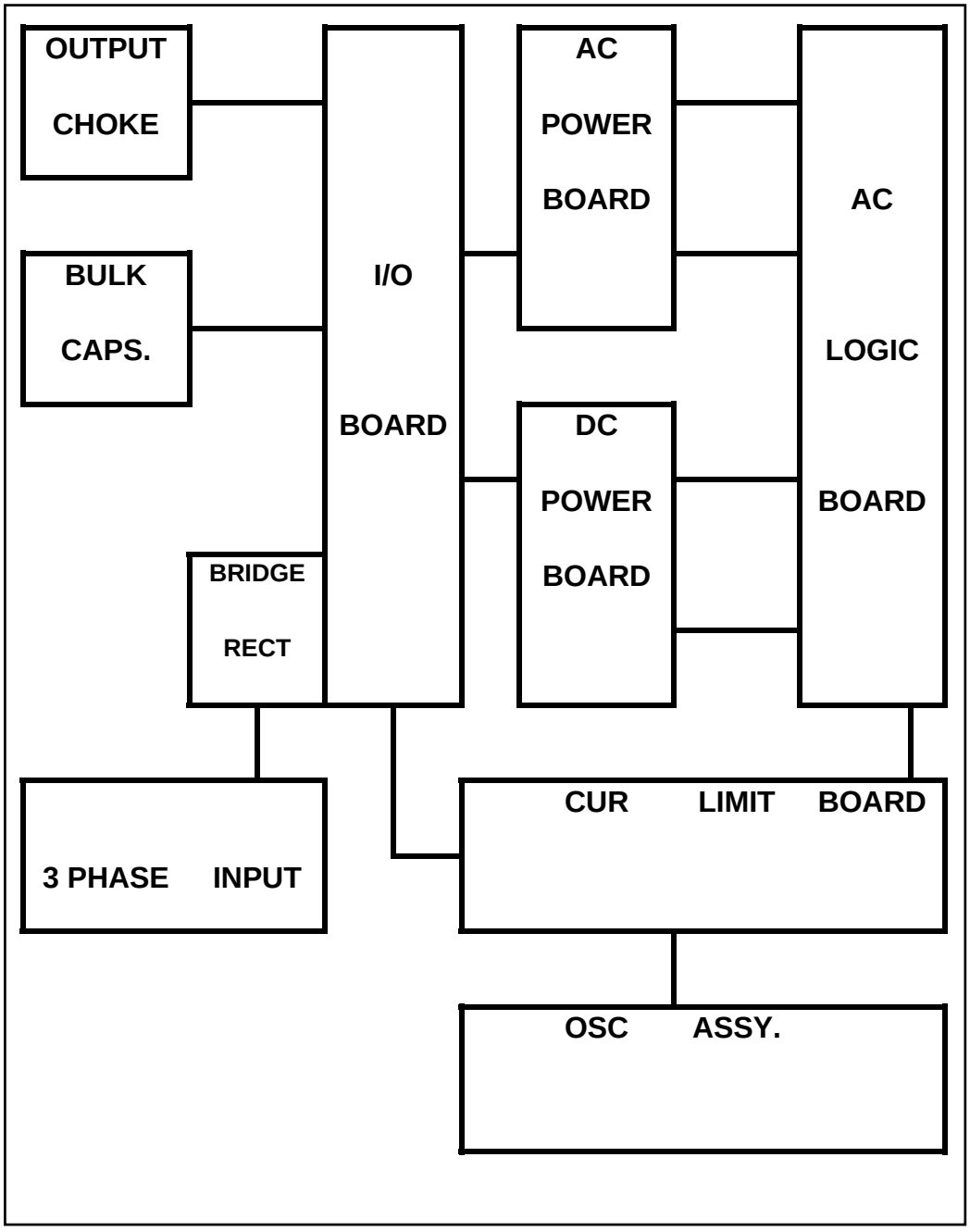
J18 is not used in a manual controller power system.

# 5. Principle of Operation

## 5.1 General

An explanation of the circuits in the 3001iM and 5001iM is given in this section. Refer to Figure 5-1 for a block diagram of the system. Figure 5-6 and Figure 5-7 show the system interconnect.

**Figure 5-1: AC Power System Block Diagram.**



## 5.2 Overall Description

Input power is routed from the back panel through an EMI filter and the circuit breaker to the input bridge rectifier. The DC output from the bridge rectifier is smoothed by a small amount of capacitance to keep the input power factor as high as possible. This DC output supplies the converter on the DC power board.

The DC converter turns the unregulated rectified AC into a smoothed, isolated, regulated DC supply. Also mounted on the DC power board is the auxiliary power supply. The auxiliary power supply supplies low voltage power to the control logic board, the oscillator board, the AC power board, and the fan. The output of the DC converter is fed to two bulk storage electrolytic capacitors on the input/output board. These two capacitors also provide holdover storage energy to ride through line dropouts.

The AC power board takes the DC input and generates isolated, direct coupled AC power. The DC bus is regulated at 270 volts for the 135/150 VAC output and 490 volts for the 270/300 VAC output.

The oscillator assembly generates the sine wave signal and provides frequency and amplitude control. The current limit board in conjunction with the oscillator board provides the current limit function.

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

## 5.3 Oscillator Assembly

The oscillator assembly consists of two printed circuit board assemblies connected by a ribbon cable. A block diagram of the oscillator is shown in Figure 5-2. The oscillator generates a sine wave signal setting the frequency, amplitude and current limit level. It also senses the output voltage to provide closed loop control of the output.

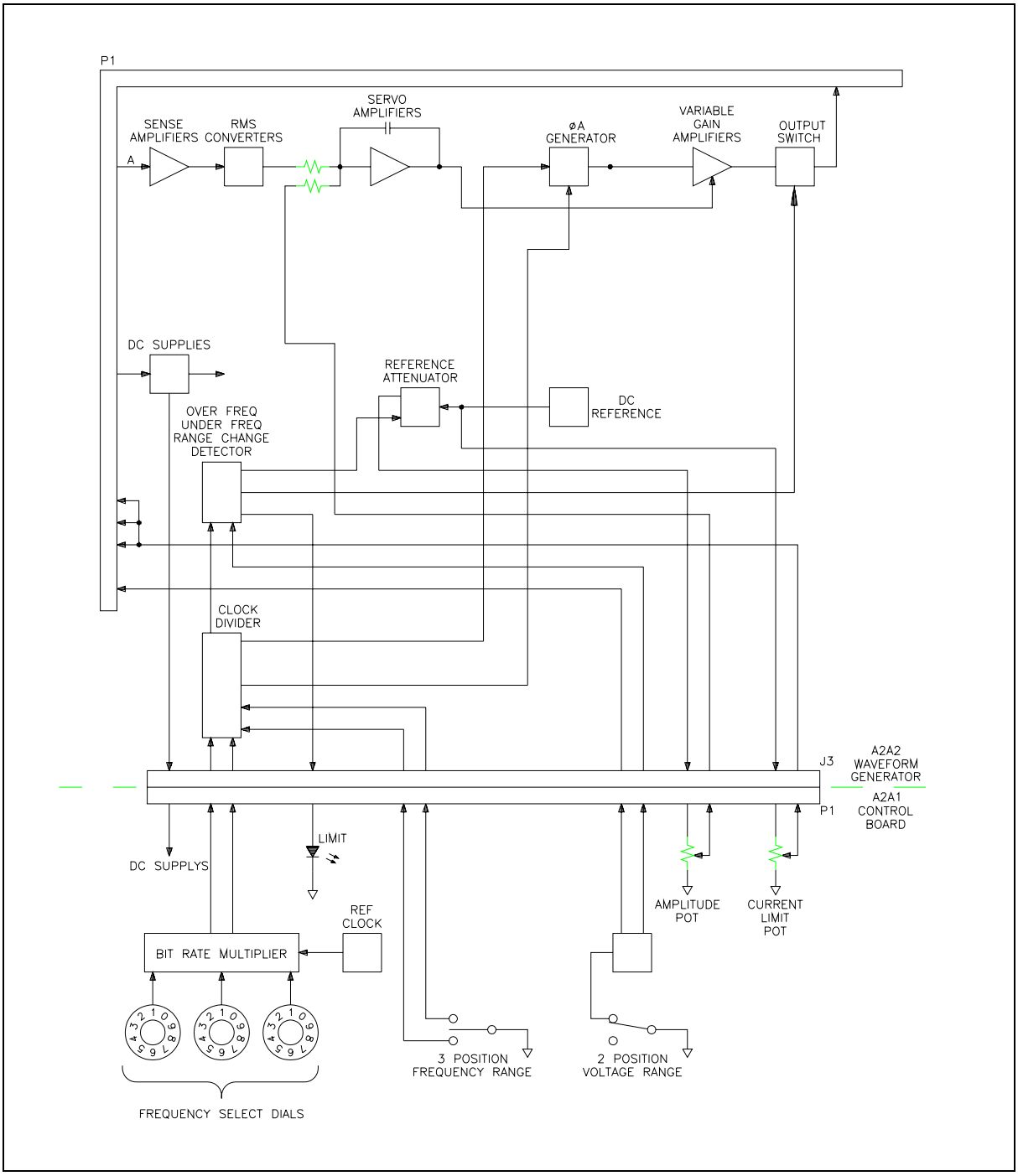
## 5.4 Control Board

The control board is mounted to the front panel and holds the frequency select dials, frequency range switch, voltage amplitude potentiometer, and current limit potentiometer. The output on/off switch and digital voltmeter are also mounted to the front panel.

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

The two position frequency range switch signals the waveform board to divide the bit rate output frequency by 10 or 100 depending on the desired output range.

**Figure 5-2: Oscillator Power Module Block Diagram.**



## 5.5 Waveform Generator Board

A block diagram of the waveform generator board is shown in the upper portion of Figure 5-2.

The clock divider divides the bit rate multiplier frequency by 10 or 100 depending on the frequency range switch setting. Outputs of the clock divider drive the phase A generator. The over frequency/under frequency range detector monitors the clock output and switches off the oscillator output if the frequency output is outside the specified range of the unit. The detector also momentarily switches off the oscillator when the voltage range switch is changed.

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

## 5.6 Current Limit Board

The current limit board receives the oscillator signal and passes it through an amplifier whose gain is controlled by a signal from the overcurrent circuit. The overcurrent circuit senses the rms value of the current. If the load current exceeds the programmed value, the output of this sensing circuit reduces the output of the oscillator amplifier. The output of the unit then becomes a sinusoidal constant current output, with the output voltage dropping as the load increases.

When two or three units are connected as a single phase system the MRA output from the master oscillator amplifier drives all the power amplifiers over the system interface cable. An overcurrent condition on any amplifier will act to reduce the output voltage and put the entire system into the sinusoidal constant current mode.

## 5.7 Auxiliary Power Supply

The auxiliary power supply is part of the DC-DC power board. The auxiliary power supply generates nine low voltage outputs. These outputs provide low voltage power to all the modules.

a) +/- 18V to the AC logic board and the oscillator.
b) +8V to the oscillator.
c) + 15V to the DC-DC converter.
d) Three + 18V supplies to the AC power amplifier gate drives.
e) +24V for the fan and relay power.
f) +8V for the digital front panel meter.

The supplies a), b), and e) have a common ground. The supplies in c) and d) are all isolated from each other and from a), b), and e). LED's on the AC logic board and the AC power board are lit when each output is in regulation. If an overload condition causes the output to drop more than 10% or the output has failed, the corresponding LED will extinguish. This feature is helpful in troubleshooting the unit. See Service Section 7.

## 5.8 DC-DC Power Converter

The DC-DC power converter is powered from the rectified AC input. The converter is a pulse width modulated full bridge type that uses IGBT's as the power switches and runs at

34.6 kHz (208/220 volt input) or 23.1 kHz (400 volt input). The control logic supply for the DC-DC converter is derived from the auxiliary power supply, so the DC-DC converter does not start switching until after the auxiliary power supply has started up and comes into regulation. This feature ensures a smooth start up.

The output of the DC converter is automatically selected for 270 VDC or 490 VDC depending on whether the low range output (135/150 VAC) or high range output (270/300 VAC) is selected. The 270/490 VDC range selection is made by a relay that selects one of two taps on the DC output transformer. The converter is fully protected with input current limit and input and output overvoltage protection. When the output of the DC converter is up and in regulation, the LED on the input output board will be lit. The LED can only be seen by looking directly down between the large storage capacitor and the input/output board. (See Figure 5-3)

## 5.9 AC Control Logic

The main function of the control board is to generate the gate drive signals for the AC power stage. This board also includes the current limit circuit for the load sharing when two or three units are operated in parallel. (See Figure 5-8.)

The signal from the oscillator is fed through a low pass filter circuit and sent to the reference input of the error amplifier. The voltage output of the unit is differentially sensed and fed back to the error amplifier thereby completing the control loop. The output of the error amplifier drives a 34.6 kHz pulse width modulator. The modulator output is sent to four gate drivers which drive the IGBT's on the AC power board after going through optocouplers that provide the necessary isolation.

**Figure 5-3: 5001iM Internal Layout**

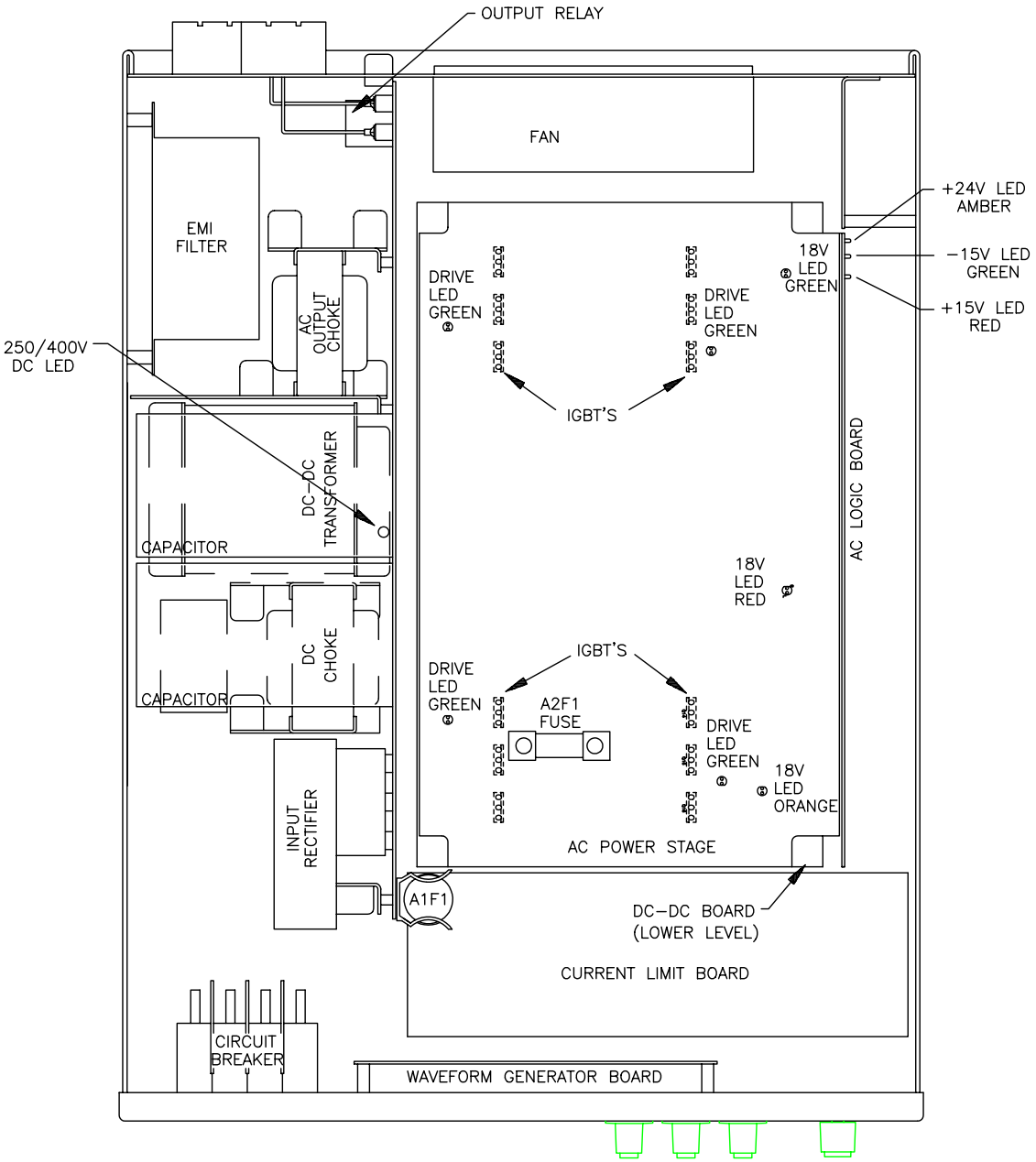
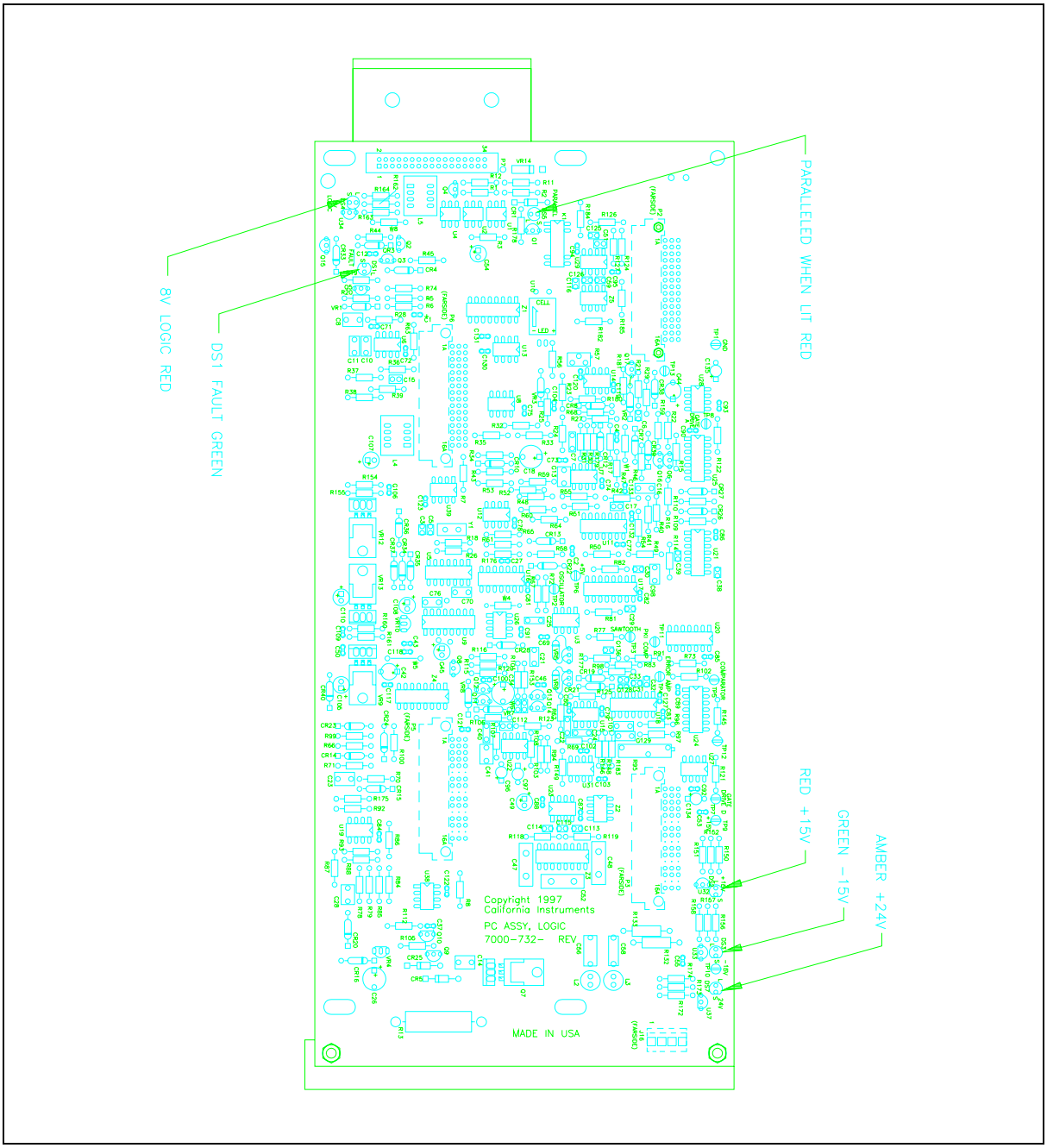


**Figure 5-4: Logic Board LED's**



There are six LED indicators on the logic board. Their positions are shown in Figure 5-4. The functions in Table 3.

Table 3: Logic Board LED's

| LED# | FUNCTION | COMMENTS |
|---|---|---|
| DS1 | FAULT | LED is normally on. No light indicates power stage failure. |
| DS2 | +15V | +15V logic supply |
| DS3 | -15V | -15V logic supply |
| DS4 | +8V | +8V oscillator supply |
| DS5 | PARALLEL | LED should be lit when units are paralleled and K1 is closed. |
| DS7 | +24V | +24V supply for relays and logic. |

## 5.10 AC Power Board

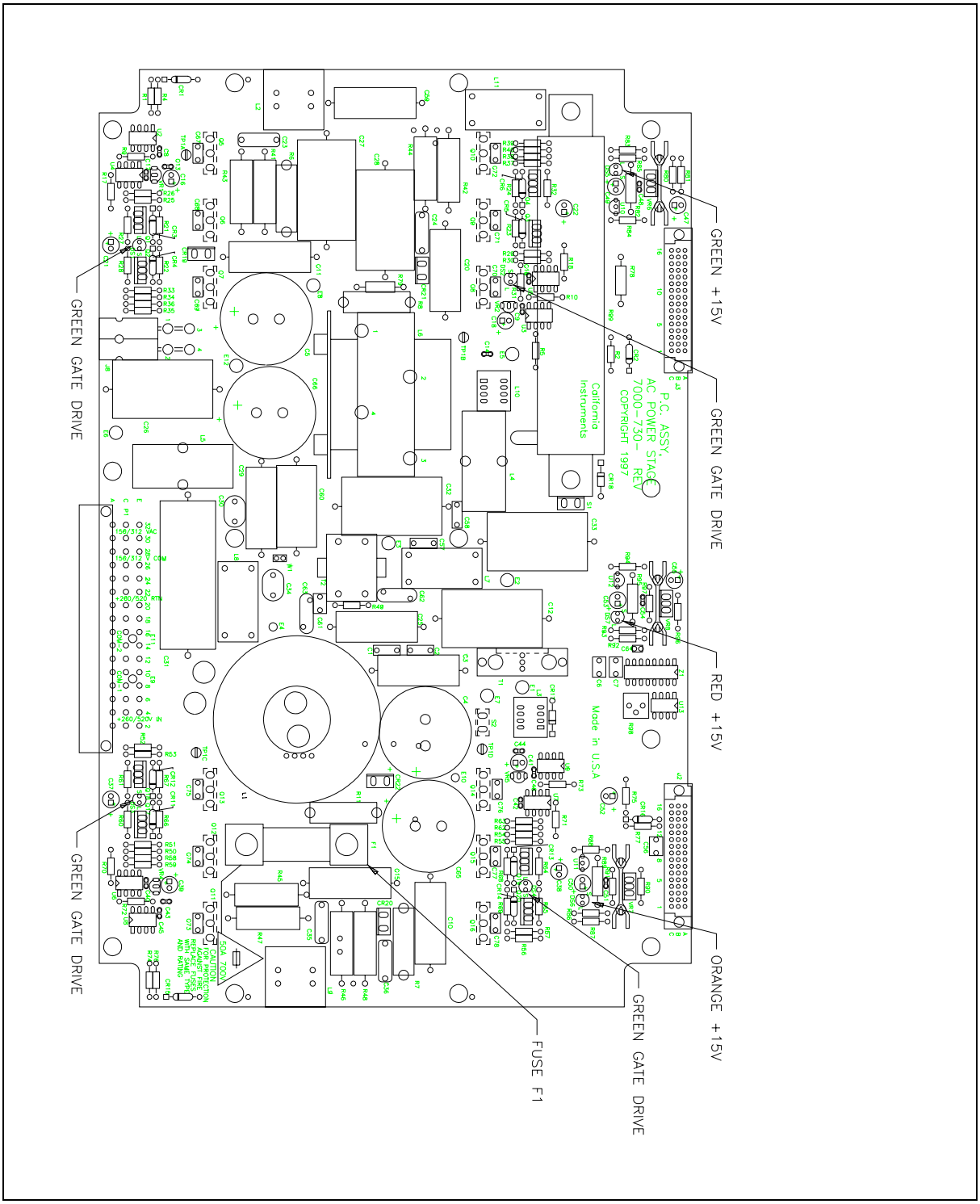
The AC power assembly takes a 270V/480V DC input and generates a 135V/270V AC direct coupled output. The AC power amplifier is a full bridge inverter with three paralleled IGBT's in each leg for a total of twelve IGBT's. The switching frequency of the bridge is 34.6 kHz and this frequency is smoothed by two inductors that are mounted beside the input/output board and several smoothing capacitors on the AC power board to provide a precision low frequency (16-500 Hz) output. (See Figure 5-3 and Figure 5-5.)

Three isolated 18V supplies provide power for the gate drives. The 18V is regulated down to 15V by three TO220 regulators that are mounted on separate heat sinks. If the 15V is in regulation an LED will be lit in front of each heat sink. There is a red, a green and an orange LED, one for each supply. The other four green LED's will be lit when there is gate drive present at the IGBT's. If the green LED's are not lit there will be no gate drive and hence no output.

## 5.11 Input/Output Board

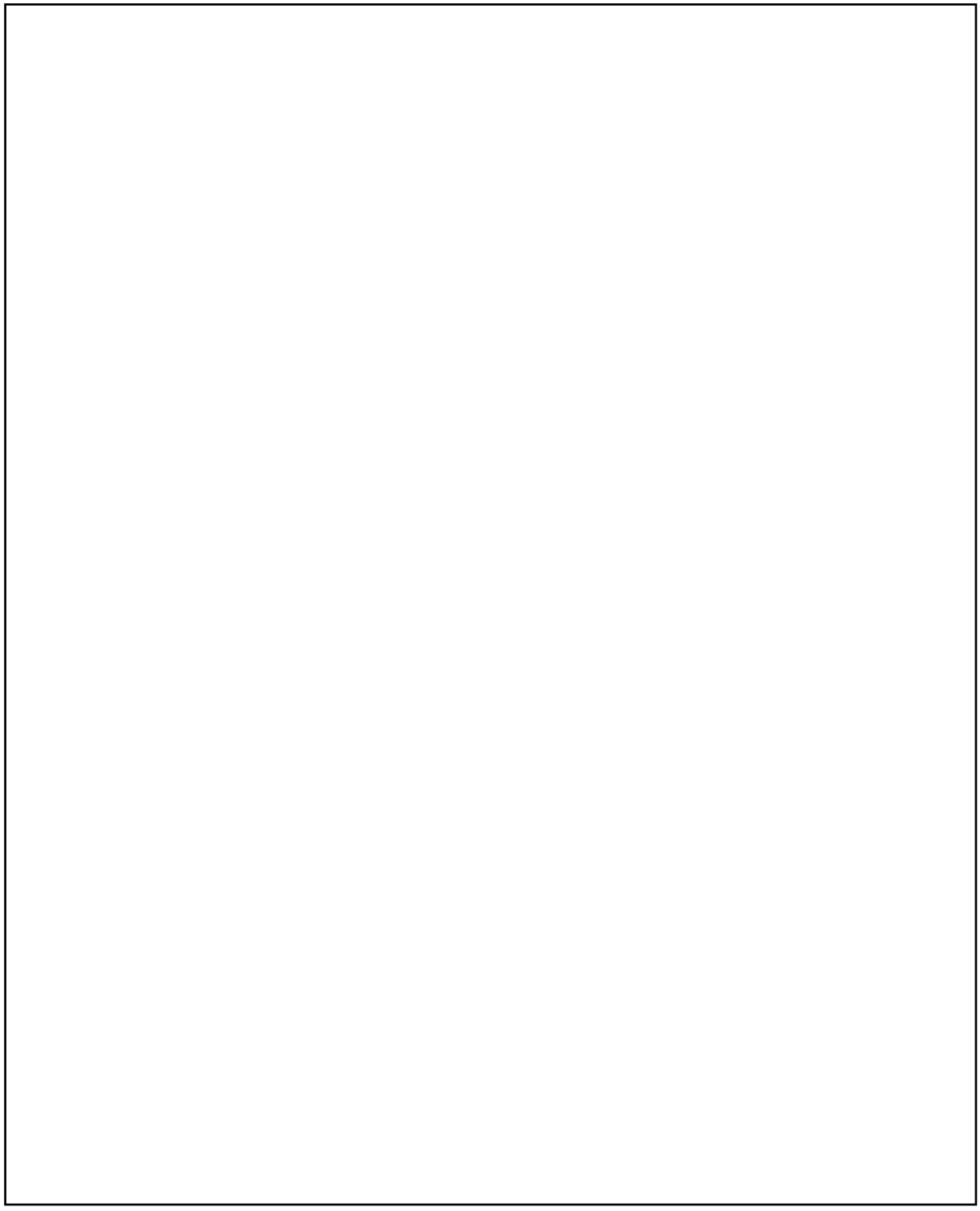
The input/output board holds many large components and provides interconnection between the AC input, the DC-DC board, the AC power board, and the output without the use of heavy cables. The output relay and the output current metering circuit are also mounted on this board. The output AC inductors, the DC-DC transformer and the DC output choke are mounted on brackets beside the input/output board. These brackets also provide support for the input/output board.

**Figure 5-5: AC Power Stage Layout**



*INSERT 11” x 17” FOLDOUT DRAWING*

**Figure 5-6: 3001iM System Interconnect Schematic**



*INSERT 11” x 17” FOLDOUT DRAWING*

**Figure 5-7: 5001iM System Interconnect Schematic**

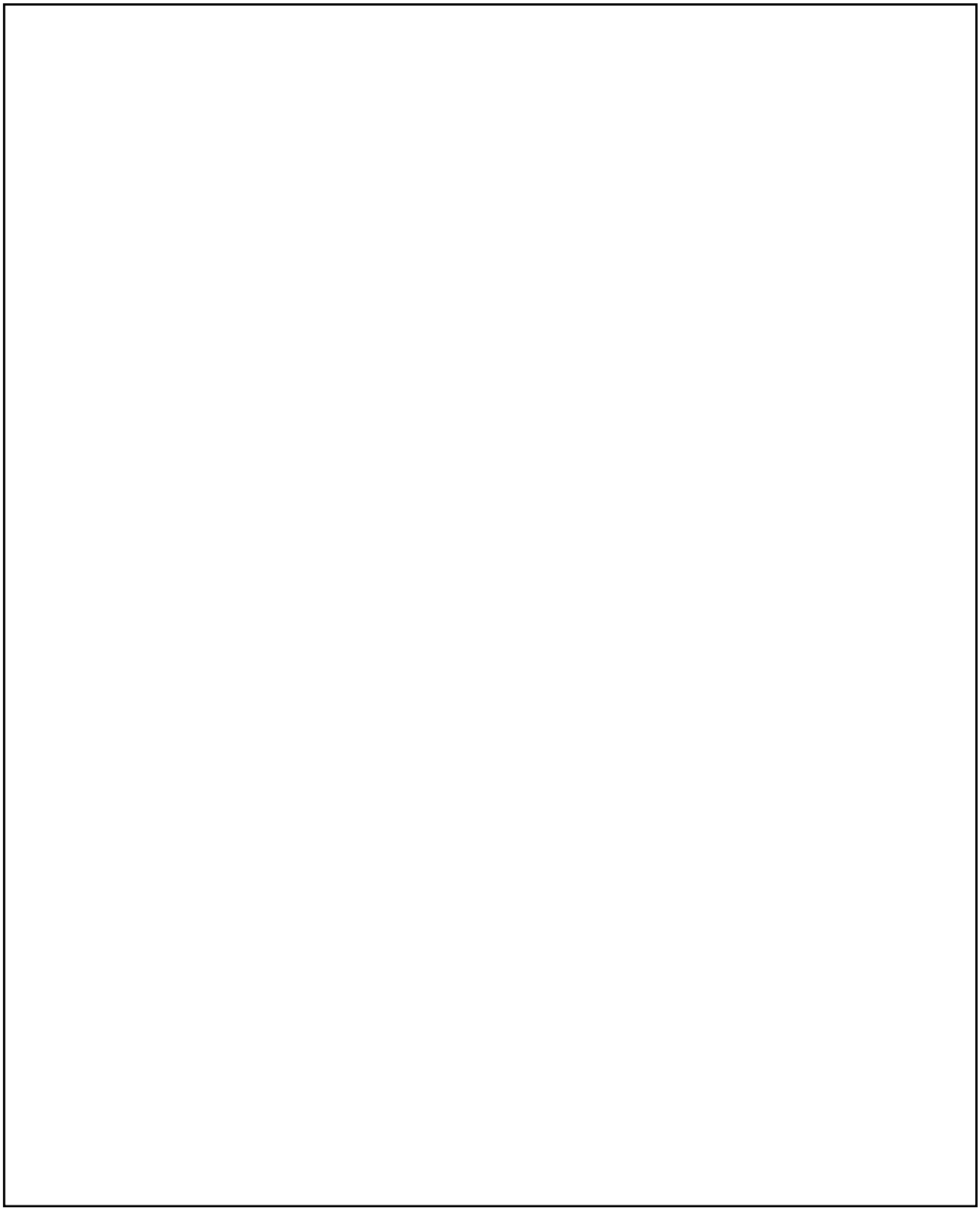
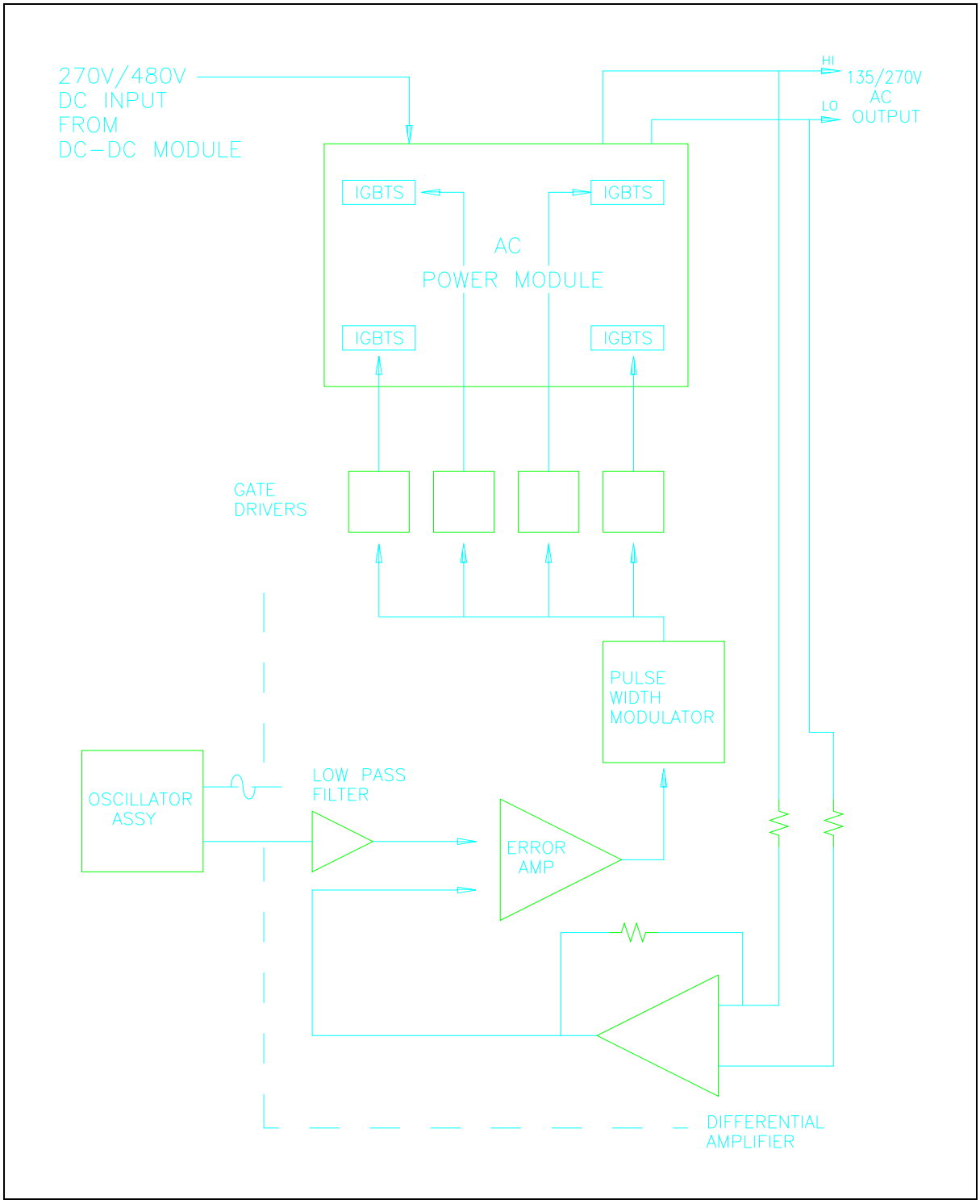
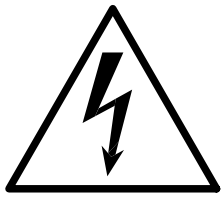


**Figure 5-8: AC Control Logic Block Diagram.**





# CAUTION

**VOLTAGES UP TO 480 VAC AND 650 VDC 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 ELECTRONIC CIRCUITS WHEN POWER IS APPLIED.**

# 6. Periodic Calibration

## 6.1 General

A routine calibration of the Power System is not normally required. The calibration adjustment listed below is only required if the oscillator board or the control board in the power section is replaced. The calibration of the front panel meter may be required occasionally. The procedure is shown in paragraph 6.4 below.

## 6.2 Test Equipment Required

AC Digital voltmeter. Example: Fluke 8840A or equivalent.

## 6.3 Open Sense Adjustment

For the following adjustments, remove all loads from the output. The external sense input A and N at TB3 on the rear panel must be connected to TB2 HI and LO before starting any adjustments. See Figure 3-8. Refer to Figure 6-2 for the location of the adjustment potentiometer.

1. Remove the top cover as detailed in paragraph 3.5.2 step 1.
2. Turn on the power source and adjust the output voltage to 135 volts, 500 Hz on the low range using the external digital voltmeter to monitor the output.
3. Disconnect the external sense inputs at TB3 on the rear panel and adjust R14 on the current limit board to bring the output to 139 volts +/- 0.25 volts.
4. Reconnect the sense leads; the output should now read 135 volts +/- 0.20 volts.

## 6.4 Front Panel Meter Calibration

(Refer to Figure 6-2)
For the panel meter calibration, switch the output to the 270V range, 60 Hz and adjust the output to 270.0V using the DVM on the output sense leads. Apply a light load to the output, approximately 10% to 40% (50 ohms). Adjust the potentiometer R46 on the current limit board so the meter reads 270V +/-1V.

**Figure 6-1: Internal Top View of DC-DC Converter Board.**

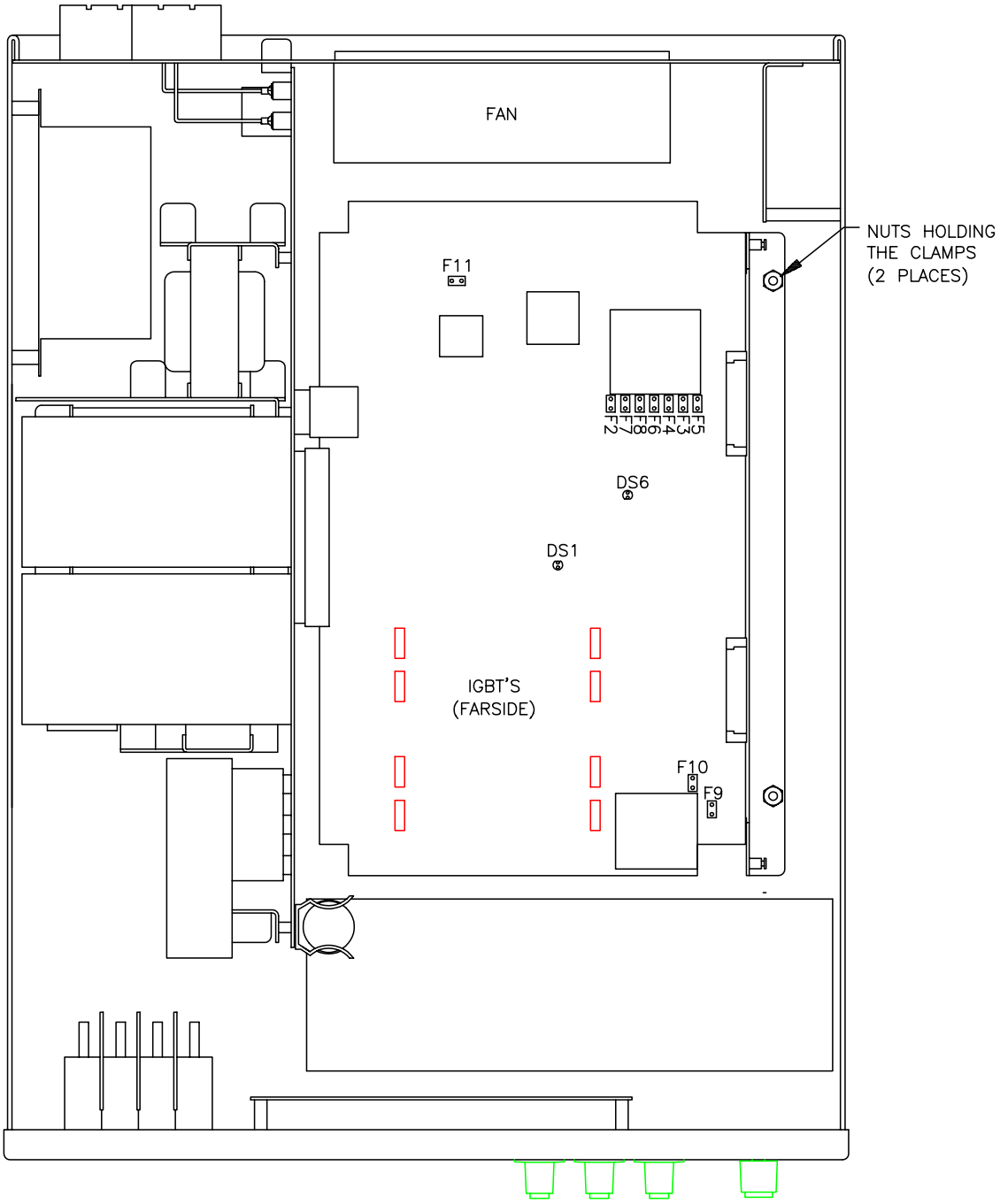
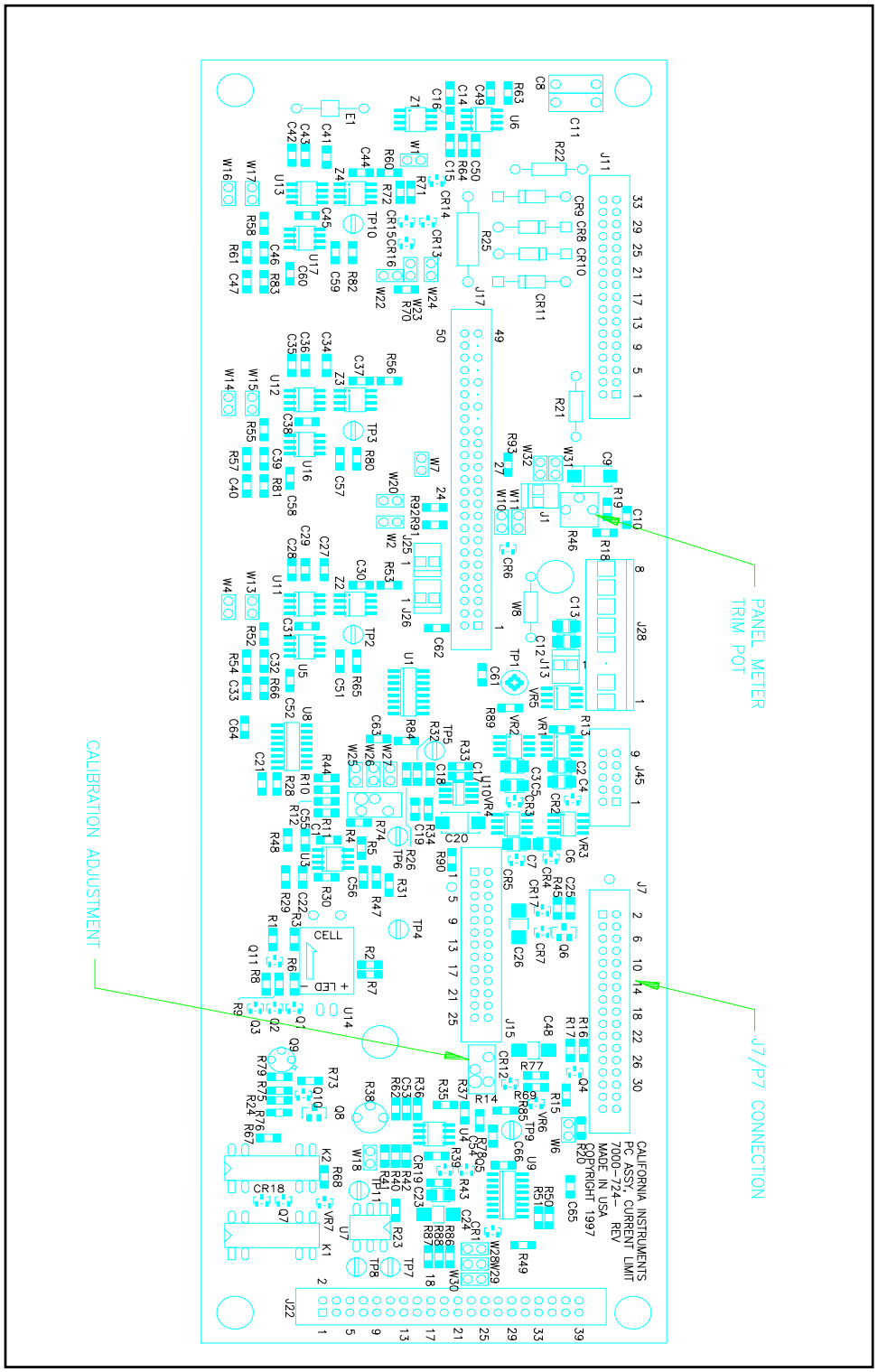


**Figure 6-2: Current Limit Board with Calibration Adjustment.**



# 7. Service

## 7.1 Cleaning

The exterior of the power source may be cleaned with a cloth dampened with a mild detergent and wrung out. Disconnect mains power to the source before cleaning. Do not spray water or other cleaning agents directly on the power source.

## 7.2 General

This section describes the suggested maintenance and troubleshooting procedures. The troubleshooting procedure is divided into two sections. The first section deals with basic operation and connection of the equipment. The second section requires opening the unit and using the LED indicators and a simple multimeter to troubleshoot the unit down to the module level. Only a qualified electronic technician should attempt this level troubleshooting.

## 7.3 Basic Operation

**Table 4: Basic Symptoms**

| PARAGRAPH | PROBLEM |
|---|---|
| 7.3.1 | Excessive Output Voltage |
| 7.3.2 | Poor Output Voltage Regulation |
| 7.3.3 | Overload Light On |
| 7.3.4 | Distorted Output |
| 7.3.5 | Unit Shuts Down After 1-2 Seconds |
| 7.3.6 | No Output and no lights on front panel |
| 7.3.7 | No output but “power on” LED on front panel is lit |

### 7.3.1 Excessive Output Voltage

| CAUSE | SOLUTION |
|---|---|
| External sense not connected | Connect the external sense to the AC power outlet TB2. |

### 7.3.2 Poor Output Voltage Regulation

| CAUSE | SOLUTION |
|---|---|
| Unit is overloaded | Remove overload |
| Unit is switched to wrong voltage range. | Select correct voltage range |
| Input line has fallen below spec limit. | Check supply voltage |

### 7.3.3 Overload Light is On

| CAUSE | SOLUTION |
|---|---|
| Unit is overloaded | Remove overload |
| Unit is switched to high voltage range | Select correct voltage range |

### 7.3.4 Distorted Output

| CAUSE | SOLUTION |
|---|---|
| Power source is grossly overloaded | Reduce load |
| The crest factor of the load exceeds 3:1 on the low range or 5:1 on the high range | Reduce load current peaks by reducing load |

### 7.3.5 Unit Shuts Down After 1-2 Seconds

| CAUSE | SOLUTION |
|---|---|
| Output shorted | Remove output short |
| Output grossly overloaded. | Remove overload |
| Operating load with too high inrush or start up currents | Consult factory for application advice |

### 7.3.6 No Output and No Lights on Front Panel

| CAUSE | SOLUTION |
|---|---|
| Input circuit breaker switched off | Switch the breaker on |
| No input power to TB3 | Ensure proper power is getting to TB3 |
| Unit tripped on overvoltage or overcurrent | Turn circuit breaker off - wait five seconds - turn breaker back on |

### 7.3.7 No Output But “Power On” LED on Front Panel is Lit

| CAUSE | SOLUTION |
|---|---|
| “OUTPUT ON” switch is turned off | Turn OUTPUT ON switch to “ON” |
| Wrong frequency set. Indicated by front panel LIMIT indicator lit | Set frequency to value between 16 Hz and 500 Hz |
| REMOTE SHUTDOWN logic line at J22 pin 36 is shorted to D COM or A COM | Remove connection from J22 pin 3 |
| Current limit control turned down to zero | Turn current limit control clockwise |
| Amplitude control turned down to zero | Turn amplitude control up |
| Unit tripped on overvoltage or overcurrent | Turn circuit breaker off - wait five seconds - turn circuit breaker back on. |

## 7.4 Advanced Troubleshooting

***WARNING: Do not connect 400-480V into the 208-240V unit, the result could be a severely damaged unit.***

***CAUTION: VOLTAGES UP TO 480 VAC AND 650 VDC ARE PRESENT IN CERTAIN SECTIONS OF THIS POWER SOURCE.***

***WARNING: 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***

### 7.4.1 Switch Off Unit

Switch off the unit at the circuit breaker on the front panel as well as removing the input power from the unit.

***WARNING: Wait 10 minutes for all internal capacitors to discharge.***

### 7.4.2 Removing Top Cover

Remove the screws securing the top cover and remove the top cover.

### 7.4.3 Initial Inspection

Make a visual inspection of the unit and ensure all the connectors are properly mated and there are no loose or broken wires.

### 7.4.4 Fuse Check

Refer to Figure 5-3 and Figure 5-5.
Check fuse F1 on the AC power board at the top of the unit using the ohmmeter. If the fuse is open do not replace but check all the IGBT's. To check the IGBT's connect the positive lead of the ohmmeter to the collector (center leg) and measure the resistance to the gate and the emitter (outside legs) of each IGBT (Q5 to Q16 inclusive). If the resistance reading is lower than 1000 ohms this indicates a blown IGBT. The IGBT's are not field replaceable and the module should be returned to the factory for exchange or repair. See paragraph 7.4.6 for disassembly instructions. If a low resistance reading is not found, replace the fuse and proceed with the check procedure.

Check the fuse F1 on the end of the input/output board. If the fuse is blown do not replace but proceed to paragraph 7.4.6 for disassembly instructions and remove the AC power board. With the AC power board removed check the IGBT's Q2 through Q9 using the procedure detailed in the paragraph above. See Figure 6-1: Internal Top View of DC-DC Converter Board. If one or more IGBT's show a low resistance reading do not replace the fuse, but return the module to the factory for exchange or repair. If a low resistance is not found replace the fuse and carry on with the check procedure.

### 7.4.5 Power-On Troubleshooting Using the LED's

If no fuses were blown or if fuses were found blown but all the IGBT's checked out good and the fuses have been replaced, reconnect power to the unit.

***WARNING: Do not touch any parts inside the unit during this test as they will be live and dangerous. Always wear safety glasses.***

Select 60 Hz on the frequency controls, turn the amplitude control fully counterclockwise and the current limit to approximately 25% clockwise. Do not apply any load at this time as running the unit at high loads with the cover off will cause overheating of some components.

**Auxiliary Power Supply:** Turn the main breaker on and check the LED's on the AC logic board (see Figure 5-4). The +15V (DS2-red), -15V (DS3-green), and the 24V (DS7-yellow) LED's located at the top right of the board should all be lit. The 8V logic supply LED (DS4-red) should be lit. On the AC power board (see Figure 5-5) the three gate drive power supply lights, DS5-green, DS6-yellow, and DS7-red, should all be lit. If any of these LED's is not lit then the most likely cause is a blown fuse. These logic power fuses are all located on the DC-DC board. Switch the unit off at the front panel breaker ***and*** remove the input power. ***Wait 10 minutes before attempting to disassemble the unit to allow the capacitors to discharge.*** Proceed to paragraph 7.4.6 for disassembly instructions. Remove the AC power board and locate the PC mount fuses F2 through F10 (see Table 5 for fuse functions). Replace any blown fuses. Always replace fuses with same type and rating. (See Table 5.)

**Table 5: Auxiliary Power Supply Fuse Ratings**

| FUSE # | FUNCTION | FUSE VALUE |
|---|---|---|
| F2 | DC-DC Converter logic | 1 amp |
| F3 | 18V - AC gate drive (2) | 1 amp |
| F4 | 18V - AC gate drive (3) | 1 amp |
| F5 | 18V - AC gate drive (1) | 1 amp |
| F6 | 24V Fan and relay power. | 3 amp |
| F7 | +15V logic power | 1 amp |
| F8 | -15V logic power | 1 amp |
| F9 | 8V Front panel meter power | 1 amp |
| F10 | +8V logic power | 1 amp |
| F11 | Auxiliary power supply input fuse. | 3 amp |

Fuse F9 supplies power to the front panel meter. If F9 blows then there is no readout. If no LED's are on at all then the auxiliary power supply may have failed. Check F11 and replace if necessary. If none of these fuses has blown proceed to the next step.

**DC-DC Converter:** The high voltage output of the DC-DC converter will light the LED that is located directly down between the large storage capacitor and the input/output board (see Figure 5-3). This LED should be lit. If this LED is not lit but the other auxiliary power supply LED's are lit then check F2 on the DC-DC board. See Table 5 and the preceding paragraph.

If no failures have been found to this point, then the AC power board has a high power input and gate drive power. The gate drives on the AC power board should all be present (see Figure 5-5). These are the green LED's DS1 through DS4. They should all be lit. If they are not lit then the gate drive has been inhibited. Recheck paragraph 7.3.7 a) and c).

**Oscillator:** If the LED's DS1 through DS4 are lit and there is still no output then there may be no output from the oscillator. To check the oscillator output turn off the unit at the main breaker. Set the DVM to AC volts and connect the meter to test point 2 (TP2) with the return on TP1 of the AC logic board. See Figure 5-4. TP2 is in the center of the AC logic board and TP1 is at the top left. Turn the breaker back on. There should be a reading on the meter which can be varied from 0 to 5 volts by the amplitude knob on the front panel. If no reading is present, check the output on the waveform generator board itself, between TP4 and TP1. ***Switch off first before relocating probes.***

If a signal is present at the waveform generator board but not at the AC logic board then the fault is in the wiring or the current limit board. Check the continuity of cables from the oscillator to the AC logic board. If there is no signal at TP4 then recheck the inhibit at paragraph 7.3.7 a) and c) or replace the oscillator assembly. The presence of the oscillator signal at the AC logic board would indicate a fault in the output relay or output wiring. See Figure 5-6.

**AC output: Switch unit off -** Check that P1 on the AC power board is making good contact with its mating half and J8 (the output to the AC smoothing inductors) is firmly engaged. Switch the unit back on and operate the power on/off switch on the front panel. Listen to hear if the relay operates. If the relay does not operate, replace the input/output board. If it does operate, check the continuity of the output wiring.

If the problem with the unit has not been isolated, please contact the factory for assistance from the California Instruments customer service department.

### 7.4.6 Disassembly Procedure

With the AC input voltage disconnected and the top cover removed, unplug P7 from the current limit board and unplug the fan from the AC logic board connector. Then carefully unplug the AC logic board from the AC and the DC power boards. The AC logic board can then be lifted from the unit.

Using a 5/16 inch socket driver remove the four bolts that hold the AC power module heatsink. There is one bolt at each corner. Carefully remove all the hardware from the unit. The AC power module can now be unplugged from the input/output board and removed from the unit.
The DC-DC module can be unplugged by first removing the two nuts (3/8 inch socket driver) holding the clamp that secures the heatsink to the chassis. See Figure 6-1. Care must be taken in unplugging the two connectors P4 and J12.

For reassembly, reverse the above procedure, taking care to ensure J12 on the DC-DC board and J8 on the AC board are properly mated. This may entail supporting the connector from behind with a screwdriver.

# 8. Top Assembly Replaceable Parts

TOP ASSEMBLY No: 7000-430-1 3001iM
7000-428-1 5001iM, 240 volt input
7000-428-2 5001iM, 480 volt input

**Table 6: Replaceable Parts**

| SEQ # | CI PART # | DESCRIPTION | VENDOR | QTY |
|---|---|---|---|---|
| A1 | 7000-725-1 | 240V - I/O PC ASSEMBLY | CI | 1 |
| A1 | 7000-726-1 | 480V - I/O PC ASSEMBLY | CI | 1 |
| A2 | 7000-419-2 | AC POWER MODULE | CI | 1 |
| A3 | 7000-420-1 | 240V - DC - DC POWER MODULE, 5001iM | CI | 1 |
| A3 | 7000-420-2 | 240V - DC - DC POWER MODULE, 3001iM | CI | 1 |
| A3 | 7000-421-1 | 480V - DC - DC POWER MODULE | CI | 1 |
| A4 | 7000-732-2 | LOGIC BOARD PC ASSEMBLY | CI | 1 |
| A6 | 7000-724-2 | CURRENT LIMIT PC ASSEMBLY | CI | 1 |
| 2 | 7000 429-1 | MAN OSC FRONT PANEL ASSY, 5001iM | CI | 1 |
| 2 | 7000 429-2 | MAN OSC FRONT PANEL ASSY, 3001iM | CI | 1 |
| B1 | 241183 | FAN 6 INCH--JD24B2 | Rotron | 1 |
| F1 | 270199 | FUSE 50A, 700V, AC BOARD | Bussman FWP-50A14F | 1 |
| F1 | 270184 | FUSE 30A 700V I/O BOARD | Bussman-KPB30 | 1 |
| K1 | 245217 | RELAY ON CHASSIS. KUHP-5DT1-24 | Potter & Brumfield | 1 |
| $F_{MISC}$ | 270183 | P.C. FUSES ON DC-DC BD, 3A $F_6$,$F_{10}$ | Bussman PCC-3 | 3 |
| $F_{MISC}$ | 270174 | P.C. FUSES ON DC-DC BD, 1A $F_2$-$F_5$, $F_7$-$F_9$ | Bussman PCC-1 | 6 |
| CB1 | 270186 | INPUT CIRCUIT BREAKER 35A (240V), 5001iM | AIRPAX 205-1111-28051-2 | 1 |
| CB1 | 270196 | INPUT CIRCUIT BREAKER 35A (250V), 3001iM | AIRPAX IELK21- 28851-1-V | 1 |
| CB1 | 270207 | INPUT CIRCUIT BREAKER 15A (480V), 5001iM-400 | AIRPAX IELHK1111-30431-1-V | 1 |

| SEQ# | CI PART # | DESCRIPTION |
|---|---|---|
| DC - DC POWER ASSY. 7000-729 AND 7000-731 | | |
| F2 | 270174 | 1 amp, 250 vac, quick acting |
| F3 | 270174 | 1 amp, 250 vac, quick acting |
| F4 | 270174 | 1 amp, 250 vac, quick acting |
| F5 | 270174 | 1 amp, 250 vac, quick acting |
| F6 | 270183 | 3 amp, 250 vac, quick acting |
| F7 | 270174 | 1 amp, 250 vac, quick acting |
| F8 | 270174 | 1 amp, 250 vac, quick acting |
| F9 | 270174 | 1 amp, 250 vac, quick acting |
| F10 | 270183 | 3 amp, 250 vac, quick acting |
| F11 | 270182 | 10 amp, 250 vac, time lag |
| AC POWER ASSY. 7000-730 | | |
| F1 | 270199 | 50 amp, 700 vac, very quick acting |
| 240 VOLT I/O ASSY. 7000-725 | | |
| F1 | 270184 | 30 amp, 700 vac, very quick acting |
| F2 | 270183 | 3 amp, 250 vac, quick acting |
| F3 | 270183 | 3 amp, 250 vac, quick acting |
| 400 VOLT I/O ASSY, 7000-726 | | |
| F1 | 270185 | 15 amp, 700 vac, very quick acting |
| F2 | 270183 | 3 amp, 250 vac, quick acting |
| F3 | 270183 | 3 amp, 250 vac, quick acting |
| F4 | 270183 | 3 amp, 250 vac, quick acting |

# 9. Index