EasyWave AC Power Source

Model EW 3001

Operation Manual

ELGAR CORPORATION
9250 Brown Deer Road
San Diego, CA 92121

EW 3001
Operation

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ELGAR ONE YEAR WARRANTY

Elgar Corporation (hereinafter referred to as Elgar) warrants its products to be free from defects in material and workmanship. This product warranty is effective for one year from the date of shipment to the original purchaser. Liability of Elgar under this warranty shall exist provided that:

- the Buyer exposes the product to normal use and service and provides normal maintenance on the product;
- Elgar is promptly notified of defects by the Buyer and that notification occurs within the warranty period;
- the Buyer receives a Return Material Authorization (RMA) number from Elgar's Customer Service Department prior to the return of the product to Elgar for repair, phone 800-73-ELGAR (800-733-5427), ext. 295;
- the Buyer returns the defective product in the original, or equivalent, shipping container;
- if, upon examination of such product by Elgar it is disclosed that, in fact, a defect in materials and/or workmanship does exist, that the defect in the product was not caused by improper conditions, misuse, or negligence; and,
- that Elgar markings and nameplates have not been altered or removed and the equipment has not been repaired or modified by anyone other than Elgar authorized personnel.

This warranty is exclusive and in lieu of all other warranties, expressed or implied, including, but not limited to, implied warranties of merchantability and fitness of the product to a particular purpose. Elgar, its agents, or representatives, shall in no circumstance be liable for any direct, indirect, special, penal, or consequential loss or damage of any nature resulting from the malfunction of the product. Remedies under this warranty are expressly limited to repair or replacement of the product.

CONDITIONS OF WARRANTY

- To return a defective product, contact an Elgar representative or the Elgar factory for an RMA number. Unauthorized returns will not be accepted and will be returned at the shipper's expense.
- For Elgar products found to be defective within thirty days of receipt by the original purchaser, Elgar will absorb all ground freight charges for the repair. Products found defective within the warranty period, but beyond the initial thirty-day period, should be returned prepaid to Elgar for repair.
- Normal warranty service is performed by Elgar during the weekday hours of 7:30 am to 4:30 pm Pacific time. Warranty repair work requested to be accomplished outside of normal working hours will be subject to Elgar non-warranty service rates.
- Warranty field service is available on an emergency basis. Travel expenses (travel time, per diem expense, and related air fare) are the responsibility of the Buyer. A Buyer purchase order is required by Elgar prior to scheduling.
- A product found, upon inspection by Elgar, to be in specification is subject to an inspection fee and applicable freight charges.
- Equipment purchased in the United States carries only a United States warranty for which repair must be accomplished at the Elgar factory.

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SAFETY NOTICE

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

WARNING!

HAZARDOUS VOLTAGES IN EXCESS OF 280 VRMS, 600V PEAK MAY BE PRESENT WHEN COVERS ARE REMOVED. THERE ARE NO USER SERVICEABLE COMPONENTS IN THE UNIT.

Installation and service must be performed by qualified personnel who are aware of dealing with attendant hazards.

Ensure that the AC power line ground is connected properly to the EW Series unit input connector. 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 the input/output power cables.

Depending on your application configuration, HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY may be generated normally on the output terminals. Ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Due to filtering, the unit has leakage current to the chassis. Therefore, it is essential to operate this unit with a safety ground.

SAFETY SYMBOLS

CAUTION
Risk of Electrical Shock

CAUTION
Refer to Accompanying Documents

Off (Supply)

Standby (Supply)

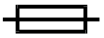
On (Supply)

Protective Conductor Terminal

Direct Current (DC)

Alternating Current (AC)

Three–Phase Alternating Current



Fuse

Earth (Ground) Terminal

CONTENTS

1 OVERVIEW

1.1 Introduction

The Elgar EW 3001 AC Power Source is a highly efficient AC Power Source providing sine wave output of low distortion. The microprocessor-controlled sine wave oscillator generates accurate and stable output voltage and frequency. The PWM (Pulse Width Modulation) approach of the power stage provides full volt-ampere and current rating to loads. The EW 3001 supplies power up to 3000 VA.

The Elgar EW 3001 AC Power Source is considerably smaller, lighter and more efficient than traditional power supplies with similar capability of outputting power.

This manual includes the specifications, installation procedures, operation and programming instructions for the EW 3001 Power Source.

1.2 Features

Configuration

- Local operation through the keypad on front panel.
- Remote operation through GPIB or RS-232C interface.
- Protection against over power, over current, over temperature, under voltage, fan failure, and open circuit.
- Temperature-controlled fan speed.
- Built-in output isolation relays.

Input/Output

- Selective full scale output: 150V/300V Auto.
- Remote control by analog voltage reference.
- Measurement of V, F, PF, CF, I, P.
- Programmable limit of output Irms.

1.3 Specifications

The operational specifications of the Elgar EW 3001 are listed below. All specifications are tested according to the standard Elgar test procedures.

All specifications are based on a full rated power resistive load at 25ºC ±1ºC specified otherwise.

Maximum distortion applies from half range to full range of the selected output voltage range with a resistive load.

1.3.1 Input

Parameter	Units	Value
Voltage	Volts AC RMS	190-250, 1 Phase
Connector Type		3 pin Terminal Block
Power Factor	N/A	0.98 minimum at nominal input voltage (220-230VAC)
Current, Inrush	Amperes, Peak	80 typical
Current	Amperes RMS	23 maximum
Frequency	Hz	47 to 63 minimum
Efficiency	N/A	80% typical

1.3.2 Output

Parameter	Units	Value
Power, Reactive	Volt amperes, RMS	3000 minimum
Voltage Programming Range	Volts RMS	Range 1 - 1 maximum to 150 minimum, Range 2 - 2 maximum to 300 minimum
Current Programming Range	Amperes RMS	Range 1 - 0 to 30 minimum, Range 2 - 0 to 15 minimum
Voltage Programming Accuracy (GPIB/RS-232/Front panel)	Percent of full scale	0.2% maximum for output ≤ 200 Hz, 0.4% maximum for output > 200 Hz

Parameter	Units	Value
Voltage Programming Resolution (GPIB/RS-232/Front panel)	Volts AC RMS	0.1 maximum
Voltage Programming Accuracy (Analog)	Percent of full scale	0.4%
Voltage Drift, excluding external analog control	Percent per degree Celsius	0.1% maximum
Inductive Output Impedance	Mh	250 maximum
Resistive Output Impedance	Ohms	0.25 maximum
Load Transient Recovery	Seconds to 75% of final value	0.5 maximum
Noise	dB below full scale	45 minimum (measured at 60Hz)
Distortion	Percent THD	0.5% maximum for output of ≤ 500Hz and linear load 1.0% maximum for output of > 500Hz and linear load
Line Voltage Regulation	Percent	0.1% maximum of full scale
Load Voltage Regulation	Percent	0.1% maximum of full scale at point of sense
Current Crest Factor	N/A	3.0 minimum for output ≤ 100 Hz, 2.5 minimum for output > 100 Hz
Frequency Range	Hz	45 to 1000 minimum
Frequency Drift	ppm per ºC of programmed value	50 maximum
Frequency Programming Accuracy (GPIB/RS-232/front panel)	Percent of programmed value	0.1 maximum
Frequency Programming Resolution (GPIB/RS-232/front panel)	Hz	0.1 maximum

1.3.3 Front Panel Display

Parameter	Units	Value
Output Voltage Accuracy	N/A	0.3% of full scale + 0.2% of reading maximum
Output Voltage Resolution	Volts RMS	0.1 maximum
Output Current Accuracy	N/A	0.3% of full scale + 0.5% of reading maximum
Output Current Resolution	Amperes RMS	0.01 maximum
Output Power Range	Watts	0 to 3000 minimum
Output Power Accuracy	percent of full scale	2.5 maximum
Output Power Resolution	Watts	0.1 maximum
Crest Factor Accuracy	N/A	1% of full scale maximum for output > 1500VA
Power Factor Accuracy	N/A	1% of full scale maximum for output 1500VA
Frequency Accuracy	percent of reading	0.25%

1.3.4 GPIB/RS-232 Readback

Parameter	Units	Value
Output Voltage Accuracy	N/A	0.3% of full scale + 0.2% of reading maximum
Output Voltage Resolution	Volts RMS	0.1 maximum
Output Current Accuracy	N/A	0.3% of full scale + 0.5% of reading maximum
Output Current Resolution	Amperes RMS	0.01 maximum
Output Power Range	Watts	0 to 3000 minimum
Output Power Accuracy	percent of full scale	2.5 maximum
Output Power Resolution	Watts	0.1 maximum
Crest Factor Accuracy	percent of reading	1 maximum with output > 1500VA
Power Factor Accuracy	percent of reading	1 maximum with output > 1500VA
Frequency Accuracy	percent of reading	0.25

1.4 Operational Panels

1.4.1 The Front Panel

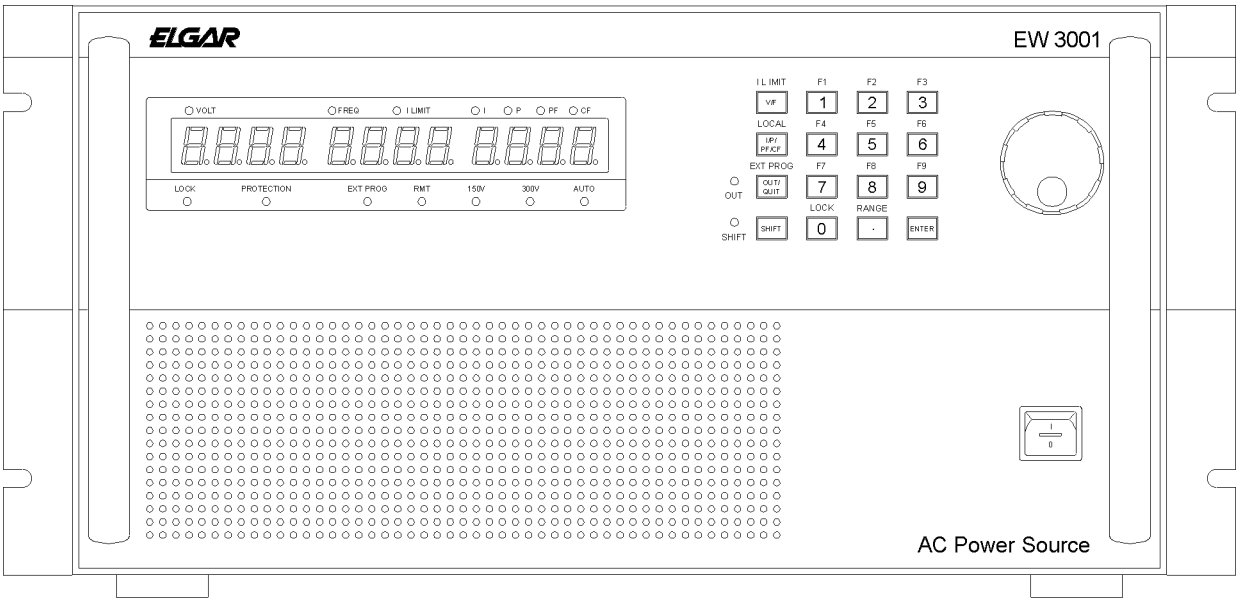


Figure 1-1 Front Panel

Item	Symbol	Description
1		***Alphanumeric LEDs:*** A row of red 7-segment LEDs display setup messages and numeric settings or measurement results. The display area is divided into three sections; values of V appear on the left, frequency or I limit appears in the middle, and any of I/P/PF/CF measurement values appear on the right.
2		***Indicator LEDs:*** LEDs located on the upper and lower part of the display panel are the indicators showing the activated status. These indicators include “VOLT”, “FREQ”, “I LIMIT”, “I”, “P”, “PF”, “CF”, “LOCK”, “PROTECTION”, “EXT PROG”, “RMT”, “150V”, “300V”, “AUTO”. The “OUT” and “SHIFT” LEDs are located next to the corresponding keys on the keypad. When illuminated, they indicate activation of output and shift modes.

Item	Symbol	Description
3	V/F ----- or ----- I limit	***V/F or I limit selection key:*** In normal mode, this key allows you to program either voltage or frequency. In shift mode, this key allows you to program the rms (root mean square) limit on the output current.
4	I/P/PF/CF ----- or ------ LOCAL	***I/P/PF/CF selection key:*** In normal mode, repeatedly press this key to cycle through and select one of the measurement values. In shift mode, this key returns control from the remote PC to the front panel keypad.
5	OUT/QUIT ----- or ------ EXT PROG	***OUT/QUIT command key:*** In normal mode, press this key to enable the EW to output power to the load. During setup procedures, use this key to quit the current setup routine. In shift mode, this key enables external programming.
6	SHIFT	***Shift mode selection key:*** Press this key to switch the EW from the normal operational mode to the shift mode, or from shift back to normal.
7	1 to 9, 0 and • ----- or ----- F1 to F9, LOCK, and RANGE	***Numeric and decimal keys:*** In normal mode, use these keys to program numeric data. In shift mode, use the keys from 1 to 9 to save data into or recall data from memory channels F1 to F9 respectively. Additionally, in shift mode, 0 enables data lock and configuration setup, and • allows programming of the full range of output voltage.
8	ENTER	***Enter key:*** Press this key to confirm parameter settings.
9		***Rotary knob:*** Turn the rotary knob to input programming data or select options.
10		***Main Power Switch:*** Power on/off the EW 3001 by this switch.

Table 1-1 Front Panel Description

1.4.2 Rear Panel

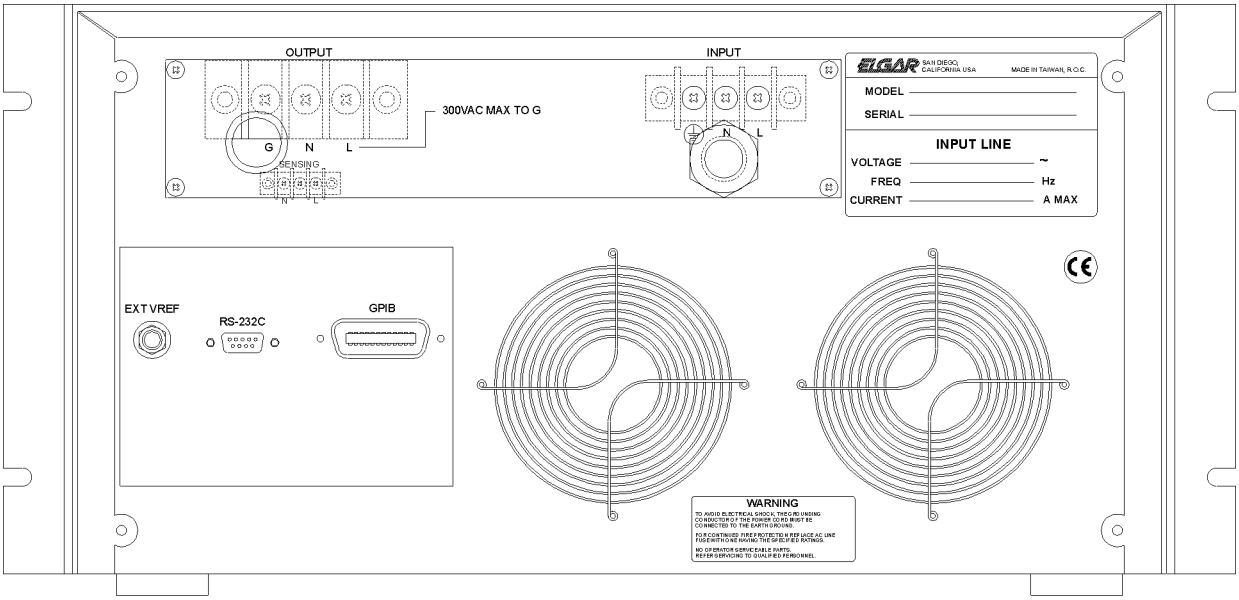


Figure 1-2 Rear Panel

Item	Name	Description
1	Series No. Label	Each set of the EW 3001 instruments has its own identification number and input rating marked on this label.
2	Output Terminal Block	Power line output is connected to the EW 3001 through this connector.
3	Power Line Input Terminal Block	Power line input is connected to the EW 3001 through this connector.
4	Cooling Fan	Cooling fan speed automatically increases or decreases as temperature rises or falls.
5	Ext. V Ref.	Control the output Vrms of the EW 3001 by external DC voltage level. Such signal is input through this BNC connector. ***NOTE:*** *This connector is optional.*
6	GPIB Connector	The interface allows the EW 3001 to communicate with the remote GPIB controller. ***NOTE:*** *This connector is optional.*
7	RS-232C Connector	This port located on the same GPIB optional board offers an alternative interface to the EW 3001 for remote operation. ***NOTE:*** *This connector is optional.*

Table 1-2 Rear Panel Description

2 INSTALLATION

2.1 Inspection

When unpacking the instrument, inspect any damage that might have occurred during shipping. Save all packing materials in case the unit has to be returned.

If any damage is found, please file a claim with the carrier immediately. Do not return the instrument to the factory without prior RMA acceptance from Elgar.

2.2 Preparation for Use

Connect the instrument with an appropriate AC line input. Since it is intelligently fan-cooled, it must be installed in sufficient space for the circulation of air. Operate the instrument in an area where the ambient temperature is under 40ºC (104ºF).

2.3 Requirements of Input Power

2.3.1 Ratings

Input Voltage Range	190 ~ 250 Vac, single phase
Input Frequency	47 ~ 63 Hz
Max. Current	25A RMS
Max. power	4000 W

Fuse Information

FUSE REFERENCE DESIGNATOR AND LOCATION	FUSE FUNCTION	FUSE RATING AND TYPE	INDICATION OF FUSE FAILURE
F1 located on "I" (Input) PCB Assembly	Main Input Power Fuse	T25A/250V 13/32" Dia. 1 ½" Length	Low Line error with proper input line voltage
F1 located on "G" (DC/DC) PCB Assembly	DC Buss Fuse Power Fuse	T8A/250V 5mm Dia 20mm Length	Fails System Test or cannot load output
F1 located on "M1" (Mother) PCB Assembly	DC Supply Fuse Power Fuse	T1A/250V 5mm Dia 20mm Length	No operation when power switch is turned ON

Note: For continued protection against fire hazard, replace only with the same type and rating of fuse.

2.3.2 Input Connection

The input power terminal block is located on the rear panel of the instrument. See Figure 2-1. Input of the EW 3001 must be connected from a three-wired single phase AC power outlet. The current rating of the power line input must be larger than or equal to that of the fuse of the instrument. Refer to *Appendix A Wire Gauge Selection* for recommendations on appropriate wire size.

WARNING! *To protect operating personnel, the wire connected to the GND terminal must be connected to an earth ground. In no event shall this instrument be operated without adequate ground connection.*

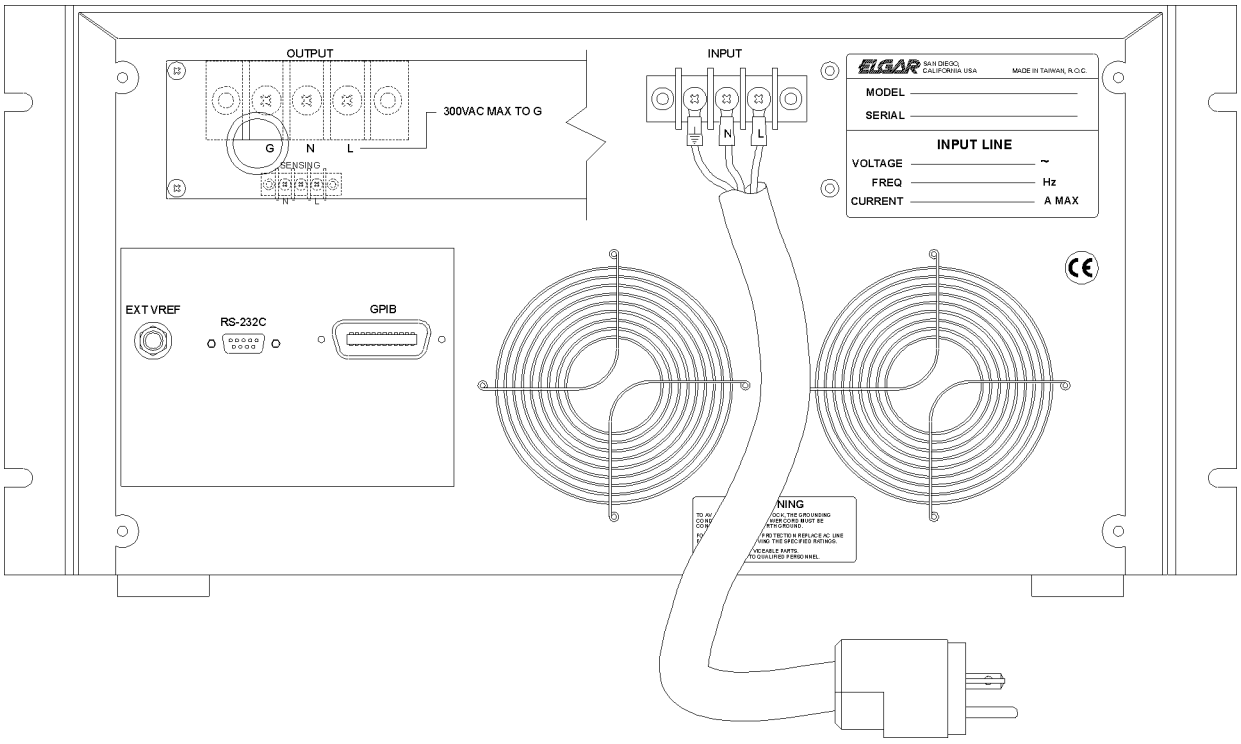


Figure 2-1 Input Connection

2.4 Output Connection

Output power can be connected from the terminal block located on the rear panel of the instrument through terminals L and N to the load as shown in Figure 2-2. For safety, the wires to the load should be of a sufficiently large gauge to ensure that they do not overheat while carrying the output current. Refer to *Appendix A Wire Gauge Selection* for recommendations on appropriate wire size.

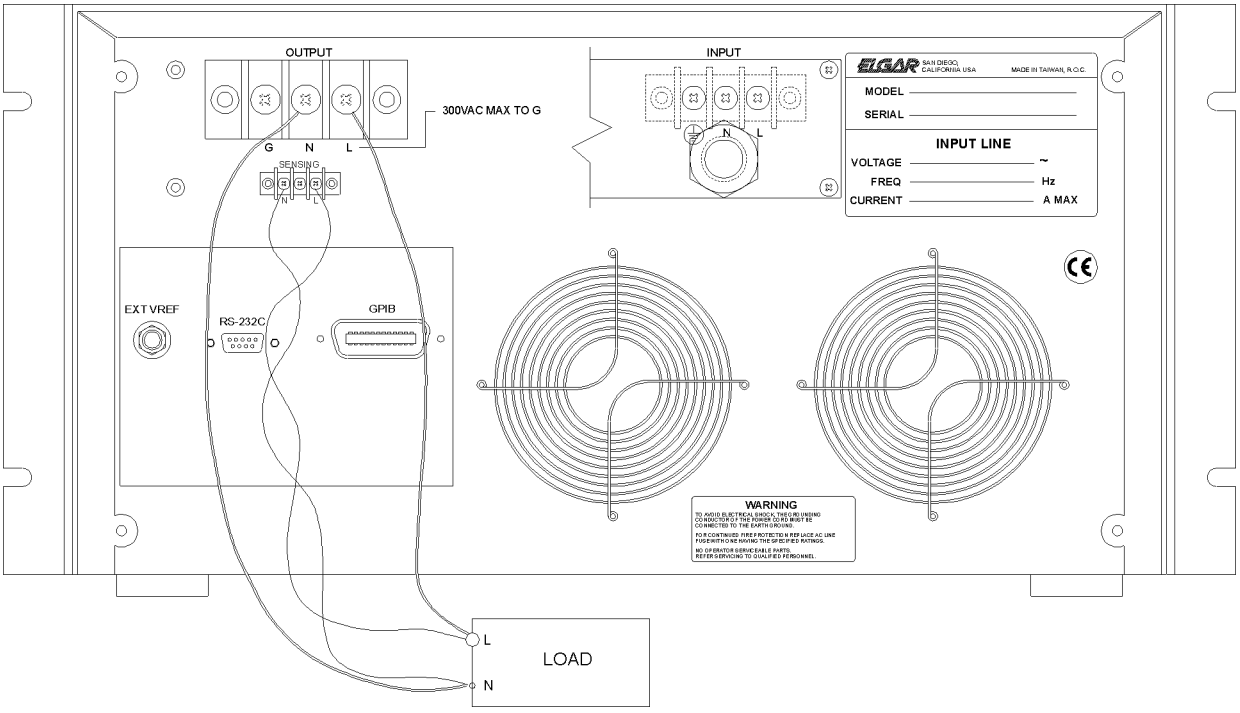


Figure 2-2 Output Connection

2.5 Remote Sense Connection

The remote sensing connection improves the voltage regulation by monitoring the voltage at the load, not at the AC power source output terminal. Remote sensing allows the power supply to increase the output voltage automatically, and compensate for the voltage drops in the load leads. Note that with remote sensing, voltage read-back is at the load.

The instrument can be managed for remote voltage sensing by connecting the load leads from the output terminals to the load, and the sensing leads from the terminals L and N to the load as shown in Figure 2-2.

2.6 Power-on Procedures

Apply the line power to the input terminals, and turn on the power switch on the front panel. No load shall be connected to the output terminal block. The instrument will do a series of self-tests whenever the user turns on the power switch. All LEDs on the front panel, including alphanumeric and indicator LEDs, are lighted for three seconds or so. Then, the seven-segment LEDs and alphanumeric LEDs will display "SELF TEST". It means that the EW 3001 is running a self-test.

Shortly afterwards, the seven-segment LEDs will display the model number, EW 3001, and the firmware version number like shown below:

```
EW3001   ver  1.2
```

If any error is detected during the self-test, an error message will be displayed on the LED like the following one:

```
ROM TEST ERR.
```

The following table defines all error messages and the recommended action:

Item	Error Message	Description	Action
1	ROM TEST ERR.	System ROM test failure.	Consult your dealer for assistance in case of self-test failure.
2	RAM1 ERROR	System RAM1 test failure.	
3	RAM2 ERROR	System RAM2 test failure.	
4	WAVEFORM ERR.	Waveform module test failure	
5	FRE. TEST ERR.	Frequency module test failure	

After the self-test is completed, the LEDs will show the current set values of V, F and the measured value of I, and indicate that the EW 3001 is ready for use as below:

```
0.0  60.0  0.00
```

WARNING! *Before the instrument is turned on, all protective earth terminals, extension cords, and devices connected to the instrument must be connected to a protective earth ground. Any interruption of the protective earth grounding will cause a potential shock hazard.*

2.7 I/O Connectors (Optional)

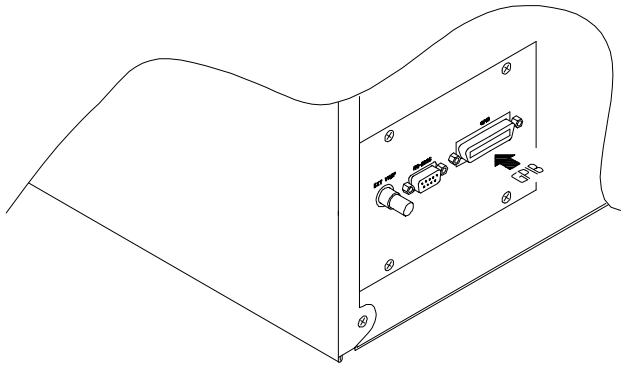


Figure 2-3 GPIB

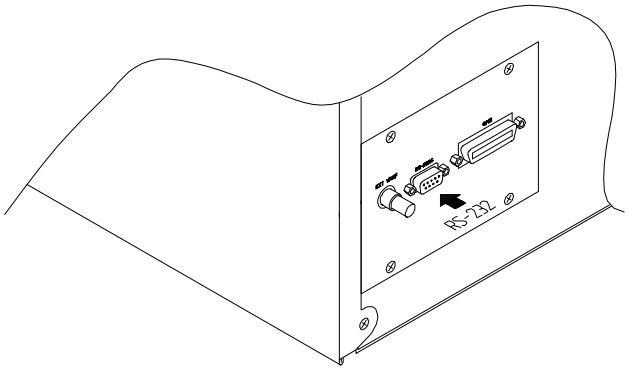


Figure 2-4 RS-232C

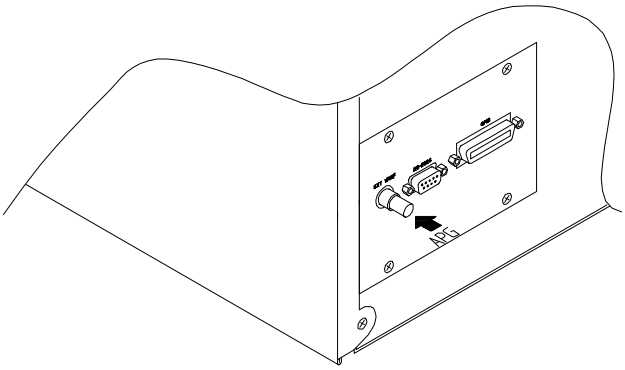


Figure 2-5 APG

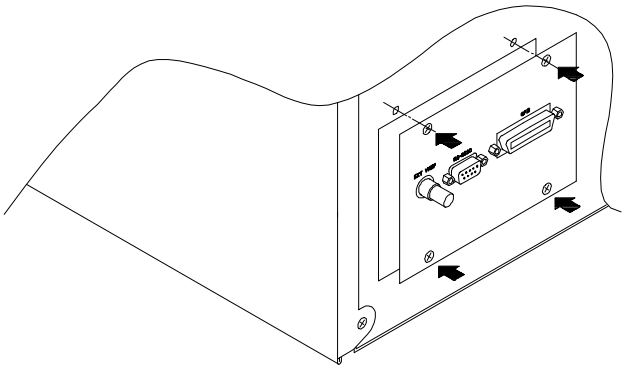


Figure 2-6 Optional Board

3 LOCAL OPERATION

3.1 Introduction

The Elgar EW 3001 AC power source can be configured to operate in local or remote mode. Operation of the EW 3001 through a keypad on the front panel for data entry and test execution in local mode are described here; remote operation through a GPIB controller is described in Section 6.

3.2 Setup

Configuration of the EW 3001 includes setting the GPIB address, RS-232C baud rate, parity, and OVP, enabling key stroke sound, and system test.

You must initiate the setup procedures for first time operation, and may modify settings as application requirements change. Before you begin setup procedures, note the following conventions:

- To confirm numeric data entry, press the ENTER key within two seconds after the last numeric keypress, or the EW disregards the programming value and the previous data is retained. This convention applies to all numeric values specified.

- Press the SHIFT key to turn on the green SHIFT indicator. Once the shift mode is enabled, the label above each key identifies that key's new function.

  To toggle back to non-shift mode, press the SHIFT key again to restore the original function identified on each key.

- Numeric keys 1 through 5 correspond to the five configuration functions available. These setup procedures are described in the sections that follow.

Follow these steps to begin setup procedures:

ACTION	LED DISPLAY
1. Press the SHIFT key to enter the SHIFT mode and turn on the green SHIFT indicator.	
2. Press and hold the 0 key for 3 seconds and you will hear beeping to indicate that you have initiated setup procedures.	SEt UP 1

NOTE: When you press the 0 key, if the red LOCK indicator turns on, release and press the key again to switch off the lock, then begin again.

3.2.1 GPIB Address

Prior to operating in remote mode (detailed in Section 6 of this manual), set the GPIB address. Valid addresses range from 0 to 30. For example, to set the GPIB address to 25:

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	`Set UP 1`
2. Press 1, ENTER.	`Gpib Addr 4`
3. Press 2, 5, ENTER.	`GPib Addr 25`
4. Press OUT/QUIT to quit this setup function.	`Set UP 1`
5. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.2.2 RS-232C

The EW provides alternative remote operation using the RS-232C bus. Prior to operating in remote mode, set the communication protocol. For example, to set the baud rate to 19200, and the parity to ODD, follow the steps below.

NOTE: Baud rate options (2400/4800/9600/19200) are displayed 24/48/96/192 respectively. Parity options (NONE, EVEN, ODD) are displayed as “nonE”, “EVEn”, and “odd”.

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	`SEt UP 1`
2. Press 2, ENTER.	`232C bAUd 96`
3. Turn the rotary knob to select "19200".	`232C bAUd 192`
4. Press ENTER.	`232C PrtY nonE`
5. Turn the rotary knob to select "ODD".	`232C PrtY odd`
6. Press ENTER.	`232C bAUd 192`
7. Press OUT/QUIT to quit this setup function.	`SEt UP 2`
8. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.2.3 OVP

The EW provides output voltage protection (OVP) to protect the load. You can specify the upper limit for output voltage; the default limit is 300V. For example, to set output voltage not to exceed 120V:

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	SEt UP 1
2. Press 3, ENTER.	OVP SEt 300.0
3. Press 1, 2, 0, ENTER.	OVP SEt 120.0
4. Press OUT/QUIT to quit this setup function.	SEt UP 3
5. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.2.4 Sound (ON/OFF)

As you use the keypad or rotary knob during programming, the EW beeps to confirm your entries. By default, this toggle On/Off feature is enabled; to disable it, follow these steps:

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	SEt UP 1
2. Press 4, ENTER.	bEEP on
3. Turn the rotary knob to set the option to OFF and press ENTER.	bEEP oFF
4. Press OUT/QUIT to quit this setup function. Repeat these steps to set the option to ON again.	SEt UP 4
5. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.2.5 System Test

The EW allows you to verify that the output power is within specification. To perform the system test verification, follow the steps below.

WARNING!

Disconnect any output load before performing the system test.

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	SEt UP 1
2. Press 5, ENTER.	SYS tESt no
3. Turn the rotary knob to set the option to YES and press ENTER.	SYS tESt YES
Upon completion of the test, the EW displays the test result as "PASS" or "FAIL." In case of failure, please contact your dealer for support.	
4. Press QUIT to quit this function.	SEt UP 5
5. Select other setup functions using the appropriate numeric keys, or press QUIT again to exit the setup procedures.	

3.2.6 Power On Status

You can set the initial value for output voltage, frequency, and range when the power switch is turned on. For example, to set the initial output data to 230V, 50Hz, and range 300:

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	SEt UP 1
2. Press 6, ENTER.	turn on r 150
3. Turn the rotary knob to 300	turn on r 300
4. Press ENTER.	turn on V 110
5. Press 2, 3, 0, ENTER.	turn on V 230
6. Press 5, 0, ENTER.	turn on F 50
7. Press OUT/QUIT to quit this setup function.	SEt UP 6
8. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.2.7 Remote Sense (ON/OFF)

The EW 3001 allows you to enable or disable remote sensing output voltage as you program via the keypad or rotary knob. By default, this toggle On/Off feature is set to OFF. To change it, follow these steps:

ACTION	LED DISPLAY
1. If required, begin configuration setup as stated in Section 3.2.	SEt UP 1
2. Press 7, ENTER.	SEnSE V OFF
3. Turn the rotary knob to set the option to ON and press ENTER.	SEnSE V ON
4. Press OUT/QUIT to quit this setup function. Repeat these steps to set the option to OFF again.	SEt UP 7
5. Select other setup functions using the appropriate numeric keys, or press OUT/QUIT again to exit the setup procedures.	

3.3 Output Setting and Execution

After the power-on self-test and configuration setup procedures are complete, the following values are displayed:

```
0.0  60.0  0.00
```

This indicates the present output setting for Vrms is 0 Volts, the output Freq is 60 Hz, and any of the measured output values (including I/P/PF/CF) is 0. Before programming for the outputs V and F, set the current limitation and output full range. They are introduced in the next sections.

3.3.1 I Limit

The function of output current limit is to guarantee that the output current does not exceed the preset value in order to protect the loading devices. The programmable range of RMS current limit is from 0 to 30 amperes. An operational example of setting the I limit to 8A is given below:

ACTION	LED DISPLAY
1. Press the SHIFT key to enter the SHIFT mode and turn on the green SHIFT indicator.	0.0 60.0 0.00
2. Press the V/F key (I LIMIT in shift mode) to turn on the I LIMIT indicator.	0.0 15.0 0.00
3. Press 8, ENTER.	0.0 8.00 0.00
4. Press SHIFT to turn off the SHIFT and I LIMIT indicators and turn on the FREQ indicator.	0.0 60.0 0.00

NOTE 1: In step 3, use either the keypad or turn the rotary knob to set the value of I LIMIT.

NOTE 2: When the I LIMIT is activated, the output is disabled.

3.3.2 Range

The full range of output voltage is selectable to 150V, 300V, or AUTO. For example, to set the range to be 300V:

ACTION	LED INDICATOR
1. Press the SHIFT key to enter SHIFT mode.	Green SHIFT indicator turns On
2. Press the . key (RANGE in SHIFT mode) a few times to cycle through the options to select 300V.	Green 300V indicator turns On
3. Press SHIFT to quit the SHIFT mode.	Green SHIFT indicator turns Off

3.3.3 Output V and F

Specify values for output voltage and frequency. For example, to set V to 135.5 volts and F to 82 Hz:

ACTION	LED DISPLAY
1. If the EXT PROG indicator is on, turn it off by pressing the SHIFT key, then OUT/QUIT (EXT PROG in shift mode).	0.0 60.0 0.00
2. If the SHIFT indicator is on, press SHIFT to quit SHIFT mode.	0.0 60.0 0.00
3. Press V/F to turn on the VOLT indicator and turn off the FREQ indicator.	0.0 60.0 0.00
4. Press 1, 3, 5,. , 5, or turn the rotary knob to the desired voltage value, then press ENTER.	135.5 60.0 0.00
5. Press V/F to turn off the VOLT indicator and turn on the FREQ indicator.	135.5 60.0 0.00
6. Press 8, 2, or turn the rotary knob to the desired frequency value, then press ENTER.	135.5 82.0 0.00
7. Press OUT/QUIT to activate output power to the load.	135.5 82.0 0.00

3.4 Save and Recall

The EW offers nine memory channels to save a set of frequently used V, F, and V full range, and to recall them for later use. For example, to save settings to the memory channel 5:

ACTION	LED DISPLAY
1. Press the SHIFT key to enter the SHIFT mode and turn on the green SHIFT indicator.	135.5 82.0 0.00
2. Press and hold the 5 key (F5 in SHIFT mode) for three seconds until you hear a beep sound signaling completion and F5 appears in the display.	135.5 82.0 F5

To recall from memory channel 4:

ACTION	LED DISPLAY
1. Press the SHIFT key to enter the SHIFT mode and turn on the green SHIFT indicator.	135.5 82.0 0.00
2. Press and release the 4 key (F4 in SHIFT mode) to display the preset values stored in memory channel 4.	40.5 60.0 0.00
If these are not the desired settings, press keys 1 through 9 (F1 through F9 in SHIFT mode) to display the values stored in additional memory channels.	
3. Press ENTER to confirm your selection.	40.5 60.0 0.00

3.5 Data Lock

After setting output values, the front panel keypad can be locked to prevent accidental changes. To use this toggle On/Off LOCK feature:

ACTION	LED INDICATOR
1. Press the SHIFT key to enter SHIFT mode.	SHIFT indicator turns On
2. Press the 0 key (LOCK in SHIFT mode) to enable or disable the lock.	Red LOCK indicator turns On when keypad is locked and Off when keypad is unlocked.

3.6 Ext Prog

The EW allows you to use an external DC voltage level as a linear control reference for output Vrms. The relationship of Vout and the Vref is as follows:

$$Vout = Vref \div 10V \times Vfs$$

Vout: The Vrms output of the EW
Vref: DC level of the external control voltage
Vfs: The present setting of full scale (full range) of output Vrms.

NOTE: The external DC voltage must not exceed 10.5 volts. Because the cap of the APG terminal is connected to earth ground, floating or hazardous voltages on the cap may cause damage.

When the EXT PROG function is active, you cannot program the value for Vout, but you can still program the value for output F. To use this function, you must connect the external device of controlled DC to the APG port on the rear panel of any of the EW 3001 as illustrated in 2.6.

ACTION	LED INDICATOR
1. Press the SHIFT key to enter SHIFT mode.	SHIFT indicator turns On
2. Press the OUT/QUIT key (EXT PROG in SHIFT mode) to enable or disable external programming. Once enabled, you can change the output frequency using the numeric keypad or the rotary knob, followed by ENTER.	EXT PROG indicator turns On when function is enabled and Off when function is disabled.
3. Press the SHIFT key again to exit SHIFT mode.	SHIFT indicator turns Off

3.7 Measurement

The EW 3001 can measure the actual performances of V, F, I, P, PF, and CF of a connected load alone when it outputs power to the load. Note that when output is enabled, the left and center sections of the 7-segment LED display show the actual voltage and frequency; when output is disabled, these sections display the programmed voltage and frequency. The right section displays one of the I, P, PF, or CF measurements according to your selection.

The sample LED shows the measurement V = 132.2V, F = 75Hz as below:

```
132.2  75.0  0.03
```

3.7.1 Select Measurement Items

To select one of the measurement parameters (I, P, PF, or CF) for automatic read-back, follow these steps:

ACTION	LED INDICATOR
1. If the SHIFT indicator is lit, press SHIFT to exit SHIFT mode.	SHIFT indicator turns Off
2. If output is not activated, press the OUT/QUIT key.	OUT indicator turns On
3. Press the I/P PF/CF key repeatedly to cycle through the four options and select the desired measurement parameter. As you cycle through the options (I ⇨ P ⇨ PF ⇨ CF ⇨ I), the value shown in the right section of the display changes to the measurement parameter currently selected.	I, P, PF, or CF indicator turns On when selected.

3.7.2 Functions of Measurement

The EW offers the following six measurement functions:

Function	Description
V	Voltage measurement readings in volts (true RMS measurement)
F	Frequency measurement readings in Hertz
I	Current measurement readings in Amperes (true RMS measurement)
P	True power measurement in Watts.
CF	Crest factor, calculation formula = Ipeak/Irms.
PF	Power factor, calculation formula = true power/(VrmsIrms)

3.8 Local Operation

During remote operation, the EW is controlled by a remote GPIB or RS-232C controller, and the green RMT indicator LED remains illuminated.

To switch from remote to local (front panel) operation:

1. Press the SHIFT key to enter SHIFT mode.
2. Press the I/P PF/CF key (LOCAL in SHIFT mode) to enable local operation.

3.9 Protection

During operation, if the EW 3001 senses under voltage (UVP), over current (OCP), shortage (SHT), over power (OPP), over temperature (OTP), fan failure (FAN), or open circuit (OPEN), the red LED indicator of PROTECTION turns on and the protection circuit disables the outputs.

Before restarting the output, you must eliminate the condition that caused the protection fault. For more information, please refer to “Troubleshooting” in Section 5.3 of this manual.

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4 THEORIES OF OPERATION

4.1 Introduction

The EW 3001 AC power source consists of 14 main boards and other discrete components. The function of each component is described in the sections below.

4.2 Description of Overall System

Figure 4-1 (on the next page) shows the block diagram of overall system. Main power flows through the A/D, D/D, and D/A power stage through the converter. The A/D power stage is designated as ***I*** board, and generates DC from the line input. The DC voltage of the A/D output is applied to the input of the next power stage.

With an isolation transformer, ***G*** board converts the DC voltage to unregulated DC voltage which is accepted by a switch-mode inverter. Then, the inverter produces desired AC voltage output on ***H*** board which consists of the full bridge.

A board is identified as CPU. The 80C188 CPU is used to communicate wtih ***BM*** and ***BS*** boards for programming variable output voltage and frequency, to monitor or control the signals and interrups, and to perform remote control through the GPIB or RS-232C interface on the optional board.

The seven-segment LEDs and keyboard are identified as ***D*** board and ***K*** board respectively. They become the interfaces between the user and the instrument. The fan is used to remove extra heat from the interior of the EW 3001 AC power source.

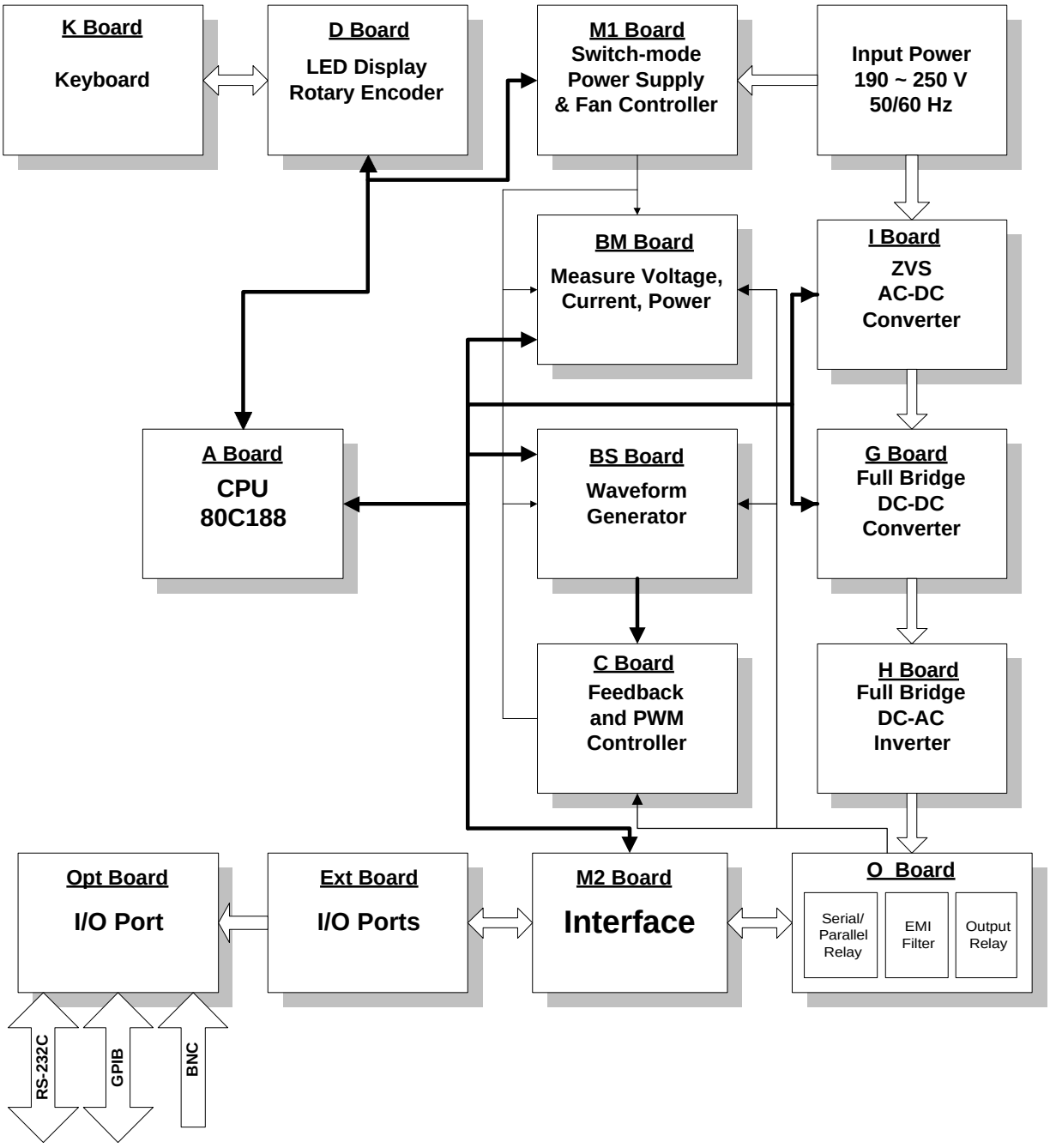

Figure 4-1 EW 3001 Block Diagram

4.3 AC/DC Power Stage Converter

The switch -mode PWM converter is composed of a power factor controller and a boost circuit on ***I*** board. To avoid the switching losses, the user has to turn on the converter at zero voltage. The auxiliary DC voltages identified as 15V, –15V, 12V, 5V, and –24V are generated on the ***M1*** board.

4.4 DC/DC Power Stage Converter

This assembly is identified as ***G*** board. It generates two isolated power outputs for the DC input voltage on ***H*** board. These two outputs of DC voltage and the input DC voltage are isolated from each other by the high frequency transformers.

4.5 DC/AC Inverter

This inverter includes ***C*** board, ***H*** board and ***O*** board. The advanced PWM technology is applied to this system in order to obtain more stability.

C board is the PWM controller. The maximum peak current is clamped to protect power MOSFET.

H board is made up of the full bridge of MOSFET power components. The PWM control signal from ***C*** board is applied to the full bridge to amplify the sine wave at the end of output. The low pass filter can reject the switching frequency component.

O board consists of the range relays and output relays. The range relays connect two sets of the secondary of output transformers together in parallel or series.

4.6 CPU

The CPU, ***A*** board, controls the circuit through 80C188 CPU. A microprocessor circuit receives commands from the GPIB, the RS-232C controller, or the keyboard on the front panel. It sends the digital signal to set the output parameters of the power source, and establishes the output sinusoidal waveform table. Data from the measurement circuits are received and reported to the seven-segment display and GPIB. The data of set parameters and one-key operation are stored in EEPROM.

4.7 Measurement

The measurement circuits on ***BM*** board monitor voltage, current, power, etc. Voltage and current from the output are scaled down first, and then convert the RMS value to DC voltage. The measurement of power is achieved by multiplying the scaled voltage and current with an integrated multiplier of output DC voltage. All outputs of DC voltage are converted to digital data, and sent to ***A*** board.

4.8 Sine Wave Generator

BS board is identified as the sine wave controller that generates sine waves, and acts as the reference input of D/A stage. Over load protection, which limits the instantaneous output current, is implemented here too.

4.9 Keyboard and Display

The keyboard is designated as ***K*** board, which is connected to ***D*** board through a short flat ribbon cable. It contains 16 key switches and two LED indicators. The display is also connected to ***D*** board through a short flat ribbon cable. It is comprised of three 4-digit, 7-segment LEDs. The programming of V, F can be done by turning the rotary knob on the front panel too.

4.10 GPIB/RS-232C/External Reference

The remote control is done through the GPIB or RS-232C interface on the optional board, which is connected to ***A*** board through the DIN connector. External reference is used to control the amplitude of output AC voltage through DC reference.

5 SELF-TEST AND TROUBLESHOOTING

5.1 Introduction

This section provides self-test information and suggested troubleshooting procedures to use in the event the EW does not operate properly. If you do not solve the problem using the information given here, contact your Elgar representative or Elgar Customer Service at 800-733-5427, ext. 2295.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting the power cable (s) and /or installing or removing the unit from the AC Power Source. Similarly, the AC Power Source power switch must be switched OFF (0) prior to connecting or disconnecting input and/or output power cable (s) and /or installing or removing the unit from the AC Power Source.

During 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 generated normally on the output terminals and present on the input terminals.

Ensure that all input and output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltage is eliminated. To guard against risk of electrical shock during open cover checks, do not touch any portion of the electrical circuits. Even when the power is off, AC line filter elements and capacitors can retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden failure of a component.

Some circuits are live even with the front panel power switch of the AC Power Source turned OFF (0). Servicing, and even fuse verification as well as connecting wiring to the chassis must be accomplished with the input line power removed via external means. Some components that can hold a charge for a time after power has been removed are used in this equipment. These parts have discharging devices connected to provide a means for the discharge of voltages when the power is removed. Wait at least six minutes after removal of power to allow the discharging of these parts.

5.2 Self-Test Routine

The EW 3001 AC power source has a built-in test program which allows you to test the unit. Do not adjust any component without prior approval. Please consult the distributor for the information of adjustment.

If the unit is not functioning normally, first perform the system test verification to ensure that it is within specification. This test procedure is detailed in Section 3.2.5.

WARNING!

Disconnect any load from the output when using the test/adjustment program. Any load from the instrument may cause test failure.

If the unit fails the system test, return it to Elgar for repair. Follow the return procedures outlined on the warranty page at the beginning of this manual. If the unit passes the test, refer to the troubleshooting table on the next page.

5.3 Troubleshooting

If you encounter problems with the EW 3001, refer to the table below for a description of the probable cause and the recommended corrective actions.

Problem	Reason	Solution
Poor Voltage Accuracy	HIGH or LOW line of output voltage may be shorted to the case ground.	Isolate the output line from the case.
Poor measurement of V, I, P	Aging of components results in deviation of characteristics. Regular calibration or adjustment is required.	Contact your Elgar representative or Elgar Customer Service at 800-733-5427, ext 2295.
Over Temperature Protection (OTP)	Ambient temperature is too high.	Operate the unit between 0°C and 40°C.
Over Load Protection (OLP)	The output is overloaded.	Reduce the output load and/or remove the overload.
Short Circuit (SHT)	The output is shorted.	Remove the short.
Over Power protection (OPP)	The output power is over the specification.	Remove the over power or lower down the output voltage.
AC Source System cannot be controlled by GPIB	1. The address of the AC source is incorrect. 2. The GPIB cable is loose at the rear panel of the AC source.	1. Update address. 2. Check connection, and tighten the screws.
Distorted Output	1. The output voltage from the AC source is too low. 2. The rectified load is too large at high frequency.	1. Program higher output voltage. 2. Reduce the load or lower the output frequency.
Fan Inhibited Protection (FAN)	The fan or the ventilation holes are blocked.	Remove the obstruction.
Under Voltage Protection (UVP)	The line input voltage of the AC source is too low.	Measure input voltage, and raise it if it is under the specification.
Open Circuit Protection (OPEN)	The output voltage is not consistent with the set value.	Consult the distributor for assistance.

6 REMOTE OPERATION

6.1 General Information

The EW 3001 AC power source can be remotely controlled through the GPIB or the RS-232C interface. It is recommended that the timeout should not be less than one second.

For RS-232C interface, only the signals of TXD, RXD, RTS, and CTS can be used for data transfer. The signals of CD, DTR, and DSR are shorted in the AC power source. Interconnection between the IBM PC/AT and the AC power source is illustrated below.

IBM PC/AT		AC SOURCE	Pin Definition
PIN	1	1	CD
	2	2	RXD
	3	3	TXD
	4	4	DTR
	5	5	SG
	6	6	DSR
	7	7	RTS
	8	8	CTS
	9	9	RI

6.2 GPIB Capability of the AC Source

GPIB Capability	Description	Interface Functions
Talker/Listener	Commands and response messages can be sent and received over the GPIB. Status information can be read through a serial polling.	AH1, SH1, T6, L4
Service Request	The AC power source will set the SRQ line true if there is a condition of enabled service request.	SR1
Remote/Local	The AC power source powers up in local state. In local state, the front panel are operative, and the AC power source may respond to the commands from GPIB. In remote state, all keys on the front panel except the local key are disabled. The pressing of local key returns the AC power source to local state. Local key can be disabled through local lockout so that only the controller or the power switch can return the AC power source to local mode.	RL1
Device Clear	The AC power source responds to the Device Clear (DCL) and Selected Device Clear (SDC) interface commands. These cause the AC power source to clear any activity that will prevent it from receiving and executing a new command. DCL and SDC do not change any programmed setting.	DCL,SDC

6.3 Introduction to Programming

All commands and response messages are transferred in the form of ASCII codes. The entire response messages should be read before a new command is sent, otherwise the remaining response messages will be lost, and a query-interrupted error will occur.

6.3.1 Conventions

< > Items within angle brackets are parameter abbreviations.
For example, <CRD> represents Character Response Data.

| Separates alternative parameters.
For example, ON | OFF indicates that either “ON” or “OFF” can be used as a parameter.

[ ] Items within square brackets are optional.
For example, OUTP[:STATe] means that :STATe may be omitted.

6.3.2 Numerical Data Formats

The EW accepts numerical data of the following formats:

Symbol	Description	Example
NR1	Digits with no decimal point. The decimal point is assumed to be to the right of the least-significant digit.	123, 0123
NR2	Digits with a decimal point.	12.3, .123
NR3	Digit with a decimal point and an exponent.	1.23E+2, 12.3E-1
NRf	Flexible decimal form that includes NR1, NR2, NR3	12, 12.3, 1.23E2
NRf+	Expanded decimal form that includes NRf, MINimum and MAXimum. MINimum and MAXimum are the minimum and maximum limit values for the parameter.	12, 12.3, 1.23E2 MIN, MAXimum

Suffixes

Numerical data may be followed by an optional suffix including a multiplier and/or unit. If the suffix is omitted, default units are used.

The default units of Frequency, Voltage, and Current are Hz, Volt, and Ampere respectively. The valid suffixes (units and multipliers) are as follows:

Class	Preferred Suffix	Allowed Suffix	Referenced Unit
Frequency	Hz	 MHz	Hertz Megahertz
Voltage	V	Volt	
Current	A	Ampere	

6.3.3 Boolean Data Format

The boolean parameter <Boolean> takes the form ON|OFF|<NRf>. Boolean parameter has a value of "0" or "1", and is unitless. Any input value of <NRf> is rounded to an integer and the non-zero result is interpreted as "1". The values "ON" and "OFF" are also acceptable on the input commands for increasing readability. "ON" represents "1", and "OFF" corresponds to "0".

Queries will return "1" or "0", not "ON" or "OFF".

6.3.4 Character Data Format

The character strings returned by a query command may take either of the following forms:

<CRD> Character Response Data: character string with maximum length of 12.
<SRD> String Response Data: character string enclosed in double quotes.

6.3.5 Basic Definitions

Command Tree Table:
The AC source commands are based on a hierarchical structure, also known as a tree system. To obtain a particular command, the full path to it must be specified. This path is represented in the table by placing the highest node in the hierarchy in the left-most position. Lower nodes in the hierarchy are indented in position to the right, below the parent node.

Program Headers:
Program headers are keywords that identify the command. The program headers follow the syntax described in section 7.6 of IEEE 488.2. The AC source accepts both upper and lower case characters without distinguishing between the cases. Program headers consist of two distinct types, common command headers and instrument-control headers.

Common Command and Query Headers:
The common command and query program header syntax is specified in IEEE 488.2 for use with the IEEE 488.2-defined common commands and queries. The commands with a leading "*" are common commands.

Instrument-Control Headers:
Instrument-control headers are used for all other instrument commands. Each instrument-control header has both a long and a short form. The AC source accepts only the exact short and the exact long forms. Note that elsewhere in this section a special notation is employed to differentiate the short form header from the long form header of the same header. The long form of the header is shown, with the short form portion shown in uppercase characters, and the rest of the header is shown in lowercase characters.

Program Header Separator:
Data must be separated from program header by at least one space.

Program Message:
Represents a sequence of zero or more program message unit elements separated by program message unit separator elements.

Program Message Unit:
Represents a single command, programming data, or query.

Examples: VOLT?, OUTPut ON.

Program Message Unit Separator (';'):
Separates the program message unit elements from one another in a program message.

Example: VOLT 110 ; FREQ 120 <PMT>

Program Message Terminator (<PMT>):
A program message terminator terminates a program message. Three valid terminators are:

- <END>: end or identify (EOI).
- <NL>: new line, which is a single ASCII-encoded byte 0A (10 decimal).
- <NL><END>: new line with EOI.

NOTE: Response message is terminated by <NL> <END> for GPIB, and <NL> for RS-232C.

6.4 Traversal of the Command Tree

Multiple program message unit elements may be sent in a program message. The first command is always referenced to the root node. Subsequent commands are referenced to the same tree level as the previous command in a program message.

Note that the common command and query headers do not affect the header path.

A column preceding a program message unit alters the header path to the root level.
For example:

- VOLT:RANG 150;LIM 140 <PMT> will set the output voltage to 150V range and the maximum rms output voltage to 140V.
- CURR:PEAK 8;VOLT 110 <PMT> will set the output peak current to 8A and generate a command error because VOLTage is not a node at the current level.
- CURR:PEAK 8;:VOLT 110 <PMT> will set the output peak current to 8A and the voltage to 110V.
- VOLT:RANG 300;*ESE 32;LIM 250 <PMT> will set the output voltage to 300V range and the Standard Event Status Enable Register to 32 and the maximum rms output voltage to 250 Volt.

Optional nodes in the tree will not alter the header path. For example:

- FREQ 120;VOLT 110 <PMT> will set the frequency to 120Hz and voltage to 110 Volt. Note that FREQ 120 doesn't change the header path to FREQ:CW.

- VOLT:LEV 110;RANG 150 <PMT> will set the rms output voltage to 110 Volt and set the output voltage range to 150V range.

6.5 Execution Order

The AC Source executes program messages in the order received. Program message units are executed in order of reception except coupled commands. The execution of coupled commands is deferred until a program message terminator is received. A coupled command sets parameters which are affected by the settings of the other commands. Problems can arise because the prior state of the AC Source can affect the response to the programming of a coupled parameter.

For example, assuming the current output voltage range is 150V, and a new state is desired with an output voltage range of 300V and amplitude 220 Volts. If the commands

VOLTage 220<PMT>

VOLTage:RANGe 300<PMT>

are sent, a **data out of range** error will occur. This error can be avoided by reversing the order, or sending the commands in one program message. For the example above, the following program message can be sent without error:

VOLTage 220;VOLTage:RANGe 300<PMT>

The following commands are coupled: VOLTage, VOLTage:RANGe, VOLTage:RANGe:AUTO, VOLTage: LIMit, VOLT:EPRogram.

6.6 The Commands of the AC Source

6.6.1 Command Tree Table

MEASure|FETCh	
[:SCALar]	
:CURRent	
:AC?	Returns the output AC rms current
:CRESTfactor?	Returns the output current crest factor
:FREQuency?	Returns the output frequency
:POWer	
:AC	
[:REAL]?	Returns the output real power
:PFACtor?	Returns the output power factor
:VOLTage	
:AC?	Returns the output AC rms voltage
OUTPut	
[:STATe] <Boolean>	Enables/Disables the output
:PROTection	
:CLEar	Causes the latched protection to be cleared
[SOURce:]	
CURRent	
:LIMit	
[:IMMediate] <NRf+>	Sets the output rms current limit
FREQuency	
[:CW|:FIXed] <NRf+>	Sets the output frequency
VOLTage	
[:LEVel]	
[:IMMediate]	
[:AMPLitude] <NRf+>	Sets the AC rms output voltage amplitude
:EPRogram	
[:STATe] <Boolean>	Enables/Disables the external program mode
:LIMit	
[:AMPLitude] <NRf+>	Sets the limit on output AC rms voltage amplitude
:RANGe 150|300	Sets the output voltage range

:AUTO <Boolean>	Enables/Disables AUTO output voltage range mode
STATus	
PRESet	Presets the PTR, NTR and Enable Registers of Questionable and Operation status
:OPERation	
[:EVENt]?	Returns the content of the Event Register
:CONDition?	Returns the content of the Condition Register
:ENABle <NRf>	Sets the Enable Register
:QUEStionable	
[:EVENt]?	Returns the content of the Event Register
:CONDition?	Returns the content of the Condition Register
:ENABle <NRf>	Sets the Enable Register
:NTRansition <NRf>	Sets the negative transition filter
:PTRansition <NRf>	Sets the positive transition filter
SYSTem	
:ERRor?	Returns the error message
:LOCal	Goes to local mode (RS-232C only)
:REMote	Goes to remote mode (RS-232C only)
:RWLock	Goes to remote with lockout mode (RS-232C only)
*CLS	Clears status
*ESE <NRf>	Sets the Standard Event Status Enable Register
*ESR?	Returns the Standard Event Status Register
*IDN?	Returns the device identification
*OPC	Generates operation complete message when operation completes
*OPC?	Returns “1” when operation completes
*RST	Reset
*SRE <NRf>	Sets Service Request Enable Register
*STB?	Returns Status Byte Register
*TST?	Performs self-test, then returns result
*WAI	Wait-to-continue

6.6.2 Command Dictionary

MEASure:CURRent:AC?

FETCh:CURRent:AC?

Description:	These queries return the output AC rms current. Note there are two kinds of commands to get measurement data. MEASure commands make new measurement and return measurement data. FETCh commands return measured data taken by previous MEASure command. Note that once a new measurement is made, all new measurement data (V, F, I, P, PF, CF) may be returned by FETCh commands.
Query Syntax:	MEASure[:SCALar]:CURRent:AC? FETCh[:SCALar]:CURRent:AC?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:CURR:AC? returns the output AC rms current.

MEASure:CURRent:CREStfactor?

FETCh:CURRent:CREStfactor?

Description:	These queries return the output current crest factor.
Query Syntax:	MEASure[:SCALar]:CURRent:CREStfactor? FETCh:[SCALar]:CURRent:CREStfactor?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:CURR:CRES? returns the output current crest factor.

MEASure:FREQuency?

FETCh:FREQuency?

Description:	These queries return the output frequency.
Query Syntax:	MEASure[:SCALar]:FREQuency? FETCh[:SCALar]:FREQuency?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:FREQ? returns the output frequency.

MEASure:POWer:AC?

FETCh:POWer:AC?

Description:	These queries return the output real power.
Query Syntax:	MEASure[:SCALar]:POWer:AC[:REAL]? FETCh[:SCALar]:POWer:AC[:REAL]?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:POW:AC? returns the output real power.

MEASure:POWer:AC:PFACtor?

FETCh:POWer:AC:PFACtor?

Description:	These queries return the output power factor.
Query Syntax:	MEASure[:SCALar]:POWer:AC:PFACtor? FETCh[:SCALar]:POWer:AC:PFACtor?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:POW:AC:PFAC? returns the output power factor.

MEASure:VOLTage:AC?

FETCh:VOLTage:AC?

Description:	These queries return the output AC rms voltage.
Query Syntax:	MEASure[:SCALar]:VOLTage:AC? FETCh[:SCALar]:VOLTage:AC?
Parameters:	None
Return Parameters:	<NR2>
Query Example:	MEAS:VOLT:AC? returns the output AC rms voltage.

OUTPut

Description:	This command enables or disables the AC power source output.
Syntax:	OUTPut[:STATe] <Boolean>
Parameters:	0 | 1 | OFF | ON
*RST Value:	OFF
Example:	OUTP ON enables output. OUTP 0 disables output.

Query Syntax:	OUTPut[:STATe]?
Return Parameters:	0 | 1
Query Example:	OUTP? returns the output enable condition.

OUTPut:PROTection:CLEar

Description:	This command clears the latch that disables the output when a short, over current, over power, over temperature, fan fail, or under voltage condition is detected. All conditions that cause the protection should be removed before the latch is cleared. Then, the output remains disabled until another OUTP ON command is received.
Syntax:	OUTPut:PROTection:CLEar
Parameters:	None
Example:	OUTP:PROT:CLE clears the latched protection.

CURRent:

Description:	This command sets the output current.
Syntax:	[SOURce:]CURRent:PEAK[:IMMediate] <NRf+>
Parameters:	0 to 30
*RST Value:	30
Example:	CURR:LIMit 15 sets the output peak current to 15A. CURR:LIMit MAX sets the output rms current to maximum value.
Query Syntax:	[SOURce:]CURRent:PEAK[:IMMediate]?
Return Parameters:	<NR2>
Query Example:	CURR:PEAK? returns the set value of output peak current.

FREQuency

Description:	This command sets the output frequency.
Syntax:	[SOURce:]FREQuency[:CW|:FIXed] <NRf+>
Parameters:	45 to 500
*RST Value:	60 Hz
Example:	FREQ 120 sets the output frequency to 120Hz. FREQ MAX sets the output frequency to 500Hz.
Query Syntax:	[SOURce:]FREQuency[:CW|:FIXed]?
Return Parameters:	<NR2>
Query Example:	FREQ? returns the set value of output frequency.

VOLTage

Description:	This command sets the AC rms output voltage amplitude. The maximum value is dependent on voltage range and the setting of voltage limit.
Syntax:	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <NRf+>
Parameters:	0 to 300
*RST Value:	0
Example:	VOLT 110 sets the AC rms output voltage to 110V.
Query Syntax:	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]?
Return Parameters:	<NR2>
Query Example:	VOLT? returns the set value of output voltage.

VOLTage:EPRogram

Description:	This command enables or disables the external program mode. During external program mode, the AC rms output voltage is controlled by an external reference DC voltage.
Syntax:	[SOURce:]VOLTage:EPRogram[:STATe] <Boolean>
Parameters:	0 | 1 | OFF | ON
*RST Value:	OFF
Example:	VOLT:EPR ON enables external program mode.
Query Syntax:	[SOURce:]VOLTage:EPRogram[:STATe]?
Return Parameters:	0 | 1
Query Example:	VOLT:EPR? returns the state of external program mode.

VOLTage:LIMit

Description:	This command sets the maximum bounds on the AC rms output voltage value. Setting a larger output voltage value will cause the output to be clamped to the LIMit value.
Syntax:	[SOURce:]VOLTage:LIMit[:AMPLitude] <NRf+>
Parameters:	0 to 300
*RST Value:	300
Example:	VOLT:LIM 130 sets the AC rms output voltage limit to 130V.
Query Syntax:	[SOURce:]VOLTage:LIMit[:AMPLitude]?
Return Parameters:	<NR2>
Query Example:	VOLT:LIM? returns the set value of output voltage limit.

VOLTage:RANGe

Description:	This command sets the output voltage range of the AC power source. Two ranges are available: 150V and 300V range. When setting output voltage to 150V range, if the setting of output voltage is greater than 150V, it will be clamped to 150V. Setting an output voltage range will disable the AUTO range mode.
Syntax:	[SOURce:]VOLTage:RANGe <NRf+>
Parameters:	150 | 300
*RST Value:	150
Example:	VOLT:RANG 300 sets the output voltage to 300V range.
Query Syntax:	[SOURce:]VOLTage:RANGe?
Return Parameters:	<NR1>
Query Example:	VOLT:RANG? returns the current output range.

VOLTage:RANGe:AUTO

Description:	This command enables or disables the AUTO output voltage range mode. In AUTO mode, the output voltage must be set as greater than 150 volts, and it will be switched to 300V range, otherwise the 150V range is selected.
Syntax:	[SOURce:]VOLTage:RANGe:AUTO <Boolean>
Parameters:	0 | 1 | OFF | ON
*RST Value:	OFF
Example:	VOLT:RANG:AUTO ON enables the AUTO output voltage range mode.
Query Syntax:	[SOURce:]VOLTage:RANGe:AUTO?
Return Parameters:	0 | 1
Query Example:	VOLT:RANG:AUTO? returns the condition of AUTO range mode.

STATus:PRESet

Description:	This command sets the PTR, NTR and Enable Registers of Questionable and Operation status as follows: all defined bits of PTR Registers to 1, all bits of NTR and Enable Registers to 0.
Syntax:	STATus:PRESet
Parameters:	None
Example:	STAT:PRES presets the PTR, NTR and Enable Registers of Questionable status.

STATus:OPERation?

Description:	This query returns the content of the Operation Event Register. The Operation Event Register is cleared when read or by the *CLS common command.
Query Syntax:	STATus:OPERation[:EVENt]?
Parameters:	None
Return Parameters:	<NR1>

STATus:OPERation:CONDition?

Description:	This query returns the content of Operation Condition Register. The Condition Register reflects the TRUE or FALSE state of Operation status.
Query Syntax:	STATus:OPERation:CONDition?
Parameters:	None
Return Parameters:	<NR1>

STATus:OPERation:ENABle

Description:	This command sets the enable mask which allows true conditions in the Operation Event Register to be reported in the Operation Status (OPER) Summary-Message of the Status Byte Register.
Syntax:	STATus:OPERation:ENABle <NRf>
Parameters:	0 to 32767
Query Syntax:	STATus:OPERation:ENABle?
Return Parameters:	<NR1>

Bit configuration of Questionable Status Register

Bit Position	8-15	7	6	5	4	3	2	1	0
Condition	---	FAN	OPP	OCP	SHT	OTP	UVP	OPEN	PFO
Bit Weight		128	64	32	16	8	4	2	1

Remarks:

FAN:	Fan failure	OCP:	Over current protection
OTP:	Over temperature protection	SHT:	Short circuit protection
UVP:	Under voltage protection	PFO:	Power failure protection
OPP:	Over power protection	OPEN:	Open circuit protection

STATus:QUEStionable?

Description:	This query returns the content of the Questionable Event Register. The Questionable Event Register latches events that are passed by Questionable PTR and/or NTR filter. It is cleared when read or by the *CLS common command.
Query Syntax:	STATus:QUEStionable[:EVENt]?
Parameters:	None
Return Parameters:	<NR1>
Query Example:	STAT:QUES? returns and clears the Questionable Event Register.

STATus:QUEStionable:CONDition?

Description:	This query returns the content of the Questionable Condition Register. The Questionable Condition Register reflects the TRUE or FALSE state of Questionable status.
Query Syntax:	STATus:QUEStionable:CONDition?
Parameters:	None
Return Parameters:	<NR1>
Query Example:	STAT:QUES:COND? returns the Questionable Condition Register.

STATus:QUEStionable:ENABle

Description:	This command sets the enable mask which allows true conditions in the Questionable Event Register to be reported in the Questionable Status (QUES) Summary-Message of the Status Byte Register.
Syntax:	STATus:QUEStionable:ENABle <NRf>
Parameters:	0 to 32767
Example:	STAT:QUES:ENAB 8 enables OTP event to be reported in the Status Byte Register.
Query Syntax:	STATus:QUEStionable:ENABle?
Return Parameters:	<NR1>
Query Example:	STAT:QUES:ENAB? returns the content of Questionable Enable Register.

STATus:QUEStionable:NTRansition

STATus:QUEStionable:PTRansition

Description:	These command sets the content of the Questionable NTR (negative transition 1-to-0) and PTR (positive transition 0-to-1) Registers. These Registers determine which type of transition in the Condition Register may set the corresponding bit in the Questionable Event Register.
Syntax:	STATus:QUEStionable:NTRansition <NRf> STATus:QUEStionable:PTRansition <NRf>
Parameters:	0 to 32767
Example:	STAT:QUES:NTR 8 enables OTP event bit to be set as 1-to-0. STAT:QUES:PTR 2 enables SHT event bit to be set as 0-to-1.
Query Syntax:	STATus:QUEStionable:NTRansition? STATus:QUEStionable:PTRansition?
Return Parameters:	<NR1>
Query Example:	STAT:QUES:PTR? returns the content of Questionable PTR Register.

SYSTem:ERRor?

Description:	This query returns the next error number followed by its corresponding error description string from the error queue. As errors are detected, they are placed in the queue. The queue is first in, first out. If the queue overflows, the last error in the queue is replaced with the error **-350,"Queue overflow"**. Reading an error from the head of the queue removes that error from the queue. When all errors have been read, further error queries will return **0, "No error"**.
Query Syntax:	SYSTem:ERRor?
Parameters:	None
Return Parameters:	<NR1>, <SRD>
Query Example:	SYSR:ERR? returns the next error number and description.

SYSTem:LOCal

Description:	This command sets the AC power source to local state, which enables the control of front panel. It can only be used with the RS-232C interface.
Syntax:	SYSTem:LOCal
Parameters:	None
Example:	SYST:LOC sets the AC power source to local state.

SYSTem:REMote

Description:	This command sets the ac source to remote state, which disables the control of front panel except the local key. Pressing the local key while in the remote state returns the AC power source to the local state. It can only be used with the RS-232C interface.
Syntax:	SYSTem:REMote
Parameters:	None
Example:	SYST:REM sets the AC power source to remote state.

SYSTem:RWLock

Description:	This command sets the AC power source to remote-lockout state, which disables the control of front panel, including the local key. It can only be used with the RS-232C interface.
Syntax:	SYSTem:RWLock
Parameters:	None
Example:	SYST:RWL sets the AC power source to remote-lockout state.

***CLS, Clear Status Command**

Description:	This command clears all Event Registers summarized in the Status Byte Register (Standard Event Status Register, Questionable Event Register), and clears the error queue. If the *CLS command immediately follows a program message terminator, the output queue and the MAV Summary-Message are also cleared.
Syntax:	*CLS
Parameters:	None

Bit configuration of Standard Event Status Register

Bit position	7	6	5	4	3	2	1	0
Condition	PON	---	CME	EXE	DDE	QYE	---	OPC
Bit Weight	128		32	16	8	4	2	1

Remarks:

PON:	Power on	QYE:	Query error
CME:	Command error	EXE:	Execution error
DDE:	Device-dependent error	OPC:	Operation complete

***ESE, Standard Event Status Enable Command**

Description:	This command sets the enable mask which allows true conditions in the Standard Event Status Register to be reported in the Event Status Bit (ESB) of the Status Byte Register. If a bit is 1 in the Standard Event Status Enable Register, and its associated event bit transitions true, the ESB of the Status Byte Register is set true. The bit configuration of ESE is the same as the ESR (see *ESR?).
Syntax:	*ESE <NRf>
Parameters:	0 to 255
Example:	*ESE 48 enables the CME and EXE events of Standard Event Status Register.
Query Syntax:	*ESE?
Return Parameters:	<NR1>
Query Example:	*ESE? returns the content of Standard Event Status Enable Register.

***ESR?, Standard Event Status Register Query**

Description:	This query returns the content of the Standard Event Status Register, and then clears it.
Query Syntax:	*ESR?
Parameters:	None
Return Parameters:	<NR1>
Query Example:	*ESR? returns the content of Standard Event Status Register.

***IDN?, Identification Query**

Description:	This query returns ASCII string which is organized into four fields separated by commas to identify the AC power source.
Query Syntax:	*IDN?
Parameters:	None
Return Parameters:	Field 1: Manufacturer Field 2: Model Field 3: Serial Number or 0 Field 4: Firmware Level or equivalent
Query Example:	*IDN?
Return Example:	ELGAR, EW3001, 0, 0.00

***OPC, Operation Complete Command**

Description:	This command causes the AC power source to set the OPC bit of Standard Event Status Register when all pending operations are completed.
Syntax:	*OPC
Parameters:	None

***OPC?,Operation Complete Query**

Description:	This query returns an ASCII “1” when all pending operations are completed.
Query Syntax:	*OPC?
Parameters:	None
Return Parameters:	1

***RST, Reset Command**

Description: This command resets the AC power source to the following states:

OUTP	OFF
CURR:LIMit	MAX
FREQ	60
VOLT	0
VOLT:EPR	OFF
VOLT:LIM	300
VOLT:RANG	150
VOLT:RANG:AUTO	OFF

Syntax: *RST

Parameters: None

Bit configuration of Status Byte Register

Bit position	7	6	5	4	3	2	1	0
Condition	OPER	MSS	ESB	MAV	QUES	---	---	---
		RQS						
Bit Weight	128	64	32	16	8			

Remarks: RQS: Request service
ESB: Event Status Bit
QUES: Questionable status
MSS: Master Summary Status
MAV: Message Available
OPER: Operation status

***SRE, Service Request Enable Command**

Description:	This command sets the content of the Service Request Enable Register, which determines which events of the Status Byte Register are allowed to set the Master Summary Status (MSS) and the Request Service (RQS) message true. If a bit is 1 in Service Request Enable Register and its associated event bit in Status Byte Register transitions true, bit 6 of Status Byte Register is then set true.
Syntax:	*SRE <NRf>
Parameters:	0 to 255
Example:	*SRE 16 enables the MAV bit event to set MSS and RQS bit.
Query Syntax:	*SRE?
Return Parameters:	<NR1>
Query Example:	*SRE? returns the content of Service Request Enable Register.

***STB?, Read Status Byte Query**

Description:	This query returns the Status Byte Register. The Status Byte Register can be read with either a serial poll or the *STB? Common query. If it is read with a serial poll, the RQS bit is sent for the position of bit 6 and then cleared. If it is read with *STB?, MSS bit is sent but not cleared.
Query Syntax:	*STB?
Parameters:	None
Return Parameters:	<NR1>
Query Example:	*STB? returns the content of Status Byte Register.

***TST?, Self-Test Query**

Description:	This query causes an internal self-test and reports the result. If the AC power source completes the self-test without any detected errors, it returns a 0, otherwise it returns a 1. Note that during the self-test caused by *TST, the output voltage will reach 300V. Please disconnect any output load.
Query Syntax:	*TST?
Parameters:	None
Return Parameters:	0 | 1
Query Example:	*TST? causes a self-test and reports the result.

***WAI, Wait-to-continue**

Description:	This command prevents the AC power source from executing any further command until all pending operations are completed.
Syntax:	*WAI
Parameters:	None

6.7 Status Reporting

The AC power source follows the status data structure and mechanism described in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. Note that undefined bits of all status registers are zero when they are read.

6.7.1 Questionable Status

The Questionable Status Registers record signals that indicate abnormal operation of the AC power source.

(1) Condition Register: It reflects the present state of TRUE (1) or FALSE (0) in its condition bits. It is a register for reading only.

(2) Negative Transition (NTR) Filter: It allows the event bit to be set TRUE when the associated condition changes from TRUE to FALSE. It is cleared at power-on or by the STATus:PRESet command.

(3) Positive Transition (PTR) Filter: It allows the event bit to be set TRUE when the associated condition changes from FALSE to TURE. All defined bits are set at power-on or by the STATus:PRESet command.

(4) Event Register: It catches conditions that are passed by PTR and/or NTR filters. It is cleared at power-on, or when it is read, or when the *CLS common command is received.

(5) Enable Regitster: It selects which event bits in the Event Register will cause the QUEStionable Status summary-message of the Status Byte Register to be TRUE when it is set. It is cleared at power-on or by the STATus:PRESet command.

6.7.2 Standard Event Status

The Standard Event Status Register latches the following conditions:

(1) Bit 7: Power On (PON). This event bit indicates that an off-to-on transition has occurred in the device‘s power supply.

(2) Bit 5: Command Error (CME). A syntax or semantic error has been detected.

(3) Bit 4: Execution Error (EXE). The data of a program are outside the legal range, or inconsistent with the capabilities of the AC power source, or the command cannot be executed due to some condition of operation.

(4) Bit 3: Device-Specific Error (DDE). This event bit indicates that an error has occurred, which is neither a Command Error, nor a Query Error, nor an Execution Error.

(5) Bit 2: Query Error (QYE). An attempt is made to read data from the output queue when no output is present or pending, or the data in the output queue have been lost.

(6) Bit 0: Operation Complete (OPC). This event bit is generated in response to the *OPC command. It indicates that the AC power source has completed all pending operations.

The Standard Event Status Register is cleared at power-on, or when it is read, or by the *CLS common command. The Standard Event Status Enable Register selects which event bits in the Standard Event Status Register may cause the ESB summary-message of the Status Byte Register to be TRUE when it is set. It is cleared at power-on.

6.7.3 Status Byte Register

The Status Byte Register summarizes summary-messages from other status. The definitions of its bits are as follows:

(1) Bit 3: Questionable Status (QUES) Summary-Message. Its state indicates if one or more of the enabled events defined in Questionable Status have occurred since the last reading or clearing of the Questionable Event Register.

(2) Bit 4: Message Available (MAV) Queue Summary-Message. Its state indicates whether or no the Output Queue is empty. Whenever the AC power source is ready to accept a request through the controller to output data bytes, the MVA summary-message is TRUE.

(3) Bit 5: Event Status Bit (ESB) Summary-Message. Its state indicates if one or more of the enabled events defined in Standard Event Status have occurred since the last reading or clearing of the Standard Event Status Register.

(4) Bit 6: Master Summary Status (MSS) Message or Request Service (RQS) Message. The MSS message indicates that at least one summary-message enabled by the Service Request Enable Register occurs. The RQS message functions the same way as MSS message except that it is cleared after serial poll.

(5) Bit 7: Operation Status (OPER) Summary-Message. The Operation Status Registers are not used in the AC power source.

The Status Byte Register can be read with either a serial poll or the *STB? common query. If it is read with a serial poll, the RQS message is sent for the position of bit 6 and then cleared. If it is read with the *STB? common query, the MSS message is sent but not changed. The *CLS common command will cause all Status Data Structures (that is, their Event Registers and Error Queue) to be cleared so that the corresponding summary messages are cleared. The Output Queue and its MAV summary message are an exception and unaffected by *CLS.

The Service Request Enable Register selects which summary-messages in the Status Byte Register may cause the MSS and RQS messages to be TRUE. The undefined bits and bit 6 of the Service Request Enable Register are always zero. When the RQS message is set TRUE, the AC power source will send an SRQ message to request service asynchronously from the controller in charge of the GPIB interface. The Service Request Enable Register is cleared at power-on.

6.8 Error Messages

As errors are detected, they are placed in a queue of first in first out. The SYSTem:ERRor? query can be used to read back the errors in the queue. If the queue overflows, the last error in the queue will be discarded and replaced with error **-350, "Queue overflow"**. When all errors have been read, further error queries will return **0, "No error"**.

Error No.	Description of the Error [description/explanation/examples]
0	No error
–100	Command error [generic]
–101	Invalid character
–103	Invalid separator
–104	Data type error
–108	Parameter not allowed [more parameters are received than expected]
–109	Missing parameter [less parameters are received than required]
–110	Command header error
–111	Header separator error
–112	Program mnemonic too long [more than 12 characters]
–113	Undefined header [the header is syntactically correct, but undefined]
–120	Numeric data error
–123	Exponent too large [the exponent magnitude is larger than 32000]
–124	Too many digits [more than 255 digits but excluding leading zeros]
–128	Numeric data not allowed [the received numeric data are not accepted for the header]
–130	Suffix error
–138	Suffix not allowed
–141	Invalid character data
–144	Character data too long [more than 12 characters]
–148	Character data not allowed

Error No.	Description of the Error [description/explanation/examples]
–221	Settings conflict [e.g., enable external program mode while the output voltage range is AUTO]
–222	Data out of range [e.g., set voltage to 200 Volts while the output voltage range is 150V]
–230	Data corrupt or stale
–350	Queue overflow [more than 16 errors]
–410	Query INTERRUPTED [a new program message was received before a response is completely sent]
–420	Query UNTERMINATED [addressed to talk but an incomplete program message was received]
–430	Query DEADLOCKED [output buffer overflows because of too many queries]
–440	Query UNTERMINATED after an indefinite response [query was received in the same program message after an indefinite response]
11	Command used for RS-232C interface only.

APPENDIX: WIRE GAUGE SELECTION

The following guidelines assist in determining the optimum cable specification for the user's power applications. These guidelines are equally applicable to both DC and low frequency AC (up to 5 KHz) power cabling. The same engineering rules apply whether going into or out of an electrical device. Thus, this guide applies equally to the input cable and output cable for the ELGAR instrument and application loads.

Power cables must be able to safely carry maximum load current without overheating or causing insulation destruction. It is important to everyday performance to minimize IR (voltage drop) loss within the cable to a maximum of 1.5 volts total path. These losses have a direct effect on the quality (tight specifications) of power delivered to and from instruments and corresponding loads.

As a rule of thumb, specifying a generously larger power cable wire gauge has a negligible fiscal impact when compared to the costly investment in time and effort to evaluate and overcome both the cable deficiencies and the performance tradeoffs associated with a marginal (smaller) wire gauge.

When specifying wire gauge, the operating temperature needs to be considered.

Wire gauge current capability and insulation performance drops with increased temperature developed within a cable bundle and with increased environmental temperature. Thus, short cables with generously overrated gauge and insulation properties come well recommended for power source applications.

Avoid using published commercial utility wiring codes. These codes are designed for the internal wiring of homes and buildings and accommodate the safety factors of wiring loss heat, breakdown insulation, aging, etc. However, these codes consider that up to 5% voltage drop is acceptable.

Such a loss directly detracts from the quality performance specifications of the ELGAR instrument. Frequently, these codes do not consider bundles of wire within a cable arrangement.

Sense lines carry very little current and, thus, have negligible gauge overrating requirements. Sense lines tend to be particularly sensitive to induced voltages from nearby cables and from electrically noisy devices. Any disturbance induced onto sense lines is immediately signaled back to the instrument with a direct adverse effect on the output terminals.

To minimize undesired sense line pickup, sense line cables should use the canceling effects of twisted pair wires.

Shielded twisted pairs are even better, if needed. Sense lines should be physically separated from high current output, ideally via a separate cable. Sense resistors, if used, should be connected as close as practical to the load. Observe the maximum remote sense voltage drop limit (refer to page A-3).

High frequency disturbances are usually minimized by prudent use of 0.01mfd to 1.0 µfd bypass capacitors.

In high performance applications, as in motor start up and associated inrush/ transient currents, extra consideration is required. The cable wire gauge must consider peak voltages and currents which may be up to ten times the average values. An underrated wire gauge adds losses which alter the inrush characteristics of the application and, thus, the expected performance.

The following table identifies popular ratings for DC and AC power source cable wire gauges.

Column 1	Column 2	Column 3	Column 4
Size (AWG)	**Amperes (Maximum)**	**Ohms/100 Feet (One Way)**	**IR Drop/100 Feet***
18	5	0.473	2.363
16	7	0.374	2.621
14	15	0.233	3.489
12	20	0.147	2.940
10	30	0.095	2.859
8	40	0.053	2.136
6	55	0.033	1.837
4	70	0.021	1.477
2	95	0.013	1.273

* A maximum of 0.75V is allowable.

Table A-1 Wire Gauge Selection Guide

The following notes apply to Table A-1 and to the power cable definition:

1. The above figures are based upon insulated copper conductors at 30°C (86°F), two current carrying conductors in the cable plus a safety ground (chassis) plus a shield.

   Column 2 and Column 3 in the table refer to the "one way" ohms and IR drop of current carrying conductors (e.g., a 50-foot cable contains 100 feet of current carrying conductors).

2. Determine which wire gauge to use for the application by knowing the expected peak load current (I_{peak}), the maximum tolerated voltage loss (V_{loss}) within the cable, and the one way cable length. The formula below determines which ohms/100 feet entry is required from Column 3. Read the corresponding wire gauge from Column 1.

   (Column 3 value) = $V_{loss}/[I_{peak} \times 0.02 \times (\text{cable length})]$

   where:

   Column 3 value = Entry of the table above

   Cable length = One way cable length in feet

   V_{loss} = Maximum loss, in volts, permitted within cable.

   Special case: Should the V_{loss} requirement be very loose, the peak may exceed the maximum amperes (Column 2). In this case, the correct wire gauge is selected directly from the first two columns of the table.

   Example: A 20 ampere (I_{peak}) circuit which may have a maximum 0.5 volt drop (V_{loss}) along its 15-foot cable (one way cable length) requires (by formula) a Column 3 resistance value of 0.083. This corresponds to wire gauge size 8 AWG.

   If the cable length was 10 feet, the Column 3 value would be 0.125 and the corresponding wire gauge would be 10 AWG.

3. Aluminum wire is not recommended due to soft metal migration at the terminal which may cause long term (years) poor connections and oxidation. If used, increase the wire gauge by two sizes (e.g., specify 10 gauge aluminum instead of 14 gauge copper wire).

4. Derate the above wire gauge (use a heavier gauge) for higher environmental temperatures since conductor resistance increases with temperature.

Temperature ºC	ºF	Current Capability
40	104	80%
50	122	50%

5. Derate the above wire gauge (go to a heavier gauge) for an increased number of current carrying conductors. This offsets the thermal rise of bundled conductors.

Number of Conductors	Current Capability
3 to 6	80%
6	70%

6. The preferred insulation material is application dependent. Elgar's recommendation is any flame retardant, heat resistant, moisture resistant thermoplastic insulation rated to a nominal 75°C (240°F). Voltage breakdown must exceed the combined effects of:

   a) The rated output voltage.

   b) Transient voltages induced onto the conductors from any source.

   c) The differential voltage to other nearby conductors.

   d) Floating or series connections of supplies/loads.

   e) Safety margins to accommodate degradations due to age, mechanical abrasion and insulation migration caused by bending and temperature.

7. Sense lines are generally 24 to 18 (more mechanical strength) gauge wire, twisted pair, shielded, and have the same insulation rating and properties as its related current carrying conductors. Sense lines are physically separated (a separate cable) from current carrying conductors to minimize undesirable pickup.

8. As frequency increases, the magnetic field of the current carrying conductors becomes more significant in terms of adverse coupling to adjacent electrical circuits. The use of twisted pairs help cancel these effects. Shielded twisted pairs are even better. Avoid close coupling with nearby cables by using separate cable runs for high power and low power cables.

9. The above general values and recommendations should be reviewed, modified and amended, as necessary, for each application. Cables should be marked with appropriate safety WARNING decals if hazardous voltages may be present.