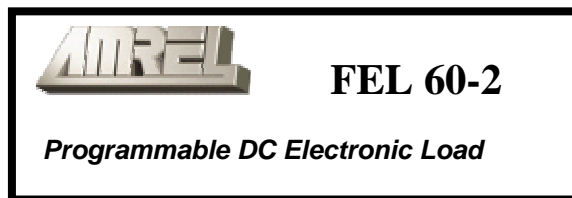


## Operation Manual



This manual covers model:

**FEL 60-2**

Date: 09/18/03  
Revision: 3.1  
F/V: B.0800.0800  
P/N: 160020

### **AMERICAN RELIANCE INC.**

3445 Fletcher Ave, El Monte, CA 91731  
PHONE: (626) 443-6818 FAX: (626) 443-8600

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## **WARRANTY INFORMATION**

### **CERTIFICATION**

American Reliance certifies that this product met its published specifications at time of shipment from the factory.

### **ONE-YEAR LIMITED WARRANTY**

American Reliance warrants to the original user or purchaser that your unit is free from any defects in material or workmanship for a period of one year from the date of purchase. If any defect is discovered within the warranty period, American Reliance will repair or replace the unit, subject to verification of the defect or malfunction, upon delivery or prepaid shipment to American Reliance.

### **IMPORTANT:**

- (1) Unless a problem is discovered upon initial inspection after purchase of the unit, please do not return the product to the distributor where it was purchased. American Reliance Inc. accepts the responsibility of keeping you a satisfied customer.**
- (2) If your product requires troubleshooting, warranty service or need a RMA number for return, contact your merchant. Or if you are unable to contact your merchant, or the merchant is unable to provide service, contact American Reliance Inc. directly at:**

<b>Phone:</b>	<b>626-443-6818</b>
<b>Toll Free #:</b>	<b>1-800-654-9838</b>
<b>Fax:</b>	<b>626-443-8600</b>
<b>Email:</b>	<b><a href="mailto:ariinfo@amrel.com">ariinfo@amrel.com</a></b>

This warranty does not apply to defects or to physical damage resulting from abuse, neglect, accident, unauthorized repair, alteration, or unreasonable use of the unit, resulting in (but not limited to) cracked or broken cases or parts, or to units damaged by excessive heat. Warranty is voided if warranty sticker is altered or removed from the unit. Except upon initial purchase, this warranty does not cover finish or appearance items nor does it cover items damaged in shipment to American Reliance for repair or calibration. American Reliance assumes no responsibility for shipping and handling. However, repaired units will be shipped back to the customer with return shipping charges paid by American Reliance.

To receive service under this warranty, you must include proof of purchase; including date and place of purchase (a copy of your purchase receipt) or American Reliance will not be responsible for repairs or replacement of the unit under warranty.

Any applicable implied warranties, including warranties of merchantable and fitness for a particular use, are hereby limited to one year from the date of purchase (invoice). Consequential or incidental damages resulting from loss of use or from a breach of any applicable express or implied warranties are hereby excluded.

This warranty is in lieu of all other agreements and warranties, general or specific, express or implied. No representative or person is authorized to assume for American Reliance any other liability in connection with the sale or use of this American Reliance product.

Some states do not allow limitations on how long implied warranties last and do not allow exclusion of incidental or consequential damages, so the above limitations and exclusions may not apply. This warranty gives the customer specific legal rights, which may vary from state to state.

### NON-WARRANTY SERVICE

Any American Reliance out-of-warranty instrument that is thought to be defective, but is considered repairable, should be sent in for non-warranty service. Please contact our service department at (800) 654-9838 for current repair charges.

The instrument should be returned to American Reliance, by following the directions under the heading "Shipping Instructions" in this section.

### EXCLUSIVE REMEDIES

This remedies provided herein are the customer's sole and exclusive remedies. American Reliance Inc. shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any legal theory.

### RMA RETURNS

Product returned for warranty and non-warranty service to American Reliance for service must be shipped, freight prepaid (will not accept COD shipments).

**American Reliance Inc.**  
**3445 Fletcher Ave.**  
**El Monte, CA 91731**  
**Attn: RMA # \_\_\_\_\_**

- ***Please call our service department at 1-800-654-9838 to obtain a return authorization (RMA #) from AMREL before returning any product.***

The instrument must be carefully packed, preferably in its original carton, and should be accompanied by a letter or note containing the following information:

User's Name	Proof of Purchase
User's Address	Description of problem
Model number	Serial number

If service is desired, such as calibration, it must be stated in the enclosed letter. For non-warranty repairs, and for calibration, the correct service charge must accompany the unit in the form of a check or money order payable to American Reliance Inc. Please do not send cash. Contact our service department at (800) 654-9838.

American Reliance will return the serviced instrument, with freight paid by American Reliance, via UPS ground service unless otherwise requested.

**\*NOTE: ALL INSTRUMENTS THAT ARE RETURNED FOR REPAIR OR CALIBRATION MUST HAVE AN ASSIGNED R.M.A. NUMBER WRITTEN ON THE FRONT OF THE PACKAGE. THIS NUMBER MAY BE OBTAINED BY OUR SERVICE DEPARTMENT. ANY INSTRUMENT DELIVERED WITHOUT THIS NUMBER WILL BE REFUSED AND RETURNED.**

---

## ***SAFETY SUMMARY***

**<NOTE>:** The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. American Reliance Inc. assumes no liability for the customer's failure to comply with these requirements.

### **WARNING**

Servicing instructions are for use by service-trained personnel. To avoid dangerous electrical shock, do not perform any servicing unless you are qualified to do so. Some procedures described in this manual are performed with power supplied to the instrument while its protective covers are removed. If contacted, the energy available at many points may result in personal injury.

### **ENVIRONMENTAL CONDITIONS**

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate at maximum relative humidity of 95% and at altitudes of up to 2000 meters. Refer to the specifications for the ac mains voltage requirements and ambient operating temperature range.

### **BEFORE APPLYING POWER**

Verify that the product is set to the appropriate line voltage, the correct line fuse is installed, and all safety precautions are taken.

### **GROUND THE INSTRUMENT**

Before switching on the instrument, the protective earth terminal of the instrument must be connected to the protective conductor of the main power cord. The mains plug shall be inserted only in an outlet socket that is provided with a protective earth contact. This protective action must not be negated by the use of an extension cord that does not have a protective conductor. Any interruption of the protective grounding or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

### **FUSES**

Only fuses with the required rated current, voltage, and specified type should be used. Do not use repaired fuses or short-circuited fuse holder. To do so could cause a shock or fire hazard.

### **AVOID ACCESS TO LIVE CIRCUITS**

Operating personnel must not remove the instrument cover. Component replacement and internal adjustments must be made by qualified service personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltage may exist even with the power cable removed, to avoid injuries, always disconnect power, discharge circuits and remove external voltage sources before touching components.

### **AVOID TROUBLESHOOTING ALONE**

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present. Any adjustment, maintenance, and repair of this instrument while it is opened and under voltage should be avoided as much as possible. If this is unavoidable, adjustment, maintenance, and repair should be carried out by only qualified personnel who are aware of the hazard involved.

### **DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT**











Because of the danger of introducing additional hazards, do not install substitute parts or perform an unauthorized modification to the instrument. Return the instrument to an American Reliance Service Department for service and repair to ensure that safety features are maintained.

## SAFETY SYMBOLS

**WARNING** The WARNING symbol denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING symbol until the indicated conditions are fully understood and met.

**CAUTION** The CAUTION symbol denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of parts or all of the products. Do not proceed beyond a CAUTION symbol until the indicated conditions are fully understood and met.

### SAFETY SYMBOL DEFINITIONS

Symbol	Description
	Direct current.
	Alternating current.
	Both direct and alternating current.
	Earth (ground) terminal.
	Protective earth (ground) terminal.
	Terminal for Neutral conductor on permanently installed equipment.
	Terminal for Line conductor on permanently installed equipment.
	Standby (supply) Units with this symbol are not completely disconnect the unit from AC mains, either disconnect the power cord or have a qualified electrician install an external switch.
	Warning, risk of electric shock.
	Caution (refer to accompanying documents).

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# ONE: FEATURES AND SPECIFICATION

## INTRODUCTION

This FEL Series Programmable DC Electronic Load from American Reliance Inc. offers a complete solution to the electronic load system requirements. This instrument was designed to assist in the development and testing of new products, as well as is being a standard instrument for automatic test systems and evaluation of dc power supplies, batteries, and power components. Other applications include use as a power circuit breaker or crowbar, high current function or pulse generator, fuel-cell and photovoltaic cell test, and de-energizing super conducting magnets. This instrument uses advanced power MOSFETs to dissipate the input power. The electronic load consumes minimum power to control maximum input power handling capability. Complex circuits are used to control the power balance and dissipation of the MOSFET. This control circuit also supports the Constant Voltage (CV), Constant Current (CC), Constant Resistance (CR), and Constant Power (CP) modes of operation. It comes with Standard Commands for Programmable Instrument (SCPI) commands, remote monitoring of input voltage and currents is a standard features. Use this electronic load can be used either on your bench or in a standard 19 in. (483 mm) rack: The programming electronic load occupies 6.968 in. (4 U) of vertical rack space. Designed for continuous use in standalone or systems applications, this electronic load is typically used to evaluate DC equipment, control circuits, or burn-in power applications.

**TABLE 1.1 GENERAL VOLTAGE AND CURRENT RANGES**

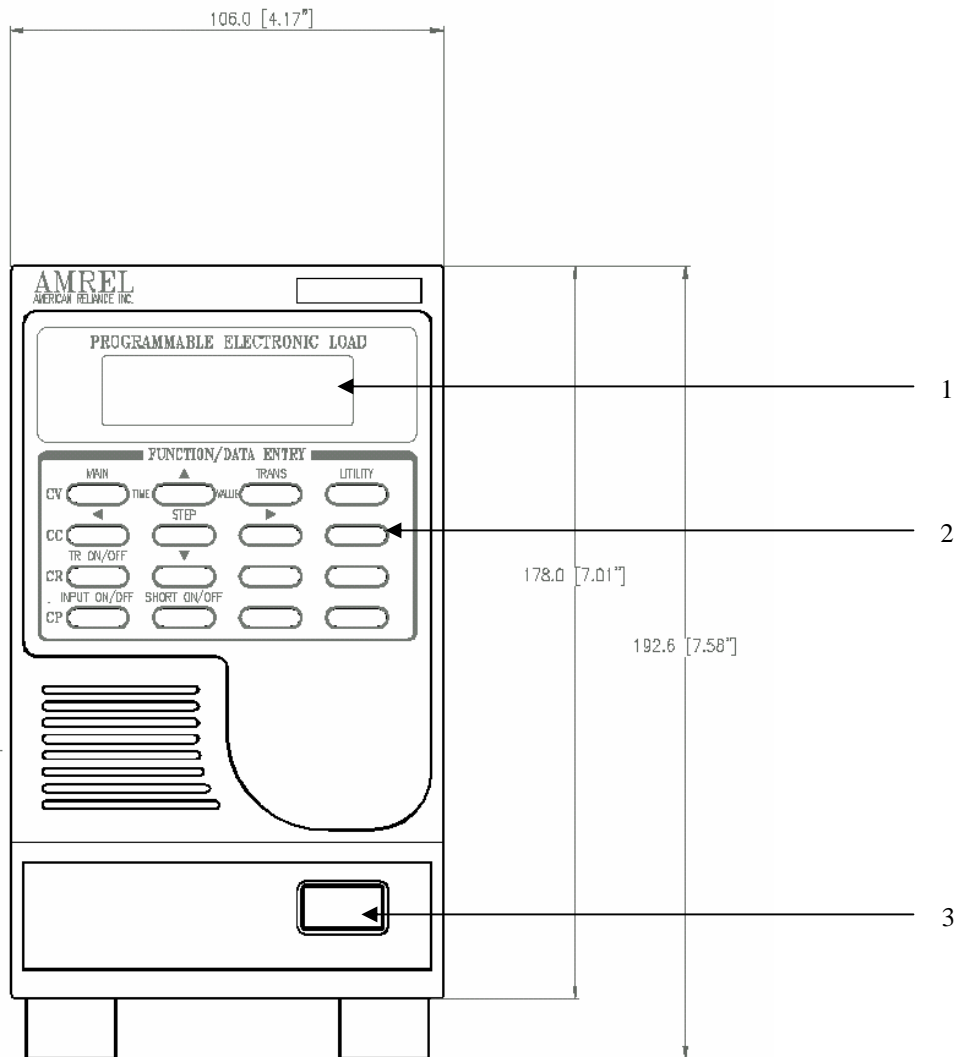
<u>Model</u>	<u>Voltage Input Range</u>	<u>Current Input Range</u>
FEL 60-2	20 Vmax	50 Amax

## FEATURES AND OPTIONS

- Four constant operating modes: Constant current (CC), constant voltage (CV), constant resistance (CR), and constant current (CP) mode operation.
- Local control and remote programming for plus amplitude, pulse width, and pulse cycle.
- Trig-In/Trig-Out and measurement functions.
- GPIB and RS-232 interface programming with SCPI command language.
- Front panel control with keypad.
- Built in pulse generator for continuous, pulsed, and toggled transient operation.
- Six programmable protection modes: Over Voltage Protection (OVP), Under Voltage Protection (UVP), Over Current Protection (OCP), Under Current Protection (UCP), Over Power Protection (OPP), and Under Power Protection (UPP).
- Fan speed control for reduced acoustic noise under light load conditions.
- 256 Real-time voltage, current, power recording capability with programmable timer setup.
- 99 point voltage, current and power self-programming capability from front panel keypad.
- “C” Operand for battery testing.
- 0-10Vdc analog programmable.
- Dual-mode transient generator.
- 256 step programmable slew rate capability.
- Simple closed-case calibration.



## ***FRONT PANEL CONTROLS***



Use this Figure 1.1 to familiarize your self with this instrument.  
See next page for keypad definition.

**FIGURE 1.1 FRONT PANEL**

### ***FRONT PANEL FEATURES***

1. Front panel Liquid Crystal Display (LCD) module.
2. Front panel keypad.
3. Power ON/OFF switch.

## FRONT PANEL KEYPAD

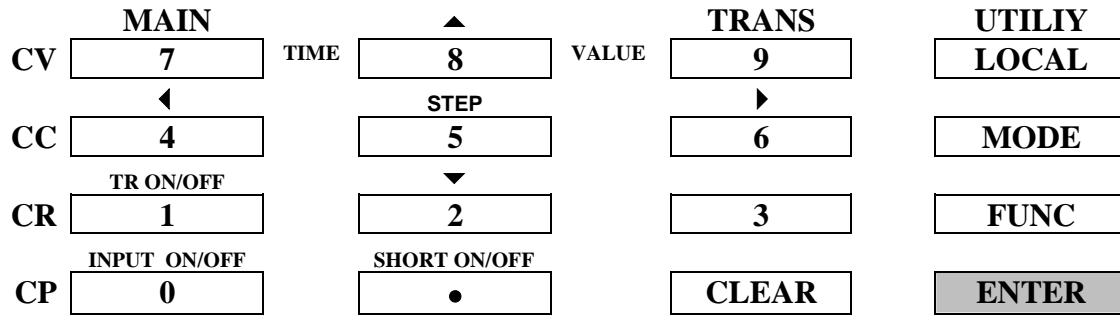


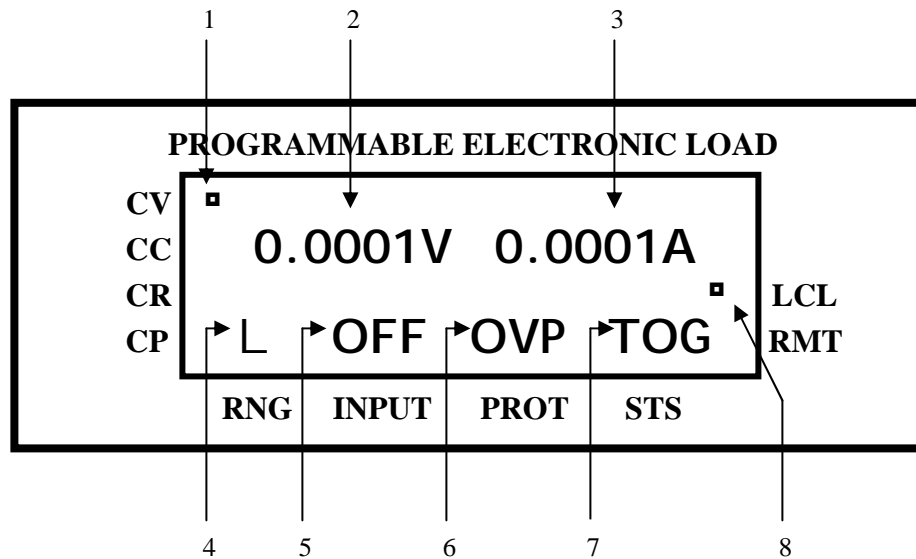
FIGURE 1.2 FRONT PANEL KEYPAD

## FRONT KEYPAD DEFINITIONS

- Key “0” Numeric entry key for number 0. Enables the Constant Power mode and INPUT ON/OFF toggle key. INPUT ON/OFF key also activates the recording capability when recording time is greater than 0 (zero).
- Key “.” Numeric entry key for decimal dot. Enables SHORT ON/OFF, toggle key.
- Key “1” Numeric entry key for number 1. Enables Constant Resistance mode of operating, TR transient enable key, and ST stepping enable key.
- Key “2” Numeric entry key for number 2. Step Down ▼ key to decrease the step number in the stepping program function.
- Key “3” Numeric entry key for number 3. Pressing #3 key.
- Key “4” Numeric entry key for number 4. Constant Current mode enable key and the Left Shift key ◀.
- Key “5” Numeric entry key for number 5. STEP function key for step editing mode.
- Key “6” Numeric entry key for number 6. Right Shift key ▶.
- Key “7” Numeric entry key for number 7. Constant Voltage mode enable key. MAIN programming level entry key and TIME programming key in the step function operation.
- Key “8” Numeric entry key for number 8. Step Up ▲ key to increase step number in stepping programming function.
- Key “9” Numeric entry key for number 9. TRANS transient programming level entry key and VALUE setting in the step function operation.
- Key “CLEAR” Clears partially set commands and return the unit to the metering mode. By pressing the "Clear" with no entry will display "AMREL Model number and software version.
- Key “MODE” Enable CV/CC/CR/CP operating mode.
- Key “LOCAL” Returns the GPIB or RS-232 mode to local operations. Enable the system utility and allows GPIB, RS-232, Calibration, and System operation parameter and setting to be changed. Pressing the LOCAL key will change status from RMT to LCL (local operation).
- Key “FUNC” Allows programming value settings for Frequency, Duty cycle and Slew rate for Transient mode operation.
- Key “ENTER” Enters the values in the set mode and returns the unit to the metering mode.

## ***LCD STATUS ENUNCIATOR***

### **LIQUID CRYSTAL DISPLAY:**



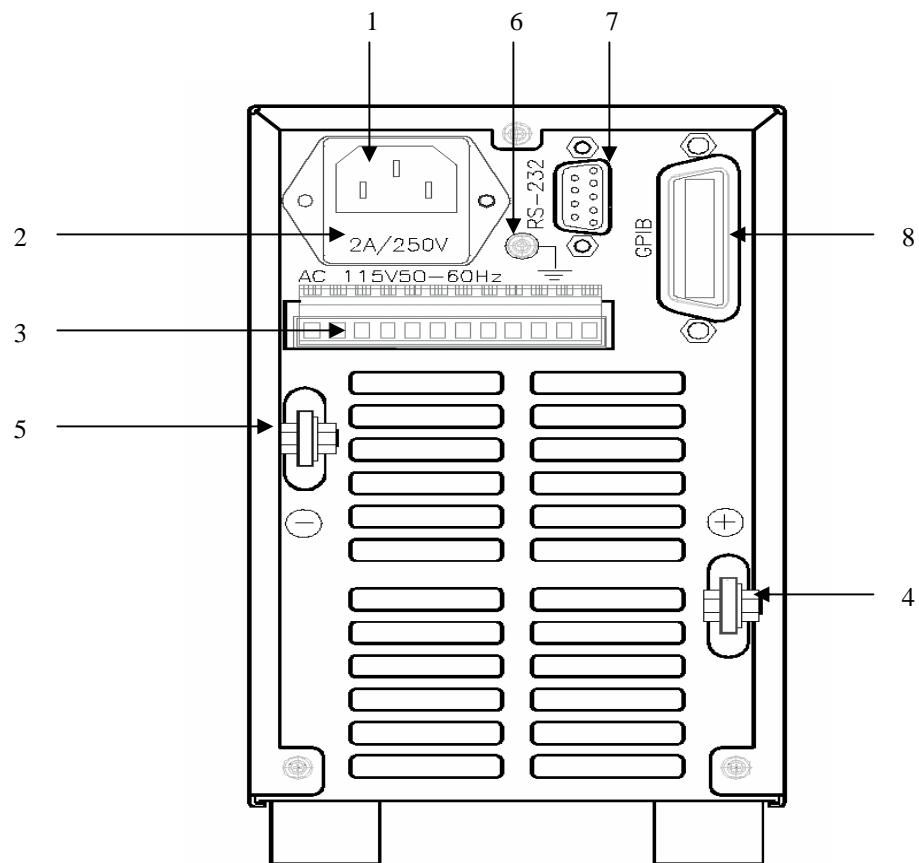
**FIGURE 1.3 LIQUID CRYSTAL DISPLAY**

**<NOTE:>** The LCD displays real time input Voltage/Current & mode status. These messages are viewed in either local or remote mode.

### ***LCD DESCRIPTION***

1. Mode indicator: Constant Voltage (CV), Constant Current (CC), Constant Resistor (CR), and Constant Power (CP).
2. Voltage reading indicator.
3. Current reading indicator.
4. RNG operating range indicator: Low range (L), Middle range (M), and High range (H).
5. INPUT ON/OFF.
6. PROT operating protection indicator: (Un-regular (UNR), Over/Under Voltage Protection (OVP/UVLP), Over/Under Current Protection (OCP/UCP), Over/Under Power Protection (OPP/UPP), and Over Temperature Protection (OTP).
7. STS operating status indicator: Transient Mode (TRAN), Toggle Mode (TOG), Stepping Mode (STEP), Pulse Mode (PULS), and Short Mode (SHT)
8. Local mode (LCL) / Remote mode (RMT) indicator.

## ***REAR PANEL CONNECTORS***



**FIGURE 1.4 REAR PANEL**

## ***REAR PANEL FEATURES***

1. AC power inlet.
2. Fuseholder.
3. External programming signal port.
4. Positive input connector.
5. Negative input connector.
6. Chassis / line ground lug screw.
7. 9-pin D-sub male connector for RS232 Interface.
8. Standard GPIB interface connector.

## EXTERNAL PROGRAMMING PORT

The external programming port provides remote sense inputs, input voltage monitoring, input current monitoring, external trigger input, external trigger output, and analog programming signal.

$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$	$\oplus$
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12	11	10	9	8	7	6	5	4	3	2	1
D	T	T	P	F	N	I	V	A	A	-	+
G	R	R	O	A	C	M	M	N	G	S	S
N	I	I	R	U		O	O	A	N		
D	G	G	T	L		N	N	L	D		
	O	I		T				O			
	U	N						G			
	T										

Pin 1	+S	Positive remote sense.
Pin 2	-S	Negative remote sense.
Pin 3	AGND	Analog Ground. Provides common (reference) connection for external programming input. When an external programming function is not used, connect this point to Analog pin 4 to prevent EMI Noise.
Pin 4	ANALOG	External analog programming signal. Only in CC mode middle range, the electronic load can be programmed externally by 0-10Volts DC or DC + AC voltage. When external analog programming function is not used, connect this point to AGND pin 3 to prevent EMI Noise.
Pin 5	VMON	Input voltage monitoring signal. Generates a 0-10Volt output signal that is linearly proportional to the electronic load's 0 to full-scale voltage.
Pin 6	IMON	Input current monitoring signal. Generates a 0-10Volt output signal that is linearly proportional to the electronic load's 0 to full-scale current.
Pin 7	NC	No connection
Pin 8	FAULT	Fault signal output. A TTL compatible signal that becomes active (high) when any of the protections are triggered.
Pin 9	PORT	Digital port output. (Not implemented)
Pin 10	TRIGIN	External trigger signal input. A TTL compatible signal is used to activate the electronic load. Trig-in is used to change to a preset mode or switch between settings in transient mode, generate a pulse in pulse mode, or trigger the stepping mode.
Pin 11	TRIGOUT	External trigger signal output. A TTL compatible signal that is activated via the Trig-in or GPIB command *TRG. This output follows the state of the TRIGIN input. External trigger output is used for triggering oscilloscopes, power supplies, or other electronic loads that have external trigger input
Pin 12	DGND	Digital Ground. Provides the common (reference) connection for Trig-in and Trig-out.

## ***SPECIFICATION***

The following is the performance specification for the FEL60-2, Programming DC Electronic Load. All specifications are at the rear terminals with a power source, and local sensing unless otherwise stated.

## ***INPUT VOLTAGE LIMIT***

The programming electronic load can handle voltages within nominal values and surge voltages less than 10% above nominal value. The Over-voltage protection will be tripped when the input voltage exceeds 10% of nominal value.

For CV mode application, the input power source should have current limit capability to prevent exceeding the electronic load's input current range.



### **WARNING**

Insure that the maximum voltage applied to electronic load will not cause the unit to sink more current and exceed the power rating. Damage to the power module will occur if the power source is capable of providing more power than the load can handle.

## ***INPUT CURRENT LIMIT***

The nominal current handling capability of the programming electronic load is described in the specification section. Care should be taken when the Load Bank is operating in the CV mode in order to prevent the load from drawing more than the maximum current rating. Although, an Over-current circuit to limit the maximum current to less than 10% above nominal rated power has been provided, at times the total power may exceed maximum rated power for a short term only. However, the load will be severely damaged if the total power consumption is continued to operate above maximum power rating. For CC mode operation, the input power source should have a Constant Voltage capability to prevent exceeding the loads input power rating.

Three over current protection features have been provided. 1) Over current protection to limit maximum current to 10% above nominal value. 2) Software selectable, the user can set and read back the input protection current level. 3) Each power MOSFET has its own fuse to protect the power module in the worst-case condition.



### **CAUTION**

In the event the over current circuit is not fast enough to limit the input current, a protective fuse for each power MOSFET is provided and will open if the input surge current exceeds maximum rating.

## ***INPUT POWER LIMIT***

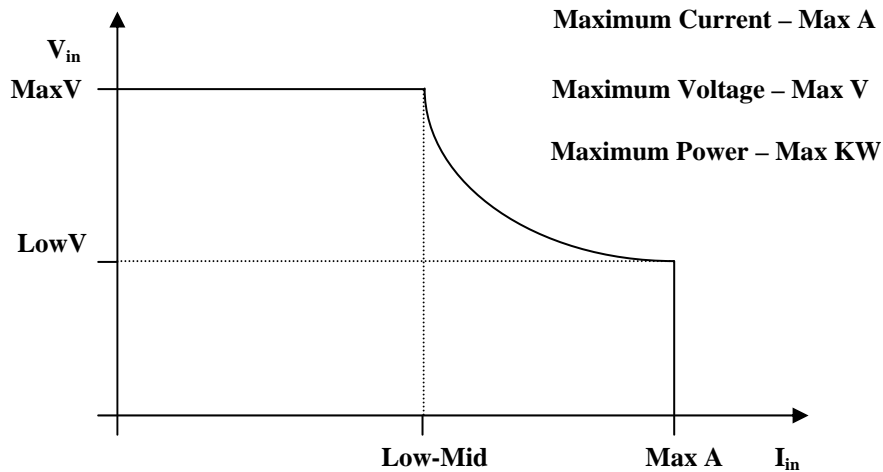
The programming electronic load is designed for rated power handling capability within an input voltage of within the maximum input voltage and input current values as described in the system specification section. Careful attention should be made to insure that the input power source does not exceed the rated power. Above all, fault or error precautions need to be taken into consideration to prevent the individual input voltage, current, and/or power from exceeding the input range settings of the unit



### **WARNING**

Anticipate the Maximum output of the power source carefully and consider the worst-case scenario. The maximum power range of the load should be higher than the output power of the source.

For CP mode application, the programming electronic load can be set to maximum power dissipation with the following limitations. Input must be within maximum voltage and current ratings. For example, FEL60-2 applied 20V/50A/60W. . Therefore, the maximum power will be limited to  $6V \times 10Amps = 60W$  only. Thus, the limits are set by the hardware's maximum value limit.



**FIGURE 1.5 INPUT VOLTAGE/CURRENT/POWER RELATION DIAGRAM**

The theory of the CP operation comes from the divider circuit built in the load. Because of the nonlinear characteristic of the divider, the input voltage, input current, and power setting will limit the CP mode of operation. The CP mode will not allow the load to operate beyond the full range of the Constant Power setting.

### ***AIRFLOW FUNCTION***

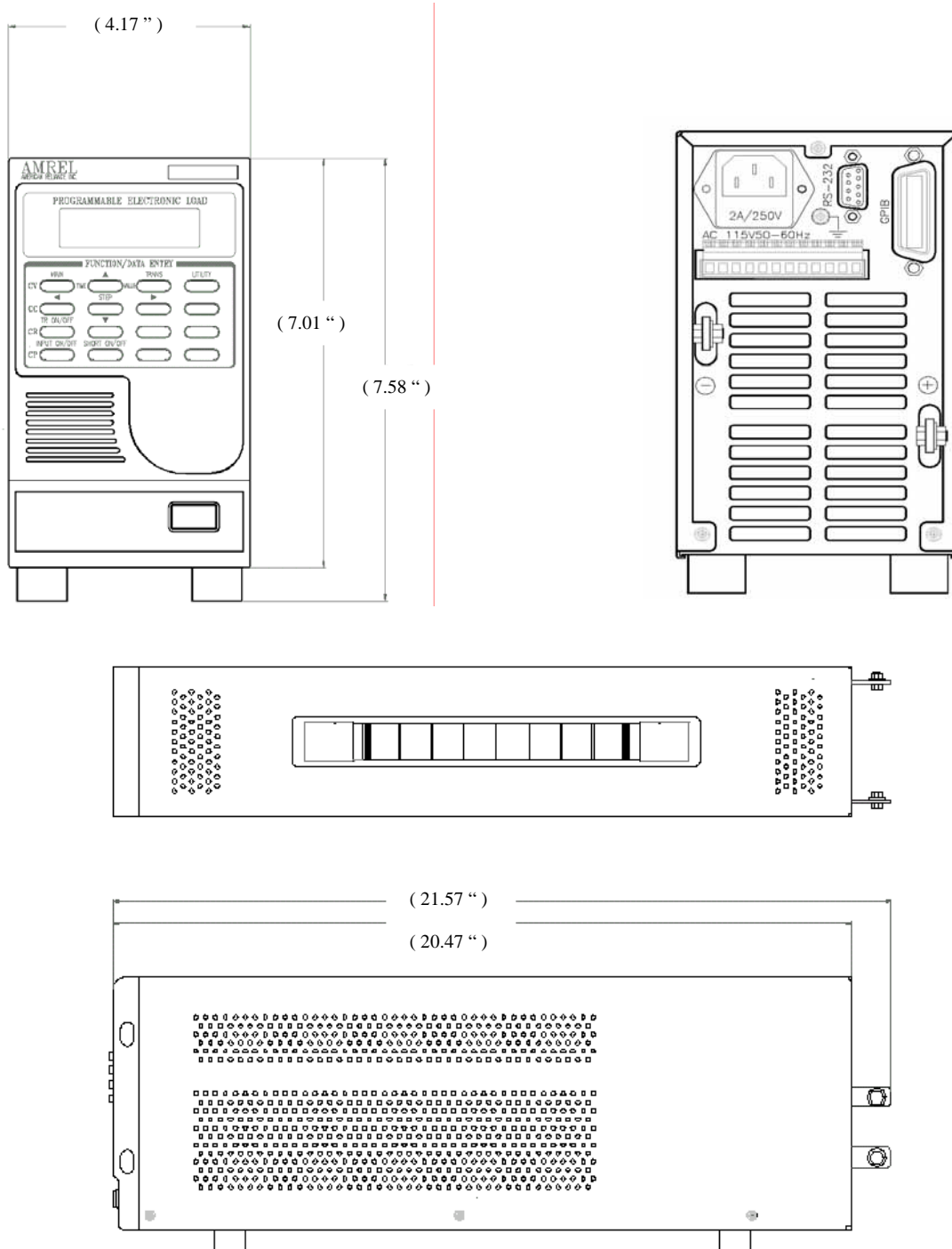
Airflow plays an important part in power dissipation. The programming electronic load uses cooling fans as a standard cooling system for removing the heat generated from the power module.

Do not impede or obstruct the ventilation holes for any reason to prevent the power components from overheating. All FEL's have OTP protection to prevent the unit from overheating. The standard programming electronic loads have forced air-cooling fans installed as the main cooling system and operate when the power-handling unit is turned on.



## DIMENSIONAL DRAWINGS

(1in. = 25.4mm)



## TWO: INSTALLATION

### *INTRODUCTION*

This section provides recommendations and procedures for inspecting, installing, and testing the electronic load.

### *BASIC SETUP PROCEDURE*

Use Table 2.1 to summarize the basic setup procedure and an overall view of the subsections. Use the procedure as a quick reference if you are familiar with the installation requirements for the programming electronic load. If you want more information, each step in the procedure refers to subsequent sections, which contain more details. Execute each step in the sequence provided.

**TABLE 2.1 BASIC SETUP PROCEDURE**

Step#	Description	Action	Reference
1	Inspection	Perform an initial physical inspection of the load.	Inspection, cleaning, and packaging.
2	Installation	Install the instrument on bench or rack mount, ensuring adequate ventilation.	Location, mounting, and ventilation.
3	Input power	Connect AC input power	AC input power connection.
4	Test	Perform functional tests for CV mode, CC mode, and front panel controls.	Functional test.
5	Source	Connect the source.	Source connection.
6	Sense	Connect sensing lines.	Local and Remote sense.

## ***INSPECTION, CLEANING, AND PACKAGING***

- **INITIAL INSPECTION:** When you first receive your unit, perform a quick physical check.
  1. Inspect the instrument for cracks, scratches, broken switches, connectors, and display.
  2. Make sure there is not damage on the AC power cord, the AC input cover is installed properly and with the strain relief.
  3. Make sure there is no loose component in the unit that may cause by the long distance shipping.

If the unit is damaged, save all the packing materials and notify the carrier immediately.

- **MAINTENANCE:** No routine servicing of the electronic load is required except for periodic cleaning. Whenever the instrument is removed from operation, first use a low pressure air to blow dust from in and around components on the printed circuit board, clean the front panel with dry cloths or with a weak solution of soap and water, clean the metal surfaces with naphtha or an equivalent solvent when used in high humidity. Then use the low-pressure air to blow it again.

## ***RETURNING ELECTRONIC LOAD TO THE MANUFACTURER***

Return Material Authorization Policy for warranty and non-warranty service:

Before returning a product directly to American Reliance Inc. you must obtain a Return Material Authorization (RMA) number and the correct manufactory Ship To: address. Products must also be shipped prepaid. Product shipments will be refused and returned at sender expense if they are unauthorized shipped without RMA # clearly marked on the outside of the shipping box, shipped "COD", or if they are shipped to the wrong location.

Please have the following information when contacting American Reliance for RMA #:

- 1- The model number of your product.
- 2- The serial number of your product.
- 3- Information about the failure and/or reason for the return.
- 4- A copy of your dated proof of purchase.

When returning the product to American Reliance Inc.:

- 1- Package the unit safely, preferably using the original box and packing materials. Please ensure that your product is shipped fully insured in the original packaging or equivalent. **THIS WARRANTY WILL NOT APPLY WHERE THE PRODUCT IS DAMAGED DUE TO IMPROPER PACKAGING.**
- 2- Include the following information:
  - The RMA# supplied by American Reliance Inc. clearly marked on the outside of the box.
  - A return address where the unit can be shipped. Post office boxes are not acceptable.
  - A contact person, telephone, email where sender can be reached during work hours.
  - A brief description of the problem.

Ship the unit prepaid to the address provided by AMREL customer service representative.

### **If you are returning a product from outside of the United States:**

In addition to the above, you must include return freight funds if you instrument is out of warranty and are fully responsible for all documents, duties, tariff, and deposits.

## ***PACKAGING FOR SHIPPING OR STORAGE***

Instructions to prepare the instrument for shipping or storage.

- 1- When returning the unit or sending it to the service center, attach a tag to the unit stating its model number (available at the front panel label) and its serial number (available at the rear panel label). Give the date of purchase and an invoice number, if you have it, as well as a brief description of the problem.
- 2- For storage or shipping, repack the electronic load in its original box. If the original box is not available, seal the instrument in a plastic bag and pack it in a 200 lb. (90Kg) test corrugated cardboard carton large enough allow 3 inches (76.2mm) of cushioning material to surround the unit or use a material such as foam slabs or chips or an appropriate wooden crate used. Please consult with AMREL shipping department for proper packing material and handling.
- 3- Label the package as shown in Figure 2.1.
- 4- Mark the address of the service center and your return address carton.
- 5- For storing, no more than two cartons high. The storage temperature should be between -40°C to 70°C.

<p><b>PROGRAMMABLE DC ELECTRONIC LOAD</b></p> <p>Model #: _____</p> <p>Serial #: _____</p> <p><b>FRAGILE – ELECTRONIC EQUIPMENT (PLEASE HANDLE WITH CARE)</b></p>
---

**FIGURE 2.1 SHIPPING OR STORAGE PACKAGE LABEL**

## ***LOCATION, MOUNTING, AND VENTILATION***

Electronic load is designed for rack-mounted or bench top applications.

### **RACK MOUNTING INTALLATION:**

- 1- Use the integral rack-mount ears at both sides of the front panel to install the electronic load in a rack mount application.
- 2- Provide adequate support for the rear of the instrument without obstructing the ventilation inlets on the sides and rear of the unit. Use a support bar at the bottom or rear of the unit. Follow the rack-mount manufacturer's instructions to install the support bar. (NOT INCLUDED)

### **VENTILATION:**

Whether you place the electronic load in a rack or on a bench, allow cooling air to reach the ventilation inlets on the sides of the instrument and allow 4 in. (101.6mm) of unrestricted air space at the rear of the unit for the fan exhaust. Any ventilation space at the top and bottom of the supply will further lower internal operating temperatures.

## ***FUSE REPLACEMENT***

If the fuse is suspected to be defective, it should be inspected and, if necessary, replaced. To inspect or replace the fuse, please contact to American Reliance service department before perform the following steps:

- (1) Disconnect the AC line cord from the unit to reduce electrical shock hazard.
- (2) Remove the fuse by sliding out the fuse holder. The fuse holder is beneath the AC receptacle. Test the fuse for electrical continuity with an ohmmeter. Other fuse holder located at the printed circuit board.
- (3) If the fuse is found to be defective, replace it with a replacement fuse as specified in the following table:

<u>Fuse Rating</u>	<u>Specification</u>	<u>Location</u>
2Amp, 250V	5 X 20mm (Fast)	External Fuse (Beneath the AC receptacle)

- (4) Replace the fuse in the fuse holder and re-install.
- (5) Re-install the cover and connect the AC power cord.



### **CAUTION**

**USE OF ANY FUSE OTHER THAN THE ONE SPECIFIED MAY CAUSE DAMAGE TO THE UNIT, POSE A SEVERE FIRE HAZARD, AND WILL VOID THE WARRANTY.**

## ***AC INPUT POWER CONNECTION***



### **WARNING**

Disconnect AC power from the instrument before removing the cover. Even with the front panel power switch in the OFF position, live line voltages are exposed when the cover is removed and the AC cord is attached. Repairs must be made by experienced service technicians only.

NOTE: You must obtain an authorization from Amrel first before removing the cover of the instrument. Otherwise the warranty will be a void.



### **WARNING**

There is a potential shock hazard if the electronic load chassis and cover are not connected to an electrical ground via the safety ground in the AC input connector. Ensure that the electronic load is connected to a grounded AC outlet with the recommended AC input connector configured for the available line voltage.

## ***AC INPUT CONNECTOR AND VOLTAGE SELECTION***



### **CAUTION**



Check the AC input voltage label (beneath the AC receptacle at the rear panel), before connecting or changing the AC input voltage (115Vac/230Vac). Most of the loads have fixed AC input.



### **CAUTION**

To prevent damage to the electronic load, turn off AC power to the unit before changing from one AC input voltage range to another. Example 115Vac to 230Vac.

The Auto Range Select function (Optional for above 2.5KW) instrument allows you to connect to either low or high AC input voltages without making any adjustments to the unit.

## AC INPUT CORD



### WARNING

The AC input cord is the disconnect device for the electronic load. The plug must be readily identifiable to the operator. The input cord must be no longer than 3 m (9.84 feet).

The AC input cord we recommend is specified in Table 2.3, “AC Cord Specification”.  
If you require a special cord, call our sales representative.

**TABLE 2.3 AC CORD SPECIFICATION**

WIRE SIZE DIMENSIONS AWG	TYPE OF CONDUCTOR	RATINGS	LENGTH (feet)
16/3	SJT	105°C	6
18/3	SJT	105°C	6

## LOAD WIRING

To select wiring for connecting the load to the electronic load, consider the following factors:

- Insulation rating of the wire
- Current carrying capacity of the wire
- Maximum load wiring length for operation with sense lines
- Noise and impedance effects of the load lines

**CURRENT CARRYING CAPACITY:** As a minimum, load wiring must have a current capacity greater than the output current rating of the power supply. This ensures that the wiring will not be damaged even if the load is shorted. Table 2.4 shows the maximum current rating, based on 450 A/cm<sup>2</sup>, for various gauges of wire rate for 105°C operation. Operate at the maximum current rating results in an approximately 30°C temperature rise for a wire operating in free air. Where load wiring must operate in areas with elevated ambient temperatures or bundled with other wiring, use larger gauges or wiring rated for higher temperature.

**TABLE 2.4 CURRENT CARRYING CAPACITY FOR LOAD WIRING**

WIRE SIZE (AWG)	MAXIMUM CURRENT (A)
2/0	303
1/0	247
1	192
2	155
4	97
6	61
8	36
10	21
12	16
14	10

## ***LOAD WIRING LENGTH FOR OPERATION WITH SENSE LINES***

For applications using remote sensing, you must limit the voltage drop across each source line. We recommend that you use the larger load wiring or ensure a smaller voltage drop (1V typical max.) along the wire, although the unit will compensate for up to 5V drop in each line.

## ***NOISE AND IMPEDANCE EFFECTS***

To minimize noise pickup or radiation, use shielded pair wiring or shortest possible length for source wires. Connect the shield to the chassis via a rear panel mounting screw. Where shielding is impossible or impractical, simply twisting the wires together will offer some noise immunity. When using local sense connections, the user must use the largest practical wire size to minimize the effects of load line impedance on the regulation of the load.

## ***LOAD CONNECTIONS***

The electronic load is designed with an air-cooling system that provides airflow through the heat sink to remove the heat generated by the Power MOSFETs. For higher efficiency heat exchange rate between heat sink and power MOSFETs, the user needs to follow the instruction outlined below to insure heat is removed from heat sink and prevent excess heat from accumulating in the power module. The efficiency of the heat exchanger is the key factor of the power handling of the load. Better efficiency results in higher reliability of the unit.

## ***INPUT TERMINAL***



### **CAUTION**

For the safety of personnel and to prevent electrical shock due to high voltage, do not come in contact or obstruct the input terminals. Refer to the next page diagram, for the location of the input terminals.

Observe the maximum current handling capability of the power cables from DUT to the Load Bank. Please refer to the Table 2.4 for higher current rating cables. Observe the maximum input current and voltage of the terminals. Do not underrate the cable, excessive current will cause the temperature to increase and cause melting of the insulation rubber of the terminal and cable insulation sleeves resulting in input cable shorts.

For the high current applications, large diameter power cables are necessary to prevent load oscillation. The power cables should be as short as possible to reduce inductance from the power cable and cause oscillation between power sources and the load unit.

## ***INPUT TERMINAL CONNECTOR***



### **WARNING**

There is a shock hazard at the load when using an electronic load with a rated output greater than 40V. To protect personnel against contact with hazardous voltages, ensure that the load, including connections, has no live parts, which are accessible. Also ensure that the insulation rating of the source wiring and circuitry is greater than or equal to the maximum output voltage of the electronic load.



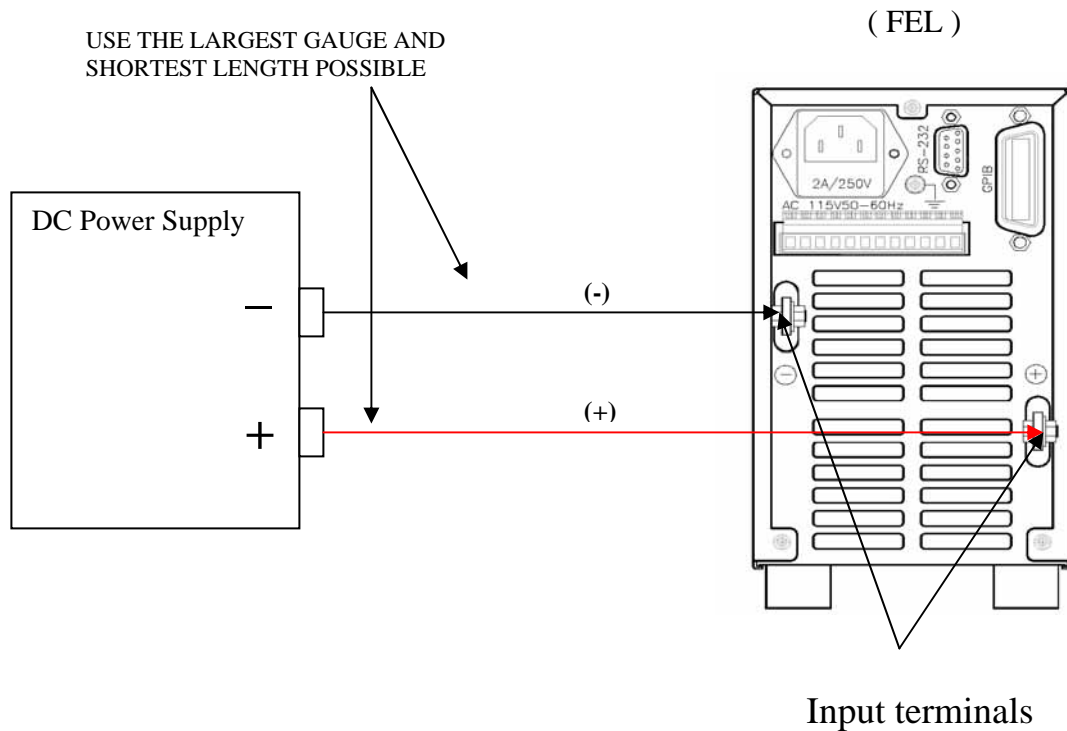
### **CAUTION**

When making connections to the bus bars, ensure that each terminal's mounting hardware and wiring assembly are placed to avoid touching the other terminal and shorting the electronic load input. Heavy connecting cables must have some form of strain relief to avoid loosening the connections or bending the bus bars.

## LOCAL SENSE CONFIGURATION

When the Electronic Load is strapped for local sensing, an unavoidable voltage drop is incurred in the load leads and this adds to the load regulation. Hence, local sensing is usually used in applications where the lead lengths are relatively short or load regulation is not critical. Local or remote sense can be set by pressing **UTILITY** key and then **ENTER** key to enter Measure Sense option.

To meet safety requirement, load wire size should be large enough to carry electric current of the source to the Electronic Load without overheating. Stranded, copper wires are recommended. The wires should be large enough to limit the voltage drop to less than 1V per lead. Refer to Table 2.4 for proper wire size selection. Input wire connections are made to the "+" and "-" terminals on the rear panel of the Load.



**FIGURE 2.2 LOCAL SENSE CONFIGURATION**



### WARNING

To protect personnel against accidental contact with hazardous voltages, ensure that the load, including connections, have no live parts, which are accessible. Also ensure that the insulation rating of the load wiring and circuitry is greater than or equal to the maximum input voltage of the electronic load.



### WARNING

Never touch the input terminal when your hands are wet. Dry your hands first before operate the instrument.



## REMOTE SENSE CONFIGURATION

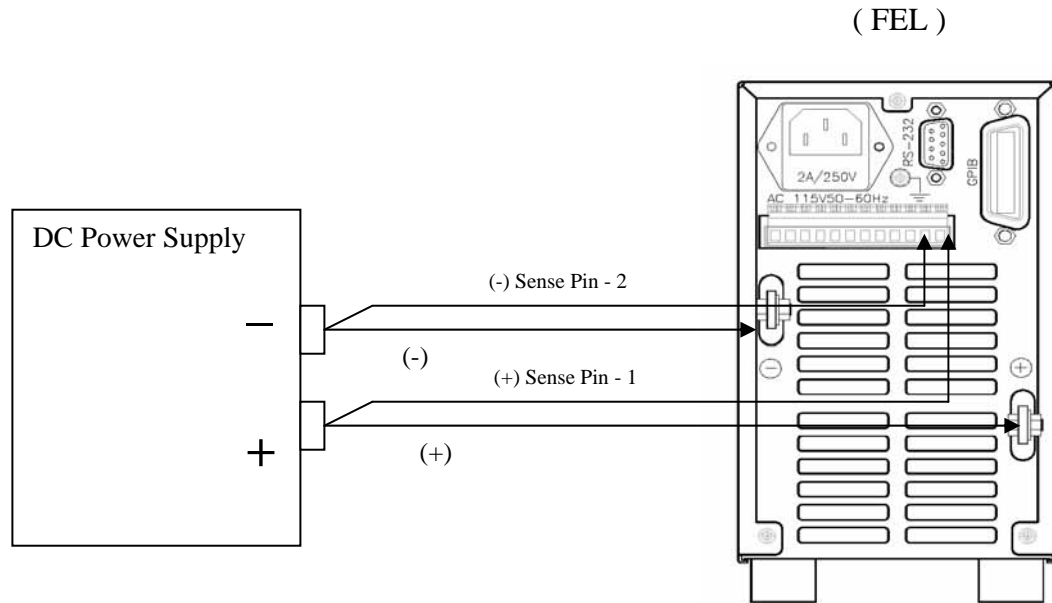


### CAUTION

Turn off the electronic load before making any connections on the rear panel terminal block.

In remote sense operation, the electronic load senses the input at output terminals of the source. As shown in figure 2.3, the remote sense terminals of the Load are connected to the output of the source. Remote sensing compensates for the voltage drop in applications that require long leads. It is only useful when the electronic load is operating in CV or CR mode, or when using voltage readback in any mode. Load leads should be bundled or tied together to minimize inductance.

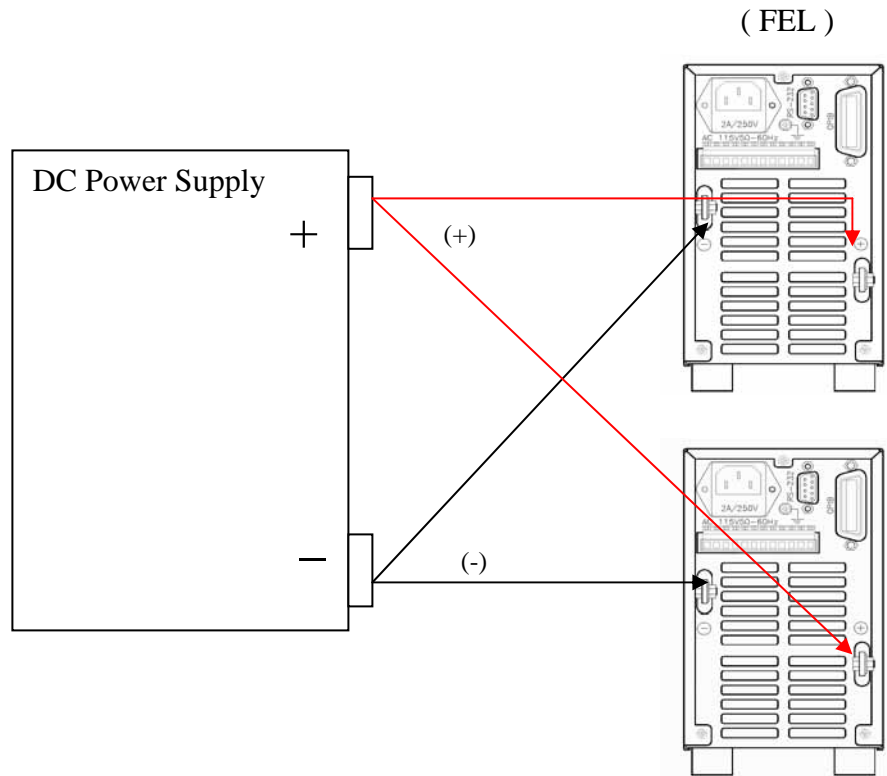
**<NOTE>: USE THE LARGEST GAUGE AND SHORTEST LENGTH POSSIBLE FOR THE SOURCE LINE.**



**FIGURE 2.3 REMOTE SENSE CONFIGURATION**

## PARALLEL CONNECTIONS

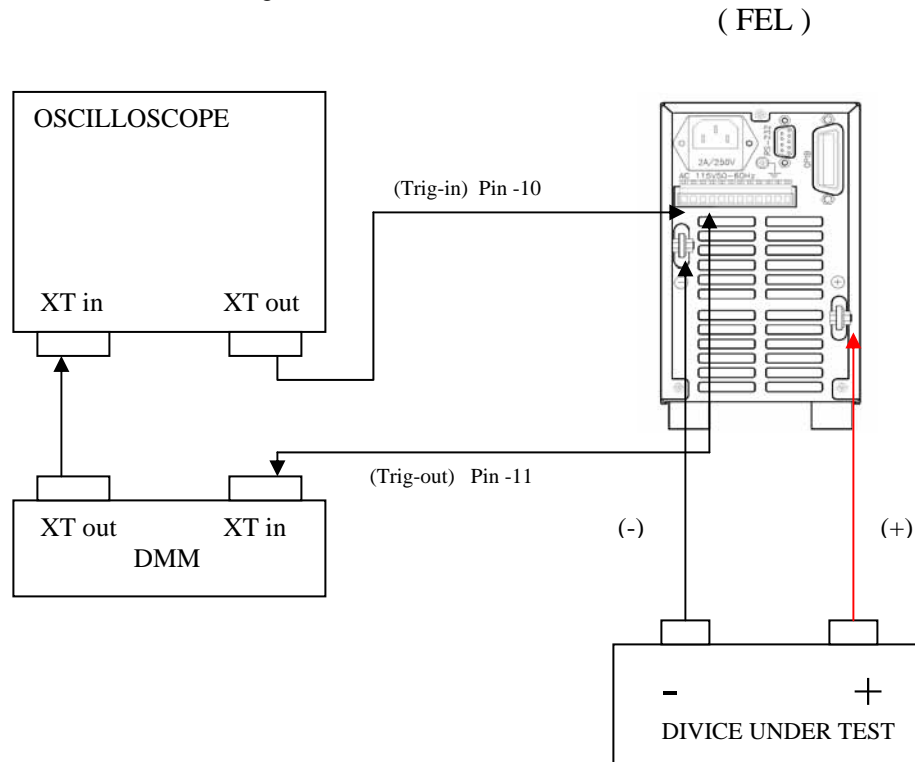
The electronic loads can be connected in parallel to increase power dissipation. Up to 5 Electronic Loads can be directly paralleled in CC or CR mode. The electronic load cannot be paralleled in CV mode. Each Electronic Load will dissipate the power it has been programmed for. If two Electronic Loads are connected in parallel, with Load 1 programmed for 10 A and Load 2 programmed for 15 A, the total current drawn from the source is 25 A. In another scenario, if Load 1 is programmed for 0.5 ohm and Load 2 is programmed for 0.5 ohm, the total equivalent resistance of the two paralleled Loads is 0.25 ohm.



**FIGURE 2.4 PARALLEL CONFIGURATION**

## TRIGGER OPERATION

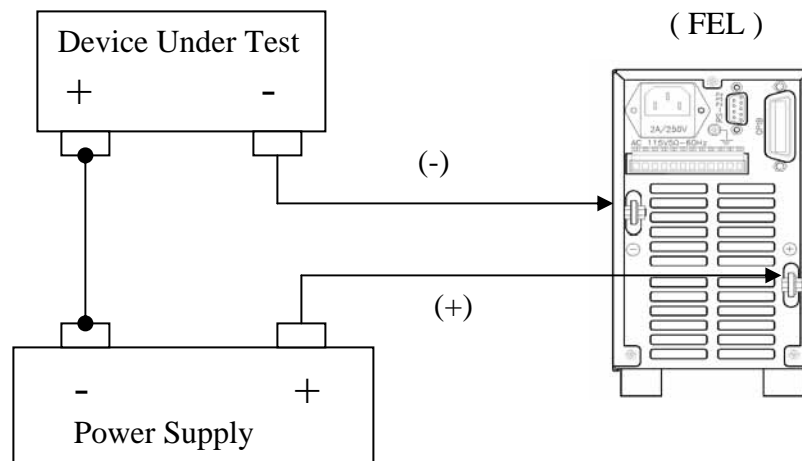
Figure 2.5 depicts the method of triggering the Electronic Loads. The TRIGOUT signal of the Electronic Load is connected to the Trigger input of DMM. Additional instruments can be daisy chained to a DMM in the same manner. Once the preset settings of the instruments have been programmed, one trigger signal can simultaneously set all instruments to their transient settings.



**FIGURE 2.5 TRIGGER CONFIGURATION**

## ZERO-VOLT LOADING CONNECTION

The Electronic Load can be connected in series with voltage sources greater than 3 V so the Electronic Load can test the devices at its full current capacity down to a zero-volt level.



**FIGURE 2.6 ZERO-VOLT LOADING**

## **THREE: LOCAL OPERATION**

### ***INTRODUCTION***

The programming electronic load provides powerful control capabilities, which consist of four operating modes CV/CC/CR/CP. To complement and enhance these features, a Transient mode is provided to simulate transient conditions. The Transient operation provides three programmable features that can be set by the user, Transient frequency, Transient duty cycle, and Transient slew rate. These features can help the user to control the FEL more efficiently and precisely and provide a comprehensive power source test.

The programming electronic load provides additional functions and capabilities, such as 99 point step programming, 255 recording points, and clock. For battery testing, we provide the “C” operand to help user in testing battery parameters without troublesome calculations.

The wide operating modes and specifications and flexibility of the electronic load enable the user to control different levels of power source. Programmable OVP, OCP, OPP protection features are provided to protect the electronic load in any load conditions. Refer to the specifications to check the maximum input current, voltage, and power range in order to safely test and obtain the best results.

### ***VOLTAGE AND CURRENT METERING INFORMATION***

The programming electronic load uses a DAC with a 12-bit resolution in the metering system and is active once the unit is turn on. With sophisticated control circuits, the load can measure full-scale input voltages and currents with Auto-Scaling capability. For example, when low voltages levels are applied, the display's decimal point will move to accurately display the lower value. The same is true for the larger input values, the decimal will move to accurately display the higher value. Refer to the Specifications for more programming and read back accuracy information.

## ***OPERATING STATUS INFORMATION***

All operating status information will be displayed when they become active. For example, when the Over-voltage is tripped, the LCD module will display OV.

**ON/OFF** indicates whether the input is disabled or enabled. When the OFF status is active the FEL input is disabled and there is no current flowing from the power source to the FEL.

The **OCP** indication on the display means the Over-current protection circuit of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **UCP** indication on the display means the Under-current protection circuit of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **OVP** indication on the display means the Over-voltage protection circuit of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **UVP** indication on the display means the Under-voltage protection circuit of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **OPP** indication on the display means the Over-power protection of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **UPP** indication on the display means the Under-power protection of the FEL has tripped and in order to operate again the indicator needs to be clear by pressing the CLEAR key.

The **TRAN** indication on the display means the Transient mode is set and will be activated when the **INPUT ON/OFF** is pressed and enabled.

The **STEP** indication on the display means the Stepping mode is set and will be activated when the **INPUT ON/OFF** is pressed and enabled.

The **PULS** indication on the display means the Pulse mode is set and will be activated when the **INPUT ON/OFF** is pressed and enabled and when **TR ON/OFF** is pressed and enabled once.

The **TOG** indication on the display means the Toggle mode is set and will be activated when the **INPUT ON/OFF** is pressed and generate a trig-in signal through the external programming port.

The **SHT** indication on the display means the Short mode is set and will be activated when the **IN ON/OFF** is pressed and enabled.

The **LCL** indication on the display means the instrument is at Local operation.

The **RMT** indication on the display means the instrument is at Remote operation (GPIB or RS-232).

The **UNR** indication on the display means un-regular operation range or improperly operation and may DAMAGE to the instrument.



### **WARNING**

Do not deliberately try to trip the OV circuit on when performing battery-testing applications. When an Over-voltage condition occurs, the electronic load will try to sink more current in order to drop the input voltage source. In other words, the input source is supplying more power than the electronic load is capable of handling. By trying to trip the Over-voltage circuit, you may severely damage both the input source and the load.

## **LOCAL AND GPIB OPERATION INFORMATION**

When the programming electronic load is first turn on, the LCD will display LCL for local communication (via keypad). When the electronic load is communicating via GPIB or RS-232 remote control operation, the LCD module will display RMT to inform the user that the keypad is disabled and the load is being controlled remotely. Pressing the LOCAL key will change status from RMT to LCL (local operation).

## **MODE MENU OPERATION AND RANGE SETTING**




The FEL provides a wide range of input operating modes CV/CC/CR/CP and range operation (Manual/Automatic). The user is capable of activating any mode during the operation of the unit; however, careful attention needs to be adhered to prior to entering the programming values for each operating mode and correct range.



### **WARNING**

The “MODE” key plays an important role in switching operating mode (CV, CC, CR, CP) and range selection. The FEL needs to be in the OFF status prior to enabling mode-switching capability. For safety purposes and to prevent over sourcing the FEL, do not activate the mode switching when the FEL is in the ON status.




### **TO SELECT THE MANUAL MODE AND RANGE, SIMPLY FOLLOW THE PROCEDURE:**

1. Set manual mode at the Range Operation by pressing UTILITY, press ENTER key when you see SYSTEM, press the key # 6 (  ) to scroll till you see range operation and then press ENTER. Use "   " to select manual then press ENTER. Press CLEAR key to back space to main menu.
2. Press MODE key to enter mode menu.
3. Select the mode by pressing CV (7)/CC (4)/CR (1)/CP (0) key. Then press ENTER key to end the mode setting.
4. Range setting will show after ending the mode setting.
5. By pressing up-arrow (8) or down-arrow (2) key to set the correct range for your operation, then press ENTER key to end the range setting mode and will return to main menu.

\*NOTE: Constant Voltage only has one range.

### **TO SELECT THE AUTOMATIC MODE AND RANGE, SIMPLY FOLLOW THE PROCEDURE:**

**Example: 60A is maximum current = middle/high range, then 6A = low range.**

- a. Set automatic mode at the Range Operation by pressing UTILITY, press ENTER key when you see SYSTEM, press the key # 6 (  ) to scroll till you see range operation and then press ENTER. Use "   " to select automatic then press ENTER. Press CLEAR key to back space to main menu.
- b. To set Constant Current (CC) mode, press MODE key and press key # 4 (CC).
- c. To set middle/high range form low range. Simply input a current value higher than 6A will automatic change to middle/high range.
- d. To set low range form middle/high range. Simply input a current main value and transient value to lower or = to 6A will automatic change to low range.

## ***MAIN LEVEL LOCAL OPERATION***

There are two levels of operations MAIN level and TRANSIENT level. The MAIN level operation and its associated set of values are for normal and continuous operation. TRANSIENT operation is for short intervals to simulate start-up conditions or special events.

The main level programming values for the four different operating modes are entered the same; the difference is the unit of measurement for each operating mode. For example CV mode is in V (Voltage) unit, CC mode is in A (Amps) unit, CR mode is in  $\Omega$  (Ohm) unit and CP mode is in W (Watts) unit.

The CC, CP and CR modes have more than one operating range. The low ranges provide better resolution for low settings. Each mode's range is selected by pressing the up or down keys in the MODE menu. See example below.

### Example 1.

1. Press "MODE" key and select CC mode by pressing "4" (CC) key, then pressing the "ENTER" key. Select the programming range by pressing the up or down keys and then pressing the "ENTER" key. Let's assume main level programming value indicates 10 amps, in the low range. Try to set the programming value to 15.0 Amps.
2. Press "7" (MAIN) key and the FEL will enter the editing mode and wait for a numerical key entry for a new value. On the second line of the LCD module the following format will be displayed: CURR = 10.000A
3. Enter the following numerical key sequence "1", "5", "." and "0".
4. If the number that was entered is not correct, then press the "CLEAR" key to erase the wrong entry and repeat step 3.
5. Press the "ENTER" key to complete the entry operation.
6. If the entered value is over the maximum rating of the current range, then the FEL will discard the new value and LCD module will return back to entry step. Either change the entered value to a number that is within the current range or select the correct range by pressing the MODE key as indicated in step 1.

### Example 2.

1. Assume that the FEL is in the CP mode and main level programming value indicates 40 Watts. Try to set the programming value up to 50.0 Watts.
2. Press "7" (MAIN) key and the unit will enter the editing mode and wait for a numerical key entry for the new value. On the second line of the LCD module the following format will be displayed: POWER = 40 W
3. Enter the following numerical key sequence "5", "0", "." and "0".
4. If the number that was entered is not correct, then press the "CLEAR" key to erase the wrong entry and repeat step 3.
5. Press the "ENTER" key to complete the entry operation.
6. If the entered value is over the maximum rating, then the FEL will discard the new value and LCD module will return back to entry step and display the old value.

After the entry steps have been completed, the new main level programming values will immediately be in effect and the FEL will return to the metering mode.

## ***SPECIAL EDITING KEYS***

In the main operating mode the "◀ (Key #4), ▶ (Key #6), ▲ (Key #8), ▼ (Key #2)" keys can be used to edit the CV/CC/CR/CP set values. Use the "◀ ▶" keys to increment or decrement the multiplier (decimal placement value), then use the "▲ ▼" keys to increment or decrement the set value by the multiplier factor.

Example: The FEL is in CV mode and we need to decrement or increment the voltage set value by (100.00) from 20.00 to 302.00V.

Press the ◀ or ▶ key once to enable the multiplier edit mode then press the ◀ key to decrement or ▶ key to increment the value located on the top-left corner of the display next to the CV indicator. Continue pressing either key until the displays reads (100.00). Then press the "▲ or ▼" key once to enable the set value edit mode use the "▲ to increment the set value by the multiplier or the ▼ key to decrement the set value by the multiplier value. In this example the original set value was 20.00, by pressing the ▲ key (3) times the display should read (320.00).

## ***UTILITY MENU FUNCTION***

The Utility function allows the user to set the different system configurations such as GPIB, RS-232, Stepping, Max/Min setting, Protection, Recording, and Calibration. It is to help users to do more functional testing in using FEL in the different situations or configurations. The Utility function is the start of the tree structure, which enables the user to branch.

Press **UTILITY** key:

\* (Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu).

\* (Use **CLEAR** key to back space or to correct the wrong value).

**(A: SYSTEM ◀ ▶ B: GPIB ◀ ▶ C: RS-232 ◀ ▶ D: MAX/MIN SETTING ◀ ▶ E: STEPPING ◀ ▶  
F: PROTECTION ◀ ▶ G: SPECIAL FUNCTION ◀ ▶ H: CAL. UTILITY)**

**A: System Menu** - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\* (Use **CLEAR** key to back space or to correct the wrong value).

**1: MEASURE SENSE ◀ ▶ 2: REM INTERFACE ◀ ▶ 3: RANGE OPERATION ◀ ▶ 4: DISPLAY  
MODE ◀ ▶ 5: DIGIT PROT ◀ ▶ 6: 'C' VALUE**

**1: MEASURE SENSE**-----press ENTER key, use ◀ ▶ to select Local / Remote sense then press ENTER.

**2: REM INTERFACE**-----press ENTER key, use ◀ ▶ to select GPIB / RS-232 via then press ENTER.

**3: RANGE OPERATION**-----press ENTER key, use ◀ ▶ to select Manual / Automatic operation then press ENTER.

**4: DISPLAY MODE**-----press ENTER key, use ◀ ▶ to select display mode (V+I, V+C, V+P, I+P, P+C) then press ENTER.

**5: DIGIT PORT**-----press ENTER key, use ◀ ▶ to enables or disables digit port the press ENTER.

**6: 'C' VALUE**-----press ENTER key twice, then input the C value.



## B: GPIB Menu - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\*(Use CLEAR key to back space or to correct the wrong value).

1: PRIMARY ADDRESS ◀ ▶ 2: SECONDARY ADDRESS ◀ ▶ 3: ADDRESS MODE ◀ ▶ 4: EOI CODE  
◀ ▶ 5: TRANSIENT MODE ◀ ▶ 7: TRIGGER OUT ◀ ▶ 8: MEASURE DELAY

**1: PRIMARY ADDRESS**-----press ENTER key, use ◀ ▶ to set the primary address ( 0 – 31 ) then press ENTER.

**2: SECONDARY ADDRESS**-----press ENTER key, use ◀ ▶ to set the second address ( 0 – 31 ) then press ENTER.

\* (NOTE: Secondary address start from address 96. Example: If the secondary address is set to address 3, then the actual address will be  $96 + 3 = \text{address } 99$  as secondary address) .

**3: ADDRESS MODE**-----press ENTER key, use ◀ ▶ to set primary or + second address then press ENTER.

**4: EOI CODE**-----press ENTER key, use ◀ ▶ to set end of interface code then press ENTER.

**5: TRANSIENT MODE**-----press ENTER key, use ◀ ▶ to select transient mode (Continuous, Stepping, Pulse, Toggle) then press ENTER.

**6: TRIGGER OUT**-----press ENTER key, use ◀ ▶ to select transient or trigger operation then press ENTER.

**7: MEASURE DELAY**-----press ENTER key, input the time number in mS, then press ENTER.

## C: RS-232 Menu - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\*(Use CLEAR key to back space or to correct the wrong value).

1: BAUD RATE

**1: BAUD RATE**-----press ENTER key, use ◀ ▶ to select baud rate ( 38400 / 9600 ) then press ENTER.

## D: MAX / MIN SETTING Menu - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\*(Use CLEAR key to back space or to correct the wrong value).

1: MAX VOLTAGE ◀ ▶ 2: MIN VOLTAGE ◀ ▶ 3: MAX CURRENT ◀ ▶ 4: MIN CURRENT ◀ ▶  
5: MAX RESISTOR ◀ ▶ 6: MIN RESISTOR ◀ ▶ 7: MAX POWER ◀ ▶ 8: MIN POWER

**1: MAX VOLTAGE**-----press ENTER key, input the maximum voltage then press ENTER.

**2: MIN VOLTAGE**-----press ENTER key, input the minimum voltage then press ENTER.

**3: MAX CURRENT**-----press ENTER key, input the maximum current then press ENTER.

**4: MIN CURRENT**-----press ENTER key, input the minimum current then press ENTER.

**5: MAX RESISTOR**-----press ENTER key, input the maximum resistance then press ENTER.

**6: MIN RESISTOR**-----press ENTER key, input the minimum resistance then press ENTER.

**7: MAX POWER**-----press ENTER key, input the maximum power then press ENTER.

**8: MIN POWER**-----press ENTER key, input the minimum power then press ENTER.

## E: STEPPING MODE Menu - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\*(Use CLEAR key to back space or to correct the wrong value).

1: LOOP NUMBER ◀ ▶ 2: STEP NUMBER

**1: LOOP NUMBER**-----press ENTER key twice, set # of loop count. 0 = infinite then press ENTER.

**2: STEP NUMBER**-----press ENTER key, use ◀ ▶ to select the step number ( 0 – 99 ) then press ENTER.

## **F: PROTECTION Menu** - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\* (Use **CLEAR** key to back space or to correct the wrong value).

1: OV PROTECTION ◀ ▶ 2: OV DELAY ◀ ▶ 3: UV PROTECTION ◀ ▶ 4: UV DELAY ◀ ▶ 5: OC PROTECTION ◀ ▶ 6: OC DELAY ◀ ▶ 7: UC PROTECTION ◀ ▶ 8: UC DELAY ◀ ▶ 9: OP PROTECTION ◀ ▶ 10: OP DELAY ◀ ▶ 11: UP PROTECTION ◀ ▶ 12: UP DELAY

- 1: OV PROTECTION**-----press ENTER key twice, input the over voltage protection then press ENTER.
- 2: OV DELAY**-----press ENTER key twice, input the over voltage delay then press ENTER.
- 3: UV PROTECTION**-----press ENTER key twice, input the under voltage protection then press ENTER.
- 4: UV DELAY**-----press ENTER key twice, input the under voltage delay then press ENTER.
- 5: OC PROTECTION**-----press ENTER key twice, input the over current protection then press ENTER.
- 6: OC DELAY**-----press ENTER key twice, input the over current delay then press ENTER.
- 7: UC PROTECTION**-----press ENTER key twice, input the under current protection then press ENTER.
- 8: UC DELAY**-----press ENTER key twice, input the under current delay then press ENTER.
- 9: OP PROTECTION**-----press ENTER key twice, input the over power protection then press ENTER.
- 10: OP DELAY**-----press ENTER key twice, input the over power delay then press ENTER.
- 11: UP PROTECTION**-----press ENTER key twice, input the under power protection then press ENTER.
- 12: UP DELAY**-----press ENTER key twice, input the under power delay then press ENTER.

## **G: SPECIAL FUNCTION Menu (Optional)** - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\* (Use **CLEAR** key to back space or to correct the wrong value).

1: INPUT RELAY ◀ ▶ 2: RECORD ◀ ▶ 3: PRINTER ON/OFF

- 1: INPUT RELAY**-----press ENTER key, use ◀ ▶ to enable / disable the input relay.
- 2: RECORD**-----press ENTER key twice, input the record value in mS, then press ENTER.
- 3: PRINTER ON /OFF**-----press ENTER key, use ◀ ▶ to select On / Off then press ENTER.

## **H: CAL. UTILITY Menu** - press ENTER key:

\*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.

\* (Use **CLEAR** key to back space or to correct the wrong value).

1: LOW MEAS POINT ◀ ▶ 2: HIGH MEAS POINT ◀ ▶ 3: TRANS OFFSET

- 1: LOW MEASURE POINT**-----press ENTER key twice, set the low measure count value then press ENTER.
- 2: HIGH MEASURE POINT**-----press ENTER key twice, set the high measure count value then press ENTER.
- 3: TRANSIENT OFFSET**-----press ENTER key twice, set the transient offset count then press ENTER.

## FUNCTION MENU REFERENCE

The Function reference allows the user to set the different system configurations such as Slew Rate, Duty Cycle, Frequency, and Pulse Time. It is to help users to do more functional testing in using FEL in the different situations or configurations. The Function reference is also the start of the tree structure, which enables the user to branch.

### FUNCTION Menu - press ENTER key:

- \*Use ◀ ▶ to select the next menu setting then press ENTER key to enter the selected menu.
- \* (Use CLEAR key to back space or to correct the wrong value).

1: SLEW ◀ ▶ 2: DUTY ◀ ▶ 3: FREQ ◀ ▶ 4: PULSE
--

- 1: SLEW**-----press ENTER key, input the slew rate value (uS) then press ENTER.
- 2: DUTY**-----press ENTER key, input the value of the duty cycle (%) then press ENTER.
- 3: FREQUENCY**-----press ENTER key, input the frequency (Hz) then press ENTER.
- 4: PULSE**-----press ENTER key, input the pulse time (mS) then press ENTER.

## SYSTEM FUNCTIONS

To enter a value for a particular function, please follow the correct key sequence indicated in the Utility Menu Function above. Press the "Utility/Local" to enter the utility command level then the ◀ ▶ keys to select the desired function. Then press the "ENTER" and ◀ ▶ keys to further select the next level of commands. Press the Enter key to confirm the selection.

For example to enter the Min Current value; press the "Utility/Local" key, then the ◀ or ▶ key until "Max/Min Setting" is displayed. Then press the "ENTER" key and the ◀ or ▶ key until the "Min Current" is displayed. Then press the "ENTER" key and enter the value for the Min Current setting.

You can press the "Clear" key repeatedly at any time to exit the function or mode level.

Measure Sense:           Local  
                              Remote

**<NOTE>: The FEL's voltage measuring points (positive and negative) can be configured in two locations. One is from the power input terminals called Local; the other is from the remote sense terminal block in the rear panel called Remote (Remote option is only available in certain models). The purpose of the Remote sense is for more accurate voltage measurement.**

Press the "Utility/Local" key then the "ENTER" key twice. Use ◀ ▶ keys to select the local and remote modes, and then press the "ENTER" key to confirm the selection. Press "Clear" key to escape the Measure Mode.

Remote Interface:       RS-232  
                              GPIB

This mode is to select the remote control interface, either RS-232 or GPIB. The FEL cannot be programmed or controlled by RS-232 and GPIB simultaneously, so the user can only use one interface control at a time.

**Press the "Utility/Local" key then ◀ ▶ keys to select the RS-232 and GPIB modes then press the "ENTER" key to confirm the selection. Press "CLEAR" key to escape the Remote Interface mode.**

Display Mode:	V + I (Voltage + Current)	V + C (Voltage + "C" operand)
	V + P (Voltage + Power)	I + P (Current + Power)
	C + P ("C" operand + Power)	

The LCD display module of the FEL can be configured to the different measuring combinations.

Press the "Utility/Local" key then the "ENTER" key. Use ◀ ▶ keys to select the Display Mode, and then press the "ENTER" key and ◀ ▶ keys to select the desired function. Press the "ENTER" key to confirm the selection. Press "CLEAR" key to escape the Display Mode.

"C" Value: 0.0000A

The FEL provides the "C" operand. This is especially useful for battery testing applications that use "C" as the battery capacity unit. The user can avoid troublesome calculations by monitoring and testing the battery directly. After the user changes the display combination to V + C, all current values entered and/or measured will be in "C" automatically.

Press the "Utility/Local" key then the "ENTER" key. Use ◀ ▶ keys to select the "C" value. Then the "ENTER" key twice and the desired value and "ENTER" to confirm. Press "CLEAR" to exit the "C" operand mode.

## ***GPIO FUNCTION***

The FEL provides the GPIO/SCPI interface control capability. The following are user configurable GPIO commands:

PRIMARY ADDR: 0 → 31

Primary address for GPIO interface has a range from 0 to 31.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the GPIO function, then the "ENTER" key. Use ◀ ▶ keys to select the PRIMARY ADDR function then use the ◀ ▶ keys to increase or decrease the GPIO address, then press the "ENTER" key to confirm the value. The number displayed with the "◀" annunciated behind it is the current selected value. Press the "CLEAR" to escape the Primary ADDR mode.

SECONDARY ADDR: 0 → 31

If the secondary addressing mode is activated, then the secondary address should be set and the GPIO addressing mode would become Primary + Secondary addressing.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the GPIO function then the "ENTER" key. Use ◀ ▶ keys to select the SECONDARY ADDR function then use the ◀ ▶ keys to increase or decrease the GPIO address, then press the "ENTER" key to confirm the value. The number displayed with the "◀" annunciated behind it is the current selected value. Press the "CLEAR" to escape the Secondary ADDR mode.

ADDRESS MODE: PRIMARY Only  
PRI+SECONDARY

The GPIO interface addressing is able to set two modes for addressing, Primary only and Primary + Secondary addressing. The GPIO interface communication is available for these two addressing methods.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the GPIO function then the "ENTER" key. Use ◀ ▶ keys to select the ADDRESS MODE then use the ◀ ▶ keys to select Primary only or Pri+Secondary address and press "ENTER" to confirm. Press "CLEAR" key to escape the ADDRESS MODE.

EOI CODE: NULL only  
CR only  
LF only  
CR + LF

In the GPIO communication, the users can define the different End of Interface (EOI) code for each end of the data or command.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the GPIB function then the "ENTER" key. Use ◀ ▶ keys to select the EOI function then use the ◀ ▶ keys to select the desired EOI code method and press "ENTER" key to confirm the selection. Press "CLEAR" key to escape the EOI CODE.

In the Transient mode, the FEL has 4 functions: continuous, stepping, pulse, and toggle. TRANS ON/OFF key can operate 4 types of functions depending on which mode is activated in the TRANSIENT MODE. If the TRANSIENT operation is activated, the TRANSIENT will be on after TRANS ON/OFF is activated. If the STEPPING mode is activated, then STEPPING will be enabled after TRANS ON/OFF key is activated.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the GPIB function then the "ENTER" key. Use ◀ ▶ keys to select the TRANSIENT MODE function by pressing the "ENTER" key then use the ◀ ▶ keys to select the CONTINUOUS, STEPPING, PULSE, or TOGGLE mode and press the "ENTER" key to confirm the selection. Press "CLEAR" key to clear the TRANSIENT MODE.

The FEL/FEL provides four different trigger TRANSIENT modes for different applications and testing procedures

For continuous mode, the trigger source comes from TRIGIN. Each trigger will switch FEL once between main level and transient level based on the duty cycle and frequency.

For pulse mode operation when amplitude and duration is programmed via GPIB or RS-232 bus. The trigger source comes from GPIB or external TTL trigger.

For toggle mode operation, the FEL will toggle once between main level and transient level whenever it receives a trigger signal from GPIB or external TTL trigger.

TRIGGER OUT:            TRANSIENT  
                             TRIGGER

TRIGGER OUT signal is for multiple loads or instrument application when user requires synchronizing of the input time, and trigger out signal to start another load or instrument.

TRANSIENT: Trigger out signal is in phase with transient signal generated from the FEL internal frequency generator.

## ***RS-232 FUNCTION***

The FEL provides an RS-232 interface for remote control. To save setup time for the RS-232 interface configuration, the FEL has default settings for parity check bit, data length, and stop bit.

Default settings:

Data Length: 8 bits	Parity Check bit: No Parity	Stop Bit: 1 bit
Handshake: Xon/Xoff	BAUD RATE:	38400 or 9600

The FEL only provide two-baud rate settings for RS-232 communication. Press the "Utility/Local" key, and then use the ◀ ▶ keys to select the RS-232 function then press the "ENTER" key twice to select BAUD RATE function. Use ◀ ▶ keys to toggle between 38400 and 9600 then press the "ENTER" key to confirm selection. Press "CLEAR" key to escape the BAUD RATE MODE.

## MAX/MIN SETTING FUNCTION

The following are special FEL MAX/MIN setting that protects the load from error data entry for specific settings or power sources that could cause damage to unit.

MAX VOLTAGE - Max V	MIN CURRENT - 0.0000 A	MAX POWER - Max W
MIN VOLTAGE - 0.000V	MAX RESISTANCE - Max OHM	MIN POWER - 0.00 W
MAX CURRENT - Max A	MIN RESISTANCE - 0.00 OHM	

To change the values, press the "Utility/Local" key then use the ◀ ▶ keys to select the Max/Min Settings function then the "ENTER" key. Use ◀ ▶ keys to select the appropriate Min/Max setting by pressing the "ENTER" key. The LCD will display the current value, press the "ENTER" key to enter a new value and press the "ENTER" key to confirm entry. Press "CLEAR" key to escape the Max/Min Setting MODE.

## STEPPING OPERATION SET-UP



### WARNING

Every time the Stepping mode is enabled, it is critical that you re-enter or check for the correct number steps in the STEP NUMBER function under Utility/Stepping mode to avoid initiating erroneous step. If the value is set higher than expected the system may perform previous steps that may exceed the power rating for the application and may damage the FEL or power source.

***All steps must be in the same constant mode (CV, CC, CR, and CP). Stepping error will occur if different modes are programmed.***

## STEPPING FUNCTION

The FEL provides 99 points for self-program stepping capability. Parameters are entered in the UTILITY configuration for the total number of steps to process and the number of loops that you want the steps repeat.

STEPPING:                      STEP NUMBER  
                                    LOOP NUMBER

STEP NUMBER is the total number of steps in a loop process that commands the FEL to perform or commands a specific function. For instance, the STEP NUMBER is set to 5, then the step procedure would start from step 0 to step 5, total of 6 steps. The STEP NUMBER range is from 0 to maximum of 99.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the STEP NUMBER function then the "ENTER" key. Use ◀ ▶ keys to select the STEP number then press the "ENTER" key twice to enter the value. Press the "ENTER" key to confirm the selection. Press "CLEAR" key to escape the STEP NUMBER MODE.

LOOP NUMBER is the number of loops the step program will be repeated. The stepping function provides loop control with LOOP NUMBER, which instructs the FEL to repeat the stepping function, based on the LOOP NUMBER. For instance, LOOP NUMBER is set to 10 and the FEL will cycle the desired steps 10 times. If the LOOP NUMBER is 0, then FEL will cycle the stepping infinitely.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the LOOP NUMBER function then the "ENTER" key. Use ◀ ▶ keys to select the LOOP number then press the "ENTER" key twice to enter the value or use the ◀ ▶ keys to increment or decrement the value. Press the "ENTER" key to confirm the selection. Press "CLEAR" key to escape the LOOP NUMBER MODE.

The FEL provides 99 points for self-programming capability for which parameters can be programmed in the Utility function. This feature allows the users to create a mini program and automate the control of the FEL without the need of computer, GPIB or RS-232 communication interface. The user is able to set Programming Points, Loop Number, and Time Duration.

## ***STEP NUMBER***

When the stepping operation starts, the FEL will program the input based on the preset programming points from step 0 to N step, where N equals the total number of steps set in the STEPPING configuration under UTILITY.

## ***ENTERING STEPPING MODE VALUES***

Example:

The test application requires (3) steps to be performed in the Stepping Mode with the following criteria. Step (1) in the CC mode with 5 amps for 800 mS, step (2) in the CC mode with 10 amps for 400 mS, and step (3) in the CC mode with 50 amps for 200 mS.

**<NOTE>: CC Mode has 2 ranges. Therefore, if stepping values are in the high range, main level value must be set to high range.**

1. Set the Stepping enable mode by toggling the /Stepping mode to Stepping via the Utility -> GPIB-> Transient Mode. Once in the Transient Mode use the ◀ ▶ keys to select STEPPING and press ENTER key to confirm.
2. Set the Step Number - enter the total number of steps that will be processed via the Utility -> Stepping mode.
3. Set the Loop Number - enter the number of time the steps will be repeated.
4. Set step value - press "5" key to enter step edit mode, press MODE key then "4" key to set CC mode then the ENTER key to confirm. Press the "9" key to edit the stored amps value. After you have entered the new amps value (5.0) press enter to confirm. Press "7" key to edit the stored time value. After you have entered the new time value (800) press enter to confirm.
5. Set step (2) values - Use the "▲" key to increment to the next step number and press enter to confirm. Press MODE key then "4" key to set CC mode then the ENTER key to confirm. Press the "4" key to edit the stored amps value. After you have entered the new amps value (10.0) press enter to confirm. Press "7" key to edit the stored time value. After you have entered the new time value (400) press enter to confirm.
6. Set step (3) values - Use the "▲" key to increment to the next step number and press enter to confirm. Press MODE key then "4" key to set CC mode then the ENTER key to confirm. Press the "9" key to edit the stored amps value. After you have entered the new amps value (50.0) press enter to confirm. Press "7" key to edit the stored time value. After you have entered the new time value (200) press enter to confirm. Press clear to return to Main operation mode.
7. To start the Stepping mode presses the "0" key to turn the INPUT ON.
8. To enable the Stepping mode press "1" key, then the ST should be displayed.
9. The INPUT will be turned off automatically when the program completes the number of step and loops.

**To edit any entry press the "5" key and use the "◀ ▶ ▲ ▼" to select the appropriate step number, then press ENTER to edit the step. Use the "▲ ▼" keys to increment or decrement the selected step by (1). Use the "◀ ▶" keys to increment or decrement the selected step by (10). To re-run the steps just press the "0".**

## ***PROTECTION FUNCTION***

OV PROTECTION  
OV DELAY  
UV PROTECTION  
UV DELAY  
OC PROTECTION  
OC DELAY

UC PROTECTION  
UC DELAY  
OP PROTECTION  
OP DELAY  
UP PROTECTION  
UP DELAY

FEL provides programmable OVP/OCPP/OPP and UVP/UCP/UPP over-limit and under-limit protection capabilities. The user can program all of the protection values and delay times. Protection will be activated when the protection mode has been tripped the FEL will interrupt the input power source. The delay time provides a programmed delay time to accommodate short duration surges without inadvertently tripping the unit off.

The delay time is 10mS minimum with resolution 10mS also. The protection can be disabled by setting the delay time to 0mS.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the PROTECTION function then the "ENTER" key. Use ◀ ▶ keys to select the appropriate protection or delay function by pressing the "ENTER" key to display the current value. Press the "ENTER" key to edit or enter the new value then press the "ENTER" key to confirm entry. Press "CLEAR" key to escape the PROTECTION MODE.

FAULT signal becomes active TTL high, whenever any of the protections, above, are tripped. When this occurs, the appropriate bits in the status register are set and the fault signal is latched. The status bits will remain set until the electronic load is reset via the GPIB or RS232 (\*RST command) or at the front panel (CLEAR key). Of course, the condition that caused the protection feature to trip must be corrected or the load will turn off again.

**<NOTE>: Because the protection is done through software, the response time for the delay trip time must be set to at least 50mS for each protection feature. Otherwise the load may not reset correctly if the trip delay time is too short.**

## ***RECORD FUNCTION (Optional)***

RECORD Setting:                      RECORD INTERVAL  
    RECORD CLEAR  
    PRINTER ON/OFF

The FEL provide 255 points of recording capability to help the user store test data without extra devices.

The RECORD INTERVAL is the time interval between desired recording points. The interval time can be set from 10mS to 600,000mS. Once the FEL INPUT has been enabled, recording is activated based on the preset interval time. Recording will be **stopped after** FEL INPUT has been disabled. If the Record Interval value is 0 (zero) the recording mode is disabled.

Press the "Utility/Local" key then use the ◀ ▶ keys to select the RECORD function then the "ENTER" key. Use the ◀ ▶ keys to select RECORD INTERVAL then press "ENTER" to display the current value. Press the "ENTER" key to edit or enter the new value then the "ENTER" key to confirm. Press "CLEAR" key to exit the RECORD MODE.

To review the recording data press the "3" key then use ◀ ▶ ▲ ▼ keys to retrieve the data from memory. All data is stored in the non-volatile memory, therefore the data will not be erased even after the power to the unit has been turned off. If the record feature is allowed to continue past 255 point, the first records will be erased. In other words memory is wrap around only 255 recording points are stored.

RECORD CLEAR erases the data in the memory, press the "3" key first then the "Utility/Local" key to clear all records in memory.



PRINTER ON/OFF toggles the printer enable mode and will print the recorded data to the local printer via RS-232 port. The printer will not function when the FEL is in the "RMT" mode should be set to local "LCL".

Press the "Utility/Local" key then use the ◀ ▶ keys to select the RECORD function then the "ENTER" key. Use the ◀ ▶ keys to select PRINTER ON/OFF mode and then press the "ENTER" key to select the mode. You can toggle the mode on or off with the ◀ ▶ keys and press the "ENTER" to confirm. Press "CLEAR" key to escape the RECORD MODE.

Recorded data will be sent to the printer via RS-232 port if the following conditions are set:

1. Printer ON/OFF is set to ON
2. Time interval is greater than or equal to 1000mS
3. FEL INPUT is ON
4. A printer (optional) is connected to the FEL's RS-232 port with a straight pin to pin cable. The FEL's D-Sub Female connector's TXD and RXD pins are internally swapped. Do not use a Null Modem Cable.
5. FEL is in local communication mode when "LCL" is displayed on LCD

## ***PROGRAMMING POINTS***

There are 100 programmable points available from step 0 to step 99 for self-programming and can be user define as needed. During operation, the user can program each point from the front panel keypad, GPIB, or RS-232.

## ***LOOP NUMBER***

Loop number controls the number of times the stepping operation will repeat (value from 0 to 99). Zero (0) stands for infinite number of loops the FEL will run. FEL stepping operation will run the indicated number specified loops other than zero.

## ***TIME DURATION***

The resolution for the time duration is 10mS and the minimum interval is 10mS. If the interval is set to 0mS, then this step will be skipped in the stepping operation.

## ***ENTERING TRANSIENT MODE VALUES***

Example:

The test application requires the main operation to be at 25 volts in a CV mode and a Transient test voltage of 50.0 volts, Frequency of 500Hz, Slew rate of 1.0 volt/ $\mu$ s, and a 50% Duty cycle.

1. Set the Transient enable mode by toggling the Continuous/Stepping/Pulse/Toggle mode to Continuous via the Utility -> GPIB-> Transient Mode. Once in the Transient Mode use the ◀ ▶ keys to select Transient and press ENTER key to confirm.
2. Set CV mode - press MODE key and the "7" key to set the main operation to CV mode.
3. Set main voltage level - press the MAIN key to enter main voltage edit mode and view stored voltage value. After you have entered the new voltage value (25.0) press ENTER to confirm.
4. Set Transient voltage value - press TRANS key to enter transient voltage edit mode and view stored voltage value. After you have entered the new voltage value (50.0) press ENTER to confirm.
5. Set transient Frequency - press the FUNCTION key and use the "◀ ▶" to select FREQUENCY and press enter key to edit or change stored value to 500 Hz then press ENTER to confirm.
6. Set transient Slew rate - press the FUNCTION key and use the "◀ ▶" to select SLEW and press enter key to edit or change stored value to 1.0 volt/ $\mu$ s then press ENTER to confirm.
7. Set transient Duty Cycle - press the FUNCTION key and use the "◀ ▶" to select DUTY and press enter key to edit or change stored value to 50% then press ENTER to confirm.
8. To enable the Transient mode at start-up press "1" key, then the TR should be displayed. You can also initiate a transient condition by pressing the "1" on or off any time by during normal operation.
9. To start the Transient mode at start-up initial input enable press the "0" key to turn the INPUT ON.

The Transient condition will terminate after the elapse slew rate has reached the transient setting level then return to main operating settings.

## ***TRANSIENT FREQUENCY, SLEW RATE AND DUTY CYCLE PROGRAMMING***

The transient frequency, slew rate and duty cycle can be programmed with the “FUNC” key via the keypad.

1. Press the “FUNC” key to access the transient frequency, slew rate and duty cycle editing mode and LCD module will display the last FREQ, SLEW, and DUTY in sequence by pressing “◀ ▶” to select desired function.
2. To change existing values to the appropriate parameter press the “ENTER” key to activate the edit entry mode.
3. For Frequency programming editing, the LCD module will display the following:

FREQ = 1000                      Hz

4. Enter the following numerical keys “2”, “0”, “0”, “.” and “0” keys in sequence in order to change the Frequency to 200Hz.
5. Make sure that the entered number is correct and press “ENTER” key to complete the entry operation.
6. Press “CLEAR” key to return to the metering mode. By pressing the "Clear" with no entry will display AMREL Model number and software version.

## ***TRANSIENT MODE***

Amrel's Programmable Electronic Load can facilitate testing sources and load simulation through the use of its internal transient generator. This transient capability allows the user to determine operating specifications for instruments such as a power supply. This capability also allows for pulse-charging a battery and for simulating battery drain.

### ***LOCAL TRANSIENT OPERATION***

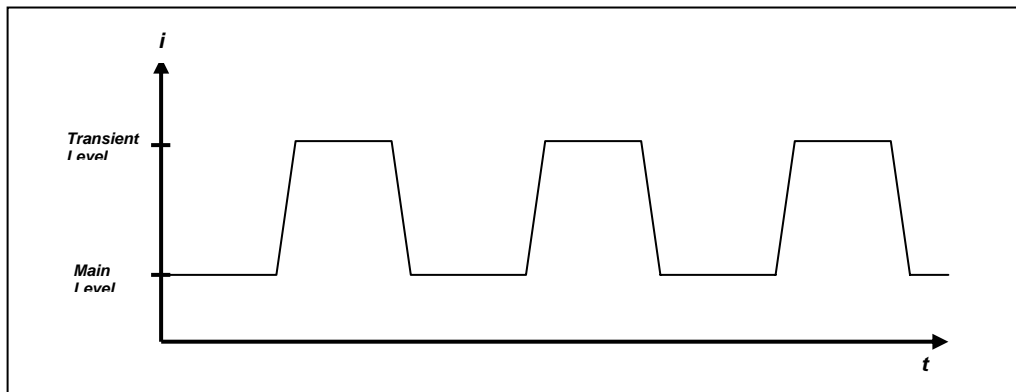
LCL Operation:

From keypad, press the "Utility/Local" key. Use ◀ ▶ and "Enter" keys to select the following submenus:

UTILITY/LOCAL→GPIB→TRANSIENT MODE→**CONTINUOUS**  
→**STEPPING**  
→**PULSE**  
→**TOGGLE**

### **CONTINUOUS MODE**

In continuous mode, the FEL input switches between 2 user defined levels; main and transient. The duty cycle and frequency is user defined.



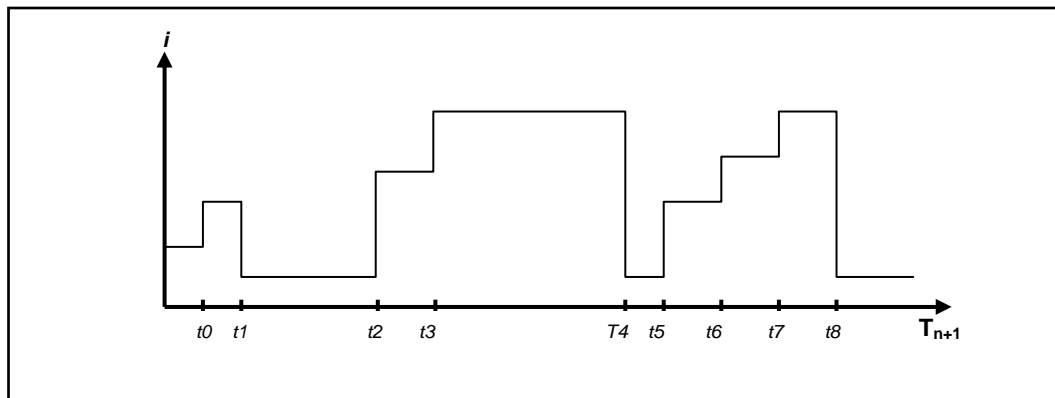
Typical application: Testing the Load Regulation (Effect) of a power Supply, defined as the voltage change in dc output due to a change in load current from minimal resistance (closed circuit) to maximum resistance (open circuit). The FEL Load can be programmed to switch between any two current levels.

LCL Operation:

- From keypad select operating mode (CC, CV, CR, CP)
- Select transient operation for continuous mode.
- Set MAIN and TRANSIENT levels by pressing the "MAIN" and "TRANS" keys.
- Set the duty cycle and frequency by pressing the "Function" key and selecting the DUTY and FREQUENCY submenus. The duty cycle can be set from 2% to 98% and the frequency from 0.1Hz to 20 KHz.
- To begin the transient operation, turn on the input and press the "TR ON/OFF". The LCD will display "ON TR".

## **STEPPING MODE**

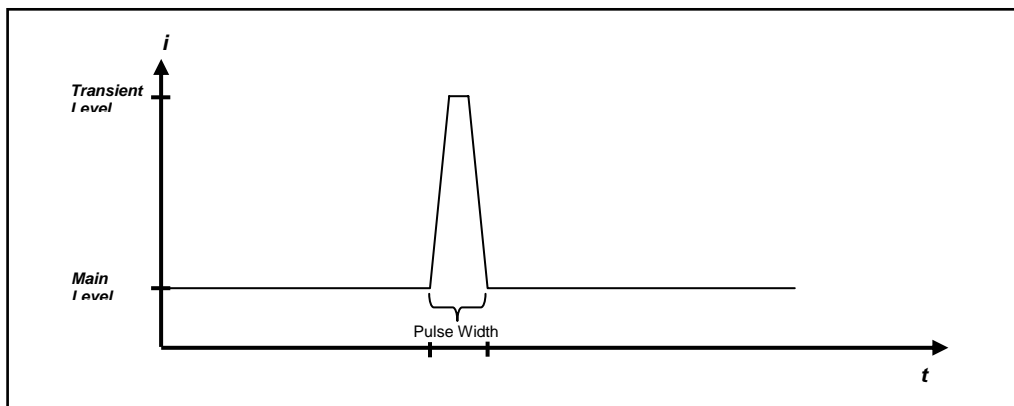
In stepping mode the FEL generates customized sequence of different input levels up to a maximum of 99 steps (points), with dwell times from 10ms to a 10seconds. This sequence can be cycled once or to a user-defined number of cycles. Stepping can be triggered with GPIB command “\*TRG” or an external TTL signal.



**Typical Application:** Simulating battery drain for testing portable, battery powered products. A cellular phone, for example, has complex battery discharge characteristics due to its different operating modes. A load profile can be created using the FEL load to simulate those characteristics.

## **PULSE MODE:**

In pulse mode, the FEL generates a pulse with a user-defined amplitude and width. The pulse width can be set from **0.05ms to 10seconds**.



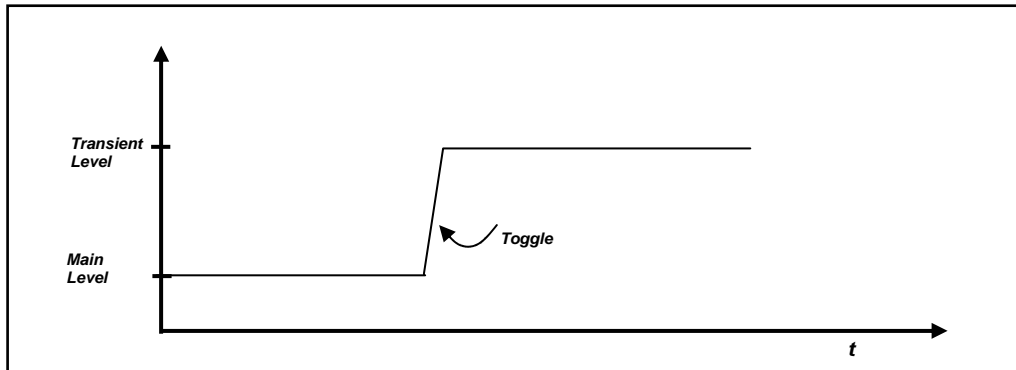
**Typical Application:** Testing the transient recovery time for a CV power supply. The recovery time for a power supply is defined as the time required for the supply to settle to a predefined settling band following a change in load current caused by an induced transient (pulse).

### **LCL Operation:**

- From keypad select operating mode (CC, CV, CR, CP)
- Select transient operation for pulse mode.
- Set MAIN and TRANSIENT levels by pressing the “MAIN” and “TRANS” keys.
- Set the pulse width by pressing the “Function” key and selecting the PULSE submenu
- To begin the transient operation, turn on the input and press the “TR ON/OFF. The LCD will display a flashing “PS” to indicate that the power supply is in pulse mode.

## **TOGGLE MODE:**

In toggle mode, the FEL input alternates between two user-defined input levels. Unlike transient-continuous mode, the input only changes from one level to another, one transition at a time.



Typical Application: Testing the transient recovery time for a CV power supply. The recovery time for a power supply is defined as the time required for the supply to settle to a predefined settling band following a change in load current caused by an induced transient (pulse).

LCL Operation:

- From keypad select operating mode (CC, CV, CR, CP)
- Select transient operation for toggle mode.
- Set MAIN and TRANSIENT levels by pressing the “MAIN” and “TRANS” keys.
- To begin the toggle operation, turn on the input and press the “TR ON/OFF”. The LCD will display a flashing “TG” to indicate that the FEL is in toggle mode.

***All the operating modes can be programmed via the front panel or by way of the GPIB/RS232 Interface. In addition, each transient can be triggered through an external TTL compatible signal.***

## **FOUR: REMOTE PROGRAMMING**

### ***INTRODUCTION***

The Programming Electronic Load is provided with GPIB and RS-232 Standard Commands for Programmable Instruments (SCPI) interface for automated testing applications. The purpose of this section is to introduce the user to SCPI commands used to control the FEL via remote communication.

### ***INTRODUCTION TO GPIB & RS-232 (SCPI) COMMANDS***

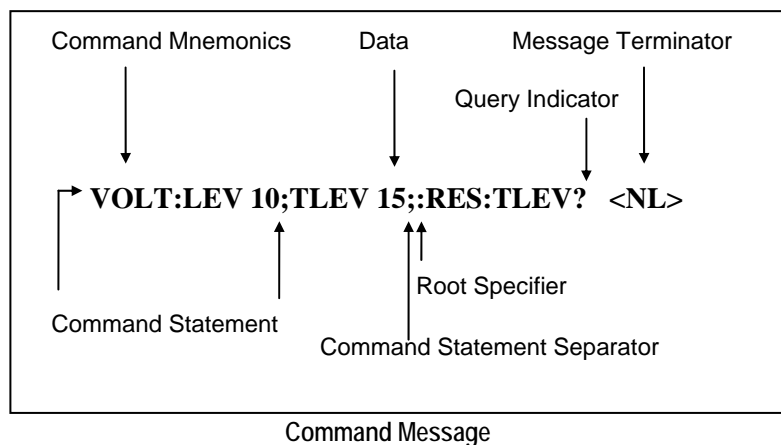
The General Purpose Interface bus is synonymous with HP-IB standard bus used for controlling electronic instruments with a computer. Also called IEEE 488 bus because ANSI/IEEE Standards 488-1978 defines it, 488.1-1987, and 488.2-1987.

Standard Commands for Programmable Instruments (SCPI) is a programming language developed to remotely control different test and measurement instruments over GPIB (IEEE 488) bus. SCPI functions with GPIB hardware conform to the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. It is a device independent command set and is layered on top of the hardware portion of IEEE 488.2. SCPI simplifies the programming task by defining a single comprehensive command set of programmable instrumentation, regardless of type or manufacturer. The same SCPI command can be applied to different classes of instruments. SCPI systems are much easier to program and maintain. In many cases, you can interchange or upgrade instruments without having to change the test program. SCPI also applies to RS-232 programming.

The electronic load's GPIB address cannot be set via GPIB bus communication or program. The address needs to be set from the front panel keypad in the UTILITY function.

## OVER VIEW SCPI LANGUAGE

The SCPI language uses a hierarchical structure in its programming syntax similar to an inverted tree. The command is organized with root level commands positioned at the top, with multiple sub commands below each root-level command. For example, **VOLTage**, which is a branch of **SOURce**, is a command mnemonic and it forms a subtree of its own. **VOLTage** has three sub-level commands: **LEVel**, **SLEW**, **TLEVel**. At the end of a sub-level command, you can attach a parameter, a question mark (for query), a colon (command mnemonics separator), a semicolon (for multiple commands in a message) or an end of line terminator. To execute a sub-level command, you must specify the complete path from root-level. Each command statement is simply I/O ASCII data strings incorporated within high-level programming language (GW-BASIC, HP BASIC, Quick Basic, Pascal, etc.).



### Syntax Overview

#### Use of the Colon ( : )

A colon is used to separate command mnemonics. It indicates a move down in branch level of the command tree. The command following a colon is a sub command of the command immediate before the colon. When a colon precedes the first command mnemonic of a message unit, it becomes a root specifier. Its action places the parser (decoder) at the root of the command tree. The parser can only travel downward the command tree. If another command at a different branch needs to be executed, a root specifier (colon) is required to place the parser at the origin and a complete path from the root level should also be defined.

#### Use of the Semicolon ( ; )

A semicolon is used to separate two command statements with the same command message string. The semicolon does not change the location of the parser in the command tree. Only command statements that are in the current path of the first command statement can be combined to form a command message.

#### Use of the Space ( )

A white space is used to separate a parameter (data) from a command mnemonic. When a command statement includes a parameter, data always follows the last keyword of a command.

#### Use of the Comma ( , )

A comma is used to separate adjacent parameters if a command requires more than one parameter.

#### Use of the Query ( ? )

A query command is used to instruct the instrument to send a response message. Queries return either measured values or internal instrument settings. When a keyword is followed by a question mark, it becomes a query. The ? follows the last keyword of a command statement. You should read back the result of the first query before you send out another query or command. Otherwise, returned data will be lost.

#### Common Commands:

Commands starting with a \* and three-letter mnemonic are called common commands. They are generally not related to specific device operation but to perform the identical function for all instruments that are compliant with the IEEE-488.2 interface standard. Common commands can be mixed in with



regular Electronic Load commands. The common command will be executed without affecting the position of the parser.

#### Root-Level Commands:

The root-level commands are those commands specific to the Electronic Load. They are device specific and can be mixed with common commands.

## ***LANGUAGE DICTIONARY***

The syntax and parameters for the IEEE 488.2 common commands and SCPI commands used by the Electronic Load is presented in this section. The section starts with description for common commands and then follows by SCPI commands specific to the electronic load.

## ***COMMANDS STRUCTURE***

The electronic load has two command types for GPIB and RS-232 interface.

### **Programming commands**

Query commands

System commands

Programming commands send programming instructions or values to the electronic load to control the CV/CC/CR/CP functions. There are two types of commands, the SCPI command and instruction commands that co-exist in the program. SCPI commands should adhere to their syntax and format structure (command line) in order to be properly process by the electronic load.

Query commands request measured values, status, or programmed settings from the electronic load.

System commands belong to the GPIB bus system commands list to controls GPIB bus condition and electronic load interface system. Some commands are not compatible with RS-232 interface.

## SCPI (GPIB & RS-232) COMMAND SET

The following describes the GPIB (IEEE488.2) command set for the Programmable Electronic Load Series. All the electronic load commands follow SCPI format and are RS232 compliant. The **commands in brackets are implicit** and don't have to be written out. The letters in bold is the short form syntax of the command mnemonic. For example, the command **CURRent**[:**LEVel**][:**IMMediate**] has the following equivalent forms:

```
CURRent:LEVel:IMMediate 5
CURRent:IMMediate 5
CURR:IMM 5
CURR 5
```

All of the above commands will set the Current value to 5Amps.

**\*NOTE:** The parameters **MIN** and **MAX** designate minimum and maximum programmable value of the range.

*Queries for each of the following commands can be obtained by placing a question mark after the command syntax.  
Example: CURR?*

### **CURRent** ⇒ Current Programming Functions

This subsystem programs the constant current mode functions of the Electronic Load. The IEEE 488.1 command, "ISET" and "SET" (if current active mode is CC mode), can also be used.

### **CURR**

This command sets the input current level that is to be applied immediately in the constant current mode. If the Electronic Load is not in the CC mode when the command is sent, the programmed level is saved and is applied when the Load changes to CC mode. The rate of input change is in accord with the slew rate in effect.

Parameter:	0 to maximum value; MIN; MAX	Units: Amp.
Example:	"CURR 50" – sets current input level to 50Amps	

### **CURR:PROT:OVER**

This command sets a protection limit to the input current that the Electronic Load will sink. When the input current reaches the programmed current limit for the programmed delay period, the Electronic Load input is off and draws no current.

Parameter:	0 to maximum value; MIN; MAX	Units: Amp.
Example:	"CURR:PROT:OVER 12"- sets the over-current protection to 12 Amps.	

### **CURR:PROT:OVER:DEL**

This command sets the delay time in millisecond for current protection. When the input current reaches the programmed current limit for the programmed delay period, the Electronic Load input is off and draws no current.

Parameter:	0 to maximum value;	Units: ms.
Example:	"CURR:PROT:OVER:DEL 200"- sets the over-current protection delay time to 200 ms.	

### **CURR:PROT:UND**

This command sets an undercurrent protection limit to the input current that the Electronic Load will sink. When the input currents falls below the undercurrent protection limit for the programmed delay period, the load input is off and draws no current.

Parameter:	0 to maximum value; MIN; MAX	Units: Amp.
Example:	"CURR:PROT:UND 1.5"- sets the undercurrent protection to 1.5 Amps.	

### **CURR:PROT:UND:DEL**

This command sets the delay time for under-current protection. When the input currents falls below the undercurrent protection limit for the programmed delay period, the load input is off and draws no current.

Parameter: 0 to maximum value Units: ms  
Example: "CURR:PROT:UND:DEL 500"- sets the undercurrent protection delay to 500 ms.

### **CURR:TRIG**

This command sets the input current level that is to be applied on occurrence of a trigger in the constant current mode. If the Electronic Load is not in the CC mode when the command is sent, the programmed TRIG level becomes a stored level that takes effect when the Load changes to CC mode. The rate of input change is in accord with the slew rate in effect.

Parameter: 0 to maximum value; MIN; MAX Units: Amp.  
Example: "CURR:TRIG 10" – sets the current trigger level to 10Amps.

### **CURR:TLEV**

This command sets the transient current level in CC mode. When the transient subsystem is on, the Electronic Load will switch between the main level and transient level at a rate determined by the slew rate in effect. If the programmed transient current level is below the main current level, the switching will not occur until the main level is below the value of CURR:TLEV. The IEEE 488.1 command, "ITR" can also be used.

Parameter: Low Range: 0 to maximum value; MIN; MAX Units: Amp.  
High Range: 0 to maximum value; MIN; MAX  
Example: "CURR:TLEV 30"- sets the current transient level to 30A.

### **CURR:DUTY**

This command sets pulse duty cycle, as a percentage of the total cycle, of continuous transient mode in CC mode. If the Electronic Load is operating in another mode, the duty cycle is stored until the Load changes to continuous mode.

Parameter: 2 to 98; MIN; MAX Unit: %  
Example: "CURR:DUTY 50" – sets a 50% duty cycle for transient current mode.

### **CURR:FREQ**

This command sets pulse frequency of continuous transient mode in Hz. If the Electronic Load is operating in another mode, the pulse frequency is stored until the Load changes to continuous mode.

Parameter: 0.25 to 20000; MIN; MAX Unit: Hz  
Example: "CURR:FREQ 1000" – sets a 1000Hz frequency for transient current mode.

### **CURR:SLEW**

This command sets the current slew rate for both ranges in CC mode. The programmed slew rate is in effect for all current changes except INP:ON or OFF. The hardware implementation selects a slew rate that is closet to the CURR:SLEW value. To determine the actual value, use the query CURR:SLEW?.

Parameter: Low Range: minimum to maximum value; MIN; MAX Units: Amp/μs.  
High Range: minimum to maximum value; MIN; MAX  
Example: "CURR:SLEW 0.1" - sets the current slew rate to 0.1A/μs.

### **CURR:LIM:MAX**

This command sets and queries the maximum input current level that is to be applied immediately in the constant current mode.

Parameter: 0 to maximum value; MIN; MAX Units: Amp.  
Example: "CURR:LIM:MAX 50" – sets maximum current input level to 50Amps

### **CURR:LIM:MIN**

This command sets and queries the minimum input current level that is to be applied immediately in the constant current mode.

Parameter: 0 to maximum value; MIN; MAX Units: Amp.  
Example: "CURR:LIM:MIN 50" – sets minimum current input level to 50Amps

## **RESistance ⇒ Resistance Programming Functions**

This subsystem programs the constant resistance mode functions of the Electronic Load. The IEEE488.1 command, “RSET” and “SET” (if current active mode is CR mode), can also be used.

### **RES**

This command sets the input resistance level that is to be applied immediately in the constant resistance mode. If the Electronic Load is not in the CR mode when the command is sent, the programmed level is saved and is applied when the Load changes to CR mode. The rate of input change is in accord with the slew rate in effect.

Parameter:	Low Range: minimum to maximum value; MIN; MAX Middle Range: minimum to maximum value; MIN; MAX High Range: minimum to maximum value; MIN; MAX	Units: $\Omega$
Example:	“RES 5” – sets the resistance level to 5ohms.	

### **RES:TRIG**

This command sets the input resistance level that is to be applied on occurrence of a trigger in the constant resistance mode. If the Electronic Load is not in the CR mode when the command is sent, the programmed TRIG level becomes a stored IMM level that takes effect when the Load changes to CR mode. The rate of input change is in accord with the slew rate in effect.

Parameter:	minimum to maximum value; MIN; MAX	Units: $\Omega$
------------	------------------------------------	-----------------

### **RES:TLEV**

This command sets the transient resistance level in the CR mode. When the transient subsystem is on, the Electronic Load will switch between the main level and transient level at a rate determined by the slew rate in effect. The IEEE 488.1 command, “RTR” can also be used. The input resistance transient switching will occur only when RES:TLEV is programmed as following:

Low Range	TLEV>LEV	
Middle and high range	TLEV<LEV	
Parameter:	minimum to maximum value; MIN; MAX	Units: $\Omega$
Example:	“RES:TLEV 15” – sets the resistance transient level to 15ohms.	

### **RES:DUTY**

This command sets pulse duty cycle, as a percentage of the total cycle, of continuous transient mode in CR mode. If the Electronic Load is operating in another mode, the duty cycle is stored until the Load changes to continuous mode.

Parameter:	2 to 98; MIN; MAX	Unit: %
Example:	“RES:DUTY 50” – sets a 50% duty cycle for transient current mode.	

### **RES:FREQ**

This command sets pulse frequency of continuous transient mode in Hz. If the Electronic Load is operating in another mode, the pulse frequency is stored until the Load changes to continuous mode.

Parameter:	0.25 to 20000; MIN; MAX	Unit: Hz
Example:	“RES:FREQ 1000” – sets a 1000Hz frequency for transient current mode.	

### **RES:SLEW**

This command sets the current slew rate for both ranges in CR mode. The programmed slew rate is in effect for all current changes except INP:ON or OFF. The hardware implementation selects a slew rate that is closest to the RES:SLEW value. To determine the actual value, use the query RES:SLEW?.

Parameter:	Low Range: minimum to maximum value; MIN; MAX High Range: minimum to maximum value; MIN; MAX	Units: Ohm/ $\mu$ s.
Example:	“RES:SLEW 0.1” - sets the resistance slew rate to 0.1A/ $\mu$ s.	

### **RES:LIM:MAX**

This command sets and queries the maximum input resistance level that is to be applied immediately in the CR mode.

Parameter:	0 to maximum value; MIN; MAX	Units: Ohm.
Example:	“RES:LIM:MAX 50” – sets maximum resistance input level to 50 Ohms.	

### **RES:LIM:MIN**

This command sets and queries the minimum input resistance level that is to be applied immediately in the CR mode.

Parameter: 0 to maximum value; MIN; MAX Units: Ohm.  
Example: "RES:LIM:MIN 50" – sets minimum resistance input level to 50 Ohms.

### **VOLTage ⇒ Voltage Programming Functions**

This subsystem programs the constant voltage mode functions of the Electronic Load. The IEEE488.1 command, "VSET" and "SET" (if current active mode is CV mode), can also be used.

### **VOLT**

This command sets the input voltage level that is to be applied immediately in the constant voltage mode. If the Electronic Load is not in the CV mode when the command is sent, the programmed level is saved to be applied when the Load changes to CV mode. The rate of input change is in accord with the slew rate in effect.

Parameter: 0 to maximum value; MIN; MAX Unit: Volt  
Example: "VOLT 120" – sets the voltage level to 120V.

### **VOLT:PROT:OVER**

This command sets a protection limit to the input voltage that the Electronic Load will shunt. When the input current reaches the programmed voltage limit for the programmed delay period, the Electronic Load input is off and shunts no voltage.

Parameter: 0 to maximum value; MIN; MAX Units: Volt.  
Example: "VOLT:PROT:OVER 12" – sets the over voltage protection to 12 Volts.

### **VOLT:PROT:OVER:DEL**

This command sets the delay times in millisecond for over-voltage protection. When the input voltage reaches the programmed voltage limit for the programmed delay period, the Electronic Load input is off and shunts no voltage.

Parameter: 0 to maximum value; MIN; MAX Units: ms  
Example: "VOLT:PROT:OVER:DEL 1000" – sets the over voltage protection delay to 1000 ms.

### **VOLT:PROT:UND**

This command sets an under voltage protection limit to the input voltage that the Electronic Load will shunt. When the input voltage falls below the under voltage protection limit for the programmed delay period, the load input is off and shunts no voltage.

Parameter: 0 to maximum value; MIN; MAX Units: Volt.  
Example: "VOLT:PROT:UND 1.5" – sets the under voltage protection to 1.5Volts.

### **VOLT:PROT:UNDER:DEL**

This command sets the delay times in millisecond for under-voltage protection. When the input voltage falls below the programmed the under voltage protection limit for the programmed delay period, the Electronic Load input is off and shunts no voltage.

Parameter: 0 to maximum value; Units: ms  
Example: "VOLT:PROT:UNDER:DEL 1000" – sets the under voltage protection delay to 1000 ms.

### **VOLT:TRIG**

This command sets the input voltage level that is to be applied on occurrence of a trigger in the constant voltage mode. If the Electronic Load is not in the CV mode when the command is sent, the programmed TRIG level becomes a stored IMM level that takes effect when the Load changes to CV mode. The rate of input change is in accord with the slew rate in effect.

Parameter: 0 to maximum value; MIN; MAX Unit: Volt  
Example: "VOLT:TRIG 100" – sets the voltage trigger value to 100V.

### **VOLT:TLEV**

This command sets the transient voltage level in CV mode. When the transient subsystem is on, the Electronic Load will switch between the main level and transient level at a rate determined by the slew rate in effect. If the programmed transient voltage level is below the main voltage level, the switching will not occur until the main level is below the value of VOLT:TLEV. The IEEE488.1 command, "VTR" can also be used.

Parameter: 0 to maximum value; MIN; MAX Unit: Volt  
Example: "VOLT: TLEV 50" – sets the voltage trigger level to 50V

### **VOLT:SLEW**

This command sets the voltage slew rate in CV mode. The programmed slew rate is in effect for all voltage changes except INP:ON or OFF. The hardware implementation selects a slew rate that is closest to the VOLT:SLEW value. To determine the actual value, use the query VOLT:SLEW?.

Parameter: 0 to maximum value; MIN; MAX Unit: V/μs  
Example: "VOLT:SLEW 6" – sets the voltage slew rate to 6V/μs

### **VOLT:DUTY**

This command sets pulse duty cycle, as a percentage of the total cycle, of continuous transient mode in CV mode. If the Electronic Load is operating in another mode, the duty cycle is stored until the Load changes to continuous mode.

Parameter: 2 to 98; MIN; MAX Unit: %  
Example: "VOLT:DUTY 50" – sets a 50% duty cycle for transient voltage mode.

### **VOLT:FREQ**

This command sets pulse frequency of continuous transient mode in Hz. If the Electronic Load is operating in another mode, the pulse frequency is stored until the Load changes to continuous mode.

Parameter: 0.25 to 20000; MIN; MAX Unit: Hz  
Example: "VOLT:FREQ 1000" – sets a 1000Hz frequency for transient voltage mode.

### **VOLT:LIM:MAX**

This command sets and queries the maximum input voltage level that is to be applied immediately in the constant voltage mode.

Parameter: 0 to maximum value; MIN; MAX Units: Volt.  
Example: "VOLT:LIM:MAX 50" – sets maximum voltage input level to 50 Volts

### **VOLT:LIM:MIN**

This command sets and queries the minimum input voltage level that is to be applied immediately in the constant voltage mode.

Parameter: 0 to maximum value; MIN; MAX Units: Volt.  
Example: "VOLT:LIM:MIN 50" – sets minimum voltage input level to 50 Volts.

## **POW<sub>er</sub> ⇒Power Programming Functions**

This subsystem programs the constant power mode functions of the Electronic Load. The IEEE 488.1 command, "PSET" and "SET" (if current active mode is CP mode), can also be used.

### **POW**

This command sets the input power level that is to be applied immediately in the constant power mode. If the Electronic Load is not in the CP mode when the command is sent, the programmed level is saved and is applied when the Load changes to CP mode. The rate of input change is in accord with the slew rate in effect.

Parameter: 0 to maximum value; MIN; MAX Units: Watt.  
Example: "POW 50" – sets current input level to 50Watts.

### **POW:PROT:OVER**

This command sets a protection limit to the input power that the Electronic Load will accept. When the input power reaches the programmed power limit for the programmed delay period, the Electronic Load input is off.

Parameter: 0 to maximum value; MIN; MAX Units: Watt.  
Example: "POW:PROT:OVER 12"- sets the overpower protection to 120 Watts.

### **POW:PROT:OVER:DEL**

This command sets the delay time for over-power protection. When the input power reaches the programmed power limit for the programmed delay period, the Electronic Load input is off.

Parameter: 0 to maximum value Units: ms.  
Example: "POW:PROT:OVER:DEL 1200"- sets the overpower protection delay time to 1200 ms.

### **POW:PROT:UND**

This command sets an under power protection limit to the input power that the Electronic Load accepts. When the input power falls below the under power protection limit for the programmed delay period, the load input is off.

Parameter: 0 to maximum value; MIN; MAX Units: Watt.  
Example: "POW:PROT:UND 1.5"- sets the under power protection to 1.5 Watts.

### **POW:PROT:UNDER:DEL**

This command sets the delay time for under-power protection. When the input power falls below the programmed power limit for the programmed delay period, the Electronic Load input is off.

Parameter: 0 to maximum value Units: ms.  
Example: "POW:PROT:UNDER:DEL 1200"- sets the under-power protection delay time to 1200 ms.

### **POW:TRIG**

This command sets the input voltage level that is to be applied on occurrence of a trigger in the constant power mode. If the Electronic Load is not in the CP mode when the command is sent, the programmed TRIG level becomes a stored IMM level that takes effect when the Load changes to CP mode. The rate of input change is in accord with the slew rate in effect.

Parameter: 0 to maximum value; MIN; MAX Unit: Watt.  
Example: "POW:TRIG 100" – sets the power trigger value to 100 W.

### **POW:TLEV**

This command sets the transient voltage level in CP mode. When the transient subsystem is on, the Electronic Load will switch between the main level and transient level at a rate determined by the slew rate in effect. If the programmed transient power level is below the main voltage level, the switching will not occur until the main level is below the value of POW:TLEV. The IEEE488.1 command, "PTR" can also be used.

Parameter: 0 to maximum value; MIN; MAX Unit: Watt  
Example: "POW: TLEV 50" – sets the power trigger level to 50 W

### **POW:SLEW**

This command sets the power slew rate in CP mode. The programmed slew rate is in effect for all voltage changes except INP:ON or OFF. The hardware implementation selects a slew rate that is closest to the POW:SLEW value. To determine the actual value, use the query POW:SLEW?.

Parameter: 0 to maximum value; MIN; MAX Unit: Watt/μs  
Example: "POW:SLEW 6"- sets the power slew rate to 6W/μs

### **POW:DUTY**

This command sets pulse duty cycle, as a percentage of the total cycle, of continuous transient mode in CP mode. If the Electronic Load is operating in another mode, the duty cycle is stored until the Load changes to continuous mode.

Parameter: 2 to 98; MIN; MAX Unit: %  
Example: "POW:DUTY 50" – sets a 50% duty cycle for transient power mode.

### **POW:FREQ**

This command sets pulse frequency of continuous transient mode in Hz. If the Electronic Load is operating in another mode, the pulse frequency is stored until the Load changes to continuous mode.

Parameter:	0.25 to 20000; MIN; MAX	Unit: Hz
Example:	“POW:FREQ 1000” – sets a 1000Hz frequency for transient power mode.	

### **POW:LIM:MAX**

This command sets and queries the maximum input power level that is to be applied immediately in the constant power mode.

Parameter:	0 to maximum value; MIN; MAX	Units: Watt.
Example:	“POW:LIM:MAX 50” – sets maximum power input level to 50 Watts.	

### **POW:LIM:MIN**

This command sets and queries the minimum input power level that is to be applied immediately in the constant power mode.

Parameter:	0 to maximum value; MIN; MAX	Units: Watt.
Example:	“POW:LIM:MIN 50” – sets minimum power input level to 50 Watts.	

## **INPut/OUTPut ⇒Input Programming Functions**

This subsystem controls the Electronic Load input.

### **INP[:STATe]**

This command turns the Electronic Load input ON and OFF. When the input is off, the Electronic Load draws minimal current at its input. The input turns on or off at the maximum rate, not in accord with the presently programmed slew rate.

Parameter:	OFF or 0; ON or 1
Example:	“INP 1”- enables the input to the load.

### **INP:SHOR[:STATe] or SHOR**

This command enables/disables electronic short across the Electronic Load input. The actual short condition depends on the active mode and its active operating range. If a mode or range is changed, the short will be reapplied to the new mode or range.

Parameter:	OFF or 0; ON or 1
Example:	“INP:SHOR 0” – disables the short across the input.

### **INP:REL**

Programming OFF closes the relay contacts; programming ON opens them.

Syntax	INPut:RElAy [STATe]
Parameters	0   1; CLOSE   OPEN; OFF   ON

## **MEASure ⇒Measurement Query**

This subsystem queries and returns the current, voltage, and power at the input of the Electronic Load.

### **MEAS:CURRENt[:DC]?**

Returns the Electronic Load input current value to the buffer.

### **MEAS:VOLTage[:DC]?**

Returns the Electronic Load input voltage value to the buffer.

### **MEAS:DEL**

This command is to sets or queries the delay time to obtain read back value for “MEAS:VOLT?” and “MEAS:CURRENt?” queries.

Parameter:	0 to 100,000	Units: ms.
Example:	“MEAS:DEL 600” – sets the delay time to 600 ms.	



**MODE / MODE? ⇒ Mode Selection Command/Query**

This subsystem selects and queries the operating mode of the Electronic Load

**MODE CC or MODE:CURR**

This command sets Electronic Load to constant current mode.

**MODE CR or MODE:RES**

This command sets Electronic Load to constant resistance mode.

**MODE CV or MODE:VOLT**

This command sets Electronic Load to constant voltage mode.

**MODE CP or MODE:POW**

This command sets Electronic Load to constant power mode.

**MODE:RANGe**

This command sets the range after the mode is set.

Parameters: 0 – 3

- i. low range
- ii. middle range
- iii. high range
- iv. ultra range

Example: “MODE:RES” – sets the Electronic Load in CR mode;  
 “MODE:RANG 2” – sets the Electronic Load in high range;  
 “MODE:RANG? CR” – queries the range for CR mode.

**TRANSient ⇒ Transient Programming Function**

This subsystem programs the transient functions of three transient modes: **CONTinuous**, **PULSe**, **TOGGle**. The input levels (**TLEVel**) and slew rate (**SLEW**) are programmed from the current, resistance, power and voltage subsystems.

**TRAN[:STATe]**

This command enables or disables the transient or stepping function. The parameter ON | 1 enables the function and OFF | 0 disables it.

Parameter: ON | 1, OFF | 0

Example: “TRAN ON” – enables the transient function

**DUTY**

This command sets pulse duty cycle, as a percentage of the total cycle, of continuous transient mode. If the Electronic Load is operating in another mode, the duty cycle is stored until the Load changes to continuous mode.

Parameter: 2 to 98; MIN; MAX Unit: %

Example: “CURR:DUTY 50” – sets a 50% duty cycle for transient current mode.

**FREQ**

This command sets pulse frequency of continuous transient mode in Hz. If the Electronic Load is operating in another mode, the pulse frequency is stored until the Load changes to continuous mode.

Parameter: 0.25 to 20000; MIN; MAX Unit: Hz

Example: “CURR:FREQ 1000” – sets a 1000Hz frequency for transient current mode.

**SLEW**

This command sets the power slew rate for the active mode. The programmed slew rate is in effect for all changes except INP:ON or OFF. The hardware implementation selects a slew rate that is closest to the SLEW value. To determine the actual value, use the query SLEW?.

Parameter: 0 to maximum value; MIN; MAX Unit: Depending on mode

Example: “SLEW 6” – sets the slew rate to 6.

## **TRAN:TWID**

This command sets pulse width of pulse transient mode in millisecond. If the Electronic Load is operating in another mode, the pulse width is stored until the Load is powered cycle.

Parameter:	0.05 to 10000	Unit: ms
Example:	"TRAN:TWID 800" – sets the pulse width to 800 ms.	
Query syntax:	"TRAN:TWID?"	
Returned parameter:	Pulse width value in second.	

## **STEP ⇒ Step Programming Functions**

This subsystem programs the stepping functions for stepping mode. The number of loops, step values, and dwell times are programmed for a specified operating mode.

### **UTIL:STEP:LOOP**

This command sets the number of loops the stepping operation will repeat.

Parameter:	0 to 99
Example:	"UTIL:STEP:LOOP 10" - sets the number of loops to 10.

If Parameter is set to 0, the loops will repeat indefinitely.

### **UTIL:STEP:COUNT**

This command sets the number of steps activated

Parameter:	1 to 99
Example:	UTIL:STEP:COUNT 5" – sets the number of steps to 5.

### **STEP:MODE <STEP COUNT> <MODE>**

This command sets the step number for a specified operating mode.

Parameter for Step count:	0 to 99
Parameter for Mode:	0 (CV); 1 (CC); 2 (CR); 3 (CP)
Example:	"STEP:MODE 0 1" – sets to step 0 (first step) in the Constant Current (CC) mode

**Note:** All steps must be set to same mode and same range.

### **STEP:VALue <STEP COUNT> <VALUE>**

This command sets the step value for a specified step.

Parameter for Step count:	0 to 99
Parameter for Value:	0 to maximum value of operating mode range
Example:	"STEP:VAL 0 5" – sets step 0 to 5Amps(CC Mode)

### **STEP:TIME <STEP COUNT> <TIME>**

This command sets the step (dwell) time for a specified step.

Parameter for Step count:	0 to 99
Parameter for Time:	10ms to 600,000ms(10min)
Example:	"STEP:TIME 0 1000" – sets time to 1000ms for step 0 (first step)

## **UTILITY ⇒ Utility Functions**

This subsystem sets or queries utility configurations.

### **UTIL:MEAS:SENSE**

This command sets or queries the measurement sense (Local / Remote ).

Parameter:	0   1 (0 – Local; 1 – Remote)
Example:	UTIL:MEAS:SENS 1 – sets measurement sense to remote sense

**UTIL:EOI**

This command sets or queries the end of string (EOS) mode for read back.

Parameter: 0 ... 1 (0 – NONE; 1 – CR)

Example: UTIL:EOI 1 – sets the EOS mode to CR

**UTIL:TR:MODE**

This command sets or queries the transient mode.

Parameter: 0 ... 3 (0 – CONTINUOUS; 1 – STEPPING; 2 – PULSE; 3 – TOGGLE)

Example: UTIL:TR:MODE 0 – sets the transient mode to continuous.

**UTIL:CURR <VAL>**

This command sets or queries the Electronic Load C value setting.

Example: UTIL:CURR 10.0 – sets C value to 10.0.

**UTIL:RANG <VAL>**

This command sets or queries the range mode.

Parameters: 0 – Manual range

1 – Auto range

Example: UTIL:RANG 0 – Sets the electronic load to manual range.

**SYST:RANG?**

This command returns the number of ranges for each mode in a “CV/CC/CR/CP” sequence.

Example: SYST:RANG? – returns “1/2/3/2” means 1 range for CV mode, 2 ranges for CC mode, 3 ranges for CR mode and 2 ranges for CP mode.

**COMMON COMMANDS**

A common command begins with an \* and consists of three letters. It is followed by a “?” if it is a query. They are generally not related to specific device operation but to perform the identical function for all instruments that are compliant with the IEEE488.2 standard. Common commands can be mixed in with regular Electronic Load commands. The FEL responds to 8 common commands that control internal operation, status and event registers, and system data.

**\*CLS Clear Status Command**

This command clears the Status Byte summary register and all event register.

**\*ESR? Event Status Register Query**

This command queries the Standard Event Status register. Reading it clears it.

**\*IDN? Identification Query**

This query requests the Electronic Load to identify itself. It returns the model number of the unit.

**\*STB? Status Byte Query**

This query reads the Status Byte Register. Reading the register does not clear it.

**\*TRG Trigger Command**

This command generates a trigger to the Electronic Load.

**\*TST? Test Query**

This query causes the Electronic Load to go through a self-test.

**\*SAV Save Command**

This command stores the present state and calibration data to internal back-up flash memory.

## COMMAND LIST

COMMAND	FORMAT	ACTION
INPUT enable	INP[?]	0/1/OFF/ON
	INP[:STAT][?]	0/1/OFF/ON
SHORT enable	SHOR	0/1/OFF/ON
	INP:SHOR[:STAT][?]	0/1/OFF/ON
<b><u>SET commands</u></b>		
SET value	SET[?]	MAX/MIN
SET Voltage	VSET[?]	MAX/MIN
	VOLT[:LEV][:IMM][?]	MAX/MIN
	VOLT[:LEV]:TRIG[?]	MAX/MIN
SET Current	ISSET[?]	MAX/MIN
	CURR[:LEV][:IMM][?]	MAX/MIN
	CURR[:LEV]:TRIG[?]	MAX/MIN
SET Resistance	RSET[?]	MAX/MIN
	RES[:LEV][:IMM][?]	MAX/MIN
	RES[:LEV]:TRIG[?]	MAX/MIN
SET Power	PSET[?]	MAX/MIN
	POW[:LEV][:IMM][?]	MAX/MIN
	POW[:LEV]:TRIG[?]	MAX/MIN
<b><u>TRANSIENT commands</u></b>		
TRANSient enable	TR[?]	0/1/OFF/ON
TLEV transient level	TLEV[?]	MAX/MIN
TRansient Volatge	VTR[?]	MAX/MIN
	VOLT:TLEV[?]	MAX/MIN
TRansient Current	ITR[?]	MAX/MIN
	CURR:TLEV[?]	MAX/MIN
TRansient Resistance	RTR[?]	MAX/MIN
	RES:TLEV[?]	MAX/MIN
TRansient Power	PTR[?]	MAX/MIN
	POW:TLEV[?]	MAX/MIN
SLEW rate value	SLEW[?]	MAX/MIN
SLEW rate Voltage	VOLT:SLEW[?]	MAX/MIN
SLEW rate Current	CURR:SLEW[?]	MAX/MIN
SLEW rate Resistance	RES:SLEW[?]	MAX/MIN
SLEW rate Power	POW:SLEW[?]	MAX/MIN
DUTY cycle	DUTY[?]	MAX/MIN
DUTY Voltage	VOLT:DUTY[?]	MAX/MIN
DUTY Current	CURR:DUTY[?]	MAX/MIN
DUTY Resistance	RES:DUTY[?]	MAX/MIN
DUTY Power	POW:DUTY[?]	MAX/MIN
FREQuency	FREQ[?]	MAX/MIN
FREQuency voltage	VOLT:FREQ[?]	MAX/MIN
FREQuency current	CURR:FREQ[?]	MAX/MIN
FREQuency resistance	RES:FREQ[?]	MAX/MIN
FREQuency power	POW:FREQ[?]	MAX/MIN
<b><u>QUERY commands</u></b>		
MEASure Voltage	MEAS:VOLT[:DC][?]	
MEASure Current	MEAS:CURR[:DC][?]	
MEASure DELay	MEAS:DEL[?]	

**PROTECTION commands**

OVER Voltage value	VOLT:PROT:OVER[?]
OVER Current value	CURR:PROT:OVER:[?]
OVER Power value	POW:PROT:OVER:[?]
UNDER Voltage value	VOLT:PROT:UND[?]
UNDER Current value	CURR:PROT:UND[?]
UNDER Power value	POW:PROT:UND[?]
OVER-V Time Delay	VOLT:PROT:OVER:DEL[?]
OVER-C Time delay	CURR:PROT:OVER:DEL[?]
OVER-P Time delay	POW:PROT:OVER:DEL[?]
UNDER-V Time Delay	VOLT:PROT:UND:DEL[?]
UNDER-C Time delay	CURR:PROT:UND:DEL[?]
UNDER-P Time delay	POW:PROT:UND:DEL[?]

**LIMIT commands**

LIMIT Voltage MAX	VOLT:LIM:MAX[?]
LIMIT Current MAX	CURR:LIM:MAX[?]
LIMIT Resistance MAX	RES:LIM:MAX[?]
LIMIT Power MAX	POW:LIM:MAX[?]
LIMIT Voltage MIN	VOLT:LIM:MIN[?]
LIMIT Current MIN	CURR:LIM:MIN[?]
LIMIT Resistance MIN	RES:LIM:MIN[?]
LIMIT Power MIN	POW:LIM:MIN[?]

**MODE and RANGE commands**

MODE Query	MODE?
CURR MODE	MODE CC
	MODE:CURR
VOLT MODE	MODE CV
	MODE:VOLT
RES MODE	MODE CR
	MODE:RES
POW MODE	MODE CP
	MODE:POW
MODE RANGE	MODE:RANGe <n> 0...3
	MODE:RANGe? <MODE>
SYSTEM RANGE	SYST:RANGe[?]

**STEP commands**

Utility STEP LOOP	UTIL:STEP:LOOP[?] <VAL>
Utility STEP COUNT	UTIL:STEP:COUNT[?] <VAL>
STEP MODE	STEP:MODE[?] <STEP COUNT> <MODE> (Must be in same mode and range)
STEP VAL	STEP:VAL[?] <STEP COUNT> <VAL>
STEP TIME	STEP:TIME[?] <STEP COUNT> <VAL>

**UTILITY commands**

Utility MEASure SENSE	UTIL:MEAS:SENSE
Utility End Of Identifier	UTIL:EOI
Utility TRansient Mode	UTIL:TR:MODE
Utility Current value	UTIL:CURR[?] <VAL> C value
Utility Range Operation	UTIL:RANG[?] <VAL>

## FIVE: CALIBRATION

### *INSTRUCTION*



#### **WARNING**

Exercise caution when using and calibrating an electronic load. High energy levels can be stored at the input voltage terminals on an electronic load in normal operation. In addition, potentially lethal voltages exist in the power circuit and on the input and sense connectors of a power supply with a rated output greater than 40V. Filter capacitors store potentially dangerous energy for some time after power is removed.



#### **CAUTION**

Only qualified personnel should attempt the calibration procedure, due to the high level of power.

This procedure describes calibration for the AMREL Programmable DC Electronic Load. The load is calibrated either through local or remote control. The following information provides calibration procedures in local mode.

**NO** hardware adjustment is necessary since all calibration is accomplished by software. The software sends calibration constants to the via the front panel keys. To maintain electronic load's precision input, calibration should be performed at least annually.

The nineteen parameters that need to be calibrated. After all the electronic load parameters are calibrated, the load returns to normal operating condition. If there are any errors in the calibration, cycle the power and recalibrate. All constants are saved in a non-volatile EEPROM.

### ***CALIBRATION SERVICE ENVIRONMENT AND PRECAUTIONS***

- Follow established antistatic procedures.
- Work at a bench with adequate room and support for the test unit and for all equipment required.
- To reduce shock hazard, use only an insulated, straight-bladed screwdriver when calibrating.

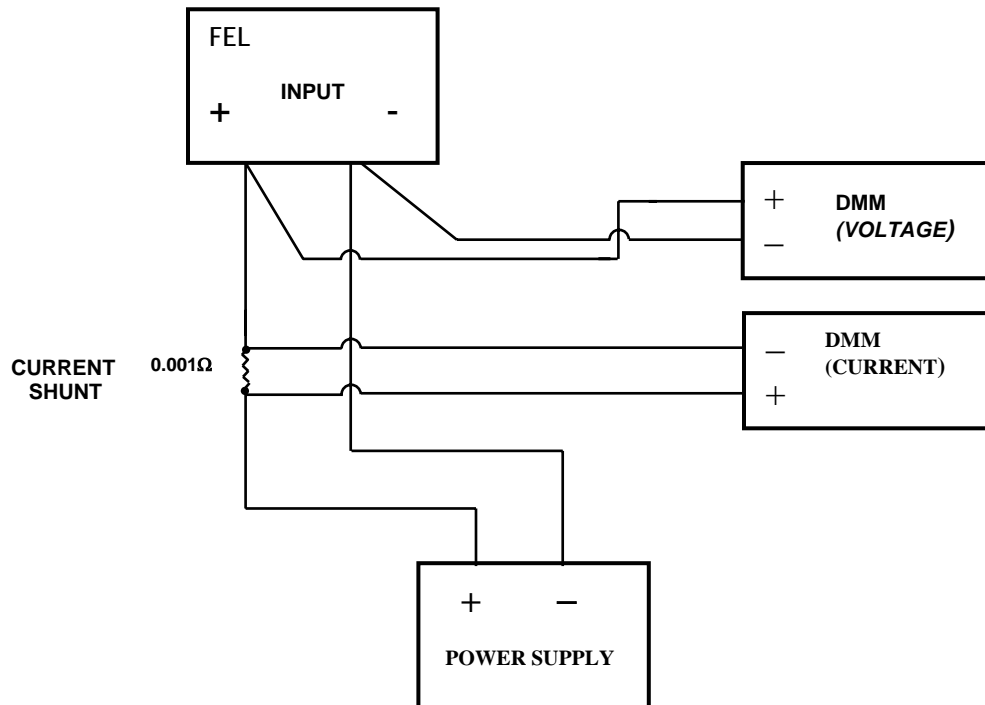
NEVER calibrate these units alone. Ensure that someone is present who can help should an accident occur.

## ***CALIBRATION REQUIRED EQUIPMENT***

- DMM
- Current Shunt (Precision Shunt Resistor-0.001ohm, 0.005% accuracy)
- DC power supplies (suitable for CV and CC maximum rating)

## ***CALIBRATION CONFIGURATION***

There are two configurations for the calibration of the electronic load. One is for measuring voltage and the other for measuring current.



## ***CALIBRATION PARAMETERS***

The following are the parameters that are calibrated.

- CV main level programming.
- CC low range main level programming.
- CC high range main level programming.
- CR low range main level programming.
- CR middle range main level programming.
- CR high range main level programming.
- CP low range main level programming.
- CP high range main level programming.
- CV transient level programming.
- CC low range transient level programming.
- CC high range transient level programming.
- CR low range transient level programming.
- CR middle range transient level programming.
- CR high range transient level programming.
- CP low range transient level programming.
- CP high range transient level programming.
- CV readback.
- CC low range readback.
- CC high range readback.

## ***LOCAL CALIBRATION PROCEDURES***

The FEL uses the two points calibration method whereby the FEL has two preset calibration points for each parameter. The microprocessor does the calculation for the operating slope and offset in programming and readback functions. The default calibration points are low point 400 count and high point 2200 count. These are the default bit counts (DAC circuit) where the 400 counts point represents approximately 10% of full scale and the 2200 counts point is at 55% full scale. Although these points can be changed in the “Calibration Utility” menu, it is not recommended.

The following is the procedure for the calibration of each parameter.

Press “ENTER” & “9” keys simultaneously to enter into calibration mode. Once in calibration mode, the operator can use “◀” and “▶” key to shift to the different calibration parameters.

All calibration procedures should be done in the local sensing mode. Voltage local sensing is at the input terminal. In the following calibrations steps, the procedures will suggest certain power supply input, voltage, current and power, but the operator must calculate the power consumption of FEL to prevent from damaging the unit during calibration.

After calibration is completed, all new values entered must be saved in the FEL’s flash memory by pressing “3” & ENTER key simultaneously. It will take approximately 3 seconds for the FEL to save the new calibration values. During this period, the LCD will display “SAVE FLASH MEMORY”. Do not turn-off FEL during this period.

**Note:** The calibration parameter does not has to be in order. You can calibrate any parameter you wish to.  
Example:

You can calibrate the CC mode’s main, transient, and read back values first then move on to other mode.

Or if the CC mode’s output is accurate, but the read back is not. You can just calibrate the CC mode’s read back only.



## ***CONSTANT VOLTAGE (CV) MAIN LEVEL CALIBRATION***

CV main level calibration requires a power supply that covers the full range of input voltage of the load and is capable of operating in CV and CC mode. Estimate the power consumption of the load, because power supply will go to CC mode while calibrating the load. Adjust the CC current level to a safe limit for load.

***Note:*** Pressing **CLEAR** key will take you back to previous menu.

Use “◀” and “▶” until you see VRO parameter. Then press enter:

VRO 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to VRO 2200 CNT.
VRO 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to VRO PARAM SAVE.
VRO PARAM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to VRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CONSTANT CURRENT (CC) LOW RANGE MAIN LEVEL CALIBRATION***

CC low range calibration requires a power supply that covers full range of the low range input current of the load. Estimate the power consumption of the load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see CRO parameter. Press enter:

CR0 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to CRO 2200 CNT.
CR0 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to CRO PARAM SAVE.
CRO PARAM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to CRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CONSTANT CURRENT (CC) MIDDLE/HIGH RANGE MAIN LEVEL CALIBRATION***

CC high range calibration requires a power supply that covers full range of high range input current of load. Estimate the power consumption of the load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see CR1 parameter. Press enter:

CR1 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to CR1 2200 CNT.
CR1 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to CR1 PARAM SAVE.
CR1 PARAM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to CR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

### ***CONSTANT RESISTANCE (CR) LOW RANGE MAIN LEVEL CALIBRATION***

CR low range main level calibration requires a power supply that has low voltage and high current, but operator has to estimate the power consumption of load.

Use “◀” and “▶” until you see RRO parameter. Press enter:

RR0	400	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR0 400 CNT current value.
RR0	400	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR0 2200 CNT voltage value.
RR0	2200	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR0 2200 CNT current value.
RR0	2200	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR0 PARAM SAVE.
RR0	PARAM SAVE: press ENTER key to save parameters. Press CLEAR key to back space to RR0 parameter, then press “▶” to select the next parameter that you wish to calibrate.		

### ***CONSTANT RESISTANCE (CR) MIDDLE/HIGH RANGE MAIN LEVEL CALIBRATION***

CR middle range main level calibration requires a power supply that has medium voltage and medium current, but operator has to estimate the power consumption of electronic load.

Use “◀” and “▶” until you see RR1 parameter. Press enter:

RR1	400	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR1 400 CNT current value.
RR1	400	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR1 2200 CNT voltage value.
RR1	2200	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR1 2200 CNT current value.
RR1	2200	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR1 PARAM SAVE.
RR1	PARAM SAVE: press ENTER key to save parameters. Press CLEAR key to back space to RR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.		

### ***CONSTANT RESISTANCE (CR) HIGH RANGE MAIN LEVEL CALIBRATION***

CR high range main level calibration requires a power supply that has high voltage and medium current, but operator has to estimate the power consumption of load.

Use “◀” and “▶” until you see RR2 parameter. Press enter

RR2	400	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR2 400 CNT current value.
RR2	400	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR2 2200 CNT voltage value.
RR2	2200	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR2 2200 CNT current value.
RR2	2200	CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to RR2 PARAM SAVE.
RR2	PARAM SAVE:		press ENTER key to save parameters. Press CLEAR key to back space to RR2 parameter, then press “▶” to select the next parameter that you wish to calibrate.

### ***CONSTANT POWER (CP) LOW RANGE MAIN LEVEL CALIBRATION***

CP low range main level calibration requires a power supply that has enough power output. For example, a FEL60-2, 20V/50A model needs at least 10V/6A power output to calibrate the unit.

Use “◀” and “▶” until you see PRO parameter. Then press enter:

PRO	400	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to PRO 2200 CNT.
PRO	2200	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to PRO PARAM SAVE.
PRO	PARAM SAVE:		press ENTER key to save parameters. Press CLEAR key to back space to PRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

### ***CONSTANT POWER (CP) MIDDLE/HIGH RANGE MAIN LEVEL CALIBRATION***

CP high range main level calibration requires a power supply that has enough power output. For instance, FEL60-2, 20V/50A model needs at least 10V/6A power output to calibrate the unit.

Use “◀” and “▶” until you see PR1 parameter. Then press enter:

PR1	400	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to PR1 2200 CNT.
PR1	2200	CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to PR1 PARAM SAVE.
PR1	PARAM SAVE:		press ENTER key to save parameters. Press CLEAR key to back space to PR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CV TRANSIENT LEVEL CALIBRATION***

CV transient level calibration requires a power supply that covers full range of input voltage of load and is capable of operating in CV and CC mode. Estimate the power consumption of FEL, because power supply will go to CC mode while calibrating the load. Adjust the CC current level to a safe limit for load.

Use “◀” and “▶” until you see TR VRO parameter. Then press enter:

TR VR0 400 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR VRO 2200 CNT.  
TR VR0 2200 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR VRO PARAM SAVE.  
TR VRO PARAM SAVE: press ENTER key to save parameters. Press CLEAR key to back space to TR VRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CC LOW RANGE TRANSIENT LEVEL CALIBRATION***

CC low range transient level calibration requires a power supply that covers full range of low range input current of load. Estimate the power consumption of the electronic load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see TR CRO parameter. Press enter:

TR CR0 400 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR CRO 2200 CNT.  
TR CR0 2200 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR CRO PARAM SAVE.  
TR CRO PARAM SAVE: press ENTER key to save parameters. Press CLEAR key to back space to TR CRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CC MIDDLE/HIGH RANGE TRANSIENT LEVEL CALIBRATION***

CC high range transient level calibration is requires a power supply that covers full range of high range input current of electronic load. Estimate the power consumption of the load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see TR CR1 parameter. Press enter:

TR CR1 400 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR CR1 2200 CNT.  
TR CR1 2200 CNT: press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR CR1 PARAM SAVE.  
TR CR1 PARAM SAVE: press ENTER key to save parameters. Press CLEAR key to back space to TR CR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CR LOW RANGE TRANSIENT LEVEL CALIBRATION***

CR low range transient level calibration requires a power supply that has low voltage and high current, but operator has to estimate the power consumption of electronic load.

Use “◀” and “▶” until you see TR RRO parameter. Press enter:

TR RR0 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR0 400 CNT current value.
TR RR0 400 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR0 2200 CNT voltage value.
TR RR0 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR0 2200 CNT current value.
TR RR0 2200 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR0 PARAM SAVE.
TR RRO PARM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to TR RR0 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CR MIDDLE/HIGH RANGE TRANSIENT LEVEL CALIBRATION***

CR middle range transient level calibration requires a power supply that has medium voltage and medium current, but operator has to estimate the power consumption of electronic load.

Use “◀” and “▶” until you see TR RR1 parameter. Press enter

TR RR1 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR1 400 CNT current value.
TR RR1 400 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR1 2200 CNT voltage value.
TR RR1 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR1 2200 CNT current value.
TR RR1 2200 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR1 PARAM SAVE.
TR RR1 PARM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to TR RR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CR HIGH RANGE TRANSIENT LEVEL CALIBRATION***

CR high range transient level calibration requires a power supply that has high voltage and medium current, but operator has to estimate the power consumption of load.

Use “◀” and “▶” until you see TR RR2 parameter. Press enter:

TR RR2 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR2 400 CNT current value.
TR RR2 400 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR2 2200 CNT voltage value.
TR RR2 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR2 2200 CNT current value.
TR RR2 2200 CNT:	press ENTER key twice and input measured current then press ENTER key. Press CLEAR key then press “▶” and ENTER key to move on to TR RR2 PARAM SAVE.
TR RR2 PARM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to TR RR2 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CP LOW RANGE TRANSIENT LEVEL CALIBRATION***

CP high range transient level calibration requires a power supply that has enough power output. For example, a FEL60-2, 20V/50A model needs at least 10V/6A power output to calibrate the unit. Only qualified personnel should attempt this calibration, due to the high level of power.

Use “◀” and “▶” until you see TR PRO parameter. Then press enter:

TR PRO 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR PRO 2200 CNT.
TR PRO 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR PRO PARAM SAVE.
TR PRO PARAM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to TR PRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CP MIDDLE/HGH RANGE TRANSIENT LEVEL CALIBRATION***

CP high range transient level calibration requires a power supply that has enough power output. For example, a FEL60-2, 20V/50A model needs at least 10V/6A power output to calibrate the unit. Only qualified personnel should attempt this calibration, due to the high level of power.

Use “◀” and “▶” until you see TR PR1 parameter. Then press enter:

TR PR1 400 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR PR1 2200 CNT.
TR PR1 2200 CNT:	press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to TR PR1 PARAM SAVE.
TR PR1 PARAM SAVE:	press ENTER key to save parameters. Press CLEAR key to back space to TR PR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CV READBACK LEVEL CALIBRATION***

CV readback main level calibration requires a power supply that covers full range of input voltage of load and is capable of operating in CV and CC mode. Estimate the power consumption of load, because power supply will go to CC mode while calibrating the load. Adjust the CC current level to safe limit of load.

Use “◀” and “▶” until you see RB VRO parameter. Then press enter:

RB VR0400 CNT:       press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB VRO 2200 CNT.  
RB VR02200 CNT:     press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB VRO PARAM SAVE.  
RB VRO PARAM SAVE:  press ENTER key to save parameters. Press CLEAR key to back space to RB VRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CC LOW RANGE READBACK LEVEL CALIBRATION***

CC readback low range calibration requires a power supply that covers full range of low range input current of load. Estimate the power consumption of the electronic load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see RB CRO parameter. Press enter:

RB CR0 400 CNT:       press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB CRO 2200 CNT.  
RB CR0 2200 CNT:     press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB CRO PARAM SAVE.  
RB CRO PARAM SAVE:  press ENTER key to save parameters. Press CLEAR key to back space to RB CRO parameter, then press “▶” to select the next parameter that you wish to calibrate.

## ***CC MIDDLE/HIGH RANGE READBACK LEVEL CALIBRATION***

CC readback high range calibration requires a power supply that covers full range of high range input current of electronic load. Estimate the power consumption of the electronic load, and adjust the voltage input to a safe limit for the load.

Use “◀” and “▶” until you see RB CR1 parameter. Press enter:

RB CR1 400 CNT:       press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB CR1 2200 CNT.  
RB CR1 2200 CNT:     press ENTER key twice and input measured voltage then press ENTER key. Press CLEAR key then press “▶” to move on to RB CR1 PARAM SAVE.  
RB CR1 PARAM SAVE:  press ENTER key to save parameters. Press CLEAR key to back space to RB CR1 parameter, then press “▶” to select the next parameter that you wish to calibrate.

**This completes the calibration for all the input parameters for the electronic load.**

**Press “3” & “ENTER” key simultaneously to save all new calibration parameters into the load’s memory.**

## ***RE-INSTALLING CALIBRATION DATA***

In case, the calibration data becomes corrupted by abnormal conditions, the Electronic Load has a built in capability for re-installing the last calibration data without having to recalibrate the load.

1. First you need to read the slope and offset values from the electronic load when you receive the unit, or you can call American Reliance Inc to get the calibration information for the electronic load (need serial number)

Get calibration data procedure:

Get slope value:

Run command: "**SYST: SLOPE? <mode>**" to get calibration slope values where "mode" is from 0 to 39. So there should be 40 values for slope data.

Get offset value:

Run command: "**SYST: OFFS? <mode>**" to get calibration offset values where "mode" is from 0 to 39. So there should be 40 values for offset data.

2. Once you obtain all the calibration information, you can resave this calibration information to the electronic load.

Resave calibration slope data to electronic load.

Run command: "**SYST: SLOPE <mode> <value>**" where "mode" is from 0 to 39, and the value is the corresponding slope value obtained from 1.

Resave calibration offset data to electronic load.

Run command: "**SYST: OFFS <mode> <value>**" where "mode" is from 0 to 39, and the value is the corresponding offset value obtained from 1.

After re-saving the calibration information for electronic load, you need test the CV and CC mode, and check if the reading back values are within spec.



# FEL60-2

Design Condition				CC Readback			
Voltage	20.00	V		CCL Resolution	0.0014	A	
Current	50.00	A		CCM Resolution	0.014	A	
Power	60.00	W		CCL Accuracy	0.20% ± 0.050	A	
CCL Transient Time	200.0	us		CCM Accuracy	0.20% ± 0.050	A	
CCM Transient Time	200.0	us		Constant Resistor Mode			
PROGRAMMABLE PROTECTION				CRL Range	0.008 ~ 0.400	Ohm	
Current				CRM Range	0.400 ~ 4.000	Ohm	
Range	55.00	A		CRH Range	4.000 ~ 400.0	Ohm	
Resolution	0.014	A		@ lin ≤ 5.000		A	
Accuracy	0.20% ± 0.139	A		CRL Resolution	0.133	mOhm	
Voltage				CRM Resolution	0.833	mS	
Range	22.00	V		CRH Resolution	0.083	mS	
Resolution	0.006	V		CRL Accuracy	1.0% ± 0.800	mOhm	
Accuracy	0.20% ± 0.056	V		@ lin > 5.0A & Vin > 0.020		V	
Power				CRM Accuracy	1.0% ± 5.000	mS	
Range	66.00	W		@ lin > 0.5A & Vin > 2.000		V	
Resolution	0.017	W		CRH Accuracy	1.0% ± 2.000	mS	
Accuracy	1.00% 0.333	W		@ lin > 0.05A & Vin > 5.000		V	
Constant Voltage Mode				CR Transient			
Maximum Input	20.00	V		CRL Range	0.008 ~ 0.400	Ohm	
Range	0.000 ~ 20.00	V		CRM Range	0.400 ~ 4.000	Ohm	
Resolution	0.006	V		CRH Range	4.000 ~ 400.0	Ohm	
Accuracy	0.10% ± 0.020	V		@ lin ≤ 5.000		A	
CV Transient				CRL Resolution	0.267	mOhm	
Range	0.000 ~ 20.00	V		CRM Resolution	1.667	mS	
Resolution	0.006	V		CRH Resolution	0.167	mS	
Accuracy	0.20% ± 0.020	V		CRL Accuracy	2.0% ± 0.800	mOhm	
Slew Rate	0.073 ~ 20.00	V/ms		@ lin > 5.0A & Vin > 0.020		V	
CV Readback				CRM Accuracy	2.0% ± 5.00	mS	
Resolution	0.006	V		@ lin > 0.5A & Vin > 2.000		V	
Accuracy	0.20% ± 0.020	V		CRH Accuracy	2.0% ± 2.000	mS	
Constant current mode				@ lin > 0.05A & Vin > 5.000		V	
Maximum Current	50.00	A		Constant Power Mode			
Minum Voltage(I <sub>Max</sub> )	0.400	V		CPL Range	0.600 ~ 6.000	W	
CCL Range	0.000 ~ 5.000	A		CPM Range	1.800 ~ 60.00	W	
CCM Range	0.000 ~ 50.00	A		CPL Resolution	0.002	W	
CCL Resolution	0.0014	A		CPM Resolution	0.020	W	
CCM Resolution	0.014	A		CPL Accuracy	1.00% ± 0.056 +		
CCL Accuracy	0.10% ± 0.050	A		0.021 ×   10.00 - Vin	W		
CCM Accuracy	0.10% ± 0.050	A		CPM Accuracy	1.00% ± 0.278 +		
CC Transient				0.104 ×   10.00 - Vin	W		
CCL Range	0.000 ~ 5.000	A		CP Transient			
CCM Range	0.000 ~ 50.00	A		CPL Range	0.600 ~ 6.000	W	
CCL Resolution	0.0014	A		CPM Range	1.800 ~ 60.00	W	
CCM Resolution	0.014	A		CPL Resolution	0.004	W	
CCL Accuracy	0.20% ± 0.050	A		CPM Resolution	0.040	W	
CCM Accuracy	0.20% ± 0.050	A		CPL Accuracy	2.00% ± 0.056 +		
CCL Slew Rate	0.00009 ~ 0.025	A/us		0.021 ×   10.00 - Vin	W		
CCM Slew Rate	0.00092 ~ 0.250	A/us		CPM Accuracy	2.00% ± 0.278 +		
				0.104 ×   10.00 - Vin	W		
				Others			

All mode specification measure at 25°C room temperature unless otherwise specified

AMREL reserves the right to change limits, test conditions, and dimensions without notice

Ver 4.2 Date : 08/16/05

